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Research paper

Short-term associations between nonsuicidal and suicidal thoughts and behaviors: A daily diary study with high-risk adolescents

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ABSTRACT

Background: In this daily dairy study of adolescents at elevated suicide risk, we examined proximal associations between nonsuicidal self-injury (NSSI) and suicidal thoughts as well as behaviors. We also investigated the prominence of the anti-suicide function underlying NSSI engagement, relative to intrapersonal and interpersonal motives.

Methods: Seventy-eight adolescents (67.9% female; ages 13-17) hospitalized due to suicide risk completed daily surveys assessing NSSI and suicidal thoughts for four weeks after discharge (n=1621 observations). Suicidal behavior (actual, aborted, interrupted suicide attempts) was assessed at 1-month follow-up.

Results: Over and above lifetime NSSI, adolescents *who* generally experienced more enduring (OR=2.54, p=<.001) and intense (OR=1.87, p=.002) suicidal ideation were more likely to engage in NSSI on a given day. Moreover, NSSI likelihood increased *when* adolescents experienced more enduring (OR=1.99, p<.001) and intense (OR=1.66, p<.001) ideation relative to their typical levels. This pattern was consistent for those with recent NSSI. The anti-suicide function of NSSI was frequently endorsed at hospitalization and when NSSI occurred daily (65.6% of the time), alongside the intrapersonal-negative motive (to avoid aversive states). Exploratory analyses suggest adolescents with suicidal behavior within the month after discharge experienced higher NSSI levels reported daily over the same period (Hedge's g=1.26, p=<.001).

Limitations: Daily-level associations were examined concurrently and generalizability of results is limited by sample characteristics.

Conclusions: The notable proximal associations between NSSI and suicidal thoughts and behaviors, as well as the prominence of the anti-suicide function, point to the importance of intervention efforts targeting these intersecting phenomena among adolescents at elevated suicide risk.

1. Introduction

Self-injurious thoughts and behaviors (SITBs), a broad term referring to a range of thoughts and actions related to deliberate self-directed injury, encompasses both nonsuicidal and suicidal forms of self-injury. Nonsuicidal self-injury (NSSI) describes deliberate self-inflicted injury without intent to die while suicidal self-injury refers to self-inflicted harm with at least some intent to die (Nock, 2010). Associated with significant impairment among youth (Copeland et al., 2017; Foley et al., 2006), the impact of SITBs is widespread. Based on cross-national estimates, 17% to 18% of youth will engage in NSSI in their lifetime (Muehlenkamp et al., 2012; Swannell et al., 2014). Moreover, nationally representative data show that approximately 19% and 9% of adolescents experienced suicidal thoughts and suicide attempts, respectively, in the prior year (Ivey-Stephenson, 2020). These high prevalence rates coincide with the sensitive developmental period of adolescence, during which SITBs tend to emerge (Nock et al., 2013; Plener et al., 2015; Swannell et al., 2014).

Although distinct from suicidal forms of self-injury, NSSI commonly co-occurs with suicidal thoughts (Glenn et al., 2017; Guan et al., 2012) and is a strong risk factor for future suicide attempts (Asarnow et al., 2011; Ribeiro et al., 2016; Wilkinson et al., 2011). Daily diary and ecological momentary (EMA) studies—wherein experiences are measured repeatedly in the person's natural environment (Moskowitz

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and Young, 2006; Shiffman et al., 2008)—have also shown that NSSI and suicidal thoughts frequently co-occur in close proximity (Czyz et al., 2019; Nock et al., 2009). For example, results from a daily diary study of adolescent inpatients showed that when NSSI was endorsed, it co-occurred with suicidal ideation over half the time (Czyz et al., 2019). Given that relatively few studies have examined daily-level associations between different forms of SITBs, additional intensive longitudinal studies are needed to further elucidate the relationship between NSSI and suicidal thoughts, as they occur in the "real world," as well as identify the extent to which NSSI episodes are proximally associated with suicidal behavior.

Studies utilizing EMAs and daily diary assessments offer unique opportunities to capture factors contributing to the occurrence of SITBs in real- or near-real time (reviews by Davidson et al., 2017; Gee et al., 2020; Rodriguez-Blanco et al., 2018). Notably, this growing literature has primarily focused on adults, underscoring the need for additional research with adolescents. Similarly, EMA and daily diary studies have improved our understanding of motives or functions underlying NSSI (review by Hepp et al., 2020). In addition to informing the field's theoretical understanding of what motivates and maintains NSSI behavior, findings from these studies could inform targeted treatment. Several theoretical frameworks have proposed that NSSI behavior is primarily motivated by avoidance of negative emotional or cognitive experiences (Chapman et al., 2006; Hasking et al., Rose, 2017; Selby et al., 2013). Another well-known framework, the Four-Function Model of NSSI (Bentley et al., 2014; Nock and Prinstein, 2004), posits that NSSI serves intrapersonal and interpersonal functions that each can be positively or negatively reinforcing: individuals engage in NSSI to avoid aversive emotional states (intrapersonal-negative), to generate desirable states (intrapersonal-positive), escape unwanted interpersonal demands (interpersonal-negative), or elicit desired reactions or interactions with others (interpersonal-positive).

Consistent with theory and results from a recent meta-analysis of largely cross-sectional research (Taylor et al., 2018), studies utilizing intensive longitudinal methods have shown that the most commonly self-reported function of NSSI involves intrapersonal negative reinforcement or regulation of aversive emotions (Andrewes et al., 2017b; Kranzler et al., 2018; Nock et al., 2009; Turner et al., 2016). These findings are in line with others showing heightened negative affect before NSSI engagement (Andrewes et al., 2017a; Armey et al., 2011; Hughes et al., 2019; Kranzler et al., 2018). Additional EMA and daily diary studies have pointed to the intrapersonal positive reinforcement function of NSSI (i.e., inducing desired emotions) as also being commonly endorsed (Andrewes et al., 2017; Muehlenkamp et al., 2009; Nock et al., 2009; Snir et al., 2015; Turner et al., 2016). On the other hand, the interpersonal functions of NSSI, serving the purpose of escaping unwanted interpersonal demands or eliciting desired interpersonal interactions, appear to be less frequently reported relative to intrapersonal functions (Horowitz and Stermac, 2018; Nock et al., 2009; Snir et al., 2015; Turner et al., 2016), a pattern consistent with cross-sectional studies (Taylor et al., 2018).

While existing research stemming from cross sectional as well as intensive longitudinal studies has improved our understanding of functions underlying NSSI behavior (Hepp et al., 2020; Taylor et al., 2018), surprisingly little is known about the anti-suicide function where NSSI is used specifically in an effort to manage suicidal thoughts and urges (Klonsky and Glenn, 2008; Saraff and Pepper, 2014). Engaging in NSSI to cope with suicidal urges could be conceptualized as falling within the broader intrapersonal function (Klonsky and Glenn, 2009); however, there are important reasons for attending to the anti-suicide function, especially among populations already at high risk for suicide. Studies have shown that individuals endorsing the anti-suicide function are at greater risk for suicidal thoughts and behaviors (Brausch and Muehlenkamp, 2018; Burke et al., 2018; Victor et al., 2015). Moreover, while relatively understudied (review by Edmondson et al., 2016), the anti-suicide function is commonly endorsed by adolescents. For example, 41% of a school-based sample of self-injuring adolescents reported engaging in NSSI to avoid suicide (Laye-Gindhu and Schonert-Reichl, 2005). Others have shown that between 32% and 48% of adolescent inpatients endorse the anti-suicide function (Kraus et al., 2020; Nixon et al., 2002). The anti-suicide function was also regularly endorsed in a previous study of adolescents surveyed daily after psychiatric hospitalization (Czyz et al., 2019). However, Czyz and colleagues did not measure other functions of NSSI, and thus the extent to which the anti-suicide function plays a dominant role at the daily level among high-risk youth remains unclear. In light of NSSI commonly co-occurring with suicidal thoughts, additional intensive longitudinal studies characterizing different NSSI functions, alongside the anti-suicide function, are needed.

1.1. Study purpose

A growing number of EMA and daily diary studies have revealed important insights about SITBs occurring in daily life, including NSSI and its underlying functions (Gee et al., 2020; Hepp et al., 2020; Rodriguez-Blanco et al., 2018). However, there are important knowledge gaps concerning the intersection of NSSI and suicidal ideation, particularly among adolescents at elevated suicide risk, as well as the anti-suicide function of NSSI that may be especially salient when suicidal ideation and NSSI co-occur. Among adolescents with recent suicidal ideation and/or suicide attempt who responded to daily surveys for a month after psychiatric hospitalization, we report on the following: (1) the association between NSSI and suicidal ideation while adjusting for lifetime NSSI; and (2) the frequency of self-reported functions of NSSI. As an exploratory objective, (3) we also explore whether average levels of daily NSSI, reported in the month after discharge, differentiate adolescents who experienced suicidal behavior (actual, interrupted, aborted suicide attempts) over the course of the same month.

In terms of the first study objective, we extend a previous smaller study of adolescent inpatients (Czyz et al., 2019), aiming to provide greater clarity regarding the association between daily-level suicidal ideation and NSSI after adjusting for baseline NSSI severity and by considering if these relationships will hold in a subsample of adolescents with recent NSSI. We anticipate that more severe suicidal ideation at both within- and between-person levels will be associated with greater NSSI likelihood above and beyond the impact of baseline NSSI severity. With regard to the second study objective, we focus on assessing daily-level endorsement of four NSSI functions that are consistent with the Four-Function Model of NSSI (Bentley et al., 2014; Nock and Prinstein, 2004). Additionally, we place emphasis on characterizing the anti-suicide function of NSSI given its relevance to adolescents at evaluated suicide risk and its link with suicidal behavior (Brausch and Muehlenkamp, 2018; Burke et al., 2018; Victor et al., 2015). Building on previous research (Hepp et al., 2020; Taylor et al., 2018), we anticipate that the intrapersonal-negative function will be most frequently endorsed.

2. Methods

2.1. Participants and procedures

This study was approved by the participating university's Institutional Review Board. Participants included 80 psychiatrically hospitalized adolescents, ages 13-17, admitted due suicide risk, based on either last-month suicide attempt and/or last-week suicidal ideation with thoughts of method, intent, or plan. Exclusion criteria included: severe cognitive impairment or altered mental status (psychosis, mania), transfer to medical unit or residential placement, no availability of a legal guardian (ward of sate), or adolescents not having a cell phone. Eligibility was determined based on a screening of admission records and consultation with the treatment team. Adolescents were recruited between March 2019 and January 2020 as part of a psychosocial

intervention pilot study (Czyz et al., 2021).

Of those eligible who were approached for parent consent and adolescent assent (n=94), 82 (87.2%) provided parental consent and adolescent assent. A total of 80 adolescents completed baseline assessments prior to discharge and continued in the study. Follow-up assessments were completed by telephone 1 and 3 months after discharge. Adolescents also completed daily surveys for 4 weeks, sent automatically to their phones via text message, each evening starting on the first day after discharge. Adolescents were able to respond to surveys between 5-8pm. Adolescents were compensated up to $222 for all study assessments, which included $4 for completing each daily survey. Responses to daily surveys were monitored by the study's on-call clinicians who contacted participants if they endorsed current ideation with intent/plan or a suicide attempt in last 24 hours. Endorsement of any suicidal thoughts resulted in a display of an automated message urging participants to seek support and providing crisis and emergency contact information. We modeled our risk management protocol after a previous study with discharged adolescents; for additional details please see Czyz and colleagues (2018). For this manuscript, analyses focus on the four-week daily survey data and the 1-month follow-up that overlaps with this 4-week time frame. The analytical sample was restricted to 78 adolescents who took part in the daily survey protocol. Across these 78 participants, the overall daily survey adherence was 74.2% (1621 out of 2,184 observations or days), and 75 (96.2%) completed the 1-month follow-up.

2.2. Measures

2.2.1. Baseline and follow-up measures

Suicidal ideation and attempts (Baseline and Follow-up). The Columbia-Suicide Severity Rating Scale (C-SSRS) (Posner et al., 2011) was used to assess suicidal ideation severity on a 0-5 scale ranging from "wish to be dead" to "suicidal ideation with specific plan and intent." In addition, the C-SSRS assesses a range of suicidal behavior (actual, interrupted, and aborted suicide attempts). We report on last-week suicidal ideation severity and lifetime attempts (yes/no) at the time of admission, obtained via medical record review; the C-SSRS is used routinely as part of clinical protocol prior to admissions. We also report on suicidal behavior assessed at the 1-month follow-up.

Non-suicidal self-injury (NSSI) history (Baseline). Adolescents were asked about NSSI history using a self-report measure adapted from the Non-Suicidal Self Injury portion of the Self-Injurious Thoughts and Behaviors Interview (SITBI; (Nock et al., 2007). Specifically, adolescents with any lifetime NSSI were asked about age of onset, what NSSI methods they had ever used (e.g., cutting/carving skin, hitting/punching self, burning self, scrapping/scratching skin to point of drawing blood, picking at wound or other areas to draw blood, biting self, inserting objects under skin or nails), lifetime and last-year NSSI frequency, as well as NSSI functions. Lifetime NSSI frequency was assessed using a 7-point scale, ranging from "once" to "more than 100 times." Last-year NSSI frequency was measured on a 7-point scale from "never" to "every day." Adolescents were also asked about the number of NSSI events in the last month. With respect to functions, adolescents rated, on a scale from 0 to 4, the extent to which they engaged in NSSI in order to: get rid of bad feelings [intrapersonal-negative]; feel something because of feeling numb or empty [intrapersonal-positive]; communicate feelings to someone or get attention [interpersonal-positive]; get out of doing something or get away from others [interpersonal negative]. We added an item assessing the extent to which adolescents engaged in NSSI to stop suicidal thoughts or impulses, i.e. the anti-suicide function, modeled after the Inventory of Statements about Self-Injury (ISAS) (Klonsky and Glenn, 2009).

Post-discharge NSSI (Follow-up). Presence of NSSI since discharge was assessed with a dichotomous (yes/no) item from the C-SSRS. NSSI methods were also assessed.

2.2.2. Daily survey measures

Daily suicidal ideation. Each day, adolescents responded to questions assessing thoughts of suicide in reference to the last 24 hours. An endorsement of any suicidal ideation was followed by a question assessing suicidal ideation duration on a 5-point scale (from "a few seconds or minutes" to "more than 8 hours/continuous"), an item based on the C-SSRS (Posner et al., 2011). Modeled after an item from another intensive longitudinal study (Nock et al., 2009), adolescents also rated the intensity of suicidal urges on a 7-point scale (from "low" to "high"). Thus, two continuous scales were created for ideation duration (0-5) and urge intensity (0-7), where 0 represented absence of suicidal thoughts.

Daily NSSI Behavior and Functions. Each day, adolescents were asked about presence of NSSI: "At any point in the last 24 hours, did you harm yourself or hurt your body on purpose (such as cutting, burning, biting, hitting self) without the intention to die?" Adolescents then indicated when the behavior took place in the 24-hour period (e.g., morning, evening). Participants endorsing NSSI were asked five NSSI function items, each on a 3-point scale, that mirrored the wording of the baseline questions assessing four functions (i.e. intrapersonal-negative, interpersonal-positive, interpersonal-positive, and interpersonal-negative) modeled after the SITBI (Nock et al., 2007) and the anti-suicide function based on the ISAS (Klonsky and Glenn, 2009).

2.2.3. Data analysis

Descriptive statistics, including means and frequencies, are provided to describe baseline and follow-up data. The association between daily NSSI functions were calculated using the repeated measures correlation (Bakdash and Marusich, 2020), which accounts for between-person variance. To determine the relationship between daily NSSI and time-varying predictors (suicidal ideation duration, suicidal ideation urge intensity), we fitted a series of generalized linear mixed models for each predictor of interest. Predictors were group mean-centered to examine within-person effects. Each model also included the predictor's corresponding group (participants') mean to examine between-person effects. All models also included a random intercept and slope. All models controlled for baseline severity of lifetime NSSI and adjusted for the effect of time. As the data came from a pilot intervention study, all models initially controlled for intervention effects. However, group indicators were removed from the final models due to not being associated with the NSSI outcome and the results being consistent. Models were conducted using the full analytic sample and then with the subset of participants with NSSI in the month prior to hospitalization. Finally, in exploratory analyses, we used Analysis of Covariance (ANCOVA) to explore if youth with and without suicidal behavior within the month after discharge differ based on average NSSI, which was aggregated over the month after discharge using daily NSSI ratings. The mean NSSI variable was cube root transformed to satisfy the assumptions of ANCOVA (e.g., normality, constant variance assumption), and the analyses adjusted for baseline history of suicide attempts and lifetime NSSI frequency. All analyses were conducted using R (R Core Team, 2020).

3. Results

3.1. Baseline sample characteristics

Participating adolescents were 67.9% (n=53) biological females, with a mean age of 15.19 (SD=1.35) years. Over 7% (n=6) of youth self-identified as transgender or non-binary. The racial/ethnic distribution was (more than one category could be selected): 83.3% (n=65) White, 6.4% (n=5) African American/Black, 5.1% (n=4) Asian, 5.1% (n=4) American Indian or Alaska Native, and 1.3% (n=1) Native Hawaiian or Other Pacific Islander, 2.6% (n=2) Other. Nine participants (11.5%) self-identified as Hispanic. At hospitalization, half of participants (n=39) had at least one lifetime suicide attempt and 34.6% (n=27) attempted suicide more than once. All adolescents had last-week ideation at the time of hospitalization, with the mean ideation (range 0-5)

being 3.90 (*SD*=0.91).

3.2. Baseline NSSI and functions

At baseline, 60 participants (76.9%) reported having engaged in NSSI in their lifetime. The mean age of NSSI onset was 12.70 (*SD*=1.78) years. On average, participants endorsed 3.37 (*SD*=1.31) NSSI methods, with the five most common including cutting or carving skin (*n*=51, 85.0%), hitting or punching self (*n*=32, 53.3%), picking at wound or other areas to draw blood (*n*=29, 48.3%), scraping or scratching skin to the point of drawing blood (*n*=27, 45.0%), and burning self (*n*=18, 30.0%). Of those with lifetime NSSI, 58 (96.7%) engaged in NSSI in the last year and 50 (83.3%) reported past-month NSSI. Adolescents reported engaging in NSSI for the following reasons (range 0-4), in order of frequency: 2.88 (SD=1.31) to reduce negative emotion (n=52 reported or 88.1%); 2.58 (SD=1.33) to induce emotion (n=53 reported or 89.8%); 2.08 (SD=1.48) to cope with suicidal thoughts (n=46 reported or 78.0%); 0.97 (SD=1.23) to communicate with others or obtain attention (n=30 reported or 50.8%); 0.59 (SD=1.02) to escape interpersonal demands or responsibilities (n=18 reported or 30.5%). The magnitude of intercorrelations between baseline NSSI functions were low to moderate (range 0.05-0.46). The anti-suicide function showed significant correlation only with the function directed at reducing negative emotion (r=0.46, p<.01).

3.3. Frequency of NSSI at follow-up

NSSI reported at 1-month follow-up. Twenty-one participants (28%) out of 75[1] interviewed at the 1-month follow-up endorsed NSSI. The methods most commonly reported were cutting (n=15) or scraping (n=3) skin, followed by hitting (n=2) and burning (n=2) self.

NSSI reported via daily diaries. NSSI was endorsed on 127 daily surveys/days (out of 1621 daily surveys/days; 7.8%) completed by 33 (42.3%) participants. These 33 adolescents endorsed at least 174 separate instances of NSSI across these 127 days. Nearly all (*n*=32, 97.0%) had lifetime NSSI history. The majority of the 174 NSSI events took place in evening (5pm to 12am; *n*=67, 38.5%), followed by the afternoon (12pm to 5pm; *n*=56, 32.2%), morning (6am to 12pm; *n*=36, 20.7%), and nighttime (12am to 6am; *n*=15, 8.6%).

When comparing NSSI endorsement in the subset of 75 participants who completed the 1-month follow-up, significantly more adolescents reported NSSI via daily diaries (41.3% versus 28.0%; Chi-square=29.05, *p*=<.001). Two adolescents reported NSSI at the 1-month follow-up but not via the daily diaries.

In terms of association between daily-level NSSI and baseline characteristics, there were no significant bivariate associations with age (OR=0.82 [CI=0.51–1.31], p=0.40), sex (OR=0.41 [CI=0.10–1.69], p=0.22), dichotomous race (white versus non-white) (OR=2.48 [CI=0.41–14.84], p=0.32), or history of lifetime suicide attempt (OR=1.88 [0.51–6.95], p=0.34). However, there was association with lifetime NSSI severity (OR=1.77 [CI=1.34–2.32], p< 0.001), such that those with greater lifetime NSSI frequency were more likely to report NSSI via daily diaries.

3.4. Daily-level NSSI functions

The most frequently endorsed NSSI functions were: 73.6% (n=92 days) to reduce negative emotion; 65.6% (n=82 days) to cope with suicidal thoughts; 51.2% (n=64 days) to induce emotion; 25.6% (n=32 days) to communicate with others or obtain attention; and 7.2% (n=9 days) to escape interpersonal demands or responsibilities. Each function was endorsed at least once by all 33 participants reporting NSSI. On average, participants reported 2.2 functions (SD=1.09) when NSSI was endorsed. The magnitude of associations between these daily functions was small (range 0.03-0.29). Table 1 also shows the intraclass correlations (ICCs) for the five NSSI functions, indicating that 43% to 89% of the variance was due to within person (1-ICC), or day-to-day, variability.

3.5. Co-occurrence of daily NSSI and suicidal ideation

Thoughts of suicide were reported on 631 days (38.9%) by 64 (82.1%) participants. When NSSI was endorsed, co-occurring suicidal ideation was reported 78% of the time (on 99 days) by a total of 31 adolescents; these 31 adolescents represent 93.9% of those with any NSSI over the 28-day period. On days NSSI and suicidal ideation co-occurred, the most commonly endorsed reasons for NSSI were to reduce negative emotions (n=73 days or 75.3%) as well as to cope with suicidal thoughts (n=73 days or 75.3%); to induce emotions (n=53 days or 54.6%); to communicate with others or obtain attention (n=26 days or 26.8%); and to escape interpersonal demands or responsibilities (n=8 days or 8.2%).

3.6. Within- and between-person predictors of NSSI

The ICCs for NSSI and suicidal ideation duration and urge intensity were, respectively, 0.62, 0.59, 0.53. Results from generalized mixed models (Table 2) suggest that the probability of NSSI was significantly higher for adolescents who generally had more enduring (OR=2.54, p=<.001) and severe (OR=1.87, p=.002) suicidal ideation over the month-long follow-up period relative to those with lower levels of ideation. Moreover, when adolescents experienced more enduring (OR=1.99, p<.001) and intense (OR=1.66, p<.001) suicidal ideation, relative to their own typical levels of ideation, the probability of NSSI also increased. This pattern of results held for the full sample as well as those with recent (last-month) NSSI. While these findings were consistent for both suicidal ideation duration and intensity, within- and between-person effects for suicidal ideation duration tended to have greater magnitude (odds ratio). Importantly, the associations between daily suicidal ideation indicators and NSSI were significant after controlling for lifetime NSSI frequency assessed at baseline, which itself was associated with greater NSSI likelihood for the full sample but not for the subsample of adolescents with recent NSSI.

Supplemental analyses*:* Given the notable concurrent associations between suicidal ideation and NSSI, we conducted supplemental analyses to investigate if this significant relationship holds for another proximal time scale, namely if suicidal ideation indicators (duration and urge severity) are associated with next-day NSSI. Supplemental Table 1

Table 1
Associations among daily-level functions of nonsuicidal self-injury (NSSI)

Variables	ICC	n days endorsed	1	2	3	4	5
1. NSSI function 1 Reduce negative emotions	0.11	92	-				
2. NSSI function 2 Induce emotions	0.43	64	-0.29*	-			
3. NSSI function 3 Communicate /get attention	0.57	32	0.11	-0.16	-		
4. NSSI function 4 Get out of doing something / get away	0.30	9	0.07	-0.03	-0.15	-	
5. NSSI function 5 Stop suicidal thoughts or impulses	0.40	82	0.11	0.05	-0.03	0.14	-

Notes: n=125 observations; *p< .01; ICC interclass correlation

[1] Participants who did (n=75) and did not (n=3) complete the 1-month assessment did not differ in terms of demographic and key baseline characteristics, including NSSI and suicide attempt history.

Table 2
Mixed effects logistic models examining daily associations with nonsuicidal self-injury (NSSI)

Variable	Overall sample (n=1613) B(SE)	Odds Ratio (OR)	OR CI (lower, upper)	*p*	Subsample with last-month NSSI (n=993) B(SE)	Odds Ratio (OR)	OR CI (lower, upper)	*p*
Suicidal Ideation (SI) Duration								
Between-person SI duration	0.93 (0.25)	2.54	(1.56, 4.14)	**<.001**	0.98 (0.24)	2.67	(1.66, 4.28)	**<.001**
Within-person SI duration	0.69 (0.15)	1.99	(1.48, 2.69)	**<.001**	0.80 (0.17)	2.22	(1.58, 3.11)	**<.001**
Lifetime NSSI severity (baseline)	0.42 (0.13)	1.53	(1.18, 1.97)	**.001**	0.13 (0.16)	1.14	(0.84, 1.55)	.401
	Model R^2= 0.49				*Model R^2*= 0.24			
SI Urge Severity								
Between-person SI urge	0.63 (0.21)	1.87	(1.25, 2.80)	**.002**	0.70 (0.21)	2.02	(1.34, 3.03)	**.001**
Within-person SI urge	0.51 (0.12)	1.66	(1.32, 2.10)	**<.001**	0.55 (0.12)	1.73	(1.36, 2.19)	**<.001**
Lifetime NSSI severity (baseline)	0.42 (0.14)	1.53	(1.17, 2.00)	**.002**	0.13 (0.17)	1.14	(0.82, 1.58)	.437
	Model R^2=0.31				*Model R^2*= 0.23			

Notes: All four models include random intercept and slope and adjust for effect of time; CI=confidence interval.

shows that, although in the expected direction (ORs 1.11-1.20), the association between within-person suicidal ideation and next-day NSSI did not reach statistical significance in the full sample or in the subsample with recent NSSI (*p* values .090-.150).

3.7. Association between NSSI and suicidal behavior

At the 1-month follow-up, six adolescents (8.1%) experienced suicide-related behavior (i.e., actual, aborted, interrupted, attempts). In exploratory analyses, we found that the magnitude of difference in mean NSSI levels between those with and without suicidal behavior over the same 1-month period was large based on effect size measure (Hedge's g=1.26, p=<.001),[2] where those with suicidal behavior reported significantly higher levels of NSSI. In further ANCOVA analyses, after controlling for lifetime history of suicide attempt and lifetime frequency of NSSI, this group difference in mean level of NSSI remained statistically significant (p<.001).

4. Discussion

This daily diary study of adolescents hospitalized due to suicide risk adds to the growing body of research examining SITBs in individuals' daily life. The main study objectives were to improve our understanding of the proximal relationship between suicidal thoughts and NSSI, as they occur on the daily-level. We also examined the prominence of the anti-suicide function of NSSI among high-risk adolescents, a function that may be particularly relevant in the context of intersecting suicidal ideation and NSSI. Given that NSSI is a well-documented risk factor for suicide attempts (Asarnow et al., 2011; Ribeiro et al., 2016; Wilkinson et al., 2011), we explored the association between NSSI reported daily over the month after discharge and suicidal behavior during the same period. The study provided several important findings, as described below.

First, this study extends prior intensive longitudinal research (Gee et al., 2020; Hepp et al., 2020) by providing enhanced temporal information about the association between NSSI and suicidal ideation among at-risk adolescents over a high-risk period following discharge from inpatient hospitalization. Extending previous research on the co-occurrence of NSSI and suicidal thoughts (Czyz et al., 2019), these findings indicate that NSSI and suicidal ideation are related at both the between- and within-person levels, even after controlling for baseline NSSI. At the between person level, those with more enduring and intense suicidal ideation over the four-week period were more likely to engage in NSSI. At the within person level, NSSI was more likely to occur when adolescents experienced more enduring and intense ideation compared to their typical levels. These findings suggest not only *who* is of risk for NSSI, but *when* they may be most at risk for engaging in NSSI. Notably, in the subsample of youth with recent NSSI, daily suicidal ideation was a better predictor of NSSI than an adolescent's prior NSSI. Given that the post-discharge period indicates a time of heightened suicide risk, interventions targeting both suicidal thinking and NSSI are particularly pertinent. For example, helping these high-risk youth identify early warnings signs and periods of vulnerability to heightened suicidal thinking may present opportunities for engagement in effective coping that may both attenuate suicidal ideation and prevent engagement in NSSI. Moreover, adolescents at elevated suicide risk who use more coping skills after hospitalization are less likely to engage in NSSI (Czyz et al., 2019), and thus focusing on building a range of coping strategies may be similarly important.

Second, this study significantly extends prior research on NSSI functions, specifically the anti-suicide function. At baseline, the most common functions were intrapersonal functions (intrapersonal-negative followed by intrapersonal-positive) with interpersonal (negative and positive) functions endorsed less frequently, consistent with prior cross-sectional research (Taylor et al., 2018). At baseline, the anti-suicide function (i.e., to cope with suicidal thoughts) was also highly endorsed, with approximately 78% of adolescents engaging in NSSI for this reason. Baseline patterns of NSSI functions were largely similar at the daily level: intrapersonal were most common and interpersonal were least common. Notably, the anti-suicide function was the second most highly endorsed function, more so than the intrapersonal-positive function. On days when NSSI and suicidal ideation co-occurred, the anti-suicide function was reported as often as the intrapersonal-negative function of NSSI. Although endorsement of the anti-suicide function was low in some prior studies with less clinically severe samples (Andrewes et al., 2017; Horowitz and Stermac, 2018; Klonsky and Glenn, 2009), the high endorsement of this function shown in this study is aligned with research in higher-risk samples (Czyz et al., 2019; Kraus et al., 2020; Nixon et al., 2002). These findings also add to growing research indicating that the anti-suicide function of NSSI is strongly related to suicidal thoughts and behaviors (Brausch and Muehlenkamp, 2018; Burke et al., 2018; Victor et al., 2015). Importantly, associations between different functions at the daily level were weaker than at baseline, indicating that these functions may be distinct for specific episodes of NSSI. These results underscore the need to give greater attention to daily-level NSSI functions, and the anti-suicide function in particular, as it may elucidate the connection between NSSI and suicidal thoughts and behaviors. Moreover, the fact that NSSI functions appear to be distinct for specific NSSI episodes, coupled with daily surveys capturing more instances of NSSI, highlight potential benefits of real-time assessment and intervention. Paralleling this study's results showing that more adolescents reported NSSI behavior via daily surveys, previous EMA and daily diary studies have similarly demonstrated their ability to capture more instances of suicidal ideation relative to end-of-study assessments (Czyz et al., 2018; Gratch et al., 2021). Thus, intensive longitudinal approaches may allow for identifying more instances of self-harm, as

[2] Results were consistent for cube-root transformed and non-transformed data. For ease of interpretation, Hedge's g is based on non-transformed data.

well as periods of greater vulnerability to these episodes, and provide opportunities for highly tailored interventions addressing NSSI risk and specific NSSI functions in everyday life.

Finally, exploratory analyses indicated that higher NSSI levels were related to suicidal behavior over the same post-discharge period, even when controlling for lifetime suicide attempts and history of NSSI. Although we did not explore this link prospectively, findings from the current study indicate that NSSI is related to suicidal behavior over a short-term and clinically important period. These findings are consistent with prior long-term longitudinal research demonstrating that NSSI uniquely predicts risk for future suicidal behavior (Asarnow et al., 2011; Wilkinson et al., 2011). However, we cannot rule out an alternative explanation: NSSI might be associated with suicidal behavior because it is a marker of psychiatric severity or due to its association with other risk factors. Future intensive longitudinal research is needed to clarify the relationship between NSSI and suicidal behavior (between-person vs. within-person effects) during high-risk periods, such as post discharge.

Taken together, this study adds to growing evidence of the complex relationship between SITBs. That is, NSSI is commonly performed in high-risk samples to cope with suicidal thoughts and urges. However, NSSI also increases risk for suicidal behavior. There are potential explanations for these patterns. For one, although the anti-suicide function is commonly endorsed when NSSI and suicidal thoughts co-occur, it may not be effective. In a cross-sectional study, Braush and Muehlenkamp (2018) examined effectiveness of NSSI functions and found that the anti-suicide function was rated as moderately effective (5.33 on a 0-12 scale), which was less effective than the commonly endorsed intrapersonal functions (affective regulation and self-punishment) but more effective than interpersonal functions. However, in a recent cross-sectional study that retrospectively examined NSSI functions at three different points in time (before NSSI, during NSSI, and after NSSI), the anti-suicide function was reported as frequently as intrapersonal functions before NSSI, but much less so during or after NSSI (Kraus et al., 2020). Further, the same study demonstrated that whereas reports of intrapersonal motivations increased over the course of NSSI (i.e., from before to after NSSI), reports of the anti-suicide function did not. These findings may suggest that although NSSI is seen as a short-term strategy to cope with suicidal thoughts, it is ultimately not effective in managing suicidal urges (as it is not a primary motivation during or after NSSI). We do not know why individuals choose NSSI as a strategy to reduce suicidal thoughts in the first place. The emotion regulation function of NSSI is the most common motivation, even for those who engage in NSSI for other reasons (Klonsky, 2007). It may be that youth first engage in NSSI to reduce emotional distress more broadly, and then turn to NSSI as a previously used strategy to cope with suicidal thoughts as well. Working with youth to become aware of these patterns, and ultimately work toward consistently engaging in effective skills, could be an important focus of treatment. Interventions that emphasize the acquisition of healthy coping skills may be particularly beneficial. Even if NSSI does reduce suicide risk over the short-term, unfortunately the cost may be that it also increases habituation to self-injury—such as via acquired capability proposed as part of the interpersonal-psychological theory and incorporated in other frameworks (Klonsky and May, 2015; Van Orden et al., 2010)—and reinforces use of self-injury for escaping distress (Chapman et al., 2006), which may increases risk for suicidal behavior over time (Brausch and Muehlenkamp, 2018). Although NSSI is nonsuicidal by definition, for those with co-occurring NSSI and suicidal ideation, helping reduce engagement in NSSI may be an important target to reduce risk for suicidal behavior.

These findings should be interpreted in light of study limitations. First, the majority of participants self-identified as white and were recruited from a single inpatient unit, limiting generalizability. Second, although the study's intensely sampled data allowed for a fine-grained examination of near-term relationships between SITBs during a post-discharge period, it is important to emphasize that these proximal relationships are cross-sectional. Future studies employing multiple assessments per day, i.e. EMAs, may afford even greater granularity and enable a prospective examination of near-term associations between SITBs, including their temporal relationship as well as determine the time scale on which these SITBs are linked. While this study's supplemental analyses did not find a significant association between previous-day suicidal ideation and next-day NSSI, we are unable to rule out the possibility that this association exists on a much shorter time scale (e.g., within minutes or hours). This represents an important question for future research. Third, studies with larger samples and longer follow-ups are needed to capture more instances of SITBs, particularly of NSSI and suicidal behavior, to examine the link between the anti-suicide function of NSSI and suicidal behavior. For example, future research could examine if individuals for whom the association between suicidal ideation and NSSI is particularly robust (e.g., NSSI is more likely to follow suicidal ideation), or for whom NSSI appears effective in terms of reducing subsequent ideation intensity, are more at risk for future suicidal behavior. Finally, it is important note that this study focused on a specific set of self-reported motives for engaging in NSSI and may not have sampled other functions of NSSI. Relatedly, we were unable to determine if the self-reported functions served their intended purpose following NSSI engagement; some research indicates that NSSI motives may not necessarily produce their intended purpose (Hepp et al., 2020). Future research is needed to further elucidate the mechanisms leading youth to engage in NSSI for anti-suicide reasons, as well as linking NSSI to increased suicidal behavior over time.

In conclusion, this study's findings provide an in-depth examination of the interplay between SITBs at the daily level among high-risk adolescents. While the temporality of concurrent associations cannot be determined, our findings nevertheless align with and extend previous research by pointing to notable proximal relationships between NSSI and suicidal thoughts and behavior. Moreover, this study is among the first to examine the anti-suicide function, among intrapersonal and interpersonal functions of NSSI, in youth using a daily diary approach. Results indicate the that the anti-suicide function is frequently endorsed among adolescents engaging in NSSI in the post-discharge period. Findings highlight the need for effective interventions targeting the intersection between SITBs among adolescents at high risk for suicide, including novel approaches that incorporate real-time assessment and interventions.

Author contributions

Ewa Czyz Conceptualization, methodology, funding, designed the study, oversaw all aspects of data collection, and wrote the initial draft of the introduction, methods, and results section. Catherine Glenn conceptualized the study and wrote the initial draft of the discussion section. Alejandra Arango assisted with data collection as well as drafting and editing of the manuscript. Hyun Jung Koo assisted with data curation and carrying out the data analytic plan. Cheryl King assisted with the design of the study, including conceptualization, and drafting and editing the manuscript. All authors contributed to and have approved the final manuscript.

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The funding source had no role in the study design; in the collection, analysis, and interpretation of data; in the writing the manuscript; or in the decision to submit the manuscript for publication.

Declaration of Competing Interest

The authors do not have conflicts of interest to disclose.

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Supplementary materials

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