Psychiatry Research 278 (2019) 268–274

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

An examination of individual forms of nonsuicidal self-injury

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ARTICLE INFO

Keywords:
Self-injury severity
NSSI methods
NSSI correlates
Self-injury and suicide

ABSTRACT

Nonsuicidal self-injury (NSSI) is a growing public health concern, and there is an increasing need to better characterize and identify severe NSSI behavior. One readily accessible, yet understudied, avenue for improving the assessment of NSSI severity is through the examination of individual forms, or methods, of the behavior. The present study aimed to address this gap in the literature by investigating the relationship between 12 different NSSI methods with three NSSI severity indicators and three distinct suicidal thoughts and behaviors among 1,436 undergraduate students with a history of NSSI (70.90% female, *M* age = 20.69, *SD* = 3.32). Results across six decision tree analyses highlighted the use self-hitting / punching, in addition to cutting oneself, as the most informative NSSI methods for differentiating outcome severity. Gender differences were only found for the outcome of suicidal ideation. The present study provides preliminary evidence that the examination of individual NSSI methods may be useful in identifying individuals at risk for negative correlates of NSSI, including NSSI-related hospital visits, unintended serious injury, and suicidal behavior. Upon replication in longitudinal work, findings have important clinical utility by providing a potential marker of prognosis and the need for higher levels of care.

1. Introduction

Over the prior several decades nonsuicidal self-injury (NSSI) has emerged as a significant public health concern. In 2000, more than 324,000 self-inflicted injuries in the United States received medical attention, amounting to an estimated cost of $1 billion for medical treatment and $32 billion for lost productivity (Corso et al., 2007). While NSSI occurs in relatively limited rates among adults (Klonsky et al., 2014), it is more common in adolescents and emerging adults (Whitlock and Knox, 2007). In particular, the prevalence of NSSI has varied between 10 and 20% among university students (Heath et al., 2008; Swannell et al., 2014; Whitlock et al., 2011). Among those who engage in NSSI, the behavior is linked to functional difficulties at the personal level, including interpersonal and emotion-regulation problems (Andover and Morris, 2014; Tatnell et al., 2014) and elevated psychiatric comorbidities (Cox et al., 2012; Selby et al., 2012).

Perhaps one of the most critical concerns related to NSSI is that it serves as a robust risk factor for suicidal thoughts and behaviors (Klonsky et al., 2016), a relationship that may be stronger among more severe forms of NSSI; a single visit to an emergency department due to NSSI is reported to increase the risk of suicide by nearly 6-fold (Crandall et al., 2006). Moreover, earlier onset of NSSI has been reported to increase the odds of suicide ideation, plan, and attempt, even after controlling for psychopathology symptomology (Kiekens et al., 2018). Taken together, empirical evidence supports a clear association between more severe forms of NSSI and increasingly aversive outcomes, highlighting the need to improve the identification of severe NSSI.

One promising avenue for identifying NSSI severity is through the examination of the forms, or methods, of the behavior. To date, the importance of NSSI methods has largely been investigated by examining the total number of different NSSI methods an individual has utilized in relation to various psychological difficulties. Indeed, there is support for associations between the number of NSSI methods and greater psychiatric symptoms, such as depression, substance use, and suicidal behavior (Paul et al., 2015; Turner et al., 2013; Victor and Klonsky, 2014), poorer emotional and behavioral control (Adrian et al., 2011; Franklin et al., 2013; Robertson et al., 2013), and maladaptive personality characteristics (Robertson et al., 2013). While informative, this literature overlooks the potential role that individual NSSI methods may play in behavioral severity. Highlighting this possibility, some research has proposed a distinction between direct (e.g., cutting) and indirect (e.g., swallowing dangerous substances) forms of NSSI

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https://doi.org/10.1016/j.psychres.2019.06.029
Received 26 March 2019; Received in revised form 18 June 2019; Accepted 19 June 2019
Available online 20 June 2019

(Germain and Hooley, 2012; Hooley and Germain, 2014), based on the rationale that direct methods might be more effective in habituating individuals to pain, lowering their fear of death, and eventually enabling them to engage in more lethal actions (Germain and Hooley, 2013).

Despite the potential implications of individual NSSI methods, there has been relatively limited research examining associations between specific methods and NSSI-related outcomes. The existing literature does suggest, however, differing correlates among varying NSSI methods. Individuals with a preference toward the NSSI method of self-hitting have been demonstrated to have lower levels of depression (Klonsky and Olino, 2008) and elevated trait anger (Kleiman et al., 2015). In contrast, individuals who utilize self-carving may be more likely to have a history of suicidal ideation (Burke et al., 2018) and those using self-cutting may have elevated suicide attempt histories (Burke et al., 2018; Klonsky and Olino, 2008). These findings substantiate the need to examine individual NSSI methods in their own right, an attempt that has been scant due to NSSI methods being combined into groupings rather than understood on a spectrum (Birtwistle et al, 2017).

Gender may also play an important role in the examination of individual NSSI methods. A recent meta-analysis highlights that women may be more likely to use the specific methods of self-cutting for NSSI compared to men (Bresin and Schoenleber, 2015). This finding has been demonstrated among several adolescent (Barrocas et al., 2012; Sornbergeret al., 2012) and college (Andoveret al., 2010) samples. Males, on the other hand, have been documented with a tendency to engage in more burning and hitting or punching NSSI behaviors (Andover et al., 2010; Barrocas et al., 2012; Sornberger et al., 2012). While such gender differences have been well-documented, research has largely focused on the prevalence of NSSI methods. An important next step is to consider gender in the association between individual NSSI methods and important outcomes, an avenue of research that may be particularly relevant for clinical risk assessments.

1.1. Current study

The present study aimed to address this gap in the literature by examining associations between the spectrum of individual NSSI methods, gender, and related severity indicators. First, based on previous literature (Ammerman et al., 2018; Muehlenkamp and Brausch, 2016), we examined associations between individual NSSI methods and three NSSI severity indicators: age of NSSI onset, hurting oneself more severely than intended, and NSSI-related hospital visits. We also considered three distinct suicidal thoughts and behaviors: suicidal ideation, plans, and attempts. Based on extant theoretical and empirical literature (Burke et al., 2018; Germain and Hooley, 2013; Van Orden et al., 2010), we hypothesized that more direct NSSI methods (those involving explicit tissue damage; e.g., cutting, burning) would indicate more severe NSSI behavior features as compared to indirect forms of NSSI (e.g., swallowing substances, hitting / punching). Moreover, we expected that the use of direct NSSI methods would relate to greater likelihood of suicidal ideation, plans, and attempts. However, given the limited research in this area, no hypotheses were made to differentiate among the direct NSSI methods.

2. Method

2.1. Participants and procedures

Participants were 1436 undergraduate students (70.90% female, *M* age = 20.69, *SD* = 3.32) from a large urban university in the Northeast who reported at least one lifetime act of NSSI. All participants completed a series of self-report measures as part of a larger, IRB-approved study on a secure website. Participants received course credit for their participation. Approximately 64.60% of the sample identified as Caucasian, 12.00% Asian, 9.70% African American, and 5.80% mixed race. Approximately 1.80% of the sample indicated they preferred not to answer, and the remaining sample self-identified as “other.”

2.2. Measures

2.2.1. NSSI methods

Forms and Function of Self-Injury (FAFSI; Jenkins, et al., 2011) self-report measure was used to assess for the presence and frequency of NSSI, (i.e., “Have you ever, intentionally or on purpose, hurt yourself in the following ways, without the intention of killing yourself?”). Twelve different NSSI methods are assessed: “cut yourself, either to cause pain or draw blood”; “carved pictures or words into your skin”; “burned yourself on purpose with a lighter, match, or other hot object”; “swallowed something like poison, pills or a dangerous substance that you knew would make you feel sick”; “pinched yourself in order to cause severe pain or bruising”; “banged your head, hand, or another body part against a hard object or surface in order to cause severe pain or bruising”; “poked yourself with a needle or other sharp object in order to cause pain or draw blood”; “scratched, scraped or rubbed your skin hard in order to hurt yourself or draw blood”; “bitten yourself with the intent to cause severe pain or draw blood”; “pulled your hair in order to hurt yourself”; “inserted objects under your nails or skin in order to hurt yourself”; and “hit or punched yourself in order to cause severe pain or bruising.” Participants were asked to report the number of times (continuous) that they had engaged in each of the NSSI methods throughout their lifetime. The internal consistency of the measure has been supported (Jenkins et al., 2011).

2.2.2. NSSI severity indicators

The FAFSI was also used to assess for three severity indicators of NSSI, including: age of NSSI onset (i.e., youngest age of first NSSI act), the number of times they had to go to the hospital because they severely hurt themselves, and the number of times they hurt themselves more severely than intended.

2.2.3. Suicidal thoughts and behaviors

The Suicidal Behavior Questionnaire – Revised (SBQ-R; Osman et al., 2001) was used to assess for suicidal thoughts and behaviors. SBQ-R is a 4-item self-report measure, where each item of the measures assesses a dimension of suicidality; the current study only used the item assessing lifetime suicidality (i.e., “Have you ever thought about or attempted to kill yourself?”), which was coded into three variables representing presence of lifetime suicidal ideation (i.e., “It was just a brief passing thought”; endorsement coded as 0/1), presence of lifetime suicide plan (i.e., “I have had a plan at least once to kill myself but did not try to do it” and “I have had a plan at least once to kill myself and really wanted to die”; endorsement on either coded as 0/1), and presence of lifetime suicide attempt (i.e., “I have attempted to kill myself, but did not want to die” and “I have attempted to kill myself, and really hoped to die”; endorsement on either coded as 0/1). Internal consistency of the full scale has been found to be strong in previous studies (Osman et al., 2001).

2.3. Data analysis

Prior to running analyses, all data were checked for validity. Participants who completed the questionnaires quicker than two standard deviations below the mean responses time. In addition, participants were required to answer at least four of the six attention check items (e.g., *“Select ‘1’ on this item.”*) to be included in analyses.

Decision tree analyses were utilized to examine how the frequency of individual NSSI methods throughout one's lifetime (continuous variable) related to the six correlates identified as indicative of more severe NSSI behavior (resulting in six separate decision tree analyses). Decision trees recursively partition, or split, the predictor variables in a

Table 1
Prevalence and descriptive statistics of nonsuicidal self-injury methods by gender.

	Among those endorsing each method					
	Males			Females		
	% Endorse	Mean acts (SD)	Mean age of onset (SD)	% Endorse	Mean acts (SD)	Mean age of onset (SD)
Cutting skin	29.25	9.50 (12.93)	15.21 (2.96)	59.04	33.53 (115.30)	14.20 (2.26)
Carving words / Pictures	9.50	3.26 (6.72)	14.66 (2.97)	13.06	5.87 (14.98)	14.16 (2.44)
Burning skin	22.50	4.29 (7.25)	16.21 (3.20)	15.03	14.39 (81.99)	15.35 (2.55)
Swallowing dangerous substances	9.75	9.33 (23.01)	16.03 (3.03)	16.90	3.77 (7.34)	15.52 (2.39)
Pinchingskin	14.75	18.53 (65.28)	13.44 (3.94)	27.50	37.05 (145.73)	14.03 (3.01)
Banging head, Hand, or body part	51.00	66.25 (497.54)	13.98 (3.56)	26.42	15.63 (64.06)	14.28 (3.45)
Poking with needle or sharp object	5.50	14.82 (29.37)	15.14 (3.41)	9.23	35.35 (145.28)	13.79 (2.74)
Scratching / Scraping skin	5.75	36.91 (102.54)	14.00 (3.22)	23.97	50.05 (196.48)	14.17 (3.00)
Biting skin	8.75	30.51 (63.04)	13.12 (3.97)	9.14	13.92 (23.73)	13.20 (3.93)
Pulling hair	8.00	14.38 (24.46)	13.16 (3.33)	13.36	48.54 (161.58)	13.92 (3.58)
Inserting objects under nails / Skin	0.30	10.00*	21.00*	0.30	138.33 (146.32)	11.33 (3.06)
Hitting / Punching self	20.75	14.28 (26.67)	14.10 (3.83)	15.03	23.37 (86.63)	14.54 (3.40)

Note:
* = standard deviation not available given sample size; Mean Acts = lifetime frequency of each nonsuicidal self-injury method; Mean Age of Onset = age of onset for the individual nonsuicidal self-injury method;

data-driven fashion. These rule-based decisions provide easily interpretable models which can be viewed as a set of conditional rules (Hastie et al., 2009). In the NSSI literature, decision trees have largely been utilized in exploratory studies to identify the most meaningful variables that improve the prediction of NSSI characteristics (i.e., severity) or outcomes related to suicidal thoughts and behavior. For example, Jenkins and colleagues identified significant splits that differentiate NSSI engagers who are at low or high suicidal risks (Jenkins et al., 2014). Similarly, Ammerman et al. (2018), reported specific age points of NSSI onset that significantly improved the prediction of past-year NSSI frequency, number of NSSI methods, and number of hospital visits due to self-injury. Their application has been broader in the suicide literature, however (see Burke, Ammerman and Jacobucci, 2019 for review).

In the current study, the two severity indicators of the number of times one had to go to the hospital due to their NSSI and the number of times one hurt themselves more severely than intended were collected as count variables. The resultant variables demonstrated zero-inflated Poisson distributions, which the package utilized to run the decision tree analyses was unable to appropriately model. Consequently, the two variables were categorized based on frequency of occurrence: 0 = individuals who reported never experiencing the outcome; 1 = individuals who reported experiencing the outcome once; 2 = individuals who reported the experiencing the outcome multiple times (two or more times). This decision was made based on the variables distribution in our sample: for number of hospital visits due to NSSI, 91.30% of the sample reported zero visits, 6.20% reported one visit, and 2.50% reported two or more visits; for numbers of times hurt more severely than intended, 68.90% reported zero instances, 12.70% reported one instance, and 18.40% reported two or more instances.

To implement the models, we used a modified version of the recursive partition algorithm implemented in the party package (Strobl et al., 2009) in R (R Core Team, 2017). The modified tree algorithm utilizes *p*-values, based on permutation tests, to identify variables to split. In order to select the best *p*-value to split on, we tested models with a *p*-value criterion fixed to 0.05, 0.01, and 0.001. Of note, there are not appropriate power analysis procedures for exploratory data mining methods, such as decision trees; however, such analyses are appropriate for datasets of varying sizes (i.e., a few hundred to several thousand). For each outcome (i.e., the six identified correlates), we utilized repeated cross-validation with 10 folds repeated 5 times (Krstajic et al., 2014), as implemented in the caret package (Kuhn, 2008), to select a final model (across the three *p*-value criterions) and avoid over-fitting. The quality of decision tree performance can be evaluated through prediction error. For continuous (i.e., age of NSSI onset) and categorical (i.e., number of NSSI-related hospital visits, number of times someone hurt themselves more severely than intended) outcome variables, R^2 is used (Kvålseth, 1985). For categorical outcome variables (i.e., presence of suicidal ideation, plans, or attempts), a receiver operating characteristic curve (ROC curve; Hanley and McNeil, 1982) is used. A ROC curve plots the true positive rate and true negative rate of the decision tree; then, the area under the curve (AUC) of the ROC curve is calculated. Each reported prediction error metric (R^2 and AUC) is the mean across the 50 cross-validated samples.

Given the significance of gender in NSSI engagement, gender was also considered in each of the decision tree analyses. The pattern of results did not differ with the inclusion of gender, with the exception of the decision tree analysis examining lifetime suicidal ideation. Findings with and without the inclusion of gender are presented for suicidal ideation and all other findings are presented without gender for ease of interpretation.

3. Results

3.1. Preliminary results

Among males, the NSSI method with highest endorsement was banging one's head, hand, or body part (method with highest frequency among males), followed by cutting oneself, burning oneself, and hitting / punching oneself. Among females, the NSSI method with the highest endorsement was cutting oneself, followed by pinching oneself, banging one's head, hand, or body part, and scratching / scraping one's skin (method with highest frequency among females). See Table 1 for percent endorsement and descriptive statistics for each method by gender. The overall mean age of NSSI onset was 13.76 (SD = 3.31; Median = 14.00). Of the overall sample, 8.70% (n = 125) reported having at least one NSSI-related hospital visit (sample M = 0.13; SD = 0.503; Median = 0.00) and 31.06% (n = 446) reported having hurt themselves more severely than intended at least once (sample M = 1.24; SD = 5.39; Median = 0.00). Of the overall sample, 70.30% (n = 1010) reported lifetime suicidal ideation, 36.80% (n = 529) reported a lifetime suicide plan, and 14.10% (n = 203) reported a lifetime suicide attempt.

3.2. Decision tree results

3.2.1. NSSI onset

All splits were significant at $p \leq .01$; the tree structure resulted in R^2 = 0.09. In examining age of NSSI onset, the most informative split

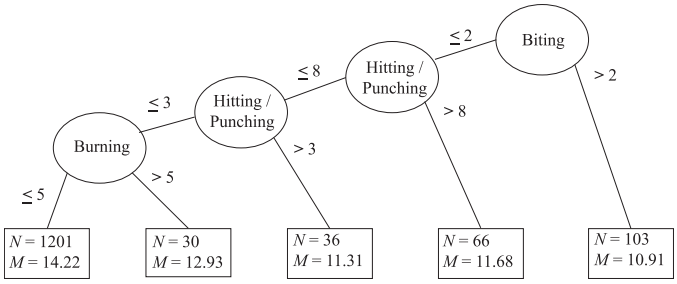

Fig. 1. Decision tree of nonsuicidal self-injury age of onset
Note: Squares represent terminal nodes; N = sample size of subgroup for each terminal node and M = mean for outcome variable (i.e., age of NSSI onset) among node subgroup.

occurred on the method of biting oneself (between 2 and 3 acts), followed by hitting / punching oneself (between 8 and 9 acts, and 3 and 4 acts), and then burning oneself (between 5 and 6 acts). See Fig. 1 for split information and descriptive statistics for resultant subgroups.

3.2.2. NSSI-related hospital visit

All splits were significant at $p \leq .003$; the tree structure resulted in $R^2 = 0.13$. In examining the number of NSSI-related hospital visits, the most informative split occurred on the method of hitting / punching oneself (between 12 and 13 acts), followed by cutting oneself (between 150 and 151 acts), swallowing a dangerous substance (between 0 and 1 acts, and 7 and 8 acts), and cutting oneself (between 45 and 46 acts). See Fig. 2 for split information and descriptive statistics for resultant subgroups.

3.2.3. Hurt oneself more severely than intended

All splits were significant at $p \leq .001$; the tree structure resulted in $R^2 = 0.09$. In examining the number of times individuals hurt themselves more severely than intended, the most informative split occurred on the method of hitting / punching oneself (between 10 and 11 acts), following by burning oneself (between 2 and 3 acts) and cutting oneself (between 9 and 10 acts). See Fig. 3 for split information and descriptive statistics for resultant subgroups.

3.2.4. Lifetime suicidal ideation

There were no significant splits on lifetime suicidal ideation without considering gender in the model. When considering gender in the model, all splits were significant at $p \leq .001$; the tree structure resulted in AUC = 0.60. The most informative split occurred on gender, followed by cutting oneself (between 1 and 2 acts). See Fig. 4 for split information and descriptive statistics for resultant subgroups.

3.2.5. Lifetime suicide plan

All splits were significant at $p \leq .05$; the tree structure resulted in AUC = 0.55. In predicting the lifetime presence of a suicide plan, the most informative split occurred on the method of hitting / punching oneself (between 15 and 16 acts). See Fig. 5 for split information and descriptive statistics for resultant subgroups.

3.2.6. Lifetime suicide attempt

All splits were significant at $p \leq .05$; the tree structure resulted in AUC = 0.55. In predicting the lifetime presence of a suicide attempt, the most informative split occurred on the method of hitting / punching oneself (between 20 and 21 acts), followed by cutting oneself (between 2 and 3 acts), swallowing a dangerous substance (between 0 and 1 acts), and cutting oneself (between 14 and 15 acts). See Fig. 6 for split information and descriptive statistics for resultant subgroups.

4. Discussion

The present study investigated the associations between individual forms of NSSI, gender, and NSSI severity indicators and suicidal thoughts and behaviors. We hypothesized that the use of direct forms of NSSI (involving explicit tissue damage) would be most indicative of negative NSSI characteristics (i.e., earlier age of onset, more NSSI-related hospital visits, greater harm than intended) and suicidal thoughts

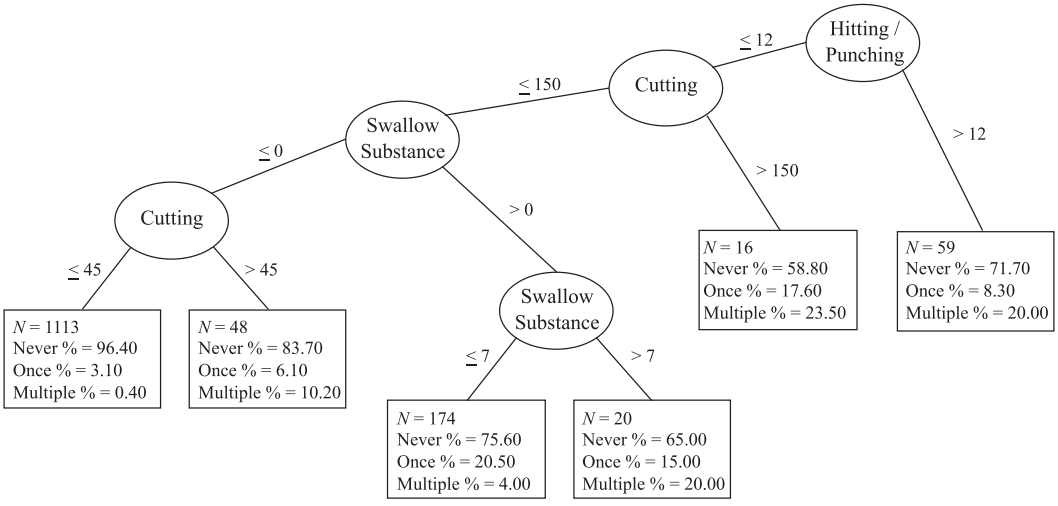

Fig. 2. Decision tree of nonsuicidal self-injury related hospital visits
Note: Squares represent terminal nodes; N = sample size of subgroup for each terminal node, Never % = percentage of individuals reporting never going to the hospital, Once % = percentage of individuals reporting going to the hospital once, and Multiple % = percentage of individuals reporting going to the hospital two or more times among node sub group.

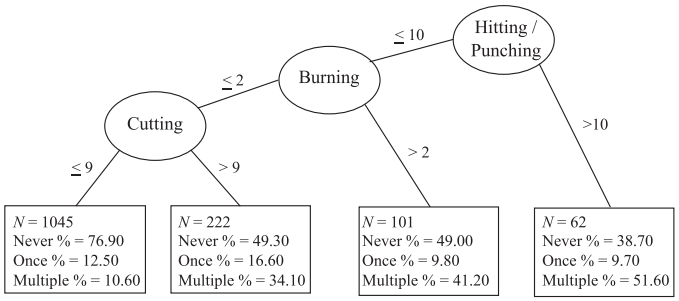

Fig. 3. Decision tree of hurt oneself more severely than intended
Note: Squares represent terminal nodes; *N* = sample size of subgroup for each terminal node, Never % = percentage of individuals reporting never hurting themselves more severely than intended, Once % = percentage of individuals reporting hurting themselves more severely than intended once, and Multiple % = percentage of individuals reporting hurting themselves more severely than intended two or more times among node subgroup.

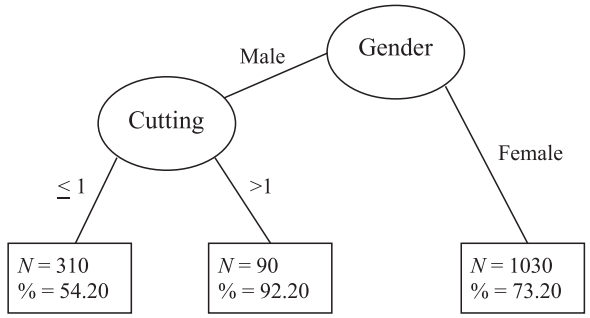

Fig. 4. Decision tree of lifetime suicidal ideation (including gender)
Note: Squares represent terminal nodes; *N* = sample size of subgroup for each terminal node and *%* = percent endorsement for outcome variable (i.e., presence of lifetime suicide ideation) among node subgroup; decision tree not including gender resulted in no significant splits.

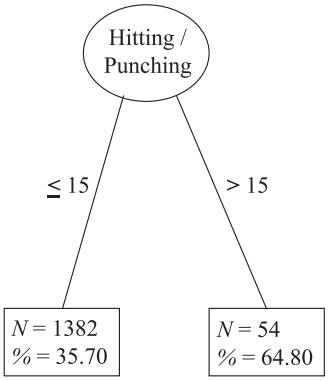

Fig. 5. Decision tree of lifetime suicide plan
Note: Squares represent terminal nodes; *N* = sample size of subgroup for each terminal node and *%* = percent endorsement for outcome variable (i.e., presence of lifetime suicide plan) among node subgroup.

and behaviors (i.e., suicidal ideation, plans, and attempts). The results provide some support for our hypotheses and mark an important first step in understanding the relationship between nonsuicidal and suicidal self-injury experiences and particular methods of NSSI.

Our decision tree analyses identified hitting / punching oneself as the most informative NSSI method across several of the assessed correlates. This pattern initially appears contrary to our overarching hypothesis that more direct forms of NSSI would indicate greater behavioral severity since self-hitting / punching does not necessarily cause (explicit) tissue damage; however, it is possible that the wording of the measure used in the current study (i.e., "… to cause severe pain or bruising") captured only the most severe cases of self-hitting / punching. Indeed, this method was found to be the most informative method for splitting on NSSI-related hospital visits and hurting oneself more severely than intended. Given the nature and visibility of wounds from hitting or punching oneself, it is possible that individuals who hit / punched themselves more than 12 times sought hospital care at the urging of others or due to the resulting impairment in activities of daily living. Importantly, however, such wounds may not be immediately visible (i.e., having a delayed onset), making it more difficult to gauge and control the level of ensuing harm. Analyses also identified hitting / punching oneself as the most informative in identifying the lifetime presence of suicide plans and suicide attempts. These findings are consistent with research revealing that self-hitting NSSI is positively associated with aggression (Kleiman et al., 2015), which in turn is positively associated with suicidal behavior (Gvion and Apter, 2011), a relationship consistent with theories of suicide (i.e., interpersonal-psychological theory of suicide; Van Orden et al., 2010).

Additional methods were also implicated in discriminating among groups with more severe outcomes. For example, the most informative combinations of NSSI methods in detecting NSSI-related hospital visits were hitting / punching oneself along with either cutting oneself or swallowing a dangerous substance. While the emergence of swallowing a dangerous substance is consistent with research identifying self-poisoning as the most common form of self-injury to receive emergency department care (Ting et al., 2012), our findings also demonstrate that it may be a combination of methods that best distinguishes individuals reporting one or more NSSI-related hospital visits. This could suggest that the individuals who are most likely to utilize hospital care may be those who use multiple NSSI methods that cause different types of tissue damage / pain (e.g., cutting or tearing vs. burning vs. bruising; Turner et al., 2013). Consistent with previous research (Kleiman et al., 2015), this may result in more severe and/or frequent NSSI. Similarly, cutting oneself and swallowing a dangerous substance, in addition to engaging in self-hitting / punching, differentiated individuals with a lifetime suicide attempt. As the three methods linked to suicide attempts, in addition to burning oneself, also emerged as informative in detecting NSSI-related hospitalization and unintended serious harm, it possible they are together indicative of a particularly severe variant of self-injury linked to an increased likelihood of an individual acting on their suicidal ideation (i.e., acquired capability for suicide; Van Orden et al., 2012). Taking these findings together, it would be informative for future research to examine whether it is a pattern of increasingly severe self-injury rather than a particular method used that is associated with these adverse outcomes.

Regarding NSSI age of onset, biting oneself was the most informative method, followed by hitting / punching oneself and carving one's skin. These findings are partially consistent with our hypotheses, as self-biting and self-carving are associated with direct tissue damage. Resultant subgroups predominantly characterized by engaging in self-biting, or a combination of self-biting, hitting / punching and self-carving, reported NSSI onset between approximately 11 and 11.5 years old. Recent research suggests that individuals who begin engaging in NSSI before age 12 exhibit more severe self-injury characteristics, including greater NSSI frequency, more NSSI-related hospital visits, and greater likelihood of making a suicide plan (Ammerman et al., 2018). Thus, early engagement in self-biting may foreshadow a longer and more potentially dangerous course of NSSI, warranting particular clinical attention and early intervention.

Limited gender differences were found in our decision tree models.

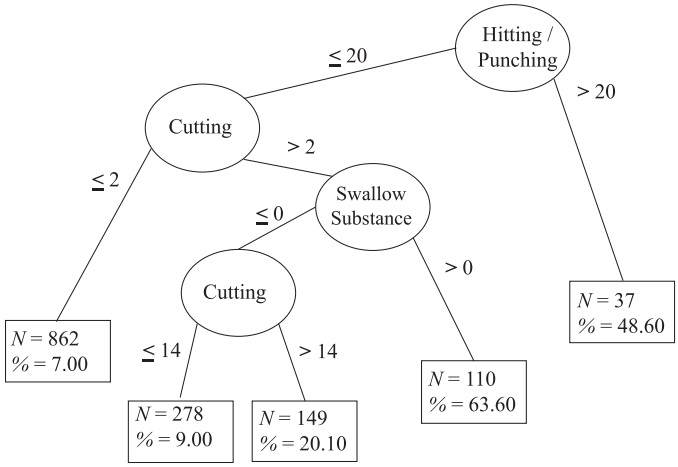

Fig. 6. Decision tree of lifetime suicide attempt
Note: Squares represent terminal nodes; *N* = sample size of subgroup for each terminal node and % = percent endorsement for outcome variable (i.e., presence of lifetime suicide attempt) among node subgroup.

This is somewhat in contrast to previous literature demonstrating gender differences in the utilization of NSSI methods (Barrocas et al., 2012; Bresin and Schoenleber, 2015; Sornberger et al., 2012). It may have been expected that NSSI methods documented to be more prevalent among each gender would have shown a differential relationship with NSSI severity indicators or suicidal thoughts and behaviors. However, the current findings do not support this, instead indicating that engaging in hitting / punching or cutting oneself, regardless of gender, may place individuals at risk for more severe NSSI behavior and increased likelihood of experiencing suicidal thoughts and behaviors. The only gender difference found was in the examination of suicidal ideation. Males who reported engaging in at least one act of cutting oneself were more likely to report a history of suicidal ideation. It may be that, given cutting is a less common method among males (Bresin and Schoenleber, 2015), engaging in this behavior is indicative of engaging in NSSI at a greater frequency or in utilizing a greater number of methods overall, both of which have been shown to distinguish among individuals along a continuum from no suicidality to suicidal ideation to suicidal behaviors (Knorr, Ammerman, Hamilton, and McCloskey, 2019). It will be important for future research to further explore this subpopulation of males who engage in NSSI.

4.1. Limitations and future directions

The present study must be interpreted in the context of its limitations. Our inclusion of only self-report measures within a cross-sectional design is a relative weakness; additional research should further examine the correlates of individual NSSI methods using clinician-rated interviews and by collecting more detailed qualitative information. Further, as we did not assess the temporal relationships between severity indicators and timing of NSSI method engagement, a longitudinal approach will be a necessary next step in the determination of whether specific NSSI methods serve as risk factors for negative outcomes. Resultant tree structures are inherently unstable due to the act of creating splits in variables that are not dichotomous in nature (e.g., Jacobucci, 2018). Therefore, the importance of one split chosen for the tree structure (i.e., between a specific number of acts), versus a split that was not chosen, may only reflect small improvements in the fit of the model. Additionally, as we did not use linear models for comparison, we cannot make statements that the use of trees, or equivalently, the use of cut points to create subgroups on the NSSI methods variables, is the optimal relationship between predictors and outcomes.[1] Thus, there is a need to replicate the current findings to support their generalizability. In light of potential clinical implications, it is particularly important to consider the generalizability of our results to psychiatric populations. Consistent with findings of similar relationships between NSSI and suicide attempt histories among undergraduate and adolescent inpatient/partial hospital samples (Klonsky, May, and Glenn, 2013), our current findings may also generalize to psychiatric samples, but further study is warranted to examine such replicability.

Finally, it is of note that while all presented decision tree splits were significant, the overall models offer slight improvements in the prediction of our outcomes. This highlights that, while the incorporation of individual NSSI methods into risk prediction may be informative, there is a need to consider additional relevant factors for the most accurate prediction of severe NSSI behavior and associated suicidal thoughts and behaviors. For example, trajectories of NSSI engagement over time may be informative with respect to outcomes, such as NSSI-related hospital visits and suicide attempts—both of which we found to be best distinguished by a combination of, rather than single, NSSI methods; examining the relative impacts of changes in NSSI engagement over time (e.g., use of additional of methods, increasing frequency with age) and the particular methods used may help identify individuals at highest risk for adverse self-injury outcomes. Moreover, as our results lend mixed support to the hypothesis that NSSI methods typically associated with the most direct tissue damage would be most informative in detecting outcomes, additional research should more explicitly examine the role of tissue damage severity. For instance, self-reported severity of physical injury and experience of pain during NSSI have been linked to such outcomes (e.g., Armiento et al., 2014; Ammerman, Burke, Alloy, and McCloskey, 2016). It would be informative to further examine the relationships between these aspects of NSSI and the additional indices of clinical severity (e.g., suicidal ideation and attempts) included in the current study.

NSSI is a serious behavior that confers a strong risk for suicidal thoughts and behaviors (Klonsky et al, 2016), a relationship that may vary as a function of the severity of NSSI behavior (Crandall et al., 2006). Although extant research has investigated the association between the number of NSSI methods one employs and negative outcomes, little work has examined the differential severity of individual forms of NSSI. The present study provides preliminary evidence that the use of certain NSSI methods, namely self-hitting or punching, ingesting

[1] This would require a model comparison approach, using cross-validation to compare fit across the tree and linear models. Since our explicit goal was to identify subgroups and cutoffs, we did not undertake this approach.

dangerous substance, and self-cutting, may be particularly useful in identifying individuals at heightened risk for negative correlates of NSSI, including NSSI-related hospital visits, unintended serious injury, and suicidal behavior. Continued research efforts to further pinpoint which NSSI methods may be most dangerous would have important clinical utility, providing a potential marker of prognosis and the need for higher levels of care.

References

Adrian, M., Zeman, J., Erdley, C., Lisa, L., Sim, L., 2011. Emotional dysregulation and interpersonal difficulties as risk factors for nonsuicidal self-injury in adolescent girls. J. Abnorm. Child Psychol. 39, 389–400.

Ammerman, B.A., Burke, T.A., Alloy, L.B., McCloskey, M.S., 2016. Subjective pain during NSSI as an active agent in suicide risk. Psychol. Res. 236, 80–85.

Ammerman, B.A., Jacobucci, R., Kleiman, E.M., Uyeji, L.L., McCloskey, M.S., 2018. The relationship between nonsuicidal self-injury age of onset and severity of self-harm. Suicide Life Threat. Behav. 48, 31–37.

Andover, M.S., Morris, B.W., 2014. Expanding and clarifying the role of emotion regulation in nonsuicidal self-injury. Can. J. Psychiatry 59, 569–575.

Armiento, J.S., Hamza, C.A., Willoughby, T., 2014. An examination of disclosure of nonsuicidal self-injury among university students. J. Commun. Appl. Soc. Psychol. 24, 518–533.

Andover, M.S., Primack, J.M., Gibb, B.E., Owens, D., Pepper, C.M., 2010. An examination of non-suicidal self-injury in men: do men differ from women in basic NSSI characteristics? Arch. Suicide Res. 14, 79–88.

Birtwistle, J., Kelley, R., House, A., Owens, D., 2017. Combination of self-harm methods and fatal and non-fatal repetition: a cohort study. J. Affect. Dis. 218, 188–194.

Burke, T.A., Jacobucci, R., Ammerman, B.A., Piccirillo, M., McCloskey, M.S., Heimberg, R.G., Alloy, L.B., 2018. Identifying the relative importance of non-suicidal self-injury features in classifying suicidal ideation, plans, and behavior using exploratory data mining. Psychiatry Res. 262, 175–183.

Bresin, K., Schoenleber, M., 2015. Gender differences in the prevalence of nonsuicidal self-injury: A meta-analysis. Clin. Psychol. Rev. 38, 55–64.

Barrocas, A.L., Hankin, B.L., Young, J.F., Abela, J.R., 2012. Rates of nonsuicidal self-injury in youth: Age, sex, and behavioral methods in a community sample. Pediatrics 130, 39–45.

Burke, T.A., Ammerman, B.A., Jacobucci, R., 2019. The use of machine learning in the study of suicidal and non-suicidal self-injurious thoughts and behaviors: a systematic review. J. Affect. Dis. 245, 869–884.

Corso, P.S., Mercy, J.A., Simon, T.R., Finkelstein, E.A., Miller, T.R., 2007. Medical costs and productivity losses due to interpersonal and self-directed violence in the United States. Am. J. Prev. Med. 32, 474–482.

Cox, L.J., Stanley, B.H., Melhem, N.M., Oquendo, M.A., Birmaher, B., Burke, A., . . ., Porta, G., 2012. A longitudinal study of nonsuicidal self-injury in offspring at high risk for mood disorder. J. Clin. Psychiatry 73, 821.

Crandall, C., Fullerton-Gleason, L., Aguero, R., LaValley, J., 2006. Subsequent suicide mortality among emergency department patients seen for suicidal behavior. Acad. Emer. Med. 13, 435–442.

Franklin, J.C., Puzia, M.E., Lee, K.M., Lee, G.E., Hanna, E.K., Spring, V.L., Prinstein, M.J., 2013. The nature of pain offset relief in nonsuicidal self-injury: a laboratory study. Clin. Psychol. Sci. 1, 110–119.

Germain, S.A.S., Hooley, J.M., 2012. Direct and indirect forms of non-suicidal self-injury: evidence for a distinction. Psychiatry Res. 197, 78–84.

Germain, S.A.S., Hooley, J.M., 2013. Aberrant pain perception in direct and indirect non-suicidal self-injury: an empirical test of Joiner's interpersonal theory. Compr. Psychiatry 54, 694–701.

Gvion, Y., Apter, A., 2011. Aggression, impulsivity, and suicide behavior: a review of the literature. Arch. Suicide Res. 15, 93–112.

Hanley, J.A., McNeil, B.J., 1982. The meaning and use of the area under a receiver operating characteristic (ROC) curve. Radiology 143, 29–36.

Hastie, T., Tibshirani, R., Friedman, J., 2009. The elements of statistical learning. Elements 1, 337–387.

Heath, N., Toste, J., Nedecheva, T., Charlebois, A., 2008. An examination of nonsuicidal self-injury among college students. J. Ment. Health Couns. 30, 137–156.

Hooley, J.M., Germain, S.A.S., 2014. Should we expand the conceptualization of self-injurious behavior? Rationale, review, and recommendations. The Oxford Handbook of Suicide and Self-Injury. pp. 47–60.

Jacobucci, R. 2018, January 18. Are decision trees stable enough for psychological research?. Retrieved from osf.io/m5p2v.

Jenkins, A.L., Connor, B.T., Alloy, L.B., 2011. The Form and Function of Self-Injury Scale (FAFSI): development and psychometric evaluation. In: The Annual Meeting of the American Psychological Association. Washington, D.C..

Jenkins, A.L., Singer, J., Conner, B.T., Calhoun, S., Diamond, G., 2014. Risk for suicidal ideation and attempt among a primary care sample of adolescents engaging in non-suicidal self-injury. Suicide Life Threat. Behav. 44, 616–628.

Kiekens, G., Hasking, P., Boyes, M., Claes, L., Mortier, P., Auerbach, R.P., ..., Myin-Germeys, I., 2018. The associations between non-suicidal self-injury and first onset suicidal thoughts and behaviors. J. Affect. Dis. 239, 171–179.

Kleiman, E.M., Ammerman, B.A., Kulper, D.A., Uyeji, L.L., Jenkins, A.L., McCloskey, M.S., 2015. Forms of non-suicidal self-injury as a function of trait aggression. Compr. Psychiatry 59, 21–27.

Klonsky, E.D., May, A.M., Saffer, B.Y., 2016. Suicide, suicide attempts, and suicidal ideation. Annu. Rev. Clin. Psychol. 12, 307–330.

Klonsky, E.D., May, A.M., Glenn, C.R., 2013. The relationship between nonsuicidal self-injury and attempted suicide: Converging evidence from four samples. J. Abnorm. Psychol. 122, 231–237.

Klonsky, E.D., Olino, T.M., 2008. Identifying clinically distinct subgroups of self-injurers among young adults: a latent class analysis. J. Consult. Clin. Psychol. 76, 22–27.

Klonsky, E.D., Victor, S.E., Saffer, B.Y., 2014. Nonsuicidal self-injury: what we know, and what we need to know. Can. J. Psychiatry 59, 565–568.

Knorr, A.C., Ammerman, B.A., Hamilton, A.J., McCloskey, M.S., 2019. Predicting status along the continuum of suicidal thoughts and behavior among those with a history of nonsuicidal self-injury. Psychiatry Res. 273, 514–522.

Krstajic, D., Buturovic, L.J., Leahy, D.E., Thomas, S., 2014. Cross-validation pitfalls when selecting and assessing regression and classification models. J. Cheminform. 6.

Kuhn, M., 2008. Building predictive models in R using the caret package. J. Stat. Soft. 28, 1–26.

Kvålseth, 1985. Cautionary note about R 2. Am. Stat. 39, 279–285.

Muehlenkamp, J.J., Brausch, A.M., 2016. Reconsidering criterion A for the diagnosis of non-suicidal self-injury disorder. J. Psychopathol. Behav. Assess. 38, 547–558.

Osman, A., Bagge, C.L., Gutierrez, P.M., Konick, L.C., Kopper, B.A., Barrios, F.X., 2001. The Suicidal Behaviors Questionnaire-Revised (SBQ-R): validation with clinical and nonclinical samples. Assess 8, 443–454.

Paul, E., Tsypes, A., Eidlitz, L., Ernhout, C., Whitlock, J., 2015. Frequency and functions of non-suicidal self-injury: associations with suicidal thoughts and behaviors. Psychiatry Res. 225, 276–282.

R. Core Team. 2017. R Development Core Team. R: a language and environment for statistical computing. Retrieved fromhttps://www.r-project.org/.

Robertson, C.D., Miskey, H., Mitchell, J., Nelson-Gray, R., 2013. Variety of self-injury: is the number of different methods of non-suicidal self-injury related to personality, psychopathology, or functions of self-injury? Arch. Suicide Res. 17, 33–40.

Selby, E.A., Bender, T.W., Gordon, K.H., Nock, M.K., Joiner Jr., T.E., 2012. Non-suicidal self-injury (NSSI) disorder: a preliminary study. Personal Disord. 3, 167.

Strobl, C., Hothorn, T., Zeileis, A., 2009. Party on!. R J. 1/2, 14–17.

Sornberger, M.J., Heath, N.L., Toste, J.R., McLouth, R., 2012. Nonsuicidal selfinjury and gender: Patterns of prevalence, methods, and locations among adolescents. Suicide Life Threat. Behav. 42, 266–278.

Swannell, S.V., Martin, G.E., Page, A., Hasking, P., St John, N.J., 2014. Prevalence of nonsuicidal self-injury in nonclinical samples: systematic review, meta-analysis and meta-regression. Suicide Life Threat. Behav. 44, 273–303.

Tatnell, R., Kelada, L., Hasking, P., Martin, G., 2014. Longitudinal analysis of adolescent NSSI: the role of intrapersonal and interpersonal factors. J. Abnorm. Child Psychol. 42, 885–896.

Ting, S.A., Sullivan, A.F., Boudreaux, E.D., Miller, I., Camargo Jr., C.A., 2012. Trends in US emergency department visits for attempted suicide and self-inflicted injury, 1993–2008. Gen. Hosp. Psychiatry 34, 557–565.

Turner, B.J., Layden, B.K., Butler, S.M., Chapman, A.L., 2013. How often, or how many ways: clarifying the relationship between non-suicidal self-injury and suicidality. Arch. Suicide Res. 17, 397–415.

Van Orden, K.A., Witte, T.K., Cukrowicz, K.C., Braithwaite, S.R., Selby, E.A., Joiner Jr., T.E., 2010. The interpersonal theory of suicide. Psychol. Rev. 117, 575–600.

Victor, S.E., Klonsky, E.D., 2014. Correlates of suicide attempts among self-injurers: a meta-analysis. Clin. Psychol. Rev. 34, 282–297.

Whitlock, J., Knox, K.L., 2007. The relationship between self-injurious behavior and suicide in a young adult population. Arch. Pediatr. Adolesc. Med. 161, 634–640.

Whitlock, J., Muehlenkamp, J., Purington, A., Eckenrode, J., Barreira, P., Baral Abrams, G., ..., Knox, K., 2011. Nonsuicidal self-injury in a college population: general trends and sex differences. J. Am. Coll. Health 59, 691–698.