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Daily Prediction of Nonsuicidal Self-Injury Among Inpatients: The Roles of Suicidal Thoughts, Interpersonal Difficulties, Hopelessness, and Affect

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Objective: Nonsuicidal self-injury (NSSI) is a major public health issue. Despite increased research efforts in clinical samples, we still have little understanding of the short-term correlates, predictors, and targets of NSSI among treatment-seeking individuals. The present study was designed to (a) evaluate how suicidal thoughts, interpersonal difficulties, hopelessness, and affective states are associated with same-day and next-day NSSI; (b) identify which factors may be effective targets in treatment through network modeling. ***Method:*** Data from 1,265 psychiatric inpatients who self-injured throughout their visit to a psychiatric hospital self-reported their suicidal ideation, negative affect, and positive affect on a daily basis (in total 36,345 prospective reports). An additional 632 patients were also surveyed regarding feelings of hopelessness, wish to live, and interpersonal difficulties. Using multilevel structural equation modeling, we examined contemporaneous and time-lagged associations with NSSI. Multilevel network analyses assessed interconnectedness of daily predictors and were compared with a matched sample of 1,265 patients who did not self-injure during their stay. ***Results:*** Increases in suicidal ideation were associated with increased probability of same-day and next-day self-injury, and an inverse relationship was observed for wish to live. Increases in positive affect were also significantly associated with decreased probability of next-day self-injury. Perceived burdensomeness had high centrality in network models, particularly among patients who self-injured, indicating it is susceptible to activation and directly associated with all predictors. ***Conclusions:*** Routine monitoring may improve prediction of when a patient is at short-term risk to self-injure and provides person-specific data that can assist in targeting risk and protective factors during treatment.

What is the public health significance of this article?
The present study finds daily assessments of cognitive–affective states may assist in identifying short-term shifts in risk for self-injury. Targeting interpersonal states, in addition to affect, may lead to reductions in a wider range of symptoms and associated risk of self-injury.

Keywords: nonsuicidal self-injury, dynamic structural equation modelling, network modelling, affect

Supplemental materials: https://doi.org/10.1037/ccp0000812.supp

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All procedures were approved by the University of Western Australia's Human Research Ethics Committee.

Research data are not shared to maintain patient confidentiality and ethical agreements.

The data used to conduct the present study accesses a historical database of survey data previously used in (Kyron et al., 2018, 2019, 2021). The present study uses all data available in the database (13 years of self-report data) to select a subsample of patients who self-harmed, as opposed to the 6-months to 2-years of data from all patients used in previous studies. These previous studies have not applied dynamic within-person modeling used in the current analyses and did not examine daily associations with affect, wish to live, and hopelessness.

Michael J. Kyron played a lead role in formal analysis, methodology and writing–original draft and supporting role in data curation. Geoff R. Hooke played a lead role in data curation, project administration and

continued

Nonsuicidal self-injury (NSSI) is defined as the deliberate, self-inflicted damage of one's own body tissue without suicidal intent (e.g., cutting, scratching, and hitting oneself; International Society for the Study of Self-Injury, 2022). Roughly one in five individuals report engaging in NSSI before the age of 25 (Gandhi et al., 2018; Gillies et al., 2018), and the 12-month prevalence is estimated to be 2%–14% among emerging adults (Benjet et al., 2017; Wilcox et al., 2012). These rates are even higher among treatment-seeking individuals, with up to one in ten reporting self-injury over the previous month (Ose et al., 2021). Although NSSI is conceptually distinct from a suicide attempt (Hamza et al., 2012), it is an important predictor of future suicidal thoughts and behaviors and psychopathology (Franklin et al., 2017; Kiekens et al., 2018; Ribeiro et al., 2016). Research to date has largely been cross-sectional, investigating the presence or severity of NSSI at one point in time. In addition, of the relatively small number of longitudinal research studies most have used observation windows from months to years (Franklin et al., 2017; Ribeiro et al., 2016). Such research has facilitated understanding of *who* is developmentally at-risk, but is inadequate to determine *when* an incident may occur for a particular individual (Kiekens et al., 2021; Stange et al., 2019). As a consequence, there remains a poor understanding of when an individual is at-risk of NSSI in the short-term. Hence, a necessary step in NSSI is examining within-level processes that indicate *when* vulnerable individuals are at an increased likelihood of engaging in NSSI from day-to-day.

An estimated 80%–90% of individuals who engaged in NSSI meet criteria for a mental health disorder (Hawton et al., 2013; Kiekens et al., 2021). Thus, NSSI is a significant issue for inpatient psychiatric care, since clinical resources need to be allocated to attend to those who have engaged in NSSI or are at heightened risk of engaging in self-injurious behaviors. Together with aggression, NSSI is one of the most frequently reported adverse clinical events (Berntsen et al., 2011). Reviews of the literature suggest a wide range from 1% to 21% of patients may self-injure while in inpatient care, influenced greatly by the clinical profile of patients within a setting (James et al., 2012). More recent research has identified rates of self-harm upward of 60% among young people during inpatient admissions (Kipoulas et al., 2021). While a high-risk population, inpatient settings allow for immediate support from nursing and other clinical staff to intervene and prevent incidents when possible. Indeed, the aforementioned rates are high considering the safety protocols in place within inpatient psychiatric settings, with clinical populations exhibiting higher lifetime and recent prevalence rates of NSSI compared to nonclinical populations (Horváth et al., 2020; Klonsky, 2011). The growing presence of routine psychological monitoring and feedback systems in inpatient psychiatric settings holds promise for measuring within-person dynamics that may provide warning signs for patients at-risk of NSSI (Kyron et al., 2019; Lambert & Harmon, 2018).

Better understanding of short-term risk of NSSI requires intensive assessments (i.e., hours, days) to determine how fluctuations in theoretically relevant factors associate with and temporally precede NSSI from day-to-day. The decision to assess individuals over days or hours is largely dependent on the context, and the balancing of rich and timely data with potential burden to patients of having to frequently complete questionnaires. Prospectively evaluating theory-grounded predictors of NSSI in daily life is critical, particularly when findings can inform just-in-time interventions to target services to those at-risk within psychiatric settings at critical points. Technological advancements in the past decade have facilitated the potential for these interventions through the growth of research implementing intensive, short-term repeated measures survey designs (Sedano-Capdevila et al., 2021). This research includes daily diary studies and ecological momentary assessment (EMA; Shiffman et al., 2008), which capture variations in key indices measured regularly through each day. The following section outlines research surrounding critical candidate risk and protective factors for NSSI, which might assist in refining risk assessments to predict and prevent a broad spectrum of self-injurious behaviors in clinical settings.

Intrapersonal Predictors of NSSI

NSSI is believed to be a means to decrease or avoid unwanted thoughts or affect (Chapman et al., 2006; Klonsky, 2007b; Kuehn et al., 2022; Taylor et al., 2018). Thus, NSSI may result due to fluctuations in negative affective states. Two systematic reviews found negative affective states such as depression and anxiety are consistently associated with NSSI (Fliege et al., 2009; Moller et al., 2013). Likewise, lower trait positive affect has been associated with an increased risk of lifetime and future NSSI behaviors (Armey & Crowther, 2008; S. A. Brown et al., 2007; Nicolai et al., 2016). In addition, hopelessness, which is a cognitive distortion characterized by the perceived absence of personal control over future negative events (Beck et al., 1974), has been linked to NSSI in cross-sectional research (Gu et al., 2021; Nock & Prinstein, 2005). However, the vast majority of these studies focused on the between person level and did not seek to determine how within-person fluctuations may prospectively indicate a short-term likelihood of engaging in self-injury. Among preliminary studies using intensive survey designs, hourly increases in negative affect correlated with an increased risk of NSSI, whereas increases in positive affect were associated with decreased likelihood of NSSI (Kiekens et al., 2020; Rodríguez-Blanco et al., 2018).

Suicidal Thoughts and NSSI

A large proportion of individuals who engage in NSSI also report suicidal thoughts (Bryan et al., 2015; Muehlenkamp & Kerr, 2010). However, there is conflicting evidence regarding the

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mechanisms underlying this association (Hamza et al., 2012). Some possible explanations are: (a) stressful or difficult life experiences act as a third variable, contributing to an increased desire for both NSSI and a concurrent desire to escape those stressors through suicide; (b) NSSI may initially be used to regulate internal states in the short-term, and suicidality increases when NSSI fails to address underlying emotional pain in the longer term; or (c) individuals who self-injure and experience suicidal thoughts may subsequently notice that NSSI helps ameliorate these thoughts in the short term (Kraus et al., 2020; Muehlenkamp & Kerr, 2010; Victor et al., 2015). Research has found that increases in a wish to die and suicidal ideation in the days prior to engaging in NSSI (Kyron et al., 2018, 2021), suggesting the occurrence in suicidal ideation may be an antecedent for NSSI (Chu et al., 2018). However, these studies have not applied appropriate within-level analyses that investigate the short-term temporal associations with self-injury.

While suicidal ideation and a wish to die represent severe negative mental health states, they can often co-occur with the presence of positive attachment to life (Bornet et al., 2021). While wish to live and die are strongly and inversely correlated, they still remain unique constructs and wish to live may provide additional explanatory power in relation to NSSI. The association between wish to live and NSSI has not been explored, although a positive wish to live has been associated with high resilience (Bornet et al., 2021).

Interpersonal Predictors and NSSI

Theorists have proposed that NSSI may have a distinct interpersonal function, including interpersonal communication (e.g., "to communicate or let others know how desperate I am"), and interpersonal influence (e.g., "to get back at or hurt someone"; Klonsky, 2007a; Taylor et al., 2018; Turner et al., 2012). Cross-sectional findings also demonstrated a link between perceived burdensomeness, thwarted belongingness, and NSSI (Assavedo & Anestis, 2016). Daily diary research has found individuals who self-injure exhibit patterns of increasing interpersonal difficulties within the 2 days prior to NSSI (Kyron et al., 2018).

Within-person fluctuations were a primary focus of a recent study (Victor et al., 2019) which used EMA to determine how interpersonal dysfunction (criticism, rejection) and negative affect were associated with NSSI urges hours later. The researchers found the effects of interpersonal factors on future NSSI urges were mediated by negative affect. Indeed, fluctuations in both negative affect and interpersonal states have been found to be interconnected over short-term periods (i.e., hours), which shows they are separable, albeit closely linked, constructs (Rath et al., 2019). To the best of our knowledge, no study has prospectively investigated the dynamic relationship of perceived burdensomeness and thwarted belongingness with NSSI in daily life.

Identifying Salient Targets for Treatment

Interventions to prevent NSSI benefit from targeting factors that efficiently drive change. Indeed, the abovementioned literature suggests a high degree of interconnectedness between affect, interpersonal adversity, and suicidal thoughts. However, interventions may benefit from identifying specific factors that are central to changes across risk factors. For instance, interpersonal problems may concurrently drive negative shifts in affect and suicidal ideation and are specific states that can be targeted during therapy (Joiner et al., 2009).

The collection of daily diary and EMA data allows for exploration of the interconnectedness between risk and protective factors through network analysis. This exploratory approach visually presents all possible relationships between all variables and can therefore guide researchers and clinicians toward more complex and dynamic thinking about mental disorders (Bringmann & Eronen, 2018). Particular variables may be central to change in a wider variety of symptoms (or alternatively, a symptom that is affected by a variety of factors), and if targetable in an efficient manner could inform timely clinical interventions. Thus, progress in clarifying these key relationships requires novel analytical approaches that can identify the strength and nuances of these time-based relationships.

Advances in network analysis have involved applications to time-series data in psychological research, which allows for examination of temporal associations between variables in a network through time-lagged associations. These models extend on traditional network models by identifying whether change in one variable may temporally precede change in another, and therefore attempts to estimate the direction of influence. For instance, a recent study applied multilevel network analysis to EMA data, finding interpersonal adversity, hopelessness, affect, and suicidal ideation exhibited a high degree of interconnectedness from hour-to-hour, with only perceived burdensomeness associated with ideation at the next assessment (Rath et al., 2019). The application of network analysis specifically to patients who have engaged in NSSI has yet to occur and may provide important targets to reduce risk of self-injury. Further, networks can be compared with individuals who do not self-injure, which assist in identifying how networks may be activated in different ways. For instance, interpersonal adversity may have a greater influence on affective states among people who self-injure, suggesting a high reactivity to negative interpersonal events that may predispose these individuals to heightened risk of self-injury.

The Present Study

The aforementioned studies provide a foundation for future research assessing short-term temporal relationships with NSSI. Few studies, however, have assessed these diverse factors within a single study. Doing so is important in delineating associations between factors that likely share psychological underpinnings and the level of interconnectedness between factors. Determining which factors are uniquely effective in predicting NSSI on a daily basis is important in predicting and preventing incidents. The current project has two main aims: (a) evaluate how the aforementioned risk (suicidal thoughts, interpersonal adversity, hopelessness, negative affect) and protective factors (positive affect, wish to live) are concurrently and prospectively associated with NSSI; (b) identify which factors may be effective targets in treatment by conducting a network analysis of risk and protective factors for patients who self-injure, and comparing these networks with those of patients who do not self-injure.

Method

Participants and Procedure

The present study was conducted as part of ongoing assessment and treatment of inpatients at a 100-bed psychiatric hospital in Perth, Western Australia. Patients were presented with the opportunity to self-report their mental health on a daily basis as part of standard care through electronic tablet devices located in patients' rooms. Daily response rates were high (70%–80%), with patients on average completing questionnaires on roughly 60% of days during their stay. Admission to the hospital was voluntary, and patients were referred by a diagnosing psychiatrist to receive specialized care tailored for a range of mental health conditions.

Information surrounding self-injurious events was provided by clinical staff, who logged reports regarding each incident as part of risk management. Staff outlined the nature of the incident, the time it occurred, the outcome (i.e., transferred to external medical hospital, minor intervention), and perceived intent (i.e., suicidal or nonsuicidal). All forms were completed in accordance with hospital policy and procedures were approved by the chief psychiatrist of Western Australia. Consent for the data to be used for research purposes was provided by patients at admission, and all procedures were approved by the University's Ethics Committee. To improve reliability of coding, nursing staff were trained regarding how to recognize potential suicidal intent regarding self-injury, completed standardized daily suicide and self-harm risk assessment forms with patients, and noted discussions with patients and other contextual factors involved in their decision making. These entries were then reviewed during handovers with other nurses, and also with the psychiatrist overseeing each patient's treatment. The present study expands on prior research within the same setting by examining a broader range of independent variables, accessing an additional decade of inpatient theory-driven data, and applying multilevel dynamic modeling (Kyron et al., 2018, 2019, 2021). Due to the sensitive nature of suicide attempts within an inpatient setting, agreements have been made with the hospital to not release the rate of suicide attempts over time. Further, the examination of suicide attempts was beyond the scope of the present study.

Measures

Suicidal Ideation and Negative Affect

Negative affect was measured through four items that assessed feelings of depression (e.g., "In the past 24 hours, I have felt depressed"), anxiousness, worthlessness, and not coping (e.g., "I have felt that I am not coping"). Suicidal thoughts were measured through a single item ("In the past 24 hours, I've had thoughts of killing myself"). All items were from the 5-item Psychological Distress Daily Index (DI-5; Dyer et al., 2014) and were measured on a 6-point Likert scale (0 = *at no time*, 5 = *all the time*). The scale has shown strong psychometric properties (Dyer et al., 2014) and clinical validity (Dyer et al., 2016). Negative affect items exhibited acceptable within-level reliability ($\omega_{within} = 0.87$)

Positive Affect

The World Health Organization 5-item Well-Being Index (WHO-5; World Health Organization, 1998) is a self-report measure of positive mental health, including feeling fresh and rested, cheerful, in good spirits, active, and calm and relaxed. Each of the five items are assessed using a 6-point Likert-type scale (0 = *at no time*, 5 = *all the time*), with reference to the past 24 hr (i.e., In the past 24 hr I have felt …). Higher scores on the measure indicate higher positive affect. The scale has exhibited high reliability and validity in prior clinical use (Newnham et al., 2010) and exhibited acceptable within-level reliability in the current sample ($\omega_{within} = 0.84$)

Hopelessness

A single item was taken from the Perceived Mastery Scale (Pearlin et al., 1981) to measure hopelessness, "In the past 24 h, I have felt there is no way I can change many of the important things in my life." It was measured on a 7-point Likert scale (1 = *not true for me at all*, 7 = *very true for me*). This item exhibited good psychometric properties in prior research using both item response theory and confirmatory factor analysis approaches (Chen et al., 2013; Eklund et al., 2012; Lim et al., 2022).

Thwarted Belongingness

Belongingness was measured by summing two items: "In the past 24 hours, I have felt that people care for me" and "In the past 24 hours, I have felt close to others." Responses were reverse scored so that higher scores indicated a greater sense of thwarted belongingness. Items were measured on a 7-point Likert-type scale (1 = *not true for me at all*, 7 = *very true for me*). Items were selected based on their strong factor loadings in clinical samples (Van Orden et al., 2012) and exhibited acceptable within-level reliability ($\omega_{within} = 0.75$).

Perceived Burdensomeness

Two items were used to measure perceived burdensomeness: "In the past 24 hours, I have felt like a burden," and "In the past 24 hours, I have felt like my death would be a relief to people." Items were measured on a 7-point Likert-type scale (1 = *not true for me at all*, 7 = *very true for me*). Item scores were combined, with higher scores representing higher perceived burden. Both thwarted belongingness and perceived burdensomeness items were adapted from the Interpersonal Needs Questionnaire (Van Orden et al., 2012), and burdensomeness items had acceptable within-level reliability ($\omega_{within} = 0.70$).

Wish to Live

A single item was taken from the Scale for Suicide Ideation (Beck et al., 1979) to measure patients' wish to live, "In the past 24 hours, my wish to live has been …," measured on a 4-point Likert-type scale (0 = *none*, 1 = *weak*, 2 = *moderate*, 3 = *strong*).

Statistical Approach

Dynamic Modeling

To assess the temporal associations with NSSI, multilevel vector autoregressive (mlVAR) models were conducted within the dynamic structural equation modeling (DSEM) framework in MPlus 8.4 (Muthén & Muthén, 2009). DSEM combines aspects

of time-series analysis and structural equation modeling suited to daily diary psychological data. In DSEM, variables are latent person mean centered, such that observed scores on daily questionnaire items are interpreted relative to a person's own average. Therefore, it allows for an examination of whether fluctuations in scores for a particular person may be associated with same-day and next-day NSSI. DSEM allows for various parameters to be modeled, including autoregressive effects (i.e., the persistence of variance in a variable from 1 day to the next), cross-sectional effects (e.g., the concurrent correlation between deviations in two variables from typical levels on the same-day), and cross-lagged effects (i.e., how variation in one variable predicts variability in another variable on the next-day).

DSEM requires a Bayesian estimator, which allows complex and computationally intensive modeling, and also provides accurate estimates for missing data (Asparouhov et al., 2018). Estimates are interpreted with their 95% credibility intervals, which give the range within which the "true" relationship is 95% likely to fall. Mplus uses a Kalman filter to account for missing data, which makes predictions of the next observation based on lagged predictors that are updated based on observed data (McNeish & Hamaker, 2020).

Where time-series elements were not investigated (i.e., autoregressive and cross-lagged effects), a standard multilevel structural equation model (MSEM) was fit to the data. Consistent with DSEM, MSEM in Mplus takes a person-centered approach to examining time-varying associations between variables, but does not take into account the time-series aspects of data that is the focus of DSEM. As DSEM models with autoregressive effects require a much larger sample to detect significant within-person associations, MSEM was instead applied when focusing on the same-day or concurrent associations between predictors and NSSI. Models focusing on time-lagged associations (i.e., negative affect predicting next-day NSSI) used a DSEM framework and were applied to patients who stayed at the hospital for seven days or more (N = 1,214).

Treatment of Variables

In the present study, NSSI was treated as a binary outcome in the models (0 = no NSSI on that day, 1 = NSSI occurred on that day). Within MSEM and DSEM, a categorical dependent variable is handled using a probit link function. A positive probit regression coefficient suggests that the probability of the categorical dependent variable (i.e., a NSSI event occurring) is increased when the predictor value increases. A larger magnitude means that this probability increases faster. Due to a degree of skew for the single-item Likert measure of hopelessness (i.e., most patients had higher levels of hopelessness), it has been treated as an ordered categorical variable in the analyses, as well as the 4-point scale of the wish to live item.

Model Specifications

Models were separately constructed to examine whether risk/protective factors predicted (a) same-day NSSI (concurrent model) or (b) next-day NSSI (time-lagged model). For the cross-sectional model, a MSEM framework was applied (i.e., no lagged effects). In the time-lagged models using DSEM, autoregressive relationships were estimated for all independent variables, which examines how variations in one factor are related to the same factor on the next-day (e.g., how much negative affect persists from 1 day to the next). Further, these DSEM models examined whether variations in risk/protective factors at a given assessment are associated with increased probability of NSSI on the next-day (i.e., cross-lagged effects). For all models, random intercepts and slopes were included in each model to capture individual variability, with random effects allowed to covary. Analyses were conducted separately for data collected since 2009 pertaining to positive and negative affect, and suicidal ideation, and also data collected since 2017 after which interpersonal difficulties, hopelessness, and wish to live were included in the patient surveys. This was done to maximize the power to detect effects with all historical data collected since 2009, while exploring a wider range of predictors with more recently collected data. All models were also run with and without suicidal ideation or wish to live as independent variables, as there was an expectation that various cognitive–affective states may simultaneously increase ideation, wish to live, and NSSI. Further, supplementary models were fit to the data with individual items from the DI-5 and WHO-5 as independent variables to examine specific aspects of affect that may be associated with NSSI. Tolerance and variance inflation factor metrics in these models were below suggested acceptable limits (O'brien, 2007).

Network Plots

To assess the interconnectedness between independent variables in DSEM models, a multilevel network model was applied to the data using the *R* package "mlVAR" (Epskamp et al., 2018). This data-driven approach explores the within-and-between person dynamics and allows for an intuitive examination of the interconnected, causal pathways between variables. Further, the mlVAR package explores autoregressive and bidirectional associations between variables at the within-level. This provides a more comprehensive assessment of the associations between variables that may be obscured by traditional network models that do not provide distinctions regarding within- and between-level processes. The focus of network models is often the level of centrality of variables in the network, encapsulated by several statistics: closeness (i.e., the sum of the shortest paths between all nodes or how quickly a variable affects others in the network), betweenness (i.e., the number of times a variable is the shortest path or a bridge between variables), and strength (i.e., sum of all absolute edge weights a node is directly connected to). As the mlVAR network models feature bidirectional associations, metrics are computed to differentiate in-strength (i.e., the combined weights of associations directed toward a node) and out-strength (i.e., the combined weights of associations directed out of a node toward other nodes). For example, out-strength would combine the edges for suicidal ideation predicting each other variable in the network on the next-day, while in-strength combines the strength of associations when all other variables in the network predict next-day suicidal ideation. These models were applied for patients who stayed 7 days or more at the hospital and did engage in NSSI throughout their stay (n = 1,214). We estimated three types of network structures: within-level time-lagged or temporal, which examines how variables are interconnected from 1 day to the next; within-level contemporaneous associations, representing

how variables are associated within the same timeframe; and between-level, which examines within-person mean levels of variables are associated on a larger time-scale (e.g., mean level of affect across participants relates to the mean level of loss of suicidal ideation; Epskamp et al., 2018). Consistent with the prior DSEM models, analyses were conducted separately for data collected since 2009 pertaining to positive and negative affect, and suicidal ideation, and also data collected since 2017 with interpersonal difficulties, hopelessness, and wish to live included. Results present within-level results, as the within-level dynamics are the focus of the present study. Visible lines connecting nodes in each model represent statistically significant edges at $p < .05$.

A matched sample ($N = 1,265$) was used to compare these networks with patients who did not self-injure. Patients were propensity score matched based on sex, age, primary diagnosis, marital status, scores on the Depression Anxiety Stress Scales (Brown et al., 1997), and length of stay. The demographics for the matched sample have been reported in Table 1. The same network models were fit to data related to these patients, and centrality metrics compared between both models. That is, are overall symptoms of people who self-injure more likely to be affected (both directly and indirectly) by interpersonal problems? The temporal networks for these patients have been presented in the Supplemental Material.

All centrality metrics in the network models have been converted into *z*-scores, as raw scores can be easily influenced by number of nodes. A positive centrality scores indicate that a node may have a stronger influence on the network, while a negative association may indicate a weaker influence. Further, it allows for easier comparisons between different networks. Although no formal tests exist to compare centrality between mlVAR networks, centrality between self-harmers and nonself-harmers in the present study are compared in a relative manner using standardized metrics. Orthogonal estimation was used for network models with interpersonal, hopelessness, and wish to live items, which fixes parameter covariances to zero (correlated estimation has been presented in Supplemental Material). For models with negative and positive affect, and suicidal ideation (i.e., only three nodes), correlated estimation was used which is feasible for application of up to six nodes. Models using the individual items from the DI-5 and WHO-5 have been presented in the Supplemental Material.

Results

Sample Characteristics

In total, 1,265 patients self-injured during their visits to the hospital over the 13 year span. The sample was predominantly female and not in a marital/de facto relationship. The majority of patients engaged in NSSI on one occasion while in hospital (62.6%), 247 on two occasions (19.5%), 226 on three or more occasions (17.9%) with a total of 2,274 self-injury events. The historical average length of stay for the hospital is approximately 16 days, which reflects the severity of the current sample who had an average length of stay of roughly 27 days. Roughly 56% of NSSI incidents required minor intervention from nursing staff (i.e., applying dressing over wounds), 23.2% required no significant intervention, and 5.2% of patients required enhanced observation (i.e., increase surveillance of patients deemed to potentially be at

Table 1

Demographic Characteristic of the Total Sample of Patients Who Self-Injured During Their Stay (N = 1,265), and a Matched Sample of Patients Who Did Not Self-Injure (N = 1,265)

Demographic characteristic	NSSI ($N = 1,265$)		No NSSI matched sample ($N = 1,265$)	
	Frequency or *M*	Proportion or *SD*	Frequency or *M*	Proportion or *SD*
Sex				
Female	1,089	89.9%	1,104	91.09%
Male	123	10.1%	108	8.91%
Marital status				
Divorced	37	3.06%	48	3.97%
Married/defacto	253	20.93%	258	21.32%
Separated	36	2.98%	55	4.55%
Single	880	72.79%	845	69.83%
Widow	3	0.25%	3	0.33%
Age	27.97 (Min = 13, Max = 71)	(*SD* = 12.02)	28.25 (Min = 14, Max = 66)	(*SD* = 11.86)
Average length of stay	27.03 (Min = 1, Max = 167)	(*SD* = 17.34)	27.19 (Min = 1, Max = 168)	(*SD* = 21.17)
Diagnosis (ICD classification)				
Adult personality disorder	191	15.76%	184	15.18%
Mood affective disorders	598	49.34%	588	48.51%
Behavioral disorder	14	1.16%	14	1.16%
Behavioral/emotional disorder with childhood/adolescence onset	6	0.50%	4	0.33%
Neurotic, stress-related	293	24.17%	310	25.58%
Organic	1	0.08%	1	0.08%
Other	4	0.33%	5	0.41%
Psychological development	2	0.17%	1	0.08%
Schizophrenic	60	4.95%	65	5.36%
Substance disorder	43	3.55%	40	3.30%
Average percent of self-reports completed	56.9% (Min = 0%, Max = 100%)	31.80%	57.4% (Min = 0%, Max = 100%)	32.26%

Note. NSSI = nonsuicidal self-injury; *M* = Mean; *SD* = Standard Deviation; ICD = International Classification of Diseases.

increased future risk despite no significant injury). Roughly 37% of individuals lived in high socioeconomic status suburbs (top 25% of the population aged 15–64 years) and 35% were from medium socioeconomic status suburbs. Information pertaining to race of patients was not made available for the present study.

Concurrent and Temporal Associations With NSSI

Affect and Suicidal Ideation

Correlations between predictors and variance inflation coefficients have been presented in the Supplemental Material, with multicollinearity being acceptable (O'brien, 2007). Results were split for data available since 2009 (suicidal ideation, positive and negative affect; Table 2) and data available from 2017 onward (interpersonal difficulties, hopelessness, wish to live; Table 3).

In MSEM models predicting same-day NSSI (Table 2), increases in suicidal ideation were significantly associated with higher odds of NSSI (β = .10, 95% credibility interval [.06, .14]), while increases in positive affect were significantly associated with lower odds of same-day NSSI (β = −.09, 95% CI [−.14, −.04]). Likewise, in the DSEM models predicting next-day NSSI, increases in suicidal ideation significantly predicted next-day NSSI (ϕ_{CL} = .10, 95% CI [.06, .16]), while increases in positive affect (ϕ_{CL} = −.08, 95% CI [−.13, −.04]) were inversely associated with next-day NSSI. When removing suicidal ideation from these models, both positive and negative affect were significantly associated with same-day and next-day NSSI (Supplemental Table 1).

Examining Individual Aspects of Positive and Negative Affect

Models were run separately for positive (WHO-5) and negative affect (DI-5) scales. In terms of positive affect (WHO-5 items), higher feelings of cheerfulness (β = −.09, 95% CI [−.14, −.04]), being calm and relaxed (β = −.06, 95% CI [−.11, −.01]), and interest in daily activities (β = −.06, 95% CI [−.10, −.01]) were associated with lower odds of same-day NSSI (Supplemental Table 2), while feelings of cheerfulness (ϕ_{CL} = −.05, 95% CI [−.09, −.01]) and feeling fresh and rested (ϕ_{CL} = −.05, 95% CI [−.10, −.00]) were associated with next-day NSSI.

In terms of items from the DI-5 scale, suicidal ideation (β = .15, 95% CI [.11, .19]) and depressed mood (β = .07, 95% CI [.02, .12]) were significantly associated with increased odds of same-day NSSI, while suicidal ideation was associated with next-day NSSI (ϕ_{CL} = .08, 95% CI [.05, .12]; Supplemental Table 3). When removing suicidal ideation from these models, depressed mood was associated with both same-day (β = .12, 95% CI [.07, .18]) and next-day NSSI (ϕ_{CL} = .06, 95% CI [.03, .11]), and feelings of not coping were associated with next-day NSSI (ϕ_{CL} = .05, 95% CI [.01, .09]; Supplemental Table 4).

Introduction of Interpersonal, Hopelessness, and Wish to Die Items

For the concurrent prediction models (i.e., predicting same-day NSSI), suicidal ideation was associated with higher odds of NSSI (β = .10, 95% CI [.05, .15]), while increases in wish to live were associated with lower odds (β = −.06, 95% CI [−.13, −.101]; Table 3). For the time-lagged DSEM models (i.e., predicting next-day NSSI), suicidal ideation remained associated with next-day NSSI (ϕ_{CL} = .09, 95% CI [.05, .14]), and increases in positive affect (ϕ_{CL} = −.08, 95% CI [−.14, −.02]) and wish to live (ϕ_{CL} = −.06, 95% CI [−.13, −.02]) were associated with lower odds of next-day NSSI. When removing suicidal ideation and wish to live from the models, negative affect and hopelessness were significantly associated with same-day NSSI, while positive and negative affect were associated with next-day NSSI (Supplemental Table 5).

Connectedness Between Predictors: Affect and Suicidal Ideation Models

Associations Between Predictors

mlVAR network models were fit to the data to depict the interconnectedness between independent variables from prior MSEM and DSEM models for patients who engaged in NSSI throughout their stay and stayed 7 days or over (n = 1,214). In Figure 1A, the temporal associations between predictors have been presented for all patients who self-injured throughout their stay. All variables were significantly, reciprocally related from 1 day to the next, suggesting a bidirectional influence. Cross-sectionally, all variables were significantly correlated on the same-day (Figure 1B).

Table 2
Daily Prediction of NSSI With Negative and Positive Affect, and Suicidal Ideation as Independent Variables

	Model 1 outcome: Same-day NSSI (T)		Model 2 outcome: Next-day NSSI (T + 1)	
Predictors (T)	Std. estimate [95% CI]	*SE*	Std. estimate [95% CI]	*SE*
Negative affect	.04 [.00, .09]	.025	.04 [.00, .09]	.021
Positive affect	**−.09 [−.14, −.04]**[a]	.023	**−.08 [−.013, −.04]**[a]	.023
Suicidal ideation	**.10 [.06, .14]**[a]	.021	**.10 [.06, .14]**[a]	.018
R^2	0.20		0.18	

Note. Significant associations are boldfaced. *SE* = standard error; NSSI = nonsuicidal self-injury; CI = credibility interval; MSEM = multilevel structural equation model; DSEM = dynamic structural equation model. Autoregressive effects were estimated for all variables (and statistically significant) in the DSEM model, with the exception of NSSI. Note, 51 less patients were included in DSEM models as their length of stay was under the 7 days required for inclusion in these time-series models. MSEM (Model 1) and DSEM (Model 2) probit regression models assessing standardized within-level concurrent (left panel) and time-lagged (right panel) predictors of NSSI for data available since 2009 (N = 1,265 for MSEM, n = 1,214 for DSEM).
[a] Associations significantly different from 0.

Table 3
Daily Prediction of NSSI With Interpersonal Variables, Hopelessness, and Wish to Live Included as Independent Variables

Predictors (T)	Model 1 outcome: Same-day NSSI (T)		Model 2 outcome: Next-day NSSI (T + 1)	
	Std. estimate [95% CI]	*SE*	Std. estimate [95% CI]	*SE*
Negative affect	.02 [−.06, .06]	.029	.03 [−.03, .10]	.033
Positive affect	−.03 [−.09, .03]	.031	**−.08 [−.14, −.02]**[a]	**.031**
Suicidal ideation	**.10 [.05, .15]**[a]	**.027**	**.09 [.05, .14]**[a]	**.031**
Perceived burdensomeness	.00 [−.06, .06]	.030	−.01 [−.06, .05]	.027
Thwarted belongingness	.00 [−.04, .05]	.024	.01 [−.04, .05]	.024
Hopelessness	.05 [−.01, .11]	.029	.02 [−.03, .08]	.028
Wish to live	**−.06 [−.13, −.01]**[a]	**.030**	**−.06 [−.13, −.02]**[a]	**.027**
R^2	0.39		0.37	

Note. Significant associations are boldfaced. *SE* = standard error; NSSI = nonsuicidal self-injury; CI = credibility interval; MSEM = multilevel structural equation model; DSEM = dynamic structural equation model. Autoregressive effects were estimated for all variables (and statistically significant) in the DSEM model, with the exception of NSSI. Note, 29 less patients were included in DSEM models as their length of stay was under the 7 days required for inclusion in these time-series models. MSEM (Model 1) and DSEM (Model 2) probit regression models assessing standardized within-level concurrent (left panel) and time-lagged (right panel) predictors of NSSI (including interpersonal difficulties, hopelessness, and wish to live; $N = 661$ for MSEM, $n = 632$ for DSEM).
[a] Associations significantly different from 0.

Centrality

The centrality metrics of variables within the network have been presented in Supplemental Figure 1. Negative affect exhibited high degree of influence on the network, acting as a bridge between positive affect and suicidal ideation (*Betweenness Centrality*), and also a direct influence on both variables (*Out Strength*).

Comparisons With Patients Who Did Not Self-Harm

Centrality metrics were also compared between patients who did and did not engage in NSSI and are presented in Supplemental Figure 1. Centrality metrics for most variables were largely comparable between the three variables in the network. When running models with the individual items from the DI-5 and WHO-5 (Supplemental Figures 2 and 3), depressed mood and worthlessness exhibited high centrality for both groups of patients. Being "interested in daily activities" exhibited relatively higher centrality for patients who self-harmed, while feeling "active and vigorous" exhibited lower centrality (Supplemental Figure 4). Increases in interest in daily activities may therefore strengthen various aspects of positive affect and lead to reductions in aspects of negative affect from day-to-day.

Network Models Including Interpersonal Difficulties, Hopelessness, and Wish to Die

Associations Between Predictors

As displayed in Figure 2A, perceived burdensomeness, negative affect, and suicidal ideation were all reciprocally related from 1 day to the next for patient who self-harmed ($n = 632$), with hopelessness also interconnected with negative affect and burdensomeness. Cross-sectionally, suicidal ideation had a notably strong correlation with perceived burdensomeness and negative affect, and an inverse association with wish to live, while positive affect was highly, inversely correlated with negative affect and thwarted belongingness (Figure 2B).

Centrality

The centrality metrics of variables within the network have been reported in Figure 3. Perceived burdensomeness and wish to live exhibited high centrality, suggesting they were short paths between other nodes and also had a strong direct influence on other variables. Further, negative affect exhibited high closeness, out-strength, and in-strength, as was exhibited by the reciprocal relationship with wish to die, burdensomeness, and suicidal ideation.

Comparisons With Patients Who Did Not Self-Harm

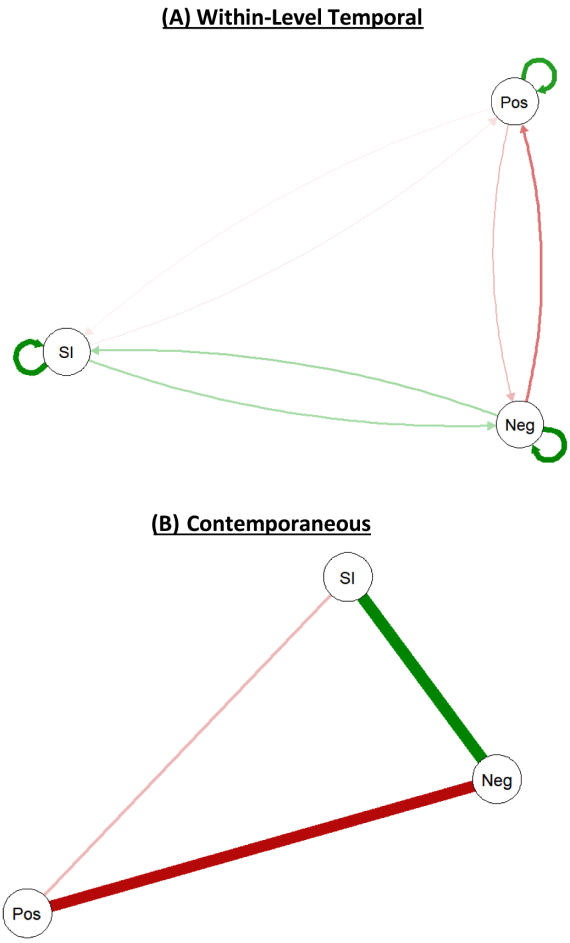
Centrality metrics for most variables were mostly comparable to patients who did not self-injure during their stay (Figure 3). Perceived burdensomeness had notably higher betweenness centrality and in-strength, suggesting it more often acted as a bridge between nodes among patients that self-injured and also was more directly affected by other variables within the network. This is evident with the statistically significant reciprocal relationships with suicidal ideation and wish to live. The out-strength of burdensomeness was comparably high in each network, suggesting perceived burdensomeness had a relatively large and direct effect on other variables within both networks. On the other hand, hopelessness and negative affect exhibited notably lower betweenness among patients who self-injured.

Discussion

The present study had two main aims designed to (a) evaluate how suicidal thoughts, interpersonal difficulties, and affective states are associated with same-day and next-day NSSI; and (b) identify which factors may be effective targets in treatment through network analysis and comparing these networks to those from patients who did not self-injure during their stay. With reference to Aim 1, increases in suicidal ideation and decreases in wish to live from typical or average levels were found to significantly predict same-day self-injury. These findings are consistent with prior recent research finding short-term changes in suicidal ideation

Figure 1

Time-Lagged and Cross-Sectional Daily Associations Between Independent Variables for Patients Who Engaged in NSSI



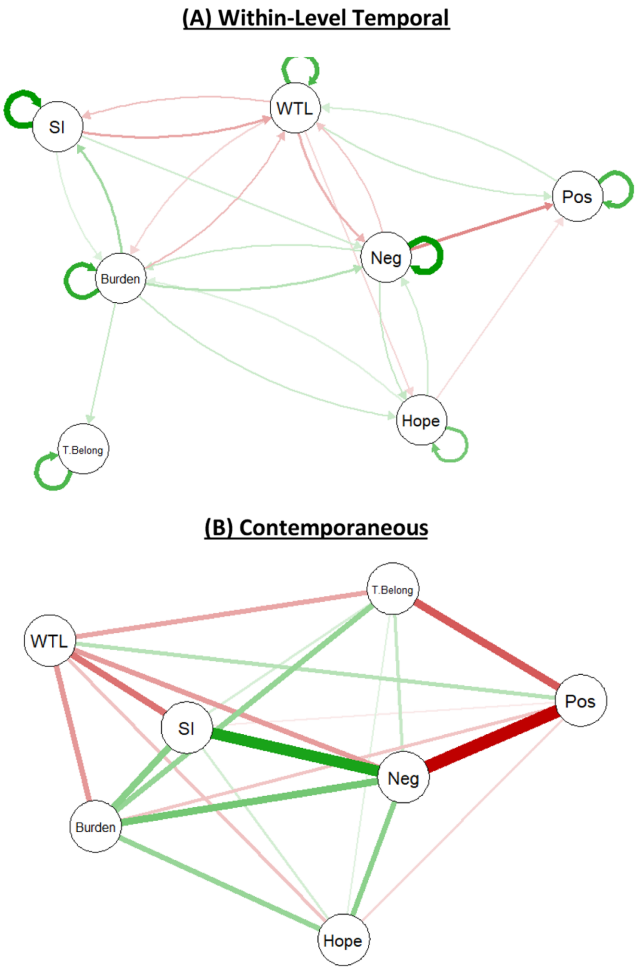
Note. (A) Within-level temporal relationships between self-report items for patients who engaged in NSSI only. Circled arrows represent autoregressive associations. Straight arrows indicate lagged associations between variables. (B) Contemporaneous associations between variables in NSSI network. Green arrows indicate positive associations, red arrows indicate inverse associations. SI = suicidal ideation; Neg = negative affect; Pos = positive affect; NSSI = nonsuicidal self-injury. All visible edges represent significant associations at $p < .05$. See the online article for the color version of this figure.

(Kyron et al., 2018) and wish to die (which is strongly linked to suicidal ideation and wish to live) are associated with NSSI (Kyron et al., 2021). Both suicidal ideation and NSSI may represent difficulties with emotion regulation, problem solving and the co-occurrence of a desire to escape from current aversive states (Muehlenkamp & Kerr, 2010). Alternatively, NSSI may ameliorate suicidal thoughts in the short term, or the failure of NSSI to remove distress may increase the likelihood of suicidal thoughts and behaviors. Wish to live may represent a distinct, but related state linked to suicidal ideation, and may therefore influence or be influenced by NSSI through similar mechanisms.

Positive affect was also found to be associated with next-day NSSI. This is consistent with findings from recent research that positive affect was inversely associated with NSSI behaviors, suggesting drops in positive affect may signal short-term risk or the presence of positive affect may act as a protective factor (Kiekens et al., 2020). That is, NSSI may not arise simply due to the presence of negative affect and a desire to avoid these affective states (Chapman et al., 2006; Klonsky, 2007a). Among positive affect items, feeling cheerful, fresh and rested, calm and relaxed, and being interested in daily activities all exhibited short-term associations with NSSI. This is in part consistent with findings from Kiekens et al. (2020), who found feeling relaxed was associated with lower probability of NSSI. The present study expands on these findings by suggesting a broader spectrum of

Figure 2

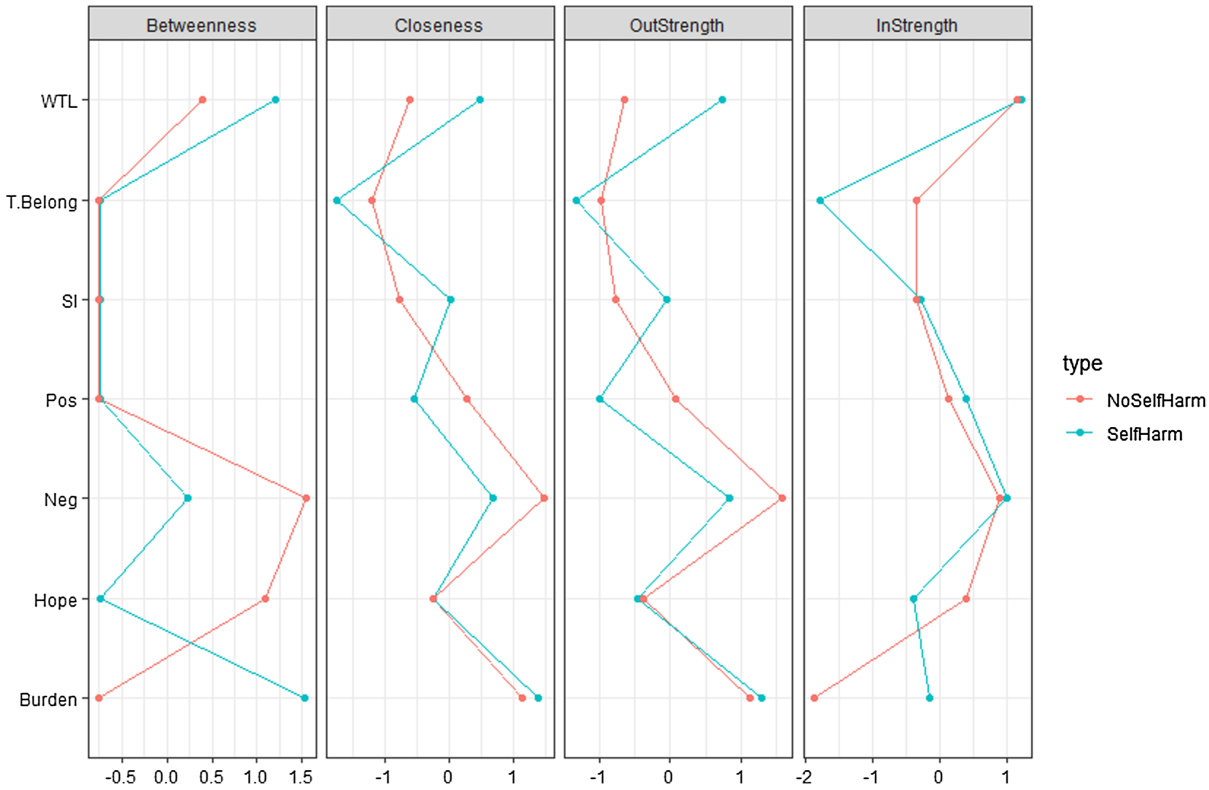
Time-Lagged and Cross-Sectional Daily Associations Between Independent Variables for Patients Who Engaged in NSSI, Including Interpersonal Factors, Hopelessness, and Wish to Live



Note. (A) Within-level temporal relationships between self-report items for patients who engaged in NSSI only. Circled arrows represent autoregressive associations. Straight arrows indicate lagged associations between variables. (B) Contemporaneous associations between variables in NSSI network. Green arrows indicate positive associations, red arrows indicate inverse associations. T.Belong = thwarted belongingness; SI = suicidal ideation; Hope = hopelessness; Neg = negative affect; Pos = positive affect; WTL = wish to live; NSSI = nonsuicidal self-injury. All visible edges represent significant associations at $p < .05$. See the online article for the color version of this figure.

Figure 3

Centrality Metrics for Temporal Models With Interpersonal Factors, Hopelessness, and Wish to Live Included



Note. Betweenness centrality represents the number of times a node is a bridge between other nodes; Closeness represents the speed in which a node spreads information; Out strength represents the direct effect on other nodes; In strength represents the extent to which a node is affected by other nodes. WTL = wish to live; Pos = positive affect; Neg = negative affect; SI = suicidal ideation; Hope = hopelessness; burden = perceived burdensomeness; T.Belong = thwarted belonging. See the online article for the color version of this figure.

positive emotional states may be associated with NSSI, although the differences in time between assessments in both studies (i.e., hours vs. days) does not allow for direct comparisons. The use of global 24-hr assessments also precludes the assessment of more fine-grained temporal effects, such as differences in associations based on self-report on the previous day or night. It is also important to note that when removing suicidal ideation from models the association between negative affect and NSSI became statistically significant, suggesting much of this variance was accounted for by increases in ideation. That is, increases in negative affect may simultaneously be associated with increases in suicidal ideation and probability of NSSI. Among negative affect items, feelings of depression and not coping emerged as particularly salient predictors of NSSI.

Network analyses provide an indication of factors that could be targeted to generate efficient change among a wider range of symptoms or antecedents of mental health problems. Perceived burdensomeness was found to be a highly central variable in the network among patients who self-injured, as it directly influenced affect, suicidal ideation, and wish to live, and also acted as a path between variables. While caution should be used when interpreting network models (e.g., highly central variables may simply be a consequence of symptom activation; see Fried et al., 2018), the multilevel temporal nature of the analyses provides more of an indication regarding directionality. Further, particular central variables may not be readily targetable (e.g., targeting insomnia may not be less efficient if the causes of insomnia are not targeted). Perceived burdensomeness represents a specific, often distorted set of cognitions (i.e., self-hate, liability) that could be targeted during psychotherapy (see Joiner et al., 2009). This does not discount the finding that burdensomeness was reciprocally related to other variables in the network, suggesting negative states may exacerbate perceptions of burden in the short-term. Interrupting these feedback loops in the most efficient manner possible becomes critical, and targeting burdensomeness may be one of several avenues. Further research using different samples and through controlled research designs is needed to support findings in the present study.

The centrality of variables within networks of patients who did or did not engage in self-injury throughout their stay exhibited some important differences. Specifically, perceived burdensomeness was more centrally connected among patients who self-injured when compared with patients who did not. This may suggest that individuals who self-injure are more susceptible to feelings of burdensomeness, with a number of positive feedback loops between ideation, wish to live, and affect. For example, negative affect and perceived burdensomeness significantly predicted each other

from 1 day to the next, suggesting negative states may perpetuate over time unless interrupted.

Findings from the present study speak to the importance of routinely monitoring the thoughts and feelings of inpatients to prevent adverse events during inpatient visits. A person-centered approach allows for identification of when particular risk and protective factors deviate from typical levels for a particular individual. When data are received on a daily basis, this information can be used to identify individuals at-risk of NSSI, and also provide targets that can be integrated into therapy (Joiner et al., 2009). Predictive models based on routinely collected patient data may also aid timely decision making in clinical settings which are often limited by available resources. This may include identifying patients with sudden drops in positive affect, or the presence of heightened perceived burdensomeness that may have knock-on effects with other symptoms of mental health problems. Incorrect treatment of at-risk patients can have significant costs, including those required to attend to patients (i.e., addressing wounds, increased observation, updating incident registers) and potential litigation. However, research is needed to evaluate the real-time utility of such predictive systems as it is largely unknown whether they would lead to adequate prevention of self-injury.

Limitations and Directions for Future Research

The present study has several important limitations that provide pathways for future research. Most notably, assessment of positive affect included self-report sleep quality or feeling of fresh and rested as an item. There has been some incongruence between self-reported sleep quality and objective measurement from actigraphy devices (Zinkhan et al., 2014). Sleep quality has emerged as a potentially important, modifiable, and interconnected correlate of NSSI that may contribute to short-term prediction (Littlewood et al., 2019). Future studies may therefore benefit from objective measurement to accurately identify sleep quality. Secondly, the sample was predominantly female, which likely reflects the relatively higher proportion of females with mood disorders and hence the numbers referred to the hospital for therapy. Further, information regarding the race of patients, and detailed socioeconomic information was not made available to the current research team, and the extent to which this sample is representative of broader settings is unclear. While supplementary analyses indicated that there were no notable differences between males and females in terms of the severity of incidents based on incident outcome (i.e., minor intervention, enhanced observation), other information, such as the method of self-injury, was not made available to researchers. In addition, developmental variability may not have been captured by pooling all age groups into a single sample, although this was done to maximize available power in the present study, and identify factors which may generally be associated with NSSI among all patients at the hospital. Future studies should look to conduct analyses separately by age and other demographic factors to identify any potential differences in predictors. Third, nurse reports were used to capture NSSI and may have resulted in underreporting if patients intentionally concealed injuries from staff. Within a clinical setting, the NSSI events identified in the present study represent more severe incidents that often require nurse interventions that occupy limited clinical resources. Further, there is the possibility that NSSI events may have been coded incorrectly or inconsistently over time. That is, some nurses may have perceived suicidal intent when this was not the case, or vice versa. However, all nurses received training on potential signs of suicidal intent (with this training not differing greatly over time), completed a standardized daily risk assessment form daily with patients to guide interpretation of intent, and were often cross-checked by psychiatrists and other nurses during patient handover. Further, the average year of admission was comparable between the control and NSSI sample. Given the low prevalence of suicidal behaviors within the hospital (and also in the wider community), it is not expected that this would greatly impact regression results in the present study if incorrectly coded as self-injury. Fourth, clinical staff may have prevented future incidents from occurring, such as through increased observations or removal of sharp devices. Thus, despite heightened risk factors, an individual may be less able to engage in self-injury in a manner typically used. This may have reduced effect sizes presented in the present study. Fifth, close to 40% of variance was explained by all predictors in the MSEM and DSEM models, suggesting other unmeasured or unmeasurable variables (e.g., removal of sharp devices by clinical staff, increased observations) may have an effect on probability of self-injurious behaviors occurring on a given day. Sixth, the findings from the present study should be interpreted within an inpatient context, and may not necessarily reflect circumstances in an outpatient context. That is, the dynamics of risk factors (e.g., burdensomeness) may be different within a home environment, such as more volatility or intensity. On the other hand, over a 24-hr period in an inpatient context, individuals may not exhibit the same patterns, although patients still were allowed visits from family/friends and interact daily with other patients. While the associations in the present study may have been attenuated to a degree due to the low daily frequency of NSSI in this inpatient context, it provides a controlled environment whereby participation rates could be maximized and reduce self-selection bias. Similar research should be conducted with other noninpatient samples to confirm these findings.

Conclusion

The present study explored the temporal associations between a range of risk and protective factors for NSSI in a clinical sample. Fluctuations in suicide ideation, positive affect, and wish to live may signal risk of next-day NSSI. The high connectedness of perceived burdensomeness in NSSI networks suggests it may also be an effective target during therapy to reduce symptoms of poor mental health. Dynamic approaches to predicting self-injury in a daily manner may benefit from capturing these risk and protective factors and also provide routine feedback to clinicians regarding the cognitive–affective states of patients.

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