Pathway linking executive function problems and non-suicidal self-injury among adolescents: The mediating role of emotion dysregulation

Aulia Rachma [ORCID],[1] Donny Hendrawan [ORCID] [2]*

[1] Master of Professional Psychology, Faculty of Psychology, Universitas Indonesia, Depok – Indonesia; [2] Life Span Development Laboratorium, Faculty of Psychology, Universitas Indonesia, Depok – Indonesia

Abstract: Non-suicidal self-injury (NSSI) is a prevalent mental health issue among adolescents, with difficulties in emotional regulation identified as a significant predictor of such behavior. A set of neurocognitive skills known as executive function (EF) is also linked to NSSI. This study investigates the relationship between executive function problems and NSSI behavior, explicitly examining the mediating role of emotional dysregulation. Participants were selected using a non-probability purposive sampling technique, with the final sample consisting of 211 Indonesian adolescents aged between 12 and 18 (M = 14.57, SD = 1.42). The measurement instruments included the Teenage Executive Function Inventory (TEXI), the Cognitive Flexibility Scale (CFS), the Difficulties in Emotion Regulation Scale Short Form (DERS-SF), and the Deliberate Self-Harm Inventory (DSHI). Mediation analysis using the PROCESS macro for SPSS (model 4), revealed that emotion dysregulation significantly mediated the relationship between EF problems and NSSI. The indirect effect of EF problems and NSSI through emotion dysregulation was statistically significant (B = 0.203, 95% CI [0.0805, 0.3741]). Adolescents with lower EF are more prone to emotional difficulties, thus increasing the risk of NSSI. The study provides implications that help elucidate the dynamics of the NSSI phenomenon among adolescents. Furthermore, the findings highlight the need for interventions targeting both cognitive and emotional regulation skills to reduce NSSI in adolescents and promote overall mental health and well-being.

Keywords: adolescent; emotion dysregulation; executive function; non-suicidal self-injury

*Corresponding Author: Donny Hendrawan (donny.hendrawan@ui.ac.id), Jl. Lkr. Kampus Raya Jl. Prof. DR. R Slamet Iman Santoso, Pondok Cina, Kecamatan Beji, Kota Depok, Jawa Barat 16424 – Indonesia.

Introduction

Adolescence is a period marked by significant transitions across multiple domains, including physical-biological, social, cognitive, and emotional development. These simultaneous changes can create a heightened sense of vulnerability, leading adolescents to psychological distress and driving them to adopt maladaptive coping strategies such as non-suicidal self-injury (NSSI) (Blakemore, 2019; Liu et al., 2016). NSSI refers to the deliberate infliction of bodily harm without suicidal intent (Selby et al., 2012), commonly including actions such as cutting, burning, scratching, banging, hitting, biting, and excessive rubbing (Klonsky et al., 2014). The Diagnostic and Statistical Manual of Mental Disorders (DSM-5) acknowledges NSSI as a condition requiring further study, highlighting its importance for clinical research and potential future preventive actions (Mendelson, 1995).

Although NSSI is not currently classified as a formal mental disorder, it has gained significant attention within the psychiatric community. In adolescents, its prevalence has raised significant concern, having increased markedly since the 21st century, with predictions that the trend will continue to rise annually (Mozafari et al., 2022; Muehlenkamp et al., 2012). Global estimates suggest that 16% of adolescents have engaged in NSSI behaviors (Farkas et al., 2024). Moreover, a study involving 478 Indonesian adolescents showed that approximately 73% of the participants had engaged in NSSI (Maharani et al., 2022). Similarly, other research indicates that approximately 30% of Indonesian students have experienced NSSI (Tresno et al., 2012). Furthermore, NSSI behaviors have been documented in adolescent populations in low- to middle-income countries, highlighting its global relevance (Lim et al., 2019).

The emergence of NSSI is associated with several factors, including executive function problems (Hu et al., 2021; Smith et al., 2019).

executive function (EF) refers to a collection of higher-order cognitive processes responsible for managing thoughts, actions, and emotions to achieve goal-oriented behavior. It encompasses three core components: inhibitory control, working memory, and cognitive flexibility (Best & Miller, 2010). These cognitive skills are fundamental for effective decision-making and self-regulation, enabling adolescents to plan, monitor, and modify their behavioral responses to dynamic situations.

Adolescents who engage in NSSI behaviors have poorer levels of inhibition, cognitive flexibility, and working memory than typical developing adolescents (Hu et al., 2021; Mozafari et al., 2022). Those with low EF tend to have reduced tolerance to challenging situations. According to Fikke et al. (2011), the diminished functioning of EF components impairs adolescents' capacity to redirect their attention from demanding and difficult situations and to suppress negative emotions, as well as restricting their ability to reconstruct their thoughts to identify alternative coping strategies, thereby increasing their vulnerability to engaging in NSSI behaviors (Guerreiro et al., 2015; Mozafari et al., 2022).

Although some neuropsychological research has found a significant link between problems in EF and emerging NSSI behaviors in adolescents, other studies have failed to find a meaningful correlation. Furthermore, EF has been shown to provide a limited explanation of the mechanisms underlying NSSI in adolescents, possibly due to the influence of affective control (Mürner-Lavanchy et al., 2022; Shen et al., 2022). Allen et al. (2019) suggest that a lack of such control may be closely related to emotional instability or, in this instance, the onset of emotional dysregulation in the context of NSSI behaviors. These findings suggest that in some cases EF problems might not always be a single distinguishing feature of NSSI, allowing

other psychological factors, such as emotion dysregulation, to play a more prominent role.

Emotion dysregulation, a significant intra-personal factor characterized by the inability to effectively manage emotions and cognitive processes during unpleasant events, has been linked to the emergence of NSSI (Heffer & Willoughby, 2018; Hooley & Franklin, 2018; Nock, 2009). It hinders individuals from achieving their intended goals effectively (Thompson, 2019). Notably, over 75% of diagnostic categories in the DSM pertain to mental health issues linked to emotion dysregulation (Sheppes et al., 2015; Werner & Gross, 2010). Research has shown that adolescents engaging in NSSI exhibit significantly poorer emotion regulation skills compared to their peers and often use NSSI to alleviate negative feelings, including anger, sadness, and anxiety (Glenn & Klonsky, 2013; Robinson et al., 2019). A theoretical integration model proposed by Nock (2012) posits that individuals may resort to NSSI as a perceived effective strategy for emotional regulation in response to adverse social experiences. In addition, the lack of emotional regulation, coupled with heightened impulsivity, predisposes adolescents to engage in maladaptive behaviors, including NSSI (Pfeifer & Allen, 2021).

Research also shows EF is closely linked to regulating emotional systems, attention, and stress levels (Lantrip et al., 2016). When individuals are unable to manage stress effectively, their ability to maintain focused attention is compromised, which in turn impairs executive function and may increase the risk of mental health problems. Adolescents who struggle with self-regulation and planning may have difficulty managing emotional distress, leading to impulsive or harmful actions such as NSSI as a way of coping with overwhelming emotions (Wolff et al., 2019). The close relationship between EF problems and emotion dysregulation reflects the dynamic interplay between cognitive and emotional

processes, significantly affecting individual behavior (Pessoa, 2008). However, the specific mechanisms through which EF problems contribute to NSSI through emotion dysregulation remain underexplored. Exploration of this gap is particularly important, as emotion dysregulation may provide more nuanced understanding of how problems in executive function may lead to maladaptive coping mechanisms such as NSSI.

Previous studies have also mostly examined the direct relationship between EF problems and NSSI, especially in clinical populations with borderline personality disorder or depression (Nilsson et al., 2021; Wang et al., 2023). The relationship between these variables in typical populations has not been extensively studied (Mürner-Lavanchy et al., 2022). Understanding the cognitive and emotional factors that contribute to NSSI in adolescents within the typical population is crucial, as they drive the emergence of preventive strategies that may prevent the development of NSSI into more serious mental health issues. The study, therefore, aims to explore the role of EF problems in the emergence of NSSI behaviors among adolescents, specifically examining the mediating effect of emotion dysregulation. The study hypothesis is that emotion dysregulation mediates the relationship between EF problems and non-suicidal self-injury (NSSI) in adolescents.

Methods

Research Design

A non-experimental, quantitative correlational design was employed to examine the relationships between the key variables, with variations in one variable hypothesized to consistently predict changes in another (Gravetter & Forzano, 2018). Specifically, the study sought to explore the relationship between EF problems, non-suicidal self-injury (NSSI) behaviors, and emotion dysregulation, together with the role of emotion dysregulation as a mediator between

such problems and NSSI. The research followed a cross-sectional approach, with data collected within a specific period, from May to July 2024.

Participants

The participants were selected using a non-probability purposive sampling technique, which involves selecting participants based on specific criteria (Kumar, 2019). The sample consisted of 211 adolescents (boys and girls) aged 11-18 (M = 14.5, SD = 1.424), who were students at junior or senior high schools and lived in the Jakarta, Bogor, Depok, Tangerang, and Bekasi (Jabodetabek) regions. Sample size was estimated using G*Power version 3.1, with statistical parameters set at α = .05, f^2 = 0.15, and *power* = 0.95. The minimum sample size calculated for adequate statistical power was 107 participants, thus confirming that the final sample of 211 participants exceeded the minimum required size.

Research Procedure

Data were collected face-to-face from students attending five junior and senior high schools in the Jabodetabek area. The schools that agreed to participate distributed informed consent to parents. Only students who voluntarily agreed to participate and obtained parental consent were included. Those who received parental permission but chose not to participate could withdraw without consequences. Once informed consent was obtained from participants and their parents, the students completed an online questionnaire via the official Universitas Indonesia survey platform (Tim Peneliti, 2024).

The survey was administered using participants' devices under direct supervision from the researchers in a classroom setting. The research was approved by the Research Ethics Committee of the Faculty of Psychology, Universitas Indonesia, No. 250/FPsi.KomiteEtik/PDP.04.00/2023.

Instruments

Executive Function

Executive function problems were assessed using two standardized instruments: the Teenage Executive Function Inventory (TEXI) and the Cognitive Flexibility Scale (CFS). The TEXI, developed by Thorell et al. (2020), consists of 20 items rated on a 5-point Likert scale (1 = 'Very Unsuitable', 5 = 'Very Suitable') and was designed to evaluate executive function performance in adolescents, particularly focusing on working memory and inhibitory control.

The CFS is a measuring instrument used to evaluate executive function abilities related to aspects of cognitive flexibility (Martin & Rubin, 1995). It comprises 12 self-report statements, rated on a 6-point Likert scale (1 = 'Strongly Disagree', 6 = 'Strongly Agree'). Both the TEXI and CFS were adapted into Indonesian using a rigorous multi-step translation process. This involved: 1) translation of the items from English into Indonesian by two certified translators; 2) synthesis of the translated versions; 3) expert judgment involving five professionals in clinical and educational psychology; 4) a readability test with six adolescents outside the study population; and 5) back-translation to English by two certified translators.

Based on the results of psychometric testing, the TEXI demonstrates strong reliability, evidenced by a Cronbach's alpha of .89, and shows good validity, with item-total correlations ranging from .30 to .60. On the other hand, the CFS exhibits acceptable reliability, with a Cronbach's alpha of .72, indicating adequate internal consistency for psychological assessment. The Indonesian version of the CFS also demonstrates good validity, with item-total correlations ranging from .30 to .50. Adolescents' executive function problems were measured by adding together the total scores from the TEXI and CFS using factor score analysis methods.

Emotion Dysregulation

Emotion dysregulation was assessed using the Difficulties in Emotion Regulation Scale - Short Form (DERS-SF), developed by Kaufman et al. (2016). This self-report instrument consists of 18 items rated on a 5-point Likert scale (1 = 'Never', 5 = 'Always') and was designed to measure difficulties in emotion regulation. Like the TEXI and CFS, the DERS-SF was adapted into Indonesian following the same translation and validation procedures. It demonstrates strong reliability, with a Cronbach's alpha value of .841.

This indicates a high level of internal consistency, making it a reliable instrument for assessing emotional regulation difficulties within the Indonesian context. The results of confirmatory factor analysis (*CFA*) show that the model has a good fit (*CFI* = .98, *TLI* = .97, *RMSEA* = .075, *SRMR* = .075), indicating that the measurement tool has good validity. Scores on the DERS-SF ranged from 18 to 90, with higher scores indicating more significant difficulties in emotion regulation.

Non-Suicidal Self-Injury (NSSI) Behaviors

NSSI was measured using the Deliberate Self-Harm Inventory (DSHI), developed by Gratz (2001) and adapted into Indonesian by Tresno et al. (2012). It consists of 17 dichotomous items that assess the occurrence of self-harming behavior, with response options of 'Yes' or 'No.' Participants were categorized as engaging in self-injury if they responded 'Yes' to any item, while those who answered 'No' to all items were classified as non-self-injuring. The Indonesian version of the DSHI demonstrated satisfactory reliability, with a Cronbach's alpha of .76. It has good validity, with total correlation values ranging from .30 to .71.

Data Analysis

The data analysis was conducted utilizing IBM SPSS version 25. Initially, the data analysis involves applying the Kolmogorov-Smirnov test to evaluate the distribution of the collected data and to determine if it conforms to a normal distribution. Furthermore, Pearson's correlation test is utilized to examine the relationships between the variables, offering a comprehensive insight into the connections across the entire dataset. This method enables a thorough exploration of potential associations, enhancing the overall quality of the analysis. To assess the hypothesis of emotion dysregulation as mediator in the relationship between EF problems and NSSI behavior, the SPSS Macro PROCESS (Hayes, Model 4) was employed. This approach facilitated the evaluation of the direct and indirect effects of executive function on NSSI behavior through emotion dysregulation, specifically within the adolescent population.

Results

Demographic Data

The study sample involved 211 adolescent participants. According to demographic data (see Table 1), 50.7% were female, with 49.3% male. Their ages ranged from 12 to 18 (*M* = 14.57, *SD* = 1.424). In terms of education, the majority were at junior high school (66.8%), with the remaining 33.2% at senior high school. The majority of participants lived in Tangerang (31.3%), followed by Depok (21.8%), Jakarta (21.3%), Bogor (19%), and Bekasi (6.6%). This demographic profile suggests that the sample consisted primarily of younger adolescents, particularly those at junior high school, with a geographical concentration in Tangerang, Depok, and Jakarta.

Prevalence of NSSI

The data on the frequency of NSSI show that 51.7% (*n* = 109) of the participants reported engaging in such behaviors, while 48.3% (*n* = 102) indicated no such history. This indicates that slightly more than half of the participants had engaged in NSSI, suggesting that self-injurious behaviors were relatively prevalent within this particular sample.

The most frequently reported methods of NSSI among the sample were intense scratching, with 49.5% of participants indicating this behavior, followed by deliberate biting of the skin until bleeding, reported by 39.4%, and intentional interference with wound healing, which corresponded to 38.5% of the sample. These findings provide insight into the prevalence and types of self-injurious behaviors among the adolescents in the study. For a detailed breakdown of the number of participants reporting a history of self-injury, please refer to Table 2, which utilizes the Deliberate Self-Harm Inventory (DSHI) as the measurement tool.

Statistical Results

The normality test results from the Kolmogorov-Smirnov test yielded a significant value of .200, which exceeds the .05 threshold. It indicates that the data distribution for the continuous variables, namely executive function and emotion dysregulation, can be assumed to follow a normal distribution. However, the NSSI variable could not be subjected to a normality test due to the nature of the instrument used, the DSHI, which is based on a dichotomous scale. Since such as scale only provides two response options, "Yes" or "No," it is classified as a nominal scale and does not meet the requirements for normality testing.

The findings from the Pearson correlation analysis (Table 3) reveal a significant relationship between the study variables. The strongest correlation was identified to be between EF problems and emotion dysregulation, indicating that an increase in EF problems is associated with higher emotion dysregulation scores ($r = .37$, $p < .01$). Additionally, a significant correlation exists between emotion dysregulation and NSSI, which suggests that higher levels of emotion dysregulation correlate with an increase in NSSI behaviors ($r = .29$, $p < .01$). Furthermore, the correlation between EF problems and NSSI shows a positive but weak relationship ($r = .19$, $p = .004$). This implies that increasing EF problems may be linked with an increased likelihood of NSSI behaviors among adolescents.

Mediation analysis was conducted to investigate the relationship between EF problems (X) and NSSI behavior (Y) through emotion dysregulation (M). The results displayed in Table 4 indicate that EF problems have a significant effect on emotion dysregulation ($B = 0.36$, $p < .001$), with a 95% confidence interval ranging from 0.2415 to 0.4950, confirming that higher levels of poor EF are associated with higher levels of emotional dysregulation.

Additionally, the results reveal a significant positive relationship between emotional dysregulation and NSSI behavior ($B = 0.55$, $p < .001$). The 95% *CI* for this relationship ranged from 0.2300 to 0.8737, indicating that increased emotional dysregulation correlates with a higher likelihood of engaging in NSSI.

The direct effect of EF problems on NSSI was also assessed, but the relationship was not found to be statistically significant ($B = 0.23$, $p = .15$), as the *CI* ranged from -0.0793 to 0.5356, indicating that poor EF does not have a direct impact on NSSI when emotion dysregulation is accounted for (see Table 4).

In Table 5, the indirect effect analysis reinforced the finding that the relationships between EF problems and NSSI through emotion dysregulation were statistically significant ($B = 0.203$, 95% *CI* [0.0805, 0.3741]. It further supports the hypothesis that emotional dysregulation fully mediates the relationship between EF problems and NSSI behaviors in adolescents.

Table 1

Demographic Data (N = 211)

Variable	N	%
Gender		
Male	104	49.3
Female	107	50.7
Age		
12	7	3.3
13	39	18.5
14	83	39.3
15	21	9.9
16	37	17.5
17	18	8.5
18	6	2.8
Education		
Junior High School	141	66.8
Senior High School	70	33.2
Domicile		
Jakarta	45	21.3
Bogor	40	18.9
Depok	46	21.8
Tangerang	66	31.3
Bekasi	14	6.6

Table 2

Number of Adolescents based on the Type of NSSI Behavior (N = 109)

	Type of NSSI Behavior	ƒ	%
1	Cutting	38	34.9
2	Burning skin with cigarette	7	6.4
3	Burning skin with lighter or match	16	14.7
4	Inscribing words into skin	23	21.1
5	Engraving pictures onto skin surface	12	11.0
6	Intense scratching leading to bleeding	54	49.5
7	Intentional biting to damage the skin	43	39.4
8	Scraping the skin with sandpaper	12	11.0
9	Dripping acid on skin	3	2.7
10	Using bleach or oven cleaner to scrub skin	4	3.6
11	Sticking pins, needles or staples into the skin	37	33.9
12	Rubbing glass into the skin	20	18.3
13	Breaking bones	5	4.5
14	Banging head	29	26.6
15	Punching self	38	34.9
16	Disruption of wound healing process	42	38.5
17	Other forms of self-harm	26	23.8

Table 3

Pearson Correlation Results

No.	Variable	*Mean*	*SD*	1	2	3
1	Executive Function problems	.000	1.00	-	-	-
2	Dysregulation Emotion	.000	1.00	.368**	-	-
3	Non-Suicidal Self-Injury (NSSI)	.5166	.500	.196**	.289**	-

Note: *N* = 211. *SD* = standard deviation. ** *p* <.01

Table 4

Mediation Analysis Results

Effect	*B*	*SE*	*Z score*	95% *CI*		*p*
				LL	*UL*	
EF to DE (a)	0.3682	.0643	5.7260	0.2415	0.4950	< .001
DE to NSSI (b)	0.5518	.1642	3.3606	0.2300	0.8737	< .001
EF to NSSI (c')	0.2282	.1569	1.4543	-0.0793	0.5356	.1458

Note: **p* < 0.05. EF = Executive Function, DE = Dysregulation Emotion, NSSI = Non-Suicidal Self-Injury

Discussion

The study investigates the mediating role of emotion dysregulation in the relationship between EF problems and non-suicidal self-injury (NSSI) behavior in adolescents. The findings demonstrate that emotion dysregulation fully mediates the association between EF problems and NSSI behavior, suggesting that difficulties in emotion regulation are a crucial mechanism through which poor EF contributes to the risk of NSSI. The results support the theoretical model developed based on previous research findings, in which EF impairment is related to NSSI behavior (Zhang et al., 2022). Executive function abilities in adolescents, which encompass planning, decision-making, impulse control, and problem-solving, are closely intertwined with their capacity for emotional regulation (Binder et al., 2020; Lantrip et al., 2016; Warmansyah et al., 2024). Adolescents experiencing chronic emotional distress are often found to exhibit deficits in EF. Moreover, previous research has consistently indicated that emotion dysregulation is closely associated with the emergence of NSSI behavior in this population (Andover & Morris, 2014; Wolff et al., 2019).

The findings underscore the heightened risk of NSSI in adolescents with poor EF, which plays a critical role in how individuals respond to stress and influences both emotional and social competence (Mozafari et al., 2022). Additionally, previous study findings on students with NSSI tendencies, regardless of gender, have indicated elevated levels of executive dysfunction (Zhou et al., 2024). Adolescents with diminished executive function may struggle to inhibit impulsive behaviors, including NSSI, as a maladaptive coping strategy for managing negative emotions such as anxiety and fear during stressful situations (Allen & Hooley, 2015). Research also suggests that adolescents engaging in NSSI often have significant difficulties in controlling impulsive tendencies, further supporting the notion that NSSI may serve as a mechanism for coping with overwhelming emotional states (Guerreiro et al., 2015; Mozafari et al., 2022). A study by Fikke et al. (2011) found that adolescents who engage in NSSI exhibit poorer decision-making skills. It implies that

problems in these cognitive domains may contribute to such adolescents' difficulties in managing their emotions and making healthier choices when confronted with stress or emotional challenges.

This study confirms that emotion dysregulation significantly mediates the relationship between EF problems and NSSI. It implies that adolescents with low executive function may not directly engage in NSSI, but do so through their inability to regulate their emotions effectively. This finding aligns with previous research, which has posited that emotion dysregulation is a central mechanism which links cognitive function and self-harm behaviors (Hasking et al., 2017). Problems in EF can result in various challenges in managing emotions, thoughts, and behaviors, potentially contributing to suicidal ideation and/or behaviors (Bredemeier & Miller, 2015). Adolescents with NSSI demonstrate significantly diminished connectivity in the medial prefrontal cortex (mPFC) compared to healthy controls, suggesting that alterations in this brain region are pivotal for the effective functioning of executive processes (Santamarina-Perez et al., 2019). These neural modifications may underlie the challenges faced in emotional regulation, decision-making, problem-solving, and impulse control, reinforcing the association between executive dysfunction and NSSI.

NSSI serves various functions, including alleviating negative emotions, suppressing painful affective states, and addressing feelings of emptiness. For some adolescents, it transforms passive emotional pain into something tangible or active (Robinson et al., 2019). Those who engage in NSSI have been found to struggle with multiple facets of emotion regulation, as indicated by significant impairments on the Difficulties in Emotion Regulation Scale (DERS) (Emery et al., 2016). Additionally, Gratz and Roemer (2008) highlighted that individuals' lack of access to adaptive emotion regulation strategies and difficulties in identifying and explaining their emotions exacerbates NSSI behavior.

The results of this study indicate that just over half of the participants reported having engaged in NSSI, which suggests that self-injurious behaviors are relatively common within this specific sample, particularly among the younger adolescents. The nearly equal split between those who engage in NSSI and those who do not highlights the importance of addressing NSSI within this population, as a significant proportion of adolescents are involved in such behaviors. A longitudinal study investigating the trajectory of NSSI among adolescents highlighted critical patterns in the prevalence of such behavior across developmental stages (Esposito et al., 2023). The findings indicate that most adolescents who engage in NSSI begin doing so in early to mid-adolescence. It is also consistent with the research of Tresno et al. (2012), who identified that in Indonesia, the onset of NSSI typically occurs at around the age of 14. As adolescents progress into the late developmental phase, the study found a notable downward trend in the prevalence of NSSI (Esposito et al., 2023). Relevant to these previous findings, the dual system theory posits that socioemotional regions of the brain, such as the amygdala, rapidly mature during adolescence. In contrast, the prefrontal cortex, responsible for cognitive control and self-regulation, matures more gradually (Murray et al., 2021). Given this developmental imbalance, adolescents are more likely to engage in risky behaviors such as NSSI because their cognitive control has yet to establish itself. However, as the prefrontal cortex continues to mature with age, the propensity to participate in risky behaviors tends to decline (Strang et al., 2013).

Moreover, this study was conducted among adolescents residing in major urban areas of Indonesia. The findings indicate that such adoles-

cents are at risk of engaging in NSSI, which aligns with the findings of Li et al. (2022), which suggest that urban adolescents are more susceptible to negative thoughts associated with NSSI. Adolescents in urban areas are more widely exposed to NSSI information through social media than their rural counterparts, potentially increasing their risk of imitating NSSI behaviors (Lee et al., 2023; Wu et al., 2024). However, this study lacks comparative data on NSSI behaviors amongst urban and rural adolescents in Indonesia. It highlights a potential area for further research to explore disparities and contributing factors across different residential settings.

The findings have important implications for mental health practitioners and educators. Intervention strategies that enhance EF and emotion regulation represent a promising approach to reducing NSSI risk in adolescents. In particular, psychoeducational programs that promote the use of adaptive coping strategies can serve as early preventive measures against the development of maladaptive behaviors such as NSSI. Furthermore, the study highlights the importance of early interventions that focus on strengthening EF through cognitive stimulation beginning in childhood. Involving parents through structured training can further support adolescents' cognitive and emotional development. The study underscores the need for a developmental, preventive approach involving collaboration between families, schools, and mental health professionals.

Several limitations of the study should be acknowledged. First, measuring NSSI behavior using the DSHI is based on a dichotomous scale, which may be less sensitive in capturing nuanced differences between participants. Future research should consider continuous measures like Likert scales to allow for a broader spectrum of responses and a more refined understanding of NSSI behavior. Second, the cross-sectional design of this study limits its ability to establish causal

relationships between executive function, emotion dysregulation, and NSSI. Longitudinal studies are recommended for future research to explore these relationships' temporal dynamics.

Additionally, this study was conducted exclusively on adolescents residing in major urban areas of Indonesia, which may limit the generalizability of the findings to the broader adolescent population. Adolescents in urban environments may experience different stressors, social dynamics, and levels of access to mental health resources compared to their counterparts in rural settings. Future research should consider including adolescents from rural areas to provide a more comprehensive understanding of the dynamics of NSSI behaviors among adolescents in Indonesia.

Conclusion

The findings of the study indicate that emotion dysregulation serves as a significant mediator in the relationship between EF problems and NSSI behaviors in adolescents. Specifically, those with impaired neurocognitive abilities are more prone to experiencing difficulties in emotional regulation, which may in turn, increase their susceptibility to engaging in NSSI. The mediation role of emotion dysregulation highlights the critical mechanism by which deficits in EF are linked to NSSI behaviors.

The study provides important insights into the dynamics of NSSI, EF problems, and emotion dysregulation within the context of the Indonesian adolescent population, which remain understudied areas to the authors' knowledge. The study findings also provide a theoretical foundation for developing intervention strategies targeting both EF and emotion regulation, which may represent a promising approach to mitigating the risk of NSSI. In addition, investigating parenting patterns and cultural or socioeconomic factors may provide additional valuable insights to help understand the mechanisms of NSSI.[]

Author Contribution Statement

Aulia Rachma: Conceptualization; Data Curation; Formal Analysis; Investigation; Methodology; Project Administration; Resources; Visualization; Writing Original Draft; Writing, Review & Editing. **Donny Hendrawan:** Conceptualization; Formal Analysis; Funding Acquisition; Investigation; Methodology; Resources; Validation; Writing, Review & Editing; Supervisor.

References

Allen, K. J. D., Bozzay, M. L., & Edenbaum, E. R. (2019). Neurocognition and suicide risk in adults. *Current Behavioral Neuroscience Reports*, *6*(4), 151–165. https://doi.org/10.1007/s40473-019-00189-y

Allen, K. J. D., & Hooley, J. M. (2015). Inhibitory control in people who self-injure: Evidence for impairment and enhancement. *Psychiatry Research*, *225*(3), 631–637. https://doi.org/10.1016/j.psychres.2014.11.033

Andover, M. S., & Morris, B. W. (2014). Expanding and clarifying the role of emotion regulation in nonsuicidal self-injury. *The Canadian Journal of Psychiatry*, *59*(11), 569–575. https://doi.org/10.1177/070674371405901102

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child Development*, *81*(6), 1641–1660. https://doi.org/10.1111/j.1467-8624.2010.01499.x

Binder, A. S., Brown, H. R., & Harvey, E. A. (2020). Executive function and trajectories of emotion dysregulation in children with parent-reported behavior problems. *Journal of Abnormal Child Psychology*, *48*(4), 481–493. https://doi.org/10.1007/s10802-019-00616-4

Blakemore, S.-J. (2019). Adolescence and mental health. *The Lancet*, *393*(10185), 2030–2031. https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(19)31013-X/abstract

Bredemeier, K., & Miller, I. W. (2015). Executive function and suicidality: A systematic qualitative review. *Clinical Psychology Review*, *40*, 170–183. https://doi.org/10.1016/j.cpr.2015.06.005

Emery, A. A., Heath, N. L., & Mills, D. J. (2016). Basic psychological need satisfaction, emotion dysregulation, and non-suicidal self-injury engagement in young adults: An application of self-determination theory. *Journal of Youth and Adolescence*, *45*(3), 612–623. https://doi.org/10.1007/s10964-015-0405-y

Esposito, C., Dragone, M., Affuso, G., Amodeo, A. L., & Bacchini, D. (2023). Prevalence of engagement and frequency of non-suicidal self-injury behaviors in adolescence: An investigation of the

longitudinal course and the role of temperamental effortful control. *European Child & Adolescent Psychiatry*, *32*(12), 2399–2414. https://doi.org/10.1007/s00787-022-02083-7

Farkas, B. F., Takacs, Z. K., Kollárovics, N., & Balázs, J. (2024). The prevalence of self-injury in adolescence: A systematic review and meta-analysis. *European Child & Adolescent Psychiatry*, *33*(10), 3439–3458. https://doi.org/10.1007/s00787-023-02264-y

Fikke, L. T., Melinder, A., & Landrø, N. I. (2011). Executive functions are impaired in adolescents engaging in non-suicidal self-injury. *Psychological Medicine*, *41*(3), 601–610. https://doi.org/10.1017/S0033291710001030

Glenn, C. R., & Klonsky, E. D. (2013). Nonsuicidal self-injury disorder: An empirical investigation in adolescent psychiatric patients. *Journal of Clinical Child & Adolescent Psychology*, *42*(4), 496–507. https://doi.org/10.1080/15374416.2013.794699

Gratz, K. L. (2001). Measurement of deliberate self-harm: Preliminary data on the deliberate self-harm inventory. *Journal of Psychopathology and Behavioral Assessment*, *23*(253–263). https://link.springer.com/article/10.1023/A:1012779403943

Gratz, K. L., & Roemer, L. (2008). The relationship between emotion dysregulation and deliberate self-harm among female undergraduate students at an urban commuter university. *Cognitive Behaviour Therapy*, *37*(1), 14–25. https://doi.org/10.1080/16506070701819524

Gravetter, F. J., & Forzano, L.-A. B. (2018). *Research methods for the behavioral sciences*. Cengage Learning.

Guerreiro, D. F., Figueira, M. L., Cruz, D., & Sampaio, D. (2015). Coping strategies in adolescents who self-harm. *Crisis*, *36*(1), 31–37. https://doi.org/10.1027/0227-5910/a000289

Hasking, P., Whitlock, J., Voon, D., & Rose, A. (2017). A cognitive-emotional model of NSSI: Using emotion regulation and cognitive processes to explain why people self-injure. *Cognition and Emotion*, *31*(8), 1543–1556. https://doi.org/10.1080/02699931.2016.1241219

Heffer, T., & Willoughby, T. (2018). The role of emotion dysregulation: A longitudinal investigation of the interpersonal theory of suicide. *Psychiatry Research*, *260*, 379–383. https://doi.org/10.1016/j.psychres.2017.11.075

Hooley, J. M., & Franklin, J. C. (2018). Why do people hurt themselves? A new conceptual model of nonsuicidal self-injury. *Clinical Psychological Science*, *6*(3), 428–451. https://doi.org/10.1177/2167702617745641

Hu, Z., Yuan, X., Zhang, Y., Lu, Z., Chen, J., & Hu, M. (2021). Reasoning, problem solving, attention/vigilance, and working memory are candidate phenotypes of non-suicidal self-injury in Chinese Han nationality. *Neuroscience Letters*, *753*, 135878. https://doi.org/10.1016/j.neulet.2021.135878

Kaufman, E. A., Xia, M., Fosco, G., Yaptangco, M., Skidmore, C. R., & Crowell, S. E. (2016). The Difficulties in Emotion Regulation Scale Short Form (DERS-SF): Validation and replication in adolescent and adult samples. *Journal of Psychopathology and Behavioral Assessment*, *38*(3), 443–455. https://doi.org/10.1007/s10862-015-9529-3

Klonsky, E. D., Victor, S. E., & Saffer, B. Y. (2014). Nonsuicidal self-injury: What we know, and what we need to know. *The Canadian Journal of Psychiatry*, *59*(11), 565–568. https://doi.org/10.1177/070674371405901101

Kumar, R. (2019). *Research methodology: A step-by-step guide for beginners* (5th ed.). SAGE Pubications, Inc.

Lantrip, C., Isquith, P. K., Koven, N. S., Welsh, K., & Roth, R. M. (2016). Executive function and emotion regulation strategy use in adolescents. *Applied Neuropsychology: Child*, *5*(1), 50–55. https://doi.org/10.1080/21622965.2014.960567

Lee, T., Park, H., Ryu, J.-M., Kim, N., & Kim, H.-W. (2023). The association between media-based exposure to nonsuicidal self-injury and emergency department visits for self-harm. *Journal of the American Academy of Child & Adolescent Psychiatry*, *62*(6), 656–664. https://doi.org/10.1016/j.jaac.2023.02.004

Li, R., Wang, Y., Huo, L., Zhu, F., Zheng, T., He, K., Lu, S., Hao, J., Li, P., Su, L., & Zhou, Y. (2022). *Mediating effects of suicidal ideation in the relationship between psychological distress and non-suicidal self-injury among adolescents with major depressive disorder: The roles of sex and urban-rural status*. https://doi.org/10.21203/rs.3.rs-1852442/v1

Lim, K.-S., Wong, C. H., McIntyre, R. S., Wang, J., Zhang, Z., Tran, B. X., Tan, W., Ho, C. S., & Ho, R. C. (2019). Global lifetime and 12-month prevalence of suicidal behavior, deliberate self-harm and non-suicidal self-injury in children and adolescents between 1989 and 2018: A meta-analysis. *International Journal of Environmental Research and Public Health*, *16*(22), 4581. https://doi.org/10.3390/ijerph16224581

Liu, R. T., Cheek, S. M., & Nestor, B. A. (2016). Non-suicidal self-injury and life stress: A systematic meta-analysis and theoretical elaboration. *Clinical Psychology Review*, *47*, 1–14. https://doi.org/10.1016/j.cpr.2016.05.005

Maharani, C. N., Savitri, L. S. Y., & Pudjiati, S. R. R. (2022). Hubungan antara pola asuh positif dan perilaku melukai diri remaja. *Analitika*, *14*(1), 1–13. https://doi.org/10.31289/analitika.v14i1.6623

Martin, M. M., & Rubin, R. B. (1995). A new measure of cognitive flexibility. *Psychological Reports*, *76*(2), 623–626. https://doi.org/10.2466/pr0.1995.76.2.623

Mendelson, G. (1995). Book reviews: Diagnostic and statistical manual of mental disorders, five edition (DSM-V). *Australian & New Zealand Journal of Psychiatry*, *29*(3), 529–535. https://doi.org/10.3109/00048679509064964

Mozafari, N., Bagherian, F., Mohammadi, A. Z., & Heidari, M. (2022). Executive functions, behavioral activation/behavioral inhibition system, and emotion regulation in adolescents with non-suicidal self-injury (NSSI) and normal counterparts. *Journal of Research in Psychopathology*, *3*(7). https://jrp.uma.ac.ir/article_1146_89520560486f8a06f25fdc098afb17ae.pdf

Muehlenkamp, J. J., Claes, L., Havertape, L., & Plener, P. L. (2012). International prevalence of adolescent non-suicidal self-injury and deliberate self-harm. *Child and Adolescent Psychiatry and Mental Health*, *6*(1), 10. https://doi.org/10.1186/1753-2000-6-10

Mürner-Lavanchy, I., Koenig, J., Lerch, S., van der Venne, P., Höper, S., Resch, F., & Kaess, M. (2022). Neurocognitive functioning in adolescents with non-suicidal self-injury. *Journal of Affective Disorders*, *311*, 55–62. https://doi.org/10.1016/j.jad.2022.05.029

Murray, A. L., Zhu, X., Mirman, J. H., Ribeaud, D., & Eisner, M. (2021). An evaluation of dual systems theories of adolescent delinquency in a normative longitudinal cohort study of youth. *Journal of Youth and Adolescence*, *50*(7), 1293–1307. https://doi.org/10.1007/s10964-021-01433-z

Nilsson, M., Lundh, L., Westrin, Å., & Westling, S. (2021). Executive functioning in psychiatric patients with deliberate self-harm, as compared with a psychiatric and a healthy comparison group. *Journal of Clinical and Experimental Neuropsychology*, *43*(3), 225–237. https://doi.org/10.1080/13803395.2021.1894094

Nock, M. K. (2009). Why do people hurt themselves. *Current Directions in Psychological Science*, *18*(2), 78–83. https://doi.org/10.1111/j.1467-8721.2009.01613.x

Nock, M. K. (2012). Future directions for the study of suicide and self-injury. *Journal of Clinical Child & Adolescent Psychology*, *41*(2), 255–259. https://doi.org/10.1080/15374416.2012.652001

Pessoa, L. (2008). On the relationship between emotion and cognition. *Nature Reviews Neuroscience*, *9*(2), 148–158. https://doi.org/10.1038/nrn2317

Pfeifer, J. H., & Allen, N. B. (2021). Puberty initiates cascading relationships between neurodevelopmental, social, and internalizing processes across adolescence. *Biological Psychiatry*, *89*(2), 99–108. https://doi.org/10.1016/j.biopsych.2020.09.002

Robinson, K., Garisch, J. A., Kingi, T., Brocklesby, M., O'Connell, A., Langlands, R. L., Russell, L., & Wilson, M. S. (2019). Reciprocal risk: The longitudinal relationship between emotion regulation and non-suicidal self-injury in adolescents. *Journal of Abnormal Child Psychology*, *47*(2), 325–332. https://doi.org/10.1007/s10802-018-0450-6

Santamarina-Perez, P., Romero, S., Mendez, I., Leslie, S. M., Packer, M. M., Sugranyes, G., Picado, M., Font, E., Moreno, E., Martinez, E., Morer, A., Romero, M., & Singh, M. K. (2019). Fronto-limbic connectivity as a predictor of improvement in nonsuicidal self-injury in adolescents following psychotherapy. *Journal of Child and Adolescent Psychopharmacology*, *29*(6), 456–465. https://doi.org/10.1089/cap.2018.0152

Selby, E. A., Bender, T. W., Gordon, K. H., Nock, M. K., & Joiner, T. E. (2012). Non-suicidal self-injury (NSSI) disorder: A preliminary study. *Personality Disorders: Theory, Research, and Treatment*, *3*(2), 167–175. https://doi.org/10.1037/a0024405

Shen, J., Wang, Y., Kurpad, N., & Schena, D. A. (2022). A systematic review on the impact of hot and cool executive functions on pediatric injury risks: A meta-analytic structural equation modeling approach. *Prevention Science*, *23*(3), 366–377. https://doi.org/10.1007/s11121-021-01271-2

Sheppes, G., Suri, G., & Gross, J. J. (2015). Emotion regulation and psychopathology. *Annual Review of Clinical Psychology*, *11*(1), 379–405. https://doi.org/10.1146/annurev-clinpsy-032814-112739

Smith, A., Freeman, K., Montgomery, S., Vermeersch, D., & James, S. (2019). Executive functioning outcomes among adolescents receiving dialectical behavior therapy. *Child and Adolescent Social Work Journal*, *36*(5), 495–506. https://doi.org/10.1007/s10560-018-0578-9

Strang, N. M., Chein, J. M., & Steinberg, L. (2013). The value of the dual systems model of adolescent risk-taking. *Frontiers in Human Neuroscience*, *7*. https://doi.org/10.3389/fnhum.2013.00223

Thompson, R. A. (2019). Emotion dysregulation: A theme in search of definition. *Development and Psychopathology*, *31*(3), 805–815. https://doi.org/10.1017/S0954579419000282

Thorell, L. B., Lazarević, N., Milovanović, I., & Bugarski Ignjatović, V. (2020). Psychometric properties of the Teenage Executive Functioning Inventory (TEXI): A freely available questionnaire for assessing deficits in working memory and inhibition among adolescents. *Child Neuropsychology*, *26*(6), 857–864. https://doi.org/10.1080/09297049.2020.1726885

Tim Peneliti. (2024). *Kuesioner penelitian remaja (T)*. https://survey.ui.ac.id/857238?newtest=Y

Tresno, F., Ito, Y., & Mearns, J. (2012). Self-injurious behavior and suicide attempts among Indonesian college students. *Death Studies*, *36*(7), 627–639. https://doi.org/10.1080/07481187.2011.604464

Wang, Y., Zhou, Y., Li, G., Qin, P., Wang, J., Qi, L., Li, L., Wang, Y., Wang, J., Li, J., Liang, Z., & Zhou, Y. (2023). Executive functions in non-suicidal self-injury comorbid first-episode and drug-naïve depression among adolescents. *Psychiatry Research*, *328*, 115476. https://doi.org/10.1016/j.psychres.2023.115476

Warmansyah, J., Yuningsih, R., Sari, M., Hidayati, W. R., & Wulandari, R. (2024). The impact of executive function on emotional dysregulation in early childhood: A correlational analysis. *Child Education Journal*, *6*(1), 42–50. https://doi.org/10.33086/cej.v6i1.5926

Werner, K., & Gross, J. J. (2010). Emotion regulation and psychopathology: A conceptual framework. In A. M. Kring & D. M. Sloan (Eds.), *Emotion regulation and psychopathology: A transdiagnostic approach to etiology and treatment* (pp. 13–37). Guilford Press.

Wolff, J. C., Thompson, E., Thomas, S. A., Nesi, J., Bettis, A. H., Ransford, B., Scopelliti, K., Frazier, E. A., & Liu, R. T. (2019). Emotion dysregulation and non-suicidal self-injury: A systematic review and meta-analysis. *European Psychiatry*, *59*, 25–36. https://doi.org/10.1016/j.eurpsy.2019.03.004

Wu, H., Zhou, X., Chen, D., Zheng, Y., & You, J. (2024). Longitudinal association between social media exposure and nonsuicidal self-injury among adolescents: investigating the directionality by within-person effects. *Current Psychology*, *43*(11), 9744–9754. https://doi.org/10.1007/s12144-023-05128-5

Zhang, Y., Hu, Z., Hu, M., Lu, Z., Yu, H., & Yuan, X. (2022). Effects of childhood trauma on nonsuicidal self-injury in adolescent patients with bipolar II depression. *Brain and Behavior*, *12*(11). https://doi.org/10.1002/brb3.2771

Zhou, L., Zhang, K., Guo, J., Liu, J., Wang, S., & Gong, J. (2024). The relationship between perceived stress, impulsivity, executive dysfunction and non-suicidal self-injury thoughts among Chinese college students: A gender difference study. *Psychology Research and Behavior Management, Volume 17*, 1819–1830. https://doi.org/10.2147/PRBM.S452447

This page has been intentionally left blank.