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A controlled examination of acute warning signs for suicide attempts among hospitalized patients

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Abstract

Background. Near-term risk factors for suicidal behavior, referred to as 'warning signs' (WS), distinguish periods of acute heightened risk from periods of lower risk within an individual. No prior published study has examined, using a controlled study design, a broad set of hypothesized WS for suicide attempt. This study addressed this gap through examination of hypothesized behavioral/experiential, cognitive, and affective WS among patients recently hospitalized following a suicide attempt.

Methods. Participants were recruited during hospitalization from five medical centers across the USA including two civilian hospitals and three Veterans Health Administration facilities ($n = 349$). A within-person case-crossover study design was used, where each patient served as her/his own control. WS were measured by the Timeline Follow-back for Suicide Attempts Interview and were operationalized as factors that were present (*v.* absent) or that increased in frequency/intensity within an individual during the 6 h preceding the suicide attempt (case period) compared to the corresponding 6 h on the day before (control period).

Results. Select WS were associated with near-term risk for suicide attempt including suicide-related communications, preparing personal affairs, drinking alcohol, experiencing a negative interpersonal event, and increases in key affective (e.g. emptiness) and cognitive (e.g. burdensomeness) responses.

Conclusions. The identification of WS for suicidal behavior can enhance risk recognition efforts by medical providers, patients, their families, and other stakeholders that can serve to inform acute risk management decisions.

Introduction

Each year, there are more than 800 000 suicide deaths worldwide, with suicide representing the second leading cause of death among 15–29 years old and the leading cause of violent death among women (World Health Organization, 2014). Accordingly, the study and prevention of suicide is of critical public health importance. The ability to predict risk for suicide in the near term – that is, to identify warning signs (WS) for acute risk for suicide (Rudd et al., 2006) – is a goal that has preoccupied researchers, clinicians, and other stakeholders in the area of suicide prevention for decades. Whereas longer-term risk factors for suicide have been intensively studied (Franklin et al., 2017), there has been little systematic research of WS. Such research is needed to advance public education and awareness, potentially increasing identification and timely response to those needing swift intervention, as well as to inform clinical assessment, treatment planning, and decision-making regarding the immediate safety of patients.

In 2003, a panel of suicide prevention experts convened to identify a consensus-based list of WS for suicide which they defined as a '…detectable sign that indicates heightened risk for suicide in the near-term (i.e. within minutes, hours, or days; Rudd et al., 2006, p. 258)'. They based their discussion and conclusions on available information including clinical experience, postmortem investigations, case reports, descriptive studies, and studies of risk factors identified within one year of suicide (Rudd et al., 2006). The consensus list of WS included

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overt expression of heightened suicidality (e.g. suicidal communication) and proximal changes in other behavior (e.g. increasing substance use), affect (e.g. anger), and cognitions (e.g. hopelessness). The panel's conclusions have been widely cited in the scientific literature and broadly disseminated to the public, particularly in the USA, including through websites, information cards (Substance Abuse and Mental Health Services Administrations, 2019), trainings, and clinical practice guidelines (Assessment and Management of Risk for Suicide Working Group [AMR-SWG], 2019).

Given limitations of existing research, the expert panel considered their list of WS preliminary and called for systematic research on the topic. One potential approach to such research is through case-control postmortem studies, commonly referred to as psychological autopsy studies, that examine events, stressors, and symptoms that preceded death by suicide (Conner et al., 2012). Unfortunately, the precision of information in psychological autopsy studies is constrained by the reliance on proxy information and, with rare exception, few such studies have used controlled analyses that focused on the short periods of time (e.g. 6 or 24 h) that are required for the investigation of acute risk or WS. None have examined a broad list of WS (Conner et al., 2012). Although future psychological autopsy studies may be designed with a greater focus on WS, because of the inherent limitations of this study design, it cannot be relied on to explicate WS.

Breakthroughs in the explication of WS are more likely to come from the study of non-lethal suicide attempts which make it possible to elicit information about the minutes and hours preceding an act of suicide directly from the individuals who carried them out. In this effort, we studied WS for suicide attempts using a within-subject design, case-crossover methodology (Maclure, 1991). This design can aid in answering a critical question for treatment providers: *Why today*? Why did a specific individual attempt suicide *today* compared to a previous day, close in proximity, when he/she did not attempt suicide? Using case-crossover methodology, evidence of a WS for suicide attempt can be demonstrated by studies that include the following components: (1) a controlled within-subject design where individuals are compared to themselves, (2) evaluation of a factor (e.g. a behavior, affect, or cognition) that can vary from hour-to-hour or day-to-day, and (3) comparison of a specific period ('case period') *proximal* to a suicide attempt (e.g. the 6 h prior to a suicide attempt) compared to a 'control period' (e.g. a corresponding 6 h period on the *day prior* to the attempt). Ideally, if a factor is to be considered a WS, it should occur more frequently (or more intensely) during the case period than the control period. Using this design, several studies with a focus on a narrow range of variables have identified select WS including acute negative interpersonal life events (Bagge, Glenn, & Lee, 2013), intensive use of alcohol (Bagge & Borges, 2017), and increased intensity of affective response such as hostility (Bagge, Littlefield, & Glenn, 2017). An *uncontrolled* study provided an examination of a broad range of WS within 24 h of an attempt including most of those on the aforementioned expert panel's list (Bryan & Rudd, 2012). However, there have been no controlled studies of a broad list of potential WS for suicide attempt.

The empirical basis for risk factors for suicide attempts is based overwhelmingly on research studies of periods that are too long (e.g. 3 months) (Hendin, Al Jurdi, Houck, Hughes, & Turner, 2010) for the purpose of explicating WS. As an illustration of the importance of the examination of acute periods in the study of WS, in an Austrian case series study, nearly half (47.6%) of 82 adult suicide attempt patients (admitted to an inpatient psychiatry unit and interviewed within 3 days of the attempt) reported a period of 10 min or less between the 'first current thought' of the attempt and its execution (Deisenhammer et al., 2009). Although the study was limited by the uncontrolled design, its results underscore the dynamic nature of suicidal behavior and the need for briefer and proximate observation windows for the identification of WS.

The purpose of the current study was to analyze a broad list of WS proposed by the expert panel (Rudd et al., 2006), along with several additional WS that were chosen based on the Interpersonal Psychological Theory of Suicide (Joiner, 2007; Van Orden et al., 2010) and prior controlled studies of WS (e.g. Bagge & Borges, 2017; Bagge et al., 2013a, 2017). Our aims were: (1) to identify WS for attempts across behavioral/event, affective, and cognitive domains, and (2) to determine the extent to which a select set of WS can correctly classify the timing of a suicide attempt. We examined these objectives among inpatients hospitalized shortly after a suicide attempt, a high-risk population for repeat suicide attempts and suicide death (Carroll, Metcalfe, & Gunnell, 2014). Recruitment from civilian hospitals and Veterans Health Administration (VHA) facilities allowed for exploratory comparisons of WS in non-veterans and veterans. Because veterans have higher rates of suicide and are more likely than non-veterans to use firearms in suicide, the most lethal form of self-harm, the exploration of WS in veterans may inform targeted prevention efforts for this high-risk population (Department of Veterans Affairs [VA], 2018). We also explored sex differences in WS given marked differences in rates of suicide (males higher) and suicide attempt (females higher), along with some sex differences in risk factors for these outcomes (World Health Organization, 2014). These comparisons were exploratory because we are aware of no published data on differences in WS based on sex or veteran status using *a priori* controlled within-subject designs.

Method

Recruitment and procedures

Participants were recruited between June 2014 and August 2016 during hospitalization following a suicide attempt from five US medical centers including two civilian hospitals (Jackson, MS; Rochester, NY) and three VHA facilities (San Diego, CA; Seattle, WA; Little Rock, AR). Inclusion criteria included age 18-plus, admission to hospital within 48 h of a suicide attempt, and the subject's acknowledgement of some (non-zero) intent to die (Silverman, Berman, Sanddal, O'Carroll, & Joiner, 2007). Exclusion criteria were severe acute medical, psychiatric (e.g. hallucinations), or cognitive impairment that precluded providing informed consent and being able to participate.

In coordination with local clinical providers, participants were screened by a member of the study team, followed by completion of an informed consent procedure. Those eligible for participation included 474 patients, among whom 410 (86.5%) consented to participate (see online Supplementary Fig. S1). Next, participants were asked to complete a 2.5 h study assessment in a private location (e.g. patient's hospital room).

The study was approved by the human subjects review boards of the participating institutions and the US Army Medical Research and Materiel Command, Office of Research Protections, and Human Research Protection Office. The authors

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assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. We also obtained a Federal Certificate of Confidentiality. Participants were paid $45 for their participation.

Participants

The current study includes data from 349 participants (256 from civilian and 93 from VHA centers) who completed the interview (85% of those who were consented). The final sample comprised 53% females, mean age was 38.12 years (S.D. = 13.92; range = 18–81), and the ethnic/racial composition was 65% White, 28% Black, and 7% Other Race.

Measures

The Timeline Follow-back Interview for Suicide Attempts (TLFB-SA)

The TLFB-SA (Bagge et al., 2013a, 2013b, 2017) incorporates TLFB methodology originally developed for research on alcohol consumption (Sobell & Sobell, 1992) and focuses on precursors of suicide attempts. The TLFB-SA was used to gather retrospective information on behaviors and events, affective responses, and cognitions during the 48 h prior to the suicide attempt. First, basic information was gathered (e.g. hourly activities, location, periods of sleep) to serve as anchors for recall over this period. Second, participants were presented with stimuli (detailed lists) to assess whether certain events/behaviors occurred. Negative life events (NLE; Bagge et al., 2013a) included the experience of *Interpersonal NLE* (e.g. relationship breakup); *Work NLE* (e.g. fired); *Legal NLE* (e.g. charged with a law violation); and *Financial NLE* (e.g. evicted). Other negative events included having a *Flashback* or *Nightmare* (Bryan & Rudd, 2012). Substance use (Bagge et al., 2013) covered *Alcohol* (e.g. a standard drink) and other types of drug use such as *Marijuana*. *Reckless/Risky Behaviors* encompassed experiencing other risky behaviors (e.g. unsafe sex, stealing, driving recklessly, and impulsively spending money above what could afford; Rossotto, Yager, & Rorty, 1998). *Suicide-Related Communication* [telling someone that they were going to kill themselves, or talking/writing generally about death/dying/suicide (but not specifying their intention)] and *Preparation of Personal Affairs* for after death by suicide (e.g. writing a will) represented overt expressions of suicidal actions (Rudd et al., 2006). In reviewing these lists, subjects were asked whether they experienced any of these events or behaviors during this time period. Third, information on the exact *timing* (i.e. start- and stop-time) of all behaviors/events was collected.

Fourth, interviewers read the hour-by-hour description of the location, activities, and events/behaviors engaged in (specified by the participant) for the 6 h prior to the attempt and then the matched 6 h the day before. Participants were asked to rate the intensity (from 0 = not at all to 5 = extremely) of their affective states and cognitions. Affective responses included *Scared*, *Hostile*, *Alone*, and *Dissatisfied with Self* (from the PANAS-X; Watson & Clark, 1991), as well as *Emptiness* (Pfohl, Blum, & Zimmerman, 1994) and *Agitated* (feel a lot of emotional turmoil in my gut; Ribeiro, Bender, Shelby, Hames, & Joiner, 2011). In terms of cognitions, *Hopelessness* (the future is hopeless), *Trapped* (trapped and no way out), *No Reasons for Living* (have no reason to live) (Rudd et al., 2006), as well as thinking about *Failure* (failure or inferior), *Physical Abuse* (physical abuse or assault), *Sexual Abuse* (sexual abuse or rape), and *Combat* (think about combat) (Bryan & Rudd, 2012; Linehan, Comtois, Brown, Heard, & Wagner, 2006) were assessed. Based on the Interpersonal Theory of Suicide, *Burdensomeness* (the people in my life would be happier without me) and *Lack of Belonging* (I do not belong; Van Orden, 2009) were also included.

Reliability estimates by a trained rater were excellent for the presence/absence of behaviors and events (κ 0.79–1.00) and intensity of affective and cognitive responses (intra-class correlations: 0.89–1.00).

Sample characteristics

The study also included measures to describe the characteristics of the current sample that do not vary hour-by-hour (see online Text Supplement).

Design and approach

The within-subjects case-crossover design (Maclure, 1991) was used to examine near-term risk factors for attempts. Each participant served as his/her own control, providing a conservative, controlled examination of time-varying and unique predictors of suicide attempts (Bagge et al., 2013a). More specifically, WS variables were created to denote the presence/absence of each type of behavior/event, and the maximum value for each affect and cognition, for (1) the 6 h prior to the suicide attempt (case-time) and (2) the corresponding 6 h the day before the suicide attempt (control-time). Precedent for the use of a 6 h time frame was established in prior examinations of alcohol consumption, other drug use, negative life events (Bagge et al., 2013b), and affective responses (Bagge et al., 2017) preceding suicide attempt. Further, research shows that WS specific to thinking/preparing for suicide (e.g. mulling over whether to attempt, thinking about a suicide method, about the place of suicide) occur within 6 h prior to the attempt (e.g. Millner, Lee, & Nock, 2017).

Conditional logistic regression analyses (Jones & Kenward, 2014) analyzed matched pairs to determine the risk of the attempt. First, univariate conditional logistic regression analyses were used to estimate the near-term risk for (1) behavioral/event, (2) affective, and (3) cognitive WS categories for an attempt. Statistically significant variables from the univariate models were retained and included in a multivariable conditional logistic regression within each WS category. WS that remained statistically significant within the multivariable models of each WS category were included all together in a final multivariable conditional logistic model. In this final model, interactions between both sex and veteran status with the retained WS were tested to determine if the strength of the WS association significantly differed across these groups. To control for false discovery rate, we used the Benjamini and Hochberg (1995) procedure (Glickman, Rao, & Schultz, 2014) which uses adjusted *thresholds* for statistical significance (starting with the nominal $p < 0.05$) for each inferential test as a function of the number of tests per a set of analyses and p value rank. This approach determines the adjusted p value *thresholds* with $d \times (i/n)$ for each original p value, where $d = 0.05$ (the false discovery rate), $i = p$ value rank (where the lowest observed p value would have a rank of 1), and n = number of tests. For example, if five tests were conducted, the adjusted p value *thresholds* would be 0.01, 0.02, 0.03, 0.04, 0.05 and the five observed p values would then have to be less than the

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adjusted thresholds to be considered statistically significant, with 0.01 being the threshold for the lowest observed p value (i.e. p value rank = 1; $0.05 \times 1/5 = 0.01$), and a threshold of 0.05 for the highest observed p value (i.e. p value rank = 5; $0.05 \times 5/5 = 0.05$). This was applied to each set of analyses [e.g. 16 observed p values (11 univariate and five multivariable estimates) for the behaviors/events category].

To determine the ability of these WS to accurately classify the case period (attempt day) from the control period (non-attempt day), a generalized linear mixed model that included variables from the final multivariable conditional logistic model was estimated. Output from this model was used to produce a graph of the associated receiver operating characteristic (ROC) curve and this curve's area under the curve (AUC) following procedures outlined for ROC analysis for binary responses in mixed models. Interactions between both sex and veteran status with the retained WS were tested to determine if AUCs significantly differed across these groups. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) metrics were chosen at the threshold that maximizes Youden's J statistic (i.e. sensitivity + specificity−1). Analyses were performed in SAS 9.2.

Results

General descriptive information

As shown in online Supplementary Table S1, prior to this hospitalization 65% of participants had a history of a suicide attempt. Past year treatment experiences included the following: psychiatric hospitalization (35%); outpatient psychological counseling (46%); and psychotropic medication use (71%). On average, participants had moderately severe depressive symptoms ($M = 17.95$; S.D. = 6.36) and 36% had problematic alcohol use. The most common suicide attempt methods in the index events included overdose (77%), sharp instrument (18%), and hanging (5%), and 88% of participants used only one type of method. The index attempt was not more likely to occur on a given day of the week ($\chi^2 = 9.32$, df = 6, $p = 0.16$), but was more likely to occur during certain blocks of time ($\chi^2 = 61.03$, df = 3, $p < 0.0001$). Attempts were less likely to occur overnight (0:00–5:59 h; 14%) and in the morning (6:00–11:59 h; 15%) compared to the afternoon (12:00–17:59 h; 34%) and the evening (18:00–23:59 h; 37%). Participants were interviewed within days of their attempt ($M = 3.72$ days; S.D. = 3.22).

Conditional logistic regression analyses

Of the 11 behaviors and events (see Table 1), suicide-related communications, preparation of personal affairs, alcohol use, engaging in reckless/risky behaviors, and experiencing an interpersonal NLE were all statistically significant WS of an attempt. All univariate WS remained statistically significant in the multivariable model, except for reckless/risky behaviors.

As shown in Table 2, all six affective responses were significant WS within the univariate models. When these were included in the same model, emptiness, hostile, and scared remained statistically significant. Nine cognitions (see Table 3) were examined as WS of attempt. Of these cognitions, physical abuse, lack of belonging, burdensomeness, hopelessness, no reasons for living, thoughts of failure, and being trapped were significant in univariate models. However, when the statistically significant cognitive WS were included in the same model, only burdensomeness and no reason to live remained statistically significant.

For the full model (see Table 4), the nine variables that remained statistically significant within the multivariable models were included. All nine variables remained statistically significant in this model. Notably, for all analyses (Tables 1–4), significant original p values were lower than adjusted p value thresholds. Thus, results did not change based on adjusted thresholds. Additionally, we tested whether the parameters differed as a function of sex and veteran status. Of the 18 tested interactions, only one ('scared' by sex) was statistically significant (observed interaction p value = 0.0245). However, this interaction did not meet the adjusted p value threshold (0.0028). The nine variables included within the full model had an AUC of 80% (point estimate = 0.80; 95% CI 0.77–0.83; see Fig. 1) in determining an acute risk period (day of attempt) from the control period (day of a non-attempt). At the probability threshold of 52%, sensitivity = 0.69, specificity = 0.77, PPV = 0.74, and NPV = 0.71. Follow-up tests showed the AUCs did not significantly differ by sex or veteran status.

Discussion

The current study extends prior research involving brief lists of WS examined at a single site (Bagge & Borges, 2017; Bagge et al., 2013a, 2013b; Bagge et al., 2017) through the inclusion of a broad list of hypothesized WS within a large, multisite geographically-diverse sample. The case-crossover study methodology used is an advance compared to other research on WS that used uncontrolled designs (e.g. prevalence rates of factors near an attempt; Bryan & Rudd, 2012) or prospective studies of risk factors for suicidal behavior that were limited by longer observational periods (Franklin et al., 2017). Although rigorous studies using real-time monitoring techniques have shown associations between near-term changes in select hypothesized WS and suicidal thoughts (Kleiman et al., 2017; Nock, Prinstein, & Sterba, 2009), to our knowledge, these studies have not provided estimates of near-term associations with suicide attempts.

Current results are consistent with previous controlled studies of specific WS, such as those demonstrating that near-term risk for attempt is associated with negative interpersonal life events (Bagge et al., 2013a) and increased intensity of affective response (i.e. hostility, feeling scared) (Bagge et al., 2017), along with robust evidence that suicidal behavior is associated with intensive, acute use of alcohol (Bagge et al., 2013b; Bagge & Borges, 2017; Borges et al., 2017). Several novel results also emerged. Most notably, 'any preparation of personal affairs' was associated with very high proximal risk, OR = 36.24, $p = 0.0019$, 10-fold higher risk compared to the point estimates of other WS examined herein. Examples of preparation of personal affairs included paying off bills or giving away possessions, writing/revising a will, and arranging for others to take care of loved ones/affairs (all purposefully done for the preparation of the aftermath of one's suicide). This result is interpreted with caution given the large confidence intervals. Nonetheless, it suggests this variable is associated with markedly higher risk for suicide attempt compared to other WS and has important implications for clinical practice, including whether to recommend higher levels of care to protect an individual's safety. Note that only 10% of the participants made such preparation proximally to their attempt, indicating that it would be inappropriate to rely on this WS solely in making risk determinations. Our results concerning suicide-related communication as a near-term risk factor for suicide attempts reinforce expert recommendations that expressions of thoughts concerning death/dying/

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Table 1. TLFB-SA behaviors and events: 6 h blocks

	Case	Control	Univariate				Multivariable[a]			
Variables[b]	*N* (%)	*N* (%)	OR	95% CI	Observed *p* value	Adj. *p* value threshold to determine significance	OR	95% CI	Observed *p* value	Adj. *p* value threshold to determine significance
Suicide-related communications	94 (26.9%)	22 (6.3%)	7.00	3.82–12.82	<0.0001	<0.0031	6.81	3.41–13.60	<0.0001	<0.0125
Preparation of personal affairs	35 (10.0%)	4 (1.2%)	32.00	4.37–234.18	0.0006	<0.0219	28.1	3.55–222.81	0.0016	<0.0250
Alcohol	86 (24.6%)	40 (11.5%)	5.18	2.72–9.88	<0.0001	<0.0063	4.50	2.18–9.28	<0.0001	<0.0156
Marijuana	19 (5.4%)	22 (6.3%)	0.79	0.36–1.73	0.5556	<0.0500				
Reckless/risky behavior	60 (17.2%)	39 (11.2%)	1.91	1.16–3.17	0.0123	<0.0281	1.37	0.72–2.62	0.3413	<0.0469
Nightmare	16 (4.6%)	11 (3.2%)	2.00	0.68–5.85	0.2056	<0.0438				
Flashback	40 (11.5%)	31 (8.9%)	1.56	0.83–2.93	0.1667	<0.0344				
Interpersonal NLE	136 (39.0%)	52 (14.9%)	4.50	2.89–7.00	<0.0001	<0.0094	3.60	2.16–6.02	<0.0001	<0.0188
Work NLE	10 (2.9%)	5 (1.4%)	2.25	0.69–7.31	0.1774	<0.0375				
Legal NLE	6 (1.7%)	2 (0.6%)	3.00	0.61–14.86	0.1784	<0.0406				
Financial NLE	13 (3.7%)	6 (1.7%)	2.17	0.82–5.70	0.1159	<0.0313				

TLFB-SA, Timeline Follow-back for Suicide Attempts Interview; NLE, negative life event; 6 h blocks, case period of 6 h before the attempt and control period of the matched 6 h the day before ; Univariate, only one variable is included in the model; Multivariable, multiple variables are simultaneously included in the model. All variables were coded for the presence of any behaviors during the case *and*. control period. Adj., adjusted threshold. Given ties for the lowest observed *p* values (i.e. the six lowest observed *p* values were all $p < 0.0001$) and that all of these *p* values were below the most stringent adjusted threshold (i.e. $p < 0.0031$), the six adjusted *p* value thresholds to determine significance were assigned by the order these variables appeared in the table. All original *p* values and adjusted *p* value thresholds were rounded to four decimal places.

[a]The multivariable model included all significant variables from the univariate models.

[b]$N = 349$ for all analyses.

Table 2. TLFB-SA affective responses: 6 h blocks

	Case	Control	Univariate				Multivariable[a]			
Variables[b]	*M* (s.d.)	*M* (s.d.)	OR	95% CI	Observed *p* value	Adj. *p* value threshold to determine significance	OR	95% CI	Observed *p* value	Adj. *p* value threshold to determine significance
Alone	4.34 (1.36)	3.50 (1.80)	2.85	2.09–3.88	<0.0001	<0.0042	1.29	0.90–1.85	0.1663	<0.0458
Dissatisfied with self	4.31 (1.31)	3.43 (1.74)	2.58	2.00–3.32	<0.0001	<0.0083	1.04	0.74–1.47	0.8242	<0.0500
Emptiness	4.20 (1.57)	3.45 (1.86)	2.53	1.90–3.35	<0.0001	<0.0125	1.54	1.07–2.22	0.0207	<0.0375
Agitated	4.25 (1.45)	3.37 (1.85)	2.58	1.98–3.36	<0.0001	<0.0167	1.30	0.95–1.76	0.0896	<0.0417
Hostile	3.08 (1.97)	1.78 (1.97)	2.08	1.74–2.49	<0.0001	<0.0208	1.47	1.20–1.81	0.0003	<0.0330
Scared	3.17 (1.92)	1.80 (1.92)	2.28	1.86–2.78	<0.0001	<0.0250	1.62	1.31–1.99	<0.0001	<0.0292

TLFB-SA, Timeline Follow-back for Suicide Attempts Interview; 6 h blocks, case period of 6 h before the attempt and control period of the matched 6 h occurring the day before . Affective responses range from 0 (not at all) to 5 (extremely); Univariate, only one variable is included in the model; Multivariable, multiple variables are simultaneously included in the model; Adj., adjusted threshold. Given ties for the lowest observed *p* values (i.e. the seven lowest observed *p* values were all $p < 0.0001$) and that all of these *p* values were below the most stringent adjusted threshold (i.e. $p < 0.0042$), the seven adjusted *p* value thresholds to determine significance were assigned by the order these variables appeared in the table. All original *p* values and adjusted *p* value thresholds were rounded to four decimal places.

[a]The multivariable model included all significant variables from the univariate models.

[b]$N = 349$ for all analyses.

Table 3. TLFB-SA cognitive responses: 6 h blocks

	Case	Control	Univariate				Multivariable[a]			
Variables[b]	*M* (s.d.)	*M* (s.d.)	OR	95% CI	Observed *p* value	Adj. *p* value threshold to determine significance	OR	95% CI	Observed *p* value	Adj. *p* value threshold to determine significance
Physical abuse	1.42 (2.08)	1.13 (1.83)	1.34	1.13–1.58	0.0005	<0.0250	1.03	0.84–1.27	0.7821	<0.0500
Sexual abuse	0.98 (1.86)	0.90 (1.73)	1.12	0.94–1.34	0.2155	<0.0343				
Combat	0.28 (1.08)	0.27 (1.00)	1.14	0.69–1.88	0.6079	<0.0406				
Lack of belonging	4.15 (1.52)	3.41 (1.84)	3.10	2.20–4.37	<0.0001	<0.0031	1.38	0.90–2.12	0.1415	<0.0313
Burdensomeness	3.81 (1.84)	3.04 (2.04)	2.74	2.02–3.72	<0.0001	<0.0063	1.68	1.18–2.41	0.0048	<0.0281
Hopelessness	4.19 (1.41)	3.47 (1.79)	2.02	1.63–2.49	<0.0001	<0.0094	1.06	0.77–1.45	0.7155	<0.0469
No reasons for living	4.23 (1.47)	3.23 (1.96)	3.14	2.27–4.36	<0.0001	<0.0125	2.29	1.55–3.38	<0.0001	<0.0219
Failure	4.22 (1.48)	3.53 (1.81)	2.51	1.87–3.37	<0.0001	<0.0156	1.22	0.85–1.75	0.2800	<0.0375
Trapped	4.06 (1.70)	3.43 (1.90)	2.17	1.69–2.78	<0.0001	<0.0188	0.91	0.64–1.31	0.6119	<0.0438

TLFB-SA, Timeline Follow-back for Suicide Attempts Interview; 6 h blocks, case period of 6 h before the attempt and control period of the matched 6 h occurring the day before . Cognitions range from 0 (not at all) to 5 (extremely); Univariate, only one variable is included in the model; Multivariable, multiple variables are simultaneously included in the model; Adj, adjusted threshold. Given ties for the lowest observed *p* values (i.e. the seven lowest observed *p* values were all $p < 0.0001$) and that all of these *p* values were below the most stringent adjusted threshold (i.e. $p < 0.0031$), the seven adjusted *p* value thresholds to determine significance were assigned by the order these variables appeared in the table. All original *p* values and adjusted *p* value thresholds were rounded to four decimal places.

[a]The multivariable model included all significant variables from the univariate models.

[b]$N = 349$ for all analyses.

Table 4. TLFB-SA full model: 6 h blocks behaviors/events, affective and cognitive responses

	Case	Control	Multivariable[a]			
Variables[b]	*N* (%) *M* (s.d.)	*N* (%) *M* (s.d.)	OR	95% CI	Observed *p* value	Adjusted *p* value threshold to determine significance
Any suicide-related communications	94 (26.9%)	22 (6.3%)	3.51	1.50–8.25	0.0040	<0.0167
Any preparation of personal affairs	35 (10.0%)	4 (1.20%)	36.24	3.78–347.61	0.0019	<0.0111
Any alcohol	86 (24.6%)	40 (11.5%)	2.95	1.26–6.92	0.0129	<0.0222
Any interpersonal NLE	136 (39.0%)	52 (14.9%)	2.19	1.14–4.22	0.0192	<0.0333
Emptiness	4.20 (1.57)	3.45 (1.86)	1.52	1.05–2.19	0.0246	<0.0444
Hostile	3.08 (1.97)	1.78 (1.97)	1.31	1.05–1.63	0.0155	<0.0278
Scared	3.17 (1.92)	1.80 (1.92)	1.60	1.26–2.03	0.0001	<0.0056
Burdensomeness	3.81 (1.84)	3.04 (2.04)	1.62	1.08–2.44	0.0210	<0.0389
No reasons for living	4.23 (1.47)	3.23 (1.96)	1.52	1.03–2.26	0.0386	<0.0500

TLFB-SA, Timeline Follow-back for Suicide Attempts Interview; 6 h blocks, case period of 6 h before the attempt and control period of the matched 6 h the day before . Affective and cognitive responses range from 0 (not at all) to 5 (extremely); Multivariable, multiple variables are simultaneously included in the model; Adj, adjusted threshold. In the case of ties of the observed *p* values, adjusted *p* value thresholds to determine significance were assigned by the order these variables appeared in the table, given order did not impact statistical inference. All observed *p* values and adjusted *p* value thresholds were rounded to four decimal places.
[a]The multivariable model shown here included all significant variables from the prior multivariable models.
[b]*N* = 349 for all analyses.

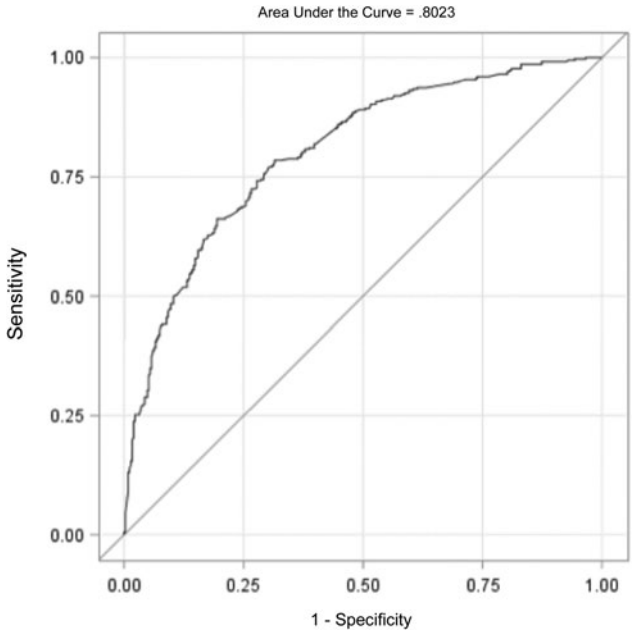

Fig. 1. Classification accuracy of imminent risk period (case period) as indexed by the receiver operating characteristic (ROC) curves and the area under the curve (AUC) for full warning signs model.

or suicide, suicidal plans, and intent warrant careful assessment (AMR-SWG, 2019).

Other WS identified using rigorous case-crossover methodology included emptiness, perception of being a burden, and perceiving no reason to live. Emptiness as a WS seems consistent with research on more distal risk factors for suicidal behavior, indicating that psychiatric disorders and traits characterized by emptiness (depression and borderline personality disorder) confer suicidal risk (American Psychiatric Association, 2013). Guided by the interpersonal-psychological theory of suicide (Joiner, 2007; Van Orden et al., 2010), we examined the perceptions of being a burden and thwarted belongingness. Results highlighted the importance of burdensomeness as a WS for suicide attempt. Perceptions of having no reason to live as a WS are consistent with theory and research concerning the importance of reasons for living in protecting against suicidal risk (Linehan, Goodstein, Nielsen, & Chiles, 1983). Results suggest that perceiving 'no reason to live' is a dynamic variable that is increased acutely prior to suicide attempt.

ROC curve analysis indicated an AUC of 0.80, suggesting that our final model provided an 80% accuracy of determining an acute risk period (day when a patient attempted) compared to a non-acute risk period (a day when a patient did not attempt suicide). For potential qualifiers in interpreting PPV/NPV, see online Text Supplement. There were not significant differences in accuracy as a function of sex and veteran status.

Including measurement of WS will likely enhance current risk assessment protocols and approaches to safety planning. Clinicians could conceivably monitor within-person changes in behavioral/event, affective, and cognitive WS through rapid assessment between sessions. Ideographic assessment approaches have been posited as a method to enhance clinical practice for a variety of psychological difficulties (Haynes, Mumma, & Pinson, 2009). Escalation of WS can be used by providers to devise a distress coping plan (Bagge & Borges, 2017) for their at-risk patients. Identification of a constellation of WS, and devising a plan for subsequently using coping strategies and resources, would help patients detect and manage distressing events or feelings before it escalates to a crisis. This information can be used by clinicians, families, and other stakeholders to recognize and intervene when a vulnerable individual has entered an acute risk state.

Limitations and future directions

The explication of WS was conducted retrospectively. Although the assessments occurred shortly following the index suicide

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attempt, nonetheless, recall biases may occur (Levine & Safer, 2002). We examined a broad list of WS, but the list was not exhaustive. We did not incorporate severity of depression symptoms, and instead assessed negative affective states (e.g. feeling alone) given that our focus was on factors that can change hourly within individuals. Future research may also consider incorporating potential transient and proximal protective factors. Many WS were based on single items and a single control period (6 h block the day prior to the attempt) was used for reference. We ruled out the use of additional control periods (e.g. occurring one week prior) to reduce participant burden (because they were already recreating the hours across a 48 h period) and given that the breadth of WS considered distinguished the current study from prior controlled research of WS. Notably, the chosen control period (day before the attempt) was viewed as the most conservative control period [i.e. a proximally close period when individuals were likely at-risk given traditional risk factors (the 'who') but an attempt did not occur].

The sample included adults hospitalized following a suicide attempt, with unclear generalizability to other populations including individuals who die by suicide. Because the study focused on the acute-risk period prior to hospital-treated suicide attempts, the data obtained most directly inform the understanding of acute risk for attempts that precede hospital presentation (see Bagge et al., 2017 for further discussion). Given the use of a within-subjects' design in a high-risk clinical sample, the WS may mark an acute amplification of enduring vulnerabilities, although more research on this question is needed.

Decades of research have identified risk factors for suicidal behavior that can inform the determination of *who* (which individuals) are at increased risk. The current study asked a different question. Specifically, it identified WS that signal *when* a high-risk individual is at acute risk, defined in our study as the 6 h before a suicide attempt, *v.* when such an individual is at lower acute risk, defined as the corresponding 6 h period the day before when he/she did not attempt suicide. Our results provide evidence of a constellation of behavioral/event, affective, and cognitive WS that can help clinicians answer the question of '*Why today*?' to inform the identification of high acute risk periods for suicidal behavior. Translation of the current results to clinical intervention or prevention will require development and evaluation. One potential direction is to use the results to refine the list of WS distributed by SAMHSA or other agencies. A second is to develop a novel WS-based (or WS-informed) intervention for future study, for example, one that uses the TLFB-SA as the foundation for an intervention to promote self-awareness of risk amplification and the development of a prevention plan when this occurs. A third is to inform modifications to scalable, evidence-based suicide risk screening and follow-up interventions that may be initiated in a hospital including emergency department settings, an example of which is ED-SAFE (Boudreaux et al., 2016). Replication of the novel findings of the current study will also be important, as will the development of ethically sound, prospective methods to study WS for suicide attempts. The practical obstacles (e.g. low incidence rate of suicide attempt, the short time windows required for the study of WS) and ethical considerations (e.g. gathering prospective data on WS may well require a plan to intervene in real time to prevent an attempt) pose challenges to mounting this type of research.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0033291721004712.

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Conflict of interest. None.

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