

ARTICLE

Predicting self-perceived risk of suicide: A Bayesian multilevel analysis of suicide status form constructs using ambulatory assessment

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Abstract

Introduction: The Collaborative Assessment of Suicidality (CAMS) is an effective clinical framework to treat suicidal thoughts and behaviours. CAMS employs the Suicide Status Form (SSF) to monitor suicide risk factors across sessions. The first six items (termed the SSF Core Assessment) include psychological pain, stress, agitation, hopelessness, self-hate and self-reported overall behavioural risk for suicide. The first five are theoretically derived risk factors. While CAMS employs session-by-session tracking, no research has investigated how the five risk factors vary together and concurrently and prospectively predict self-perceived suicide risk when assessed via ambulatory assessment.

Methods: Undergraduates ($n = 52$) with past-2-week suicidal ideation completed 5 ambulatory assessment surveys of the SSF Core Assessment variables daily over 10 days. Descriptive and variability statistics were used to describe the core assessment constructs. Multilevel models were used to examine how the first five items predicted overall behavioural risk of suicide.

Results: Each of the SSF Core Assessment variables demonstrated variability over the study period, with stress exhibiting the greatest and overall risk the lowest variability. Self-hate and hopelessness concurrently predicted self-reported overall risk for suicide within the same model. Only self-hate and agitation were significantly prospectively predictive of overall behavioural risk, even after controlling for suicidal ideation.

Conclusions: This is the first study to provide insight into the short-term variability and predictive capabilities of the SSF Core Assessment constructs. Each construct varies considerably over short time scales, suggesting

that more frequent monitoring of these constructs may be an important consideration within future CAMS treatment research.

KEYWORDS

CAMS, suicidal ideation, suicide, suicide risk

Practitioner points

- Core risk factors for suicidal thoughts and behaviours—psychological pain, stress, agitation, hopelessness, self-hate and self-reported overall behavioural risk of suicide—fluctuate significantly not only between Collaborative Assessment and Management of Suicidality (CAMS) treatment sessions, but also within hours and days.
- Self-hate is significantly predictive of changes in self-reported overall behavioural risk of suicide at the same timepoint and at the next timepoint, indicating that it may be a particularly important treatment target.
- More frequent monitoring of core suicide risk factors between CAMS sessions may enhance understanding of patient's unique risk factor variability, ultimately improving treatment effectiveness and patient outcomes.

INTRODUCTION

Effective therapies have been developed to address the underlying causes of suicide, including adaptations of Cognitive Behavioural Therapy (i.e. Bryan & Rudd, 2018) and Dialectical Behavioural Therapy (i.e. Goodman et al., 2016; see D'Anci et al., 2019 for a review). Among them is the Collaborative Assessment and Management of Suicidality (CAMS; Jobes, 2023), which emphasizes patient-defined drivers of suicide, targets suicidal ideation (SI) as the treatment focus and integrates collaborative assessment into treatment. Randomized clinical trials show CAMS significantly reduces suicidal thoughts and behaviours during treatment (Comtois et al., 2011; Ellis et al., 2015, 2017; Jobes et al., 2017; Pistorello et al., 2021; Ryberg et al., 2019; Santel et al., 2023; Swift et al., 2021). CAMS utilizes the Suicide Status Form (SSF), an instrument that elicits quantitative and qualitative information on suicide risk and tracks theoretically derived constructs related to suicidal thoughts and behaviours.

The *SSF Core Assessment* includes rating scales (1; not at all to 5; extremely) of five theoretically derived “risk” constructs: psychological pain, stress, agitation, hopelessness and self-hate, along with self-reported overall risk of suicide (Jobes, 2023; Jobes et al., 1997). These items are grounded in established theories of suicide including Shneidman's cubic model of suicide (Shneidman, 1993), Beck's cognitive model (Beck, 1986) and Baumeister's escape theory (Baumeister, 1990). Research shows improvements in all six Core Assessment constructs during CAMS treatment (Ellis et al., 2012; Gratch et al., 2021; Jobes et al., 1997, 2009; Nielsen et al., 2011).

Studies have found significant decreases in all six Core Assessment variables across treatment (Ellis et al., 2012; Graure et al., 2021; Jobes et al., 1997, 2009; Nielsen et al., 2011), but these typically examine changes from pretreatment to post treatment or between weekly sessions. Less is known about how these constructs fluctuate over shorter time periods, such as hours or days, and how these fluctuations relate to one's perceived risk of suicide. Understanding these dynamics is important because suicide risk can escalate rapidly and may go undetected by traditional assessment methods.

Ambulatory assessment (AA) refers to methods that assess individuals in real time in their natural environments, often using mobile devices to measure short-term fluctuations in thoughts, feelings and behaviours (Trull & Ebner-Priemer, 2013). AA is well suited for studying suicide risk, which can vary dramatically over the course of hours, minutes or days. For example, hopelessness has been shown to vary across the day (Forkmann et al., 2018; Gerner et al., 2023; Hallensleben et al., 2019; Kleiman et al., 2017; Mandel et al., 2024), with similar variability observed in other constructs such as psychological pain, agitation and self-hate (Baryshnikov et al., 2024; Bentley et al., 2021; Mandel et al., 2024). Stress has also been found to fluctuate significantly and is strongly associated with suicidal thoughts and behaviours (Husky et al., 2017; Oquendo et al., 2020; Victor et al., 2019). However, these constructs have not been systematically compared within the same AA framework, nor has it been determined if their variability differentially predicts one's perceived overall risk for suicide. Studying the short-term variability of these constructs is clinically meaningful, as increased suicide risk may co-occur with acute emotional states. Real-time monitoring may enhance risk detection and allow more timely intervention, as demonstrated by just-in-time adaptive interventions (Bryan et al., 2022; Fisher & Boswell, 2016). Importantly, psychological constructs may relate differently to suicide risk depending on their timing. While some constructs may predict immediate (concurrent) risk, others may predict risk at future timepoints (prospective).

Self-reported overall risk of suicide is critical to the CAMS framework. Rated on a scale from 1 (extremely low risk, will *not* kill self) to 5 (extremely high risk, will kill self), this item serves as both a treatment target and a metric for determining treatment progress. CAMS concludes when a patient demonstrates three consecutive sessions of stability in suicidality, defined as a self-reported ability to manage suicidal thoughts and feelings with no suicidal behaviour and a perceived overall risk rating below three (Jobes, 2023). Despite its centrality, little is known about how perceived risk changes in relation to the other SSF Core Assessment constructs. Graure et al. (2021) found that self-hate predicted changes in perceived overall risk of suicide from initial to outcome session when assessed weekly. Jobes et al. (2009) also examined the role of the core assessment items, but found no significant moderation of perceived risk trajectory when using the perceived overall risk item from the Behavioural Health Questionnaire-20 (BHQ; Kopta & Lowry, 2002).

To better capture temporal dynamics of the SSF core assessment, it is also necessary to distinguish within-person from between-person effects. Within-person effects reflect how changes in an individual's psychological states over time relate to fluctuations in suicide risk. By contrast, between-person effects identify whether individuals with higher average levels of certain constructs (e.g. self-hate) tend to experience greater suicide risk. Prior research has shown the value of this distinction for understanding therapeutic processes (Zilcha-Mano et al., 2018). In the context of CAMS and suicide prevention, identifying how core constructs fluctuate and relate to suicide risk within individuals could not only refine treatment strategies but also help identify important intervention targets and inform clinical decision-making.

In addition to understanding how core assessment variables relate to perceived suicide risk, it is important to examine different SI-related content, such as one's desire to die and their intent to die by suicide (Jobes et al., 2024). These facets are likely to vary throughout the day and may relate differentially to the SSF core assessment constructs. By modelling within- and between-person relationships between SI facets and the SSF items, potentially clinically meaningful dynamic patterns may be identified.

Present study

The current study had three primary aims: (1) describe the within- and between-person temporal dynamics of the SSF core assessment constructs when assessed multiple times daily using AA, (2) examine the relationships between within-person fluctuations in these constructs and facets of SI (e.g. want to die, suicidal desire and suicide intention) and (3) evaluate whether changes in the first five items of the core assessment predict concurrent and subsequent changes in self-reported overall risk of suicide.

The current study had three hypotheses. First, given that many risk factors for suicide vary dynamically over the course of the day, we hypothesized that all six constructs outlined in the core assessment would show some degree of variability over the course of the study as demonstrated by descriptive and variability statistics. Second, we hypothesized that within-person components of the SSF core assessment variables would be positively associated with facets of SI. Third, we hypothesized that changes in the first five SSF core assessment items (psychological pain, stress, agitation, hopelessness, self-hate) would demonstrate statistical significance in predicting changes in one's perceived overall risk of suicide both concurrently and prospectively.

MATERIALS AND METHODS

Participants

Undergraduates ($N=52$) were recruited from a large university in the southeastern United States over three consecutive semesters using the university's research participation system. At the start of each semester, all students in introductory psychology courses completed a screening questionnaire to determine general eligibility for research studies. Participants endorsing SI within the prior 2 weeks (defined as a response greater than zero on item one of the Depressive Symptom Index- Suicidality Subscale; Joiner et al., 2002) were invited to participate. Participants received research participation credits and \$35 for completing both baseline and follow-up sessions and at least 80% of AA prompts. Nearly half were White ($n=24$, 46.15%) and most identified as cisgender women ($n=43$, 82.69%). See Table 1 for complete demographics.

TABLE 1 Demographic data for college student sample ($N=52$).

Demographic variable	Mean (SD; range)
<i>Age</i>	19.53 (1.31; 18–22)
	<i>n (%)</i>
<i>Race/Ethnicity</i>	
White	24 (46.15%)
Black/African American	14 (26.92%)
Asian/Asian-American	4 (7.69%)
Latino(a) (Latinx)	6 (11.54%)
Biracial	5 (9.68%)
<i>Gender</i>	
Woman	43 (82.69%)
Man	6 (11.54%)
Transgender	1 (1.92%)
Gender non-conforming	3 (5.77%)
<i>Sexual orientation</i>	
Straight	33 (63.46%)
Gay or Lesbian	1 (1.92%)
Bisexual	13 (25.00%)
Not sure/Not listed	6 (11.54%)

Note: Some percentages may not equate to 100% because participants could choose more than one option.
Abbreviation: SD, standard deviation.

Procedures

The study was approved by the university's Institutional Review Board, and the procedures are similar to those used in studies outlined previously (Gerner et al., 2023; Moscardini et al., 2023; Oakey-Frost et al., 2023).

Baseline phase

After completing the screening questionnaire, participants with past 2-week SI were invited to participate in the study. Participants signed up for a time slot to meet with a research assistant via the research participation system. Participants met virtually with a graduate research assistant to review procedures, provide consent and complete a baseline survey collecting basic demographic information and history of suicidal thoughts and behaviours. Participants were guided through downloading the AA application (PIEL; Jessup et al., 2012) and received instructions on how to use the application to answer daily prompts.

As part of ethical and safety protocols, all participants completed a safety planning intervention (SPI; Stanley & Brown, 2012) with a graduate student in clinical psychology trained in the intervention. This brief intervention provided crisis resources (e.g. 988) and helped participants identify individual coping strategies should suicide-related distress occur. The SPI was included to reduce participant risk and ensure safety during the unsupervised AA data collection. Participants were informed that responses would not be monitored in real time and were encouraged to use safety planning resources should a crisis arise. To promote compliance and support, reminder emails were sent every other day and included mental health resources and answers to frequently asked questions.

Ambulatory assessment phase

Participants were prompted five times a day for 10 days through the PIEL application (Jessup et al., 2012) to complete 35 questions (about 3–5 mins per survey). Participants received notifications at random during 3-h time blocks (e.g. 9 AM–12 PM) throughout the day between the hours of 9:00 AM and 11:59 PM. Participants had 1 h to initiate a survey after the initial notification.

SSF core assessment

Psychological pain, stress, agitation, hopelessness, self-hate and self-reported overall behavioural risk of suicide were assessed at each time point using the original SSF items. To ensure the relevance of study results to the provision of CAMS, minimal wording changes to the core assessment items of the SSF were made. The words “right now” were added to the question stems for the first five constructs to ensure participants rated these experiences in the current moment. Thus, the first five constructs (psychological pain, stress, agitation, hopelessness and self-hate) read: “right now, rate [construct] on a scale from 1 (Not at all) to 5 (Extremely)” and included the definition of each construct provided on the SSF. The addition of “right now” was not made to question six, the perceived overall risk item, to avoid confusion. Asking a participant to rate “right now” for their perceived risk for suicide could be confused with suicidal intent (e.g. “right now I am going to kill myself”). Thus, item six assessed participants perceived risk for suicide for anytime in the future by asking “Rate your overall risk of killing yourself at some point in the future from 1 (Not at all) to 5 (Extremely).” Participants responded to these prompts using a slider with stops at 1, 2, 3, 4 and 5.

Suicide ideation facets

Three items were used to measure various facets of SI. Two questions attempted to measure one's desire to kill oneself (termed “suicide desire” and “suicide want” in the current study). Suicidal desire was measured using the prompt “Right now, I have an intense desire to kill myself” (Kleiman et al., 2017). Suicide want was measured using the item “Right now, I want to kill myself.” Participants responded

to these prompts using a visual analogue slider scale from 0 (Not at all) to 1 (Extremely). Participants could move the slider to any point along the continuum, and responses were rounded to two decimal places. This rating scale was not used for the SSF items in order to keep the SSF ratings as consistent as possible with their original form. Finally, “suicide intent” was measured using the item “How strong is your intent to kill yourself right now?” (Glenn et al., 2022) on a scale from 0 (absent/no intent), 1 (present but not at all strong) to 5 (extremely strong).

Debriefing

Upon completing the AA period, participants met virtually with a research assistant for debriefing. During this session, participants transferred their data to the researchers through email, arrangements for compensation and course credit were made and participants were encouraged to ask any questions regarding study involvement.

Analytical strategy

Analyses were conducted using the R Studio development environment (Posit Team, 2024). The hypotheses and analytical strategy were not preregistered. Data analysis code is available at https://osf.io/j6dng/?view_only=2bcd33e3a9840d78568282f6164a1e8.

Data preprocessing

Given the differences in scales across variables, variables were standardized to ease interpretation and comparability. The SSF items were all collected on a 1–5 scale and remained that way. The SI items of *want to kill myself* and *intense desire to kill myself* were originally collected on a 0–1 scale, while the *suicide intent* item was measured on a 0–5 scale. All SI items were standardized to match the SSF items on a scale of 1–5. Additionally, a composite score of the three SI facets was created. Information on the creation of the composite score can be found in the [Appendix S1](#).

Descriptive and variability statistics

The first aim was to describe the temporal dynamics of the core assessment constructs. To meet this aim, we calculated descriptive statistics (means, standard deviations, percentage of non-zero responses, kurtosis and skewness) as well as two types of variability statistics that reflect different aspects of change. All variables were within acceptable ranges for skewness ($\bar{F}2$) and kurtosis ($\bar{F}7$; Curran & West, 1996; Hair et al., 2010).

To assess both between-person and within-person variability, we calculated intra-class correlations (ICCs) and the root mean square of successive differences (RMSSD), consistent with prior AA studies (e.g. Kleiman et al., 2017; Stenzel et al., 2020). ICCs were calculated using the ICC package in R (Wolak et al., 2012), quantifying the proportion of total variance attributable to between-person differences, with higher values indicating greater variability between persons. RMSSD, calculated using the psych package in R (Revelle, 2007), reflects the average magnitude of change from one assessment to the next, capturing short-term fluctuations.

Both the original and re-scaled descriptive and variability statistics are reported in the tables. The second aim of the study was to examine the relationships between the SSF core constructs and facets of SI, all measured repeatedly. Repeated measures correlations were calculated using the rmcrr package in R (Bakdash & Marusich, 2017) allowing us to examine the relationships between study constructs while accounting for the nested structure of the data.

Bayesian multilevel models

To address the third aim of the study, examining whether the first five items of the SSF core assessment are associated with one's self-rated overall risk of suicide concurrently and prospectively, Bayesian hurdle-style multilevel mixed models were estimated using the *brms* package in R (Bürkner, 2017). Given the highly skewed nature of the outcome variable, a Bayesian approach was chosen to better accommodate zero-inflation and to provide greater flexibility in modelling. Additionally, the hurdle-style model allowed us to treat scale minimum values ("1") and non-minimum values as arising from distinct processes. The *brms* package does not currently support Bayesian hurdle models by default, so modelling procedures were adapted based on methods described by Yang (2020). Each model consisted of two components: (1) a logistic model predicting the presence of perceived overall risk of suicide (i.e. no risk = score of 1 on 1–5 scale; risk present = score of 2–5) and (2) a cumulative link model predicting the severity of risk among observations where risk was present.

Variable preparation

Given few ratings of three or greater (17.5%; $n=346$), a simulated hurdle approach was used. Two outcome variables were derived from the perceived overall risk item: a binary "presence" variable (with responses of "1" coded as 0, "no risk" and scores of "2" or higher coded as 1, "risk present") and a "severity" variable (restricted to responses ranging from 2 to 5). Predictor variables were disaggregated into within- and between-person components following approaches used in prior research (e.g. Mandel et al., 2024). Person-specific means for each variable were calculated by averaging each participant's scores across prompts. These were then used to calculate within-person variables by subtracting each person's mean from their momentary ratings. Between-person variables were calculated by subtracting the grand mean from each person's average score.

To assess prospective effects, both outcome variables were lagged by one time point within each participant by using the *dplyr* package (Wickham et al., 2023). Only lags that occurred within the same calendar day were retained.

Model specification

All models were estimated using Markov Chain Monte Carlo (MCMC) sampling with four chains, 4000 iterations per chain (2000 warm up) and an average acceptance probability of .95. A logit link function was used for both components. Models included random intercepts and random within-person slopes to account for individual differences in baseline risk. Model convergence was evaluated using \hat{R} and effective sample size metrics. Significant effects were interpreted as those for which the 95% credible interval did not include zero, consistent with Bayesian modelling practices.

Model 1

The first model included the first five SSF core assessment constructs at time T (both within and between-person centred) *concurrently* predicting the presence of perceived overall risk of suicide (score of 2 or above on 1–5 scale at time T).

Model 2

The second model had identical predictors to the first, but the severity of perceived overall risk of suicide served as the outcome variable.

Model 3

The third model included the first five SSF core assessment constructs at time T (both within- and between-person centred) *prospectively* predicting the presence of perceived overall risk at the next time point (T + 1) using the newly created lagged variable.

Model 4

The fourth model had identical predictors to model 3, but the severity of perceived overall risk of suicide at T + 1 served as the outcome variable.

Supplementary models

In addition to the four primary models, each model was re-run with the inclusion of composite SI as a covariate using the composite SI score. Full model specifications and results can be found in the [Appendix S1](#).

RESULTS

Descriptive statistics

On average, participants completed 38.75 surveys ($SD = 9.85$, range = 10–50 out of 50 possible) over the course of the 10-day AA period, resulting in $k = 2015$ surveys. A total of 42 survey entries had missing values (1.39%). Little's Missing Completely at Random (MCAR) test (Little, 1988) was insignificant ($\chi^2(26) = 17.6, p = .891$), supporting the assumption that the data is MCAR. Accordingly, listwise deletion was performed, resulting in a final count of $k = 1973$ surveys. The average time to complete a survey was 2 minutes and 16 seconds ($SD = 2:35$, range = 00:27–27:40). Means, standard deviations, kurtosis, skewness and percent of non-zero responses are reported in [Table 2](#).

Variability statistics

Complete variability statistics can be seen in [Table 2](#). ICCs indicated that 68% of the variance in the composite SI score can be explained by differences between participants. For the core assessment items, ICCs were generally high. The highest ICC was for self-hate, with 76% of the variance attributed to between-person variation. The lowest ICC was for stress, with 49% of the variance in stress attributable to between-person differences. RMSSD values indicated a relatively high level of variability between successive observations for most of the core assessment constructs (stress = .99, agitation = .92, psychological pain = .83, hopelessness = .79, self-hate = .71). In contrast, the composite SI score and the perceived overall risk item had much lower RMSSD values (.39 and .47, respectively), suggesting less variability between surveys across the study period for these variables.

Repeated measures correlations among study variables can be seen in [Table 3](#). Among the three measures of SI, desire and want had the strongest overall correlation ($r_{rm} = .73, p < .001$), while intent was moderately positively correlated with want ($r_{rm} = .54, p < .001$) and desire ($r_{rm} = .50, p < .001$). Among the SSF core assessment items, hopelessness and psychological pain had the strongest correlation with each other ($r_{rm} = .58, p < .001$). Psychological pain had the highest correlation with the composite SI score ($r_{rm} = .49, p < .001$). Self-hate had the strongest correlation with self-reported overall risk ($r_{rm} = .42, p < .001$). Further, the perceived overall risk score was moderately correlated with the SI composite score ($r_{rm} = .41$). In sum, the SSF core assessment variables and SI variables were moderately correlated with one another at the within-person level.

Bayesian Multilevel Models

Concurrent models

The results of the concurrent models can be seen in [Tables 4 and 5](#). In model 1 ([Table 4](#)), the average levels of agitation between individuals (i.e. between-person) significantly predicted the presence of perceived

TABLE 2 Descriptive and variability statistics of ambulatory assessment data.

	Descriptive statistics			Variability statistics		
	Mean (SD; range) 1-5 scale/Original scale ^a	% Nonzero ^b	Skew	Kurtosis	ICC [CI]	RMSSD [range] 1-5 scale/Original scale ^a
Suicidal desire	1.66 (.86; 1-5)/.17 (.22; 0-1)	59.30%	1.30	.81	.68 [.59, .76]	.47 [.02, 1.27] /.12 [.004, .32]
Suicide want	1.72 (.89; 1-5)/.18 (.22; 0-1)	61.73%	1.20	.57	.63 [.54, .73]	.52 [.02, 1.27] /.13 [.01, .34]
Suicide intent	1.42 (.72; 1-5)/.53 (.90; 0-5)	33.20%	1.97	3.74	.60 [.51, .70]	.44 [0, 1.26] /.55 [0, 1.58]
Composite SI	1.6 (.77; 1-5)	68.67%	1.45	1.58	.69 [.61, .78]	.39 [.02, 1.12]
SSF Psysc Pain	2.27 (1.25; 1-5)	64.17%	.64	-.72	.60 [.51, .70]	.83 [0, 1.77]
SSF stress	2.83 (1.35; 1-5)	79.07%	.14	-1.20	.49 [.40, .60]	.99 [0, 2.01]
SSF agitation	2.18 (1.29; 1-5)	58.24%	.81	-.52	.58 [.49, .68]	.92 [0, 2.06]
SSF hopelessness	2.08 (1.23; 1-5)	56.31%	.90	-.33	.62 [.53, .71]	.79 [0, 1.80]
SSF self-hate	2.43 (1.41; 1-5)	64.22%	.59	-.97	.76 [.69, .83]	.71 [0, 1.56]
SSF overall risk	1.72 (.91; 1-5)	48.40%	1.29	4.33	.72 [.65, .80]	.47 [0, 1.60]

Abbreviations: CI, 95% confidence interval; ICC, intra-class correlation; RMSSD, root mean square of successive differences; SD, standard deviation; SSF, suicide status form.

^aIf applicable, both the re-scaled and original scale descriptive and variability statistics are presented. The three SI items were re-scaled to match the SSF items to ease comparability.

^bMany variables were on a 1-5 scale, so rather than the percentage of non-zero responses, the percentage of responses greater than the lowest possible value are reported.

TABLE 3 Repeated measures correlations of study variables.

	Desire	Want	Intent	Composite SI	SSF Psych pain	SSF stress	SSF agitation	SSF hopelessness	SSF self-hate	SSF overall risk
Desire	1.00									
Want	.73***	1.00								
Intent	.51***	.54***	1.00							
Composite SI	.88***	.90***	.78***	1.00						
SSF Psych pain	.40***	.43***	.42***	.49***	1.00					
SSF stress	.27***	.29***	.32***	.35***	.53***	1.00				
SSF agitation	.28***	.28***	.35***	.35***	.49***	.48***	1.00			
SSF hopelessness	.35***	.42***	.44***	.47***	.58***	.45***	.43***	1.00		
SSF self-hate	.37***	.38***	.37***	.44***	.52***	.41***	.41***	.55***	1.00	
SSF overall risk	.34***	.36***	.34***	.41***	.35***	.25***	.26***	.40***	.42***	1.00

Note: Composite SI score is the average of the suicidal desire, suicide want and suicide intent variables. Asterisks (***) indicate significance at $p < .001$ for all correlations. Abbreviations: Desire, suicidal desire; Intent, intent to kill self; Psych pain, psychological pain; SI, suicidal ideation; SSF, suicide status form; Want, want to kill self.

TABLE 4 Log-Odds posterior estimates for concurrent presence model.

Parameter	Estimate	95% CI	\hat{R}	ESS
Intercept	-.22	[-2.01, 1.54]	1.00	3375.92
Psych pain (between)	-2.31	[-6.70, 2.23]	1.00	2903.16
Psych pain (within)	.58	[-.26, 1.46]	1.00	5421.21
Stress (between)	.58	[-2.51, 3.50]	1.00	3633.92
Stress (within)	-.03	[-.60, .50]	1.00	6991.41
Agitation (between)	3.81	[.21, 8.01]	1.00	3396.69
Agitation (within)	-.29	[-.66, .10]	1.00	9294.67
Hopelessness (between)	1.21	[-3.95, 6.35]	1.00	3395.88
Hopelessness (within)	.62	[.18, 1.16]	1.00	7723.67
Self-hate (between)	1.55	[-1.51, 4.74]	1.00	3413.74
Self-hate (within)	1.38	[.88, 1.97]	1.00	8562.38

Note: Estimates are posterior medians with 95% Bayesian credible intervals; all predictors were disaggregated into within- and between-person components.

Abbreviations: CI, credible interval; ESS, effective sample size; \hat{R} , Gelman-Rubin convergence statistic.

TABLE 5 Log-odds posterior estimates for concurrent severity model.

Parameter	Estimate	95% CI	\hat{R}	ESS
Intercept 1	4.50	[3.00, 6.32]	1.00	4383.20
Intercept 2	8.89	[7.27, 10.86]	1.00	4827.68
Intercept 3	12.20	[10.34, 14.42]	1.00	5217.82
Psych pain (between)	2.03	[-1.39, 5.89]	1.00	3549.83
Psych pain (within)	.10	[-.53, .74]	1.00	8704.46
Stress (between)	-1.74	[-5.54, 1.42]	1.00	3306.28
Stress (within)	.36	[-.17, .83]	1.00	7859.69
Agitation (between)	-.32	[-3.23, 2.20]	1.00	4466.56
Agitation (within)	.52	[.03, 1.08]	1.00	7676.54
Hopelessness (between)	3.18	[.80, 7.05]	1.00	3397.93
Hopelessness (within)	.68	[.27, 1.13]	1.00	7497.65
Self-hate (between)	.43	[-1.81, 3.09]	1.00	3224.84
Self-hate (within)	1.11	[.35, 1.96]	1.00	6967.40

Note: Estimates are posterior medians with 95% Bayesian credible intervals; all predictors were disaggregated into within- and between-person components.

Abbreviations: CI, credible interval; ESS, effective sample size; \hat{R} , Gelman-Rubin convergence statistic.

risk at the same timepoint (log-odds = 3.81; 95% credible interval (CI) = .21–8.01). Additionally, the extent to which a person endorsed greater hopelessness (log-odds = .62; CI = .18–1.16) and self-hate (log-odds = 1.38; CI = .88–1.97) than was typical for them (i.e. within-person) were significant predictors of the presence of perceived overall risk, controlling for all other predictors in the model. In model 2 (Table 5), only within-person hopelessness (log-odds = .68; CI = .27–1.13) and self-hate (log-odds = 1.11; CI = .35–1.96) significantly predicted the severity of perceived overall risk. When SI was added to the models (see Tables S1 and S2), the significant effects remained.

Prospective models

The results of the prospective models can be seen in Tables 6 and 7. In model 3 (Table 6), none of the within- or between-person centred core assessment items significantly predicted the presence of

TABLE 6 Log-odds posterior estimates for prospective presence model.

Parameter	Estimate	95% CI	\hat{R}	ESS
Intercept	.12	[-1.17, 1.49]	1.00	1324.57
Psych pain (between)	-1.20	[-4.28, 1.86]	1.00	2003.45
Psych pain (within)	.32	[-.25, 1.15]	1.00	5268.84
Stress (between)	.11	[-2.04, 2.26]	1.00	1960.27
Stress (within)	-.13	[-.43, .17]	1.00	7749.62
Agitation (between)	2.38	[-.25, 5.37]	1.00	1862.99
Agitation (within)	.13	[-.17, .46]	1.00	7706.79
Hopelessness (between)	.38	[-3.22, 3.72]	1.00	1553.40
Hopelessness (within)	.03	[-.36, .43]	1.00	8247.58
Self-hate (between)	1.56	[-.52, 3.75]	1.00	1892.52
Self-hate (within)	.41	[-.05, .92]	1.00	5633.78

Note: Estimates are posterior medians with 95% Bayesian credible intervals; all predictors were disaggregated into within- and between-person components.

Abbreviations: CI, credible interval; ESS, effective sample size; \hat{R} , Gelman-Rubin convergence statistic.

TABLE 7 Log-odds posterior estimates for prospective severity model.

Parameter	Estimate	95% CI	\hat{R}	ESS
Intercept 1	2.57	[1.41, 3.95]	1.00	2957.29
Intercept 2	5.79	[4.55, 7.26]	1.00	3362.16
Intercept 3	7.95	[6.59, 9.54]	1.00	3836.24
Psych pain (between)	1.02	[-1.47, 3.40]	1.00	3840.92
Psych pain (within)	-.23	[-.93, .42]	1.00	5674.00
Stress (between)	-1.98	[-4.59, .37]	1.00	3512.88
Stress (within)	.34	[-.11, .76]	1.00	6817.36
Agitation (between)	-1.30	[-4.03, 1.10]	1.00	3020.14
Agitation (within)	-.23	[-.79, .26]	1.00	5412.06
Hopelessness (between)	3.66	[.36, 7.43]	1.00	3039.12
Hopelessness (within)	.37	[-.13, .82]	1.00	6767.59
Self-hate (between)	.29	[-1.31, 2.74]	1.00	2917.29
Self-hate (within)	.53	[-.05, 1.28]	1.00	4337.46

Note: Estimates are posterior medians with 95% Bayesian credible intervals; all predictors were disaggregated into within- and between-person components.

Abbreviations: CI, credible interval; ESS, effective sample size; \hat{R} , Gelman-Rubin convergence statistic.

perceived risk at the next time point. In model 4 (Table 7), only between-person hopelessness significantly predicted the severity of perceived risk at the next time point (log-odds = 3.66; CI = .36–7.20). When SI was added to the models (see Tables S3 and S4), none of the core assessment items significantly predicted the presence of perceived overall risk at the next time point (Table S3) and between-person hopelessness no longer predicted the severity of risk at the next time point (Table S4).

DISCUSSION

The current study investigated how SSF Core Assessment variables from CAMS (Jobes, 2023) vacillate over short time periods in a sample of non-CAMS treatment-seeking individuals endorsing recent SI.

Using AA, the study examined the concurrent and prospective relationships of these constructs with perceived suicide risk. As hypothesized, the first five core assessment items demonstrated substantial variability over hours and days, greater than that of SI or self-reported overall risk. These findings align with previous AA research that has demonstrated affective, cognitive and physiological risk factors of suicide fluctuate considerably over short time periods (e.g. Baryshnikov et al., 2018; Bentley et al., 2021; Forkmann et al., 2018; Hallensleben et al., 2019; Kleiman et al., 2017). Further, these findings provide novel insights into CAMS SSF Core constructs and their clinical relevance.

Notably, perceived overall risk and SI demonstrated lower variability (RMSSD values of .39 and .47, respectively) than other Core Assessment items, consistent with prior findings that SI is more stable compared to fluctuating risk factors (Forkmann et al., 2018; Gerner et al., 2023; Kleiman et al., 2017). Self-hate showed the highest between-person variability ($ICC = .76$) and lowest RMSSD (.71) of the first five Core Assessment items, which may suggest it has more trait-like qualities than the more state-dependent variability seen in constructs like agitation (RMSSD = .92) or stress (RMSSD = .99). This pattern aligns with prior factor analytic work on the SSF demonstrating support for a two-factor solution of the SSF with one factor comprised of stress and agitation, potentially because of their more dynamic nature (Conrad et al., 2009). Repeated measures correlations revealed moderate to large positive correlations among the first five core assessment items and between the items and SI (Table 3), consistent with previous research (e.g. Conrad et al., 2009; Kleiman et al., 2017).

Recent work supports the relevance of perceived overall risk as a distinct and clinically meaningful construct. Koontz et al. (2025) found that perceived overall risk, as measured by the SSF, was highly correlated with, but not redundant to, an individual's wish to die and it retained significant associations with hopelessness, self-hate, suicide planning and past suicidal behaviour even after statistically controlling for the wish to die. These findings suggest that perceived overall risk may capture more than just an individual's wish to die, also incorporating elements of desire, capacity and intent. In the current study, perceived overall risk demonstrated substantial short-term variability and was most strongly associated with self-hate ($r_{rm} = .42$), followed by hopelessness ($r_{rm} = .40$), echoing findings by Koontz and colleagues.

The Bayesian hurdle-style models offer interesting insights into the relationships between SSF constructs. Within-person increases in momentary self-hate were associated with approximately four times greater odds of endorsing any suicide risk in that moment ($\log\text{-odds} = 1.38$) and nearly three times greater odds of reporting a higher perceived risk score among those who already endorsed risk ($\log\text{-odds} = 1.11$). Within-person hopelessness had smaller but similar effects. Between-person differences in agitation were strongly associated with concurrent perceived risk, such that a one unit increase in an individual's average agitation level was associated with nearly 45 times greater odds of reporting the presence of risk ($\log\text{-odds} = 3.81$). However, neither within- nor between-person changes in agitation were associated with the severity of risk. In prospective models, no SSF Core Assessment constructs significantly predicted the presence of perceived overall risk at the next time point. Between-person hopelessness emerged as a strong predictor of the severity of risk at the next assessment. A one unit increase in an individual's average hopelessness was associated with 39 times greater odds of reporting higher perceived risk scores at the next time point ($\log\text{-odds} = 3.66$). This finding did not remain once SI was added to the model, suggesting that SI is a stronger or more proximal indicator of next time point risk than hopelessness.

These findings partially supported the hypothesis that variability in the core assessment items would predict perceived risk of suicide concurrently and prospectively. This pattern suggests that increases in an individual's momentary hopelessness and self-hate may represent more acute markers of distress that drive concurrent suicide risk presence and severity, whereas chronic, trait-like hopelessness may increase the intensity of perceived suicide risk over time. The significance of hopelessness as a finding aligns with theoretical models of suicide (e.g. Beck, 1986) and the literature more broadly, with a prior meta-analysis demonstrating that individuals with higher average hopelessness are at a higher risk of suicide ideation, attempts and death (Ribeiro et al., 2018). Previous EMA studies have demonstrated a clear short-term, prospective relationship between hopelessness and

SI (e.g. Kleiman et al., 2017). Additionally, these findings are partially in line with findings from Bentley et al. (2021) who found that higher levels of negative affect (specifically anxiety/agitation and shame/self-hatred domains) predicted the number of days with suicidal thoughts post-discharge in psychiatric inpatients. These findings suggest that, when all risk factors are considered together competing for shared variance, self-hate, hopelessness and agitation may be particularly important indicators of an individual's self-reported overall risk level.

Finally, the current findings have implications for clinical practice and the implementation of CAMS (Jobes, 2023). This study is the first to demonstrate that the SSF Core Assessment constructs are highly variable over short time periods. Notably, these findings are within a sample of individuals *not* currently undergoing CAMS treatment, providing an important basis of comparison for future studies. It is possible that participation in CAMS treatment influences the temporal dynamics of the constructs, increasing or decreasing the strength of their association with perceived overall risk. Given that typical SSF tracking occurs about 1 week apart, there are likely important fluctuations that are missed. The significant variability observed over short time periods suggests that more frequent monitoring of the SSF core assessment constructs could offer valuable insights.

This approach is consistent with strategies used in Dialectical Behaviour Therapy, which incorporates daily diary card tracking and chain analysis to identify patterns in suicidal ideation (Linehan et al., 2015). Implementing AA measures into CAMS treatment may be a worthwhile avenue of future development and research, allowing clinicians to track patient progress between sessions and understand important fluctuations in core assessment constructs and individual drivers of suicide. Further, the current findings suggest that self-hate is a significant factor in identifying individuals who may need CAMS treatment, as it is one of the strongest predictors of one of the framework's key resolution criteria. Therefore, assessing and addressing self-hate during CAMS treatment could be crucial, especially if the patient's perceived overall risk of suicide does not decrease.

Limitations and future directions

Several limitations should be noted. First, the sample consisted of primarily female undergraduates at a large university in the southeastern United States, limiting the generalizability of the findings. Future research should replicate these results in more diverse, representative samples. Participants were not undergoing CAMS treatment, which has benefits and limitations. While this sampling provides a baseline for comparison in future research, the lack of an interview format prevented participants from asking clarifying questions about the assessed constructs. Additionally, although the SPI was not expected to directly alter the constructs assessed during the study, it is possible that creating a safety plan may have influenced participants' perceived ability to manage distress, which could in turn affect their self-reported risk ratings over the study period.

Participant engagement may also have been influenced by recruitment incentives (e.g. course credits, monetary incentives), which could have introduced selection bias by disproportionately attracting individuals motivated by external rewards. Moreover, participants endorsed relatively low average scores on the "overall risk" item, with many participants meeting one of the termination criteria for CAMS (i.e. a score below 3) at the study's outset. This restriction may have limited variability in the outcome.

Additional methodological considerations include the use of single-item measures for each SSF construct, which could reduce reliability, though single-item measures are supported in AA research (Song et al., 2022). Differences in scale formats also present as a limitation: suicidal desire and suicide want were administered using 0–1 visual analogue scales (VAS), whereas suicide intent and the CAMS Core Assessment Items were measured using Likert-style scales ranging from 0 to 5 or 1–5. This scaling discrepancy represents a methodological limitation, as differences in scale format may limit comparability. Notably, as highlighted by Haslbeck et al. (2024), VAS may be more suitable than Likert scales for AA studies, capturing small but meaningful variations. Future

studies should consider adopting CAMS items to a VAS format when used in AA research to enhance precision and consistency.

While lagged models in the current study were restricted to same-day observations, the time interval between surveys within a day was highly variable. Due to limitations of the AA application and the desire to retain as much data as possible, we did not exclude lags based on missing surveys. Instead, any survey was allowed to predict the next, provided both occurred on the same calendar day. This approach may have introduced variability and reduced temporal precision. However, future research may benefit from more fine-grained modelling of time to capture more dynamic changes in constructs across shorter intervals.

Although the perceived overall risk item is a central part of the CAMS framework, limited research has examined its relationship with suicidal behaviour. This is surprising given patient perceived risk may be as strong a predictor of future suicidal behaviour as clinician perceived risk (Nock et al., 2010). Future studies should examine whether fluctuations in perceived overall risk meaningfully correspond to future suicidal thoughts or behaviour. Finally, the current study is limited by the absence of formal psychometric evaluation of the AA-adapted Core Assessment items. While elements of construct validity were examined, future research should assess content coverage and determine whether each item adequately represents its broader construct.

CONCLUSION

This is the first study to examine the variability of CAMS SSF Core Assessment constructs over shorter time scales. Results show that psychological pain, stress, agitation, self-hate, hopelessness and perceived overall risk of suicide vary considerably over hours and days in college undergraduates. Between-person agitation and within-person hopelessness and self-hate predicted perceived suicide risk when assessed concurrently; between-person hopelessness was significantly predictive of increases in the severity of perceived risk ratings. These findings suggest that incorporating AA measures into CAMS treatment may enhance understanding of patients' unique risk factor variability, ultimately improving treatment effectiveness and patient outcomes.

AUTHOR CONTRIBUTIONS

Jessica L. Gerner: Conceptualization; data curation; formal analysis; visualization; writing – original draft; investigation; funding acquisition; methodology. **Abby A. Mandel:** Supervision; conceptualization; writing – review and editing. **Raymond P. Tucker:** Conceptualization; writing – review and editing; supervision; funding acquisition; resources. **David A. Jobs:** Conceptualization; supervision; writing – review and editing.

CONFLICT OF INTEREST STATEMENT

Dr. Jobs receives book royalties from Guilford Press and is the founder and co-owner of CAMS-care, LLC. Dr. Tucker receives compensation for training health care providers in the Collaborative Assessment and Management of Suicidality (CAMS). The remaining authors have no conflicts of interest to disclose.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are openly available in OSF at https://osf.io/j6dng/?view_only=2bcdb33e3a9840d78568282f6164a1e8.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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