Ecological momentary assessment of self-harm thoughts and behaviours: A systematic review of constructs from the Integrated Motivational-Volitional model

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Abstract

Background: The Integrated Motivational-Volitional (IMV) model is one of the leading theoretical models of suicidal thoughts and behaviour. There has been a recent proliferation in the assessment of suicidal and non-suicidal self-harm thoughts and behaviours (SHTBs) in daily life.

Objective: This systematic review synthesises evidence from ecological momentary assessment (EMA) studies to address the following questions: i) Which constructs within the IMV model have been assessed using EMA, and how have they been assessed? ii) Do different constructs from the IMV model fluctuate in daily life? iii) What is the relationship between the different IMV constructs and SHTBs in daily life?

Methods: Consistent with PRISMA guidelines, we conducted systematic searches of five databases – Web of Science, Embase, MEDLINE, PsycInfo, and Europe PMC Preprints – from inception to 26th March 2024.

Results: Our searches resulted in the inclusion and narrative synthesis of 53 studies across 58 papers. Fifteen IMV constructs were measured using EMA across included papers. The most frequently measured constructs were thwarted belongingness (24 studies), future thinking (20 studies) and perceived burdensomeness (16 studies). The least frequently measured were humiliation, social problem-solving, mental imagery, and perceived capability for suicide. None of the included papers measured memory biases, goals, norms, or resilience using EMA. Comparison of intra-class coefficients (45 studies) revealed inconsistency in, but at least moderate, within-person variance across all examined constructs. We found evidence (39 studies) of concurrent associations between almost all constructs and SHTBs in daily life, with some evidence that entrapment, shame, rumination, thwarted belongingness, hopelessness, social support and impulsivity are additionally associated with SHTBs in lagged (i.e. longitudinal) relationships.

Conclusions: Comparisons were hindered by variation in methodology, including populations studied, EMA sampling scheme, operationalisation of IMV constructs and SHTBs, and statistical approach used. Our findings suggest that EMA studies are a useful methodology for examining risk factors for SHTB, however more research is needed for some IMV constructs. Quality assessment suggested several areas for how reporting EMA studies in this field might be improved.

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Keywords: Integrated Motivational-Volitional (IMV) model; ecological momentary assessment; suicidal and non-suicidal self-harm thoughts and behaviours

Introduction

Suicidal and non-suicidal self-harm thoughts and behaviours (SHTBs) are a global public health

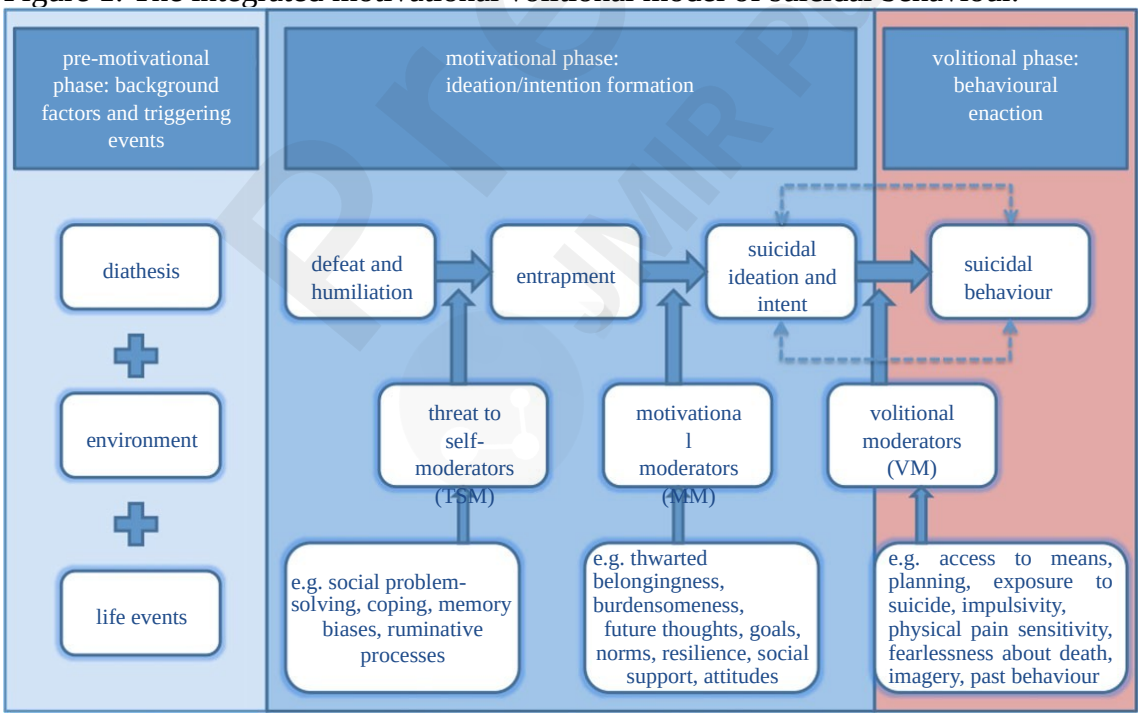
concern, with estimates suggesting that more than 14.6 million individuals are affected by self-harm (defined as any form of self-injury irrespective of motivation or intent) each year and over 700,000 deaths per year are attributable to suicide [1]. Understanding factors that contribute to the development of SHTBs is essential for prevention and early intervention.

The Integrated Motivational-Volitional model (IMV) is one of the leading theoretical models of suicidal behaviour, developed by O'Connor [2] and later refined by O'Connor & Kirtley [3] (Figure 1). The IMV model consists of three phases: the pre-motivational stage, describing the bio-psychosocial context in which suicidal thoughts and behaviour may emerge; the motivational phase describing the factors that lead to the development of suicidal thoughts; and the volitional phase describing the factors that predict the transition from thoughts to behaviours.

Core constructs of the motivational phase include feelings of defeat, humiliation and entrapment which drive the emergence of suicidal thoughts. These can be facilitated or impeded by the presence of moderating variables, termed 'threat to self', and 'motivational' moderators. The transition from suicidal thoughts to behaviours is, in turn, influenced by the presence of 'volitional moderators'. Although the IMV model was developed in relation to suicidal thoughts and behaviour, the central concepts of the model can also be applied to non-suicidal self-harm thoughts and behaviours [4].

A recent systematic review of studies testing the IMV model of suicidal behaviour yielded support for the central components of the model – i.e. the defeat-entrapment-suicidal ideation pathway – but called for more focus on the constructs referred to as threat-to-self and motivational moderators within the model [5]. The review identified extensive testing of the model using cross-sectional retrospective methods, whilst highlighting the need for more prospective (including intensive longitudinal) testing of IMV constructs.

Figure 1: The integrated motivational volitional model of suicidal behaviour.



Reproduced with permission. Source: O'Connor RC, Kirtley OJ. 2018 The integrated motivational–volitional model of suicidal behaviour. Phil. Trans. R. Soc. B 373: 20170268. http://dx.doi.org/10.1098/rstb.2017.0268

Ecological Momentary Assessment

Recent technological advances have made it easier for researchers to gain insight into SHTBs in real time, using intensive longitudinal methods. These methods are commonly referred to in the literature as experience sampling methods (ESM), ambulatory assessment, daily diaries, and ecological momentary assessment (EMA). From this point onwards, for brevity, we use the term EMA to refer to this methodology. EMA is a diary-based method, involving repeated and frequent assessment of feelings, behaviours, and contexts, in an individual's natural environment. This minimises recall bias, maximises ecological validity and enables dynamic processes to be captured. Assessment may be once daily (daily diaries) or repeated throughout the day at pseudo-randomised or specific times in a signal-contingent sampling scheme, or repeated based on reporting of a specific event, such as an act of non-suicidal self-injury (NSSI) (event-contingent). Despite concerns around the demands placed on research participants from intensive sampling, it has been found to be both acceptable and feasible, with generally good compliance reported [6]. Whilst there have been further concerns about the repeated reporting of mental states having an influence on an individual's mental state, there is no strong evidence of such iatrogenic effects [7,8].

Existing EMA studies of suicidal thoughts have shown them to be highly variable over time [9] however less is known about the extent to which proximal risk factors for SHTB, such as those proposed by the IMV model, fluctuate in daily life. A recent proliferation of EMA studies in the field of suicide and self-harm has prompted the need for a comprehensive synthesis of this literature. Whilst others have reviewed EMA literature on self-harm [10-12], suicidal thoughts [8,10,13,14], and interpersonal processes in an SHTB context [15], EMA studies specifically assessing key constructs across both motivational and volitional phases of the IMV model have not yet been synthesised. Additionally, existing reviews of EMA studies have typically focused on the relationship between risk factors and SHTB and less attention has been paid to the characteristics of the risk factors themselves.

We conducted a systematic review of the SHTB literature in which constructs from the motivational and volitional phases of the IMV model have been assessed using EMA. We offer a narrative synthesis, describing how IMV constructs have been assessed in daily life, characterising their within-person variability, and summarising the evidence of the proximal relationships between each IMV construct and SHTBs. We identify gaps in the evidence base and propose directions for future research.

Primary review questions

1. Which of the key constructs within the Integrated Motivational-Volitional (IMV) model have been assessed in Ecological Momentary Assessment studies, and how have they been assessed?
2. Do different constructs from the IMV model show fluctuation in daily life and what is the nature and timing of this fluctuation?

Secondary review question

1. What is the relationship between the different IMV constructs and suicidal and non-suicidal thoughts and behaviours in daily life?

Methods

The review was pre-registered on the PROSPERO database (ID: CRD42022349514), and on Open Science Framework, OSF [16]. Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines were followed, in addition to Non-Interventional, Reproducible, and Open (NIRO) Systematic Review guidelines [17]. We searched the databases Web of Science, Embase, MEDLINE, PsycInfo, and Europe PMC Preprints. We also hand searched reference lists and citations of included papers for additional papers not returned by the database searches.

The full search terms and strategy are available on OSF [16]. We searched for studies using intensive longitudinal methods, often referred to as ecological momentary assessment, experience sampling, ambulatory assessment or daily diary methods. We did not include a date limit on the search. The initial search was conducted in October 2022, yielding 40 papers, with an updated search in November 2023 yielding an additional 13 papers. A final pre-submission update conducted in March 2024 yielded an additional 6 studies over 5 papers.

Records were exported to, stored, and managed using the application Rayyan. Two authors independently screened (blinded) the papers for inclusion based on the title and abstract simultaneously against the inclusion and exclusion criteria, with disagreements resolved by discussion. One author conducted full screening of the selected papers based on the full text. Full details are available at Winstone et al. [16].

Inclusion and Exclusion Criteria

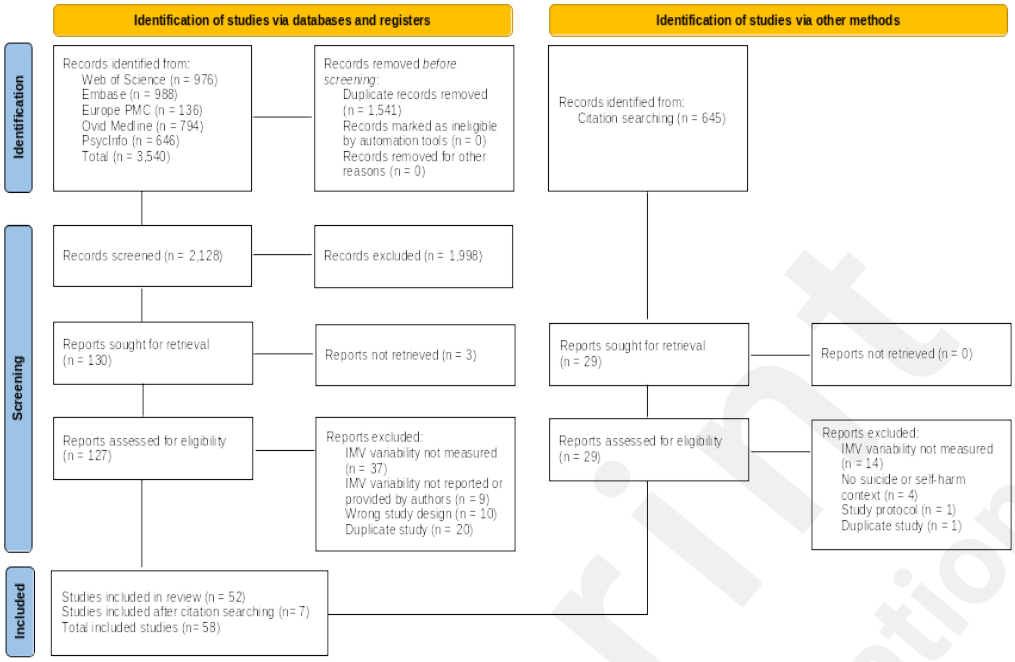
We included studies which had assessed at least one of the IMV constructs in daily life, using intensive longitudinal data-collection methods (i.e. EMA). These include the core motivational phase factors (defeat, shame, humiliation, and entrapment); threat to self-moderators (problem solving, coping, memory bias, rumination); motivational moderators (thwarted belongingness, burdensomeness, future thinking, goals, norms, resilience, social support, attitudes) and volitional moderators (suicide planning, exposure to self-harm, impulsiveness, pain sensitivity, fearlessness about death, imagery). To be included, studies needed to report details of within-person variability in IMV constructs (i.e. ICC, see ‘data analysis’). Where not reported, we contacted authors to request this information. If ICCs were not available, and no association between at least one IMV construct and SHTBs was reported, the study was excluded.

We included PhD theses published online and excluded studies that were meta-analyses, reviews, editorials, or commentaries, as well as articles not written in English. We did not limit inclusion of studies according to population or participant characteristics, and both clinical and non-clinical samples were included.

We will not describe assessment of, or within-person variability in SHTB in this study, as this has been covered by previous reviews [8,11,13,14].

Data analysis

Figure 2: PRISMA flow diagram



Data extraction (template available on OSF [16]) included a range of descriptive data for each study, including demographic information about the sample, whether the study sampled a clinical or community-based population, study design, and information about the IMV constructs measured. Intraclass correlation coefficients (ICC) were extracted to describe the level of within-person variability in each construct. ICCs indicate the proportion of a variable's variance that is due to between-person and within-person variability [18]. The within-person variability is calculated as 1 minus the ICC. When within-person variability is low, this means the variability in a construct is mostly due to differences between people and there is little fluctuation in the construct within people, i.e. the construct may be considered more trait-like than state-like. For example, a hypothetical ICC of 0.83 would mean just 17% within-person variance, suggesting that construct is more trait-like and shows little fluctuation within people. Conversely, an ICC of 0.26 would mean 74% within-person variance, suggesting that construct is more state-like and shows large fluctuation within people over time.

Where studies tested associations between IMV constructs and SHTBs – either concurrent or lagged – these associations were also extracted. Quality assessment of the reporting of studies was conducted according to an EMA-specific quality assessment tool [15]. Example reporting criteria included participant training in the EMA protocol being detailed in the methods, reporting the construct validity of EMA items, compliance rate and reasons for non-compliance, discussion of EMA-specific limitations, and open code for analysis (full criteria available at Winstone et al., [16]).

Results

Description of included studies

Fifty-three studies (unique samples) were included in the review, across 58 papers, all from higher income countries with the majority from North America (40), United Kingdom (3) and Germany (3). Studies varied substantially in terms of population, sample size, design, and constructs measured. Several papers reported different analyses using the same study sample, i.e., the same sample was used to report different IMV constructs across different papers. To avoid double counting of samples and designs, table 1 reports a summary of 53 studies[1].

Sample size ranged from 10 to 743 participants (mean sample size=85.3, SD=105.4, median=54). Most studies included largely female samples; in 2/53 (4%) samples all participants were female or women [19,20]; in 4/53 (8%) samples participants were mostly male or men [23,25,60,42]; 15/53 (28%) samples included a small number of transgender, non-binary or gender non-conforming participants; in one sample all participants were transgender or gender-diverse [21]. In 29/53 (55%) samples the majority of participants were White/Caucasian; 10/53 (19%) studies did not report participants' race or ethnicity. The mean sample age ranged from 15.0 to 47.7 years, with 15/53 (28%) studies using a sample of young people (aged 25 years or under). In 14/53 (26%) of samples participants were recruited from the general population, with 12/53 (23%) from Universities and the remaining samples recruited from clinical settings or a mix of clinical and community settings.

Table 1. Overview of samples of included studies

Sample size	
Total (combined)	4523
Mean (SD)	85.3 (105.4)
Median	54
Minimum	10
Maximum	743
Age (years)	
Mean age range	15.0-47.7
Minimum age in any study	12
Maximum age in any study	85
Population	
Non-clinical (general population)	14
University students	12
Clinical (inpatient)	10
Clinical (outpatient)	8
Mixed (clinical: inpatient and outpatient)	1
Mixed (clinical and non-clinical)	8
Sampling protocol	
Daily diary (mixture of random and specific times)	13
Signal-contingent (pseudo-random)	33

[1] 58 papers reporting results from 53 independent samples

Signal-contingent (specific times)	4
Mixed (signal- and event-contingent)	2
Event-contingent	1
Number of assessments per day	
1x per day (daily diary study or aggregated measure used)	15
2-4x per day	16
5-10x per day	22
Study duration (number of days)	
Mean (SD)	19.9 (18.6)
Median	14.0
Range	3.4-90
Method of assessment	
smartphone app	30
Weblink to surveys sent by text message	10
Weblink to surveys sent by email	4
PDA	2
other (e.g. pre-programmed smartphone or iPad)	1
smartwatch	1
phone call (telephone interview)	1
paper (prompted by pager)	1
Not reported	3

About a quarter of the studies 15/53 (28%) adopted a daily diary design with one assessment per day. Of the remaining 38 EMA studies, the number of measurements ranged from 2 to 10 per day (mean=4.2 measurements, SD=2.3) and most were delivered using a signal-contingent sampling scheme at pseudo-randomised intervals. Study duration ranged from 3.4 to 90 days (Mean=19.8 days, SD=18.5 days, Median=14.0 days) with some studies (6/53 (11%)) reporting varying durations based on length of hospitalization [22-27]. EMA smartphone apps were most often used for data collection, including Illumivu, MetricWire and MovisensXS.

Which of the key constructs within the Integrated Motivational-Volitional (IMV) model have been assessed in Ecological Momentary Assessment studies, and how have they been assessed?

In the following section, we refer to the 58 individual papers. Two papers [25,26] each report two independent samples. Several other papers report the same sample but report different IMV constructs [28,29]; [30-32]; [33,34]; [35-37]; [38,39]. 26/59 (44%) papers report more than one IMV construct. In 7/59 (12%) papers [26,35,37,39,40-42] the study used a signal-contingent (pseudo-random) sampling scheme but one or more IMV construct was assessed once per day or an aggregated daily measure was used.

Across the 58 papers included in this review, the motivational moderators within the IMV model have been most frequently assessed in EMA studies (Table 2). The constructs measured

most frequently were thwarted belongingness (24/58, 41% studies), positive or negative thoughts about the future (20/58, 34% studies) and perceived burdensomeness (16/58, 28% studies). The least frequently measured constructs were humiliation, social problem-solving, mental imagery, physical pain sensitivity, and fearlessness about death. None of the included papers measured memory biases, goals, norms, or resilience using EMA.

Table 2. IMV constructs measured using intensive longitudinal methods, by the number of assessments per day[2]

	Number of studies			
	1x per day (daily diary)	**2-4x per day**	**5-10x per day**	**Total**
Motivational phase				
Defeat			3	3
Humiliation		1	2	3
Entrapment	1	1	3	5
Threat-to-self moderators				
Coping	4	1	2	7
Rumination	2	2	4	8
Social problem-solving	1		1	2
Motivational moderators				
Future thoughts	5	6	9	20
Perceived burdensomeness	6	6	4	16
(Thwarted) belongingness	8	9	7	24
Social support	3		2	5
Volitional moderators				
Impulsivity	3	2	2	8 (including 1 event-contingent)
Mental imagery	1	2		3
Physical pain sensitivity	3	1	1	6 (including 1 event-contingent)
Fearlessness about death	2	1	1	4
Access to means		1	1	2

Do different constructs from the IMV model show fluctuation in daily life and what is the nature and timing of this fluctuation?

ICCs were available in 78% (45/58) of papers. These estimates varied substantially, but for most constructs showed an overall pattern of at least moderate within-person variance (Table 3). A small number of constructs showed levels of within-person variance under 20% across a small number of studies (6/58, 10% studies), suggesting a more stable and trait-like construct in these particular samples.

[2] suicidal thoughts and behaviours are not included in our results, as these outcomes have been widely reported and discussed in other reviews of EMA studies.

Table 3. Proportion of within-person variance reported for each IMV construct, by sample type[3]

	Range across all studies[4]	
	Clinical sample	**Community sample**
Motivational phase		
Defeat	53% (1)	48% (1)
Shame (humiliation)	18-89% (3)	-
Entrapment	39-48% (2)	46-63% (2)
Threat-to-self moderators		
Coping	49-96% (3)	28-42% (1)
Rumination	41-84% (5)	20-78% (4)
Social problem-solving	34-75% (2)	-
Motivational moderators		
Future thoughts	26-56% (11)	22-70% (6)
Perceived burdensomeness	14-60% (11)	37-47% (2)
(Thwarted) belongingness	4-57% (15)	33-90% (9)
Social support	19-98% (5)	22-56% (3)
Volitional moderators		
Impulsivity	25-78% (4)	59% (1)
Mental imagery	64% (1)	56-79% (2)
Physical pain sensitivity	48-74% (3)	29-61% (2)
Fearlessness about death	53% (1)	12-31% (2)
Access to means	-	34-45% (2)

There was variability across studies measuring the same IMV construct, however no consistent patterns were seen in comparisons between IMV constructs measured in clinical vs community populations, or in comparisons between different sampling frequency (number of assessments per day, see Table S1 for full details). Findings are described for each concept below and summarised in Tables 3 and 4.

Table 4. Overview of included studies

Authors	**Report type**	**Country setting**	**Sample type**	**Sample size**	**Mean age (SD), years**	**Gender/ Sex**	**Ethnicity/ Race**	**Mental health profile**	**Study duration, days**	**Number of assessments per day**	**Constructs measured**	**ICC reported**	**Association with SHTB reported**
Aadahl et al., 2021 [43]	Peer-reviewed article	UK	Mixed (clinical and community)	27	34.2 (13.9)	66% female; 34% male	93% White British; 7% White Other	Recent SI; 26% personality disorder; 45% affective disorder; 7% psychotic disor	7	6	Defeat	-	Concurrent
											Entrapment	-	-
											Hopelessness	-	Concurrent
											Suicidal ideation	n/a	n/a

[3] Within-person variance = 1- ICC

[4] Number of studies indicated in parentheses.

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
								der; 3% eating disorder; 19% not stated					
Al-Dajani & Czyz, 2022 [30]	Peer-reviewed article	USA	Clinical (inpatient)	78	15.2 (1.4)	68% assigned female at birth	83% White; 6% Black; 5% Asian; 5% American Indian / Alaska Native; 4% other	Recent SI or SA	28	1	Perceived burdensomeness	0.40	Concurrent & Lagged
											Peer belongingness	0.59	Concurrent & Lagged
											Family belongingness	0.43	Concurrent & Lagged
											Suicidal urge intensity	n/a	n/a
Al-Dajani & Uliaszek, 2021 [44]	Peer-reviewed article	USA	Mixed clinical and non-clinical (inc. university)	39	30.9 (8.8)	67% female; 26% male; 5% non-binary or transgender	49% White; 19% Black; 16% Other; 10% East Asian; 8% South Asian	59% lifetime SA	14	4	Hopelessness	0.49	-
Al-Dajani et al., 2022 [32]	Peer-reviewed article	See Al-Dajani & Czyz, 2022									Coping (personal-support)	0.49	Lagged
											Coping (professional-support)	0.27	
											Coping (non-cognitive)	0.38	
											Coping (cognitive)	0.55	
											Coping (perceived helpfulness)	0.42	
											Coping (total strategies used)	0.51	
											Suicidal urge intensity	n/a	n/a
Ammerman et al., 2017 [45]	Peer-reviewed artic	USA	Non-clinical	51	28.8 (9.8)	75% female	52% African American; 33%	65% lifetime NSSI; 100	7	4	Impulsivity	n/a	Concurrent
											NSSI	n/a	n/a

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
	le						White; 10% Asian; 6% Other	% BPD and depressive disorder					
Baryshnikov et al., 2024 [22]	Peer-reviewed article	Finland	Clinical (inpatient)	67	37.3 (12.5)	66% female; 27% male; 7% other	Not reported	37% suicidal behaviour; 100% unipolar depression	Varied (M=3.4 days)	3	Hopelessness	-	Lagged
											Suicidality	n/a	n/a
Bayliss et al., 2024 [46]	Peer-reviewed article	Australia	Non-clinical	75	36.5 (10.8)	64% female; 24% male; 12% other	Not reported	67% lifetime SA	14	4			
Bentley et al., 2021 [23]	Peer-reviewed article	USA	Clinical (inpatient)	83	38.4 (13.6)	52% male; 42% female; 4% transgender; 2% other	83% European descent; 5% Black/ African American; 5% Asian; 6% Other	100% recent SI/SA	Varied (M=8.52 days, SD=5.73; range: 2-46)	4	Shame (as synonymous with humiliation)	0.82	-
Ben-Zeev et al., 2012 [47]	Peer-reviewed article	USA	Clinical (inpatient)	31	39.3 (11.0)	77% female	67% White; 13% African American; 3% Latinx; 17% Other	58% lifetime SA; 100% depressive disorder	7	6	Helplessness	-	Lagged
											Hopelessness	-	Lagged
											Suicidal ideation	n/a	n/a
Burke et al., 2021 [48]	Peer-reviewed article	USA	University (high risk)	60	20.1 (2.1)	92% female	68% White; 20% Asian; 7% Mixed; 3% Other	100% lifetime history of repetitive NSSI	10	3	Impulsivity	-	Lagged
											NSSI urge	n/a	n/a

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
Christensen et al., 2023 [49]	Peer-reviewed article	USA	Non-clinical	93	23.5 (4.3)	14% Cisgender men; 56% Cisgender women; 5% Transgender men; 23% Gender queer or gender non-conforming; 2% Another gender identity	67% Non-Hispanic/Latinx White; 14% Hispanic/ Latinx White; 3% Black; 6% Asian; 10% Multiracial	100% recent NSSI urges	7-14	6	Social support	0.78	Lagged
											NSSI urge	n/a	n/a
Cloos et al., 2020 [19]	Peer-reviewed article	Germany	University	19	24.6 (4.5)	100% female	Not reported	100% recent NSSI; 89% personality disorder; 95% affective disorder	10	1	Entrapment	0.37	-
											Mental imagery Compellingness	0.21	-
											Mental imagery Vividness	0.29	-
											Mental imagery Controllability	0.22	-
											Mental imagery Nowness	0.29	-
											Mental imagery Distress	0.33	-
											Mental imagery Comfort	0.44	-
Coppersmith et al., 2019 [50]	Peer-reviewed article	USA	Non-clinical	53	23.5 (4.3)	77% female	75% White; 8% Asian; 2% Black/ African American; 15% Other	100% past year SA	28	1	Social support	0.44	Concurrent & Lagged
											Suicidal ideation	n/a	n/a
Czyz et al., 2019a [33]	Peer-revie	USA	Clinical (inpatient)	34	15.5 (1.	77% female	85% White; 9%	100% recen	28	1	Hopelessness	0.67	Concurrent & Lagged
											Perceived	0.69	

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
	wed article				4)		Black/ African American;9% Asian	t SI/SA; 85% depressive disorder; 71% anxiety disorder; 18% ADHD			burdensomeness		
											Connectedness	0.63	
											Suicidal ideation	n/a	
Czyz et al., 2019b [34]	Peer-reviewed article	See Czyz et al., 2019a									Coping (number of strategies used)	-	Concurrent
											NSSI	n/a	n/a
Czyz et al., 2021 [31]	Peer-reviewed article	See Al-Dajani & Czyz, 2022									Hopelessness	0.58	-
											Perceived burdensomeness	0.62	-
											Connectedness to friends	0.44	-
											Connectedness to family	0.59	-
											Rumination	0.47	-
											Suicidal ideation duration	n/a	n/a
Czyz et al., 2023 [51]	Peer-reviewed article	USA	Clinical (outpatient)	102	20.9 (2.1)	81.4% female, 18.6% male	75% White; 9% More than one category; 6% Asian; 5% Black or African American; 5% Other	100% recent SI/SA	56 days	4	Rumination	0.59	n/a
											Hopelessness	0.73	
											Perceived burdensomeness	0.71	
											Closeness to others (belongingness?)	0.59	
											Coping	0.48	
											Self-harm, suicidal ideation	n/a	
Defayette et al., 2023 [52]	Peer-reviewed article	USA	University	42	19.6 (1.3)	Sex at birth: 83.3% female,	45% White; 17% African American; 17% Asian; 14%	100% recent SI	28	6	Thwarted belongingness (social exclusion)	-	Concurrent & Lagged

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
						16.7% male; Gender identity: 73.8% women, 16.7% men, 9.5% nonbinary	Multiracial; 7% Other				Suicidal ideation	n/a	
Ewing & Hamza, 2024 [53]	Peer-reviewed article	Canada	University	160	19.7 (1.8)	83% Female; 12% male; 5% transgendered, unsure, non-binary or agendered persons	44% White; 22% East Asian; 11% as South Asian; 23% Filipino, Latin American, Black, Arab/ West Asian, South East Asian, or Aboriginal	100% recent NSSI urges & past year NSSI	14	1	Coping (problem-focused)	0.58	n/a
											Coping (avoidant)	0.63	
											Coping (emotion-focused)	0.72	
											Coping (socially supported)	0.63	
Gerner et al., 2023 [54]	Peer-reviewed article	USA	University	43	19.1 (1.3)	70% Woman 14% Man 12% Gender non-conforming 5% Not listed	63% White; 21% Black/ African American; 7% Asian/ Asian-American; 5% Latinx; 15% Biracial	100% recent SI	10	5	Thwarted belongingness	0.64	Concurrent & Lagged
											Perceived burdensomeness	0.53	
											Hopelessness	0.37	
											Suicidal ideation	n/a	
Glenn et al., 2022 [55]	Peer-reviewed article	USA	Clinical (outpatient)	48	15.0 (1.6)	65% female; 17% male; 19% non-binary	77% White; 14% Hispanic; 10% Mixed; 8% Black; 2% Americ	100% lifetime SI; 85% lifetime SA; 94%	28	3	Thwarted belongingness	8 items ranging from 0.67-0.78	Lagged
											Suicidal thoughts	n/a	n/a

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
							an Indian	anxiety disorder; 28% ADHD; 83% major depressive disorder					
Hallard et al., 2021 [56]	Peer-reviewed article	UK	Clinical (inpatient) and non-clinical	24	35.3 (14.3)	67% female	92% White British; 8% White Other	100% recent SI; 79% lifetime SA; 50% mood disorder; 30% personality disorder	6	7	Rumination	-	Lagged
											Suicidal ideation	n/a	
Hallensleben et al., 2019 [36]	Peer-reviewed article	Germany	Clinical (inpatient)	79	37.6 (14.3)	72% female	Not reported	100% lifetime SI; 34% lifetime SA; 87% depressive disorder	6	10	Hopelessness	0.74	Concurrent & Lagged
											Perceived burdensomeness	0.66	
											Thwarted belongingness	0.57	
											Passive and active suicidal ideation	n/a	
Harper, 2019 [37]	Thesis	USA	University	145	20.1 (5.4)	72% female; 27% male	46% White; 33% African American; 15% Hispanic; 8% Asian	Not reported	7	3	Loneliness (thwarted belongingness)	0.50	-
Hughes et al., 2019 [58]	Peer-reviewed artic	USA	Non-clinical	47	19.1 (1.8)	62% female; 30% male; 2%	38% White; 19% Asian; 17%	100% recent SH	14	5	Rumination	0.70	Lagged
											NSSI thoughts	n/a	n/a

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
	le					transgender	Hispanic; 15% Black/ African American; 11% Mixed				and behaviours		
Jacobucci et al., 2023 [59]	Peer-reviewed article	USA	Non-clinical	35	25.9 (5.8)	63% identified as females; 20% male; 14% transgender / other	69% identified as White; 6% Black; 11% Asian; 12% other or more than 1 race	100% past year SHTBs; 70% 'seeing someone for emotional, psychiatric or substance use problems'	30	4	Perceived burdensomeness	-	Lagged
											Thwarted belongingness	-	
											Suicidal ideation	-	
Jeong et al., 2021 [60]	Peer-reviewed article	South Korea	Non-clinical	23	40.0 (8.7)	78% male	Not reported	Not reported	15	1	Impulsivity	0.41	-
											Suicidal ideation	n/a	n/a
Kaurin et al., 2022 [61]	Peer-reviewed article	USA	Clinical and non-clinical	186	33.7 (9.4)	80% female	76% White; 15% Black/ African American; 4% Asian; 3% Pacific Islander; 2% other	56% lifetime SA; 82% BPD	21	Event-contingent	Impulsivity (during a social interaction)	0.54	Concurrent
											Suicidal ideation	n/a	n/a
Kaurin et al., 2023 [38]	Peer-reviewed article	USA	Clinical and non-clinical	153	33.6 (9.6)	81% female	Not reported	69% lifetime SA; 100% BPD	21	6	Impulsivity	-	Concurrent
											Suicidal ideation	n/a	
Kellerman et al., 2022 [24]	Peer-reviewed article	USA	Clinical (inpatient)	118	15.8 (1.8)	80% female	81% White, non-Hispanic, 4% Asian, 4%	87% lifetime SI; 63% lifetime	Varied (M=6.1, SD=6.1)	1	Social support from staff	0.71	Lagged
											Social support from other patients	0.73	Lagged

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
							African American, 4% Hispanic	NSSI; 54% lifetime SA; 77% depressive disorder; 49% anxiety disorder			Social support from family members	0.74	Lagged
											Social support from friends	0.81	Lagged
											NSSI	n/a	n/a
Kirtley et al., 2022 [40]	Peer-reviewed article	Belgium	Non-clinical	743	16.9 (2.4)	59% female	Not reported	7% recent SI	6	10	Short-term future thinking (1x per day)	0.30	-
Kleiman et al., 2017 [25]	Peer-reviewed article	Global	Non-clinical	54	23.2 (5.3)	80% female	72% European descent; 7% Hispanic; 7% Asian; 14% other	100% past year SA	28	4	Hopelessness	0.57	Concurrent & Lagged
											Loneliness	0.49	Concurrent & Lagged
											Perceived burdensomeness	0.58	Concurrent & Lagged
											Suicidal ideation	n/a	n/a
		USA	Clinical (inpatient)	36	47.7 (13.1)	44% female	82% European descent; 6% Hispanic; 6% Asian; 6% other	100% recent SA/ SI	Varied (M=10.3, SD=6.5)	4	Hopelessness	0.66	Concurrent & Lagged
											Loneliness	0.61	Concurrent & Lagged
											Suicidal ideation	n/a	n/a
Krall et al., 2024 [26]	Peer-reviewed article	USA	University	129	20.0 (1.6)	76% female biological sex assigned at birth; 24% male	49 % White; 38% Asian; 7% Black/ African American, and all others endorsed another or multiple races	100 % SI	56	7	Pain (1x per day)	0.39	n/a
											Hopelessness	0.78	n/a
			Clinical (outpatient)	20	28.5 (10.9	80% female biological sex	80% Caucasian; 15%	100 % BPD	Varied (up to 7 week	6	Pain	0.24	n/a
											Hopelessness	0.45	n/a

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
					)	assigned at birth; 20% male	Asian; 5% Black/ African American.		s)				
Kudinova et al., 2023 [62]	Peer-reviewed article	USA	Clinical (inpatient)	158	15.2 (1.4)	68% were assigned female sex at birth. 61% identified as female; 32% male	1% Asian; 9% Black or African American; 1% Native or Alaska Native; 66% White; 15% identified with more than one race.	100% recent SI; 86% depressive disorder; 59% anxiety disorder	21	5	Shame	0.11	Lagged
											NSSI	n/a	
Kuehn, 2022 [63]	Thesis	USA	Clinical (outpatient) and non-clinical	60	18.6 (1.3)	77% female sex; 23% male sex	53% self-identified as White; 12% Hispanic/ Latinx; 10% reported a mixed ethnicity; 20% Asian; 3% Black/ African American; 2% Middle Easter	100% recent SH/ SI/ past-year SA	14	5	Coping (cognitive re-appraisal)	0.31	Concurrent and lagged
											Coping (self-invalidation)	0.32	
											Coping (suppression)	0.31	
											Coping (distraction)	0.24	
											Coping (acceptance)	0.25	
											Coping (avoidance)	0.04	
											Rumination	0.16	
											Problem solving	0.25	

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
							n				Social support	0.02	
											Impulsivity	0.75	
											Shame	0.38	
											SITBs	n/a	
López et al., 2023 [64]	Peer-reviewed article	USA	University	49	19.7 (1.6)	71% female; 29% male	45% White; 12% African American; 22% Asian; 8% Multiracial; 12% Other	100% recent SI	28	6	Thwarted belongingness	0.39	n/a
Lucht et al., 2022 [35]	Peer-reviewed article	See Hallensleben et al., 2019									Impulsivity (1x per day)	4 items ranging from 0.22-0.36	Concurrent
											Suicidal ideation	n/a	n/a
MacNeil et al., 2023 [65]	Peer-reviewed article	Canada	Clinical (outpatient) and non-clinical	55	15.6 (1.6)	75% female	75% White	44% major depressive disorder	10	1	Thwarted belongingness	0.53	n/a
											Perceived burdensomeness	0.67	
Mitchell et al., 2023 [66]	Peer-reviewed article	USA	University	41	19.3 (2.0)	17% male; 83% female	34% Asian; 32% White; 15% Multiracial; 12% Black; 7% Hispanic/ Latinx	29% lifetime NSSI; 32% lifetime SA	5	1	Rumination	0.22	n/a
Molaie, 2022 [67]	Thesis	USA	University	197	19.4 (1.8)	79% of participants identified as female; 19%	49% White; 23% Hispanic/Latinx; 14% Asian	Not reported	14	1	Thwarted belongingness	0.67	n/a

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
						male; 0.5% non-binary/gender nonconforming	American; 7% (Multi-ethnic; 4% African American ; 2% Native Hawaiian or Pacific Islander; 1% Middle Eastern; 2% Other						
Mournet et al., 2022 [41]	Peer-reviewed article	USA	University	74	19.4 (1.0)	70% cisgender female, 26% cisgender male, 3% transgender female, 1% non-binary, and 1% chose not to disclose	50% Asian, 31% White, 5% African American/Black, 1% American Indian/Alaskan Native, and the remainder endorsed multiple races or chose not to disclose.	100% recent SI	56	6	Loneliness (1x per day)	-	Concurrent & Lagged
											Perceived burdensomeness (1x per day)	-	Concurrent & Lagged
											Suicidal ideation	n/a	n/a
Nuij et al., 2022 [42]	Peer-reviewed article	Netherlands	Clinical (outpatient)	17	32.1 (9.2)	47% female	Not reported	100% recent SI; 94% depressive disorder; 53% lifetime SA	90	4	Perceived burdensomeness	0.86	-
											Thwarted belongingness (1x per day)	-	-
											Entrapment	0.52	-
											Future thoughts (1x per day)	0.60	-
											Hopelessness	0.44	-
											Mental Imagery	0.36	-
											Impulsivity	0.75	-

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
											(1x per day)		
											Problem-solving/ coping (1x per day)	0.66	-
											Rumination	0.47	-
Parrish et al., 2021 [68]	Peer-reviewed article	USA	Clinical (outpatient)	96	43.9 (11.2)	55% female	48% Black/ African American; 28% White/ Caucasian; 24% Hispanic; 24% other	100% current diagnosis of schizophrenia, schizoaffective disorder, bipolar disorder with psychotic features, or major depressive disorder with psychotic features	10	3	Perceived burdensomeness	0.69	-
											Thwarted belongingness	0.59	-
Peters et al., 2022 [27]	Peer-reviewed article	Canada	Clinical (inpatient)	39	36.3 (13.0)	69% female	Not reported	100% recent SI	Varied (M=12)	3	Social connectedness (i.e., thwarted belongingness)	0.56	Concurrent
											Suicidality	n/a	n/a
Reeves, 2022 [69]	Thesis	USA	Clinical (outpatient)	10	Not reported	50% gender nonconforming or variant; 40% cis-gender	60% White/ European descent; 10% Chinese; 10% Middle Eastern; 20%	100% lifetime SI; 100% depressive disor	14	9	Thwarted belongingness	0.74	-
											Perceived burdensomeness	0.44	-
											Hopelessness	0.48	-

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
						female; 10% cis-gender male	Other	der					
Rogers, 2023 [70]	Peer-reviewed article	USA	Non-clinical	237	27.1 (8.6)	62% female; 16% non-binary; 9% transgender male; 7% male; 2% transgender female;	87% White/ European American; 4% Black/ African American; 7% Hispanic/ Latino/a; 4% Asian; 3% other	100% recent SI; 68% lifetime SA	14	6	Rumination	0.56	Concurrent & Lagged
											Suicide-Specific Rumination	0.80	
											Thwarted belongingness	0.54	
											Perceived burdensomeness	0.63	
											Hopelessness	0.63	
											Fearlessness about death	0.88	
											Access to means	0.66	
											Suicidal ideation & intent	n/a	n/a
											NSSI	n/a	n/a
Selby et al., 2019 [71]	Peer-reviewed article	USA	Clinical (outpatient) and non-clinical	47	19.1 (1.8)	68% female; 30% male; 2% transgender	38% White; 15% African American; 19% Asian; 17% Hispanic/ Latino; 11% Mixed	100% recent NSSI	14	5	Physical pain (event-contingent) – pre-NSSI pain rating	0.26	-
											NSSI behaviours	n/a	n/a
Silva et al., 2022 [72]	Peer-reviewed article	USA	Clinical (outpatient)	16	43.8 (10.8)	81% female	100% Hispanic/Latino	69% major depressive episode; 25% PTSD	14	4	Thwarted belongingness	0.85	-
											Perceived burdensomeness	0.81	-
											Emotional loneliness	0.85	-
											Social loneliness	0.96	-

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
								; 25% GAD; 19% psychotic disorder			Suicidal ideation	n/a	n/a
Spangenberg et al., 2019 [37]	Peer-reviewed article	See Hallensleben et al., 2019									Fearlessness about death (1x per day)	0.47	-
											Pain tolerance (1x per day)	0.52	-
Stanley et al., 2021 [73]	Peer-reviewed article	USA	Clinical (outpatient)	50	30.6 (11.0)	86% female	56% Caucasian	100% BPD; 100% current SI; recent NSSI and/or recent SA	7	6	Coping strategies (engagement and effectiveness)	-	Lagged
											Suicidal ideation	n/a	n/a
Stenzel et al., 2020 [74]	Peer-reviewed article	Germany	Non-clinical	61	24.2 (7.0)	89% women	Not reported	No current mental illness	7	5	Defeat	0.52	-
											Entrapment	0.54	-
Tsypes et al., 2022 [39]	Peer-reviewed article	See Kaurin et al., 2023									Reasons for living (1x per day)	0.63	Concurrent & Lagged
											Suicidal ideation	n/a	n/a
Turner et al., 2016 [28]	Peer-reviewed article	Canada	Non-clinical	60	23.4 (4.3)	85% female	53% White; 18% East Asian; 8% Southeast Asian; 3% Native Canadian; 2% Black or African Canadian; 2% Hispanic/ Latina/		14	1	Perceived social support	0.56	Lagged
											NSSI urges	n/a	n/a

Authors	Report type	Country setting	Sample type	Sample size	Mean age (SD), years	Gender/ Sex	Ethnicity/ Race	Mental health profile	Study duration, days	Number of assessments per day	Constructs measured	ICC reported	Association with SHTB reported
							o						
Turner et al., 2019 [29]	Peer-reviewed article		See Turner et al., 2016								Daily coping strategies	n/a	Concurrent & Lagged
											NSSI urges	n/a	n/a
van Ballegooijen et al., 2022 [75]	Peer-reviewed article	UK	Clinical and non-clinical	51	35.5 (12.8)	67% women	Not reported		7	6	Defeat	0.47	Concurrent & Lagged
											Entrapment	0.58	Concurrent & Lagged
											Suicidal ideation	n/a	n/a
Victor et al., 2019 [20]	Peer-reviewed article	USA	Non-clinical	63	22.0 (1.6)	100% women	71% African American; 24% non-Hispanic Caucasian		21	6	Interpersonal stress (thwarted belongingness)	0.10	Lagged
											Rejection (thwarted belongingness)	0.17	Lagged
											Self-injurious and suicidal urges	n/a	n/a
Wolford-Clevenger et al., 2020 [76]	Peer-reviewed article	USA	University	206	19.1 (2.4)	73% women	82% White/ Caucasian; 8% Hispanic/ Latino/a		90	1	Thwarted belongingness	-	Lagged
											Perceived burdensomeness	-	Lagged
											Hopelessness	-	Lagged
											capability for suicide (pain tolerance and fearlessness about death)	-	Lagged
											Suicidal ideation	n/a	n/a
Wolford-Clevenger et al., 2021 [21]	Peer-reviewed article	USA	Non-clinical (including University)	38	28.6	100% transgender, gender-diverse, of trans experience, or hav[ing] transitioned.	84% non-Hispanic White		30	1	Hopelessness	-	Lagged
											Social connectedness (thwarted belongingness)	-	Lagged
											Suicidal ideation	n/a	n/a

Motivational phase

Defeat

Three papers [43,74,75] measured defeat, each with 5-10 assessments per day. ICCs were available in two studies, with 48% within-person variance reported across a community sample of 61 young adults, mostly women [74] and 52% within-person variance reported across a mixed clinical and community sample of 51 adults [75]. Defeat was measured using a single item and operationalised variously as 'powerless' [43], 'emotionally defeated' [75] or using two items (wording not reported) selected based on factor loadings from the defeat scale [74].

Humiliation

Three studies [23,62,63] measured humiliation. Bentley et al. [23] reported 18% within-person variance across a clinical sample of 83 (mostly male) adults with 4 assessments per day, whereas Kudinova et al. [62] reported 89% within-person variance in 'anger at self' across a clinical sample of 158 (mostly female) adolescents. In a mixed sample of mostly female young adults (N=60), Kuehn [63]reported 62% within-person variance with 5 assessments per day. All three studies reported measuring humiliation with items from PANAS or PANAS-X, but Bentley et al. [23] used a derived variable combining items measuring 'ashamed, guilty, humiliated and self-hate'.

Entrapment

Five studies [19,42,43,74,75] measured entrapment, with 4-6 assessments per day, or once per day in a daily diary study [19]. While Cloos et al [19] reported 63% within-person variance in a community sample of 19 young women, three EMA studies reported similar proportions of within-person variance (42-48%) across a small adult clinical sample [42], a community sample of 61 young (mostly female) adults [74] and a mixed clinical and community sample of 51 adults [75]. Entrapment was measured with two items in each study except Nuij et al. [42], and Cloos et al [19] who each used a single item ("I feel trapped" and "How much did you feel entrapped in your current situation today? Meaning that you perceived your current situation as unpleasant (e.g., due to own thoughts or feelings, or to outer circumstances) and would have liked to leave it yet felt unable to.")

Threat-to-self moderators

Coping

Using a range of sampling frequencies, seven studies measured coping [29,32,34,51,53,63,73] and we found substantial variation in how this construct was operationalised. Eight coping strategies were grouped into personal support, professional support, cognitive and non-cognitive strategies in Al-Dajani et al. [32], with participants asked to report daily level of engagement with each group of coping strategy to deal with suicidal thoughts or stressful events (45-73% within-person variance in a clinical, mostly female adolescent sample), overall perceived helpfulness (regardless of strategy, 58% within-person variance) and total coping strategies used (49% within-person variance). Czyz et al. [51] used the same grouping of strategies, assessed four times per day for 8 weeks, but reported a single ICC for overall engagement (52% within-person variance in a young adult, mostly female clinical sample).

Ewing & Hamza [53] provided separate ICCs for daily frequency of engagement in coping strategies grouped into problem-focused, avoidant, emotion focused and socially supported coping (28-42% within-person variance in a predominantly female, young adult community sample). In a mixed, young adult sample, Kuehn [63] included rumination, problem-solving and social support as coping strategies, alongside cognitive reappraisal (69%), self-invalidation (68%), suppression (69%), distraction (76%), acceptance (75%) and avoidance (96%; within-person variance in parentheses). In Stanley et al. [73], adult, clinical participants were asked six times per day whether they had used each of the following strategies and rated their perceived effectiveness in reducing distress: keeping busy; socializing; positive thinking; doing something good for self; calming self; finding perspective; and sitting with feelings until they passed. In a predominantly female community sample of 60 young adults, Turner et al [29] asked participants once per day whether they had used each of 15 strategies (grouped as problem-focused, support-seeking, and avoidant coping) to deal with a named problem or stressor encountered that day (reporting 44% within-person variance).

Rumination

Eight studies measured rumination using both a daily diary design [31,66] and 4 or more assessments per day [42,51,53,56,63,70], using different operationalisations. Within-person variance differed substantially across studies, with 53% reported in a clinical adolescent sample (assessed once daily using a single item, "I was dwelling on my feelings and problems") [31] and Nuij et al [42] in a clinical adult sample, assessed four times per day using the item "I can't escape my thoughts". Within-person variance was 41% when assessed four times per day over 8 weeks, in a clinical young adult, predominantly female sample [51]. In a mixed adult sample, Hallard et al. [56] used two items, "I was thinking about my failures and weaknesses; I was analysing why I feel the way I do" but did not report an ICC. Hughes et al., [53] reported lower within-person variance (30%) in a community sample of 47 young adults, using an 8-item scale of repetitive negative thinking, whereas Kuehn [63] reported much higher within-person variance (84%) in a mixed young adult sample, measuring rumination as a binary coping strategy. In another sample of young adults in the community, Mitchell et al. [66] reported similarly high within-person variance (78%) when measuring rumination with two items: "Please think back to the single most emotionally provoking negative event that happened to you today…" I thought about how I felt about what I had experienced; I was preoccupied with what I thought and felt about what I had experienced". Rogers [70] measured both rumination (two items, "I have been dwelling on my mistakes, failures, or losses… I keep thinking about something negative that has happened") and suicide-specific rumination ("When I have had thoughts of suicide… I cannot escape these thoughts… I imagine the process of how I want to kill myself") in an adult community sample, and found lower within-person variance in the latter (20% compared to 44%).

Social problem-solving

Two studies measured social problem-solving; in both cases this was operationalised as a form of coping. Kuehn [63] reported 75% within-person variance in a mixed young adult (predominantly female) sample (N=60), measuring social problem-solving five times per day as a binary coping strategy. However, Nuij et al [42] reported 44% within-person variance in a clinical adult sample, assessing the construct once daily using the item "Today I felt capable of solving my problems".

Motivational moderators

Thoughts about the future

Future thinking was measured in 20 studies, most frequently operationalised as 'hopelessness' and measured once per day [21,31,33,76] or 3-10 times per day [22,25,26,36,42,43,44,47,51,54,69,70]. Studies generally measured 'hopelessness' with a single item, e.g., "I see only bad things ahead of me, not good things"[31,33,51]; asking participants to rate "how hopeless you feel [right now]" [21,25,26,44,54,70,76]; "are you discouraged about the future?" [47] or two items, e.g., "I look forward to the future… Things don't work out the way I want" [43], "My future seems dark to me… I might as well give up because there is nothing I can do about making things better for myself" [36]. The proportion of within-person variance reported differed substantially across studies measuring 'hopelessness', from 22% when assessed seven times per day in a (N=129) young adult community sample [26], to 63% when assessed five times per day in a similar (N=43) young adult community sample [54].

Other studies operationalised the construct as short-term future thinking (70% within-person variance in a large adolescent community sample, measured once each morning using the item "how much you are looking forward to today" [40]), future thinking (40% within-person variance in a clinical adult sample, measured once per day using the item "I'm looking forward to tomorrow" [42]), and a six-item reasons for living scale, including the item about plans participants looked forward to carrying out (37% within-person variance in a clinical adult sample, measured once per day [39]).

Perceived burdensomeness

Sixteen studies measured perceived burdensomeness in daily diary studies [30,31,33,41,65,76] or with three or more assessments per day [25,36,42,51,54,59,68-70,72]. Operationalisation of perceived burdensomeness was more homogenous across studies than for some of the other constructs. Most studies used a single item taken from the Interpersonal Needs Questionnaire (INQ), e.g., "I felt people in my life would be happier without me" or "I feel like a burden for others" [25,30,31,33,36,42,59,68-70,72,76]. Gerner et al., [54] used an item from the Interpersonal Hopelessness scale, "I believe I will always fail the people in my life".

Reported within-person variance ranged from 14% in a small clinical adult sample assessed four times per day (47% female) [42] to 60% in a clinical adolescent sample, assessed six times per day (68% female0 [30].)

Thwarted belongingness

Thwarted belongingness was the most frequently included IMV model construct across studies, with 24 studies measuring thwarted belongingness in a daily diary design [21,30,33,41,42,51,65,67] or with three or more assessments per day [20,25,27,36,51,52,54,55,57,59,64,68-70,72]. The construct was variously referred to as 'connectedness', 'closeness to others', 'social exclusion', 'loneliness' and 'thwarted belongingness'.

Most studies used a single item taken from the Interpersonal Needs Questionnaire (INQ), e.g., "I am close to other people"[31,33,42,51] or "I do not belong"[59,68,69] or 2-4 items from the same scale [21,36,55,67,69,70,76]. Two studies [30,55] distinguished between peer and family belongingness. Gerner et al., [54] used an item from the Interpersonal Hopelessness scale, "I

expect that people will never care about me", reporting 36% within-person variance in a community sample of young adults with recent suicidal ideation. Harper [57] measured loneliness in a community sample of young adults, using six items from the UCLA Loneliness Scale, reporting 50% within-person variance. López et al. [64] measured 'social rejection severity' in a community sample of young adults, using five items, e.g., "how excluded by a group have you felt… how alone have you felt?", and reported 41% within-person variance. Kleiman et al. [25], MacNeil et al. [65] and Mournet et al. [41] used a single-item measure of loneliness as a proxy for thwarted belongingness. Peters et al. [27] asked participants in an adult, clinical sample, "how close or connected to people do you feel right now?"

There was large variation in reported proportions of within-person variance. This ranged from 15% when measured as 'TB' (using four items from the INQ) or 'emotional loneliness' (and just 4% when measured as 'social loneliness', using a 6-item DeJong Gierveld Loneliness Scale) four times per day in a small, Hispanic/ Latino adult, predominantly female clinical sample [72] – suggesting more stable, trait-like constructs – to 83% and 90%, when measured as 'rejection' ("since the last prompt, have you felt rejected, excluded or left out?") and 'interpersonal stress' ("since the last prompt, have you felt insulted or criticized?"), six times per day in a community sample of predominantly African American young women [20], suggesting more unstable, state-like constructs.

Social support

Social support was operationalised differently across five studies [24,28,49,50,63]. In Kellerman et al [24], participants were asked (on a scale from 1 to 10) to report how supported they felt by staff in the psychiatric unit in which they were hospitalised (29% within-person variance), other patients on the unit (27%), family members (32%), and friends outside of the unit (19%). Kuehn [63] meanwhile included 'social support' as a coping strategy, with participants asked whether they had or had not used this (98% within-person variance). Coppersmith et al [50] asked participants to rate (on a scale from 1 to 5) how supported they felt from friends and family that day compared to a typical day (56% within-person variance in a sample of young adults reporting a past-year suicide attempt). Turner et al [28] reported a daily perceived support score (on a scale from 1 to 7) averaging ratings from items regarding romantic partners, parents, and peers if the participant reported having contact with each since the last assessment (44% within-person variance in a sample of young adults with NSSI thoughts or urges in the past 2 weeks). Christensen et al [49] averaged two items rating generic perceived emotional support ("At this moment... I have someone who understands my problems; …I feel there are people I can talk to if I'm upset") and reported 22% within-person variance in a community sample of young adults with past-month NSSI urges.

Volitional moderators

Impulsivity

Eight studies assessed impulsivity once per day [35,42,60], three or more times per day [38,45,48,63], or using event-contingent sampling [61].

Ammerman et al [45] used a single item measure ("to what extent do you feel impulsive right now") to assess impulsivity four times per day in a community sample of adults with Borderline Personality Disorder. Burke et al [48] measured impulsivity three times per day in a

community sample of (predominantly female) young adults using three items from the negative urgency subscale of the UPPS-P Impulsivity Scale (UPPS–P), "Right now… I feel like doing something I will later regret in order to make myself feel better now… it feels hard to resist acting on my feelings… it feels hard to keep my feelings under control." Kaurin et al [38] measured impulsivity six times per day in a sample of (predominantly female) adults with Borderline Personality Disorder, using items from the disinhibition domain of the Computerized Adaptive Assessment of Personality Disorder (CAT-PD), including irresponsibility ("I said/did things that I wish I hadn't"), non-planfulness ("I acted without thinking"), and risk taking ("I did something risky"). In a community sample of young adults, Kuehn [63] reported 25% within-person variance, using the item "When I am upset, I often act without thinking" (the wording was intended to assess momentary impulsivity but a 'global' measure was mistakenly implemented).

In a small, mostly male, community sample of adults in South Korea with chronic pain, Jeong et al [60] reported 59% within-person variance in impulsivity, measured once per day using the full 12-item negative urgency subscale of the UPPS-P Impulsivity Scale. Lucht et al [35] used a 4-item Momentary Impulsivity Scale to measure impulsivity once per day in an adult sample of psychiatric inpatients, reporting 64-78% within-person variance for each item. Nuij et al [42] measured impulsivity once per day with a single item from the UPPS-P scale, "today, I acted without thinking", reporting 25% within-person variance.

Kaurin et al [61] used an event-contingent sampling scheme to assess impulsivity during a social interaction with a single item. 46% within-person variance was reported in a mostly female sample of participants drawn from a mixture of clinical and community sources, most of whom had a diagnosis of Borderline Personality Disorder.

Mental imagery

Mental imagery was measured by three studies. Nuij et al [42] asked participants four times per day, "during the past hour, mental images related to suicide came to mind… (if yes) how intense were those images?", reporting 64% within-person variance in a small clinical sample.

Bayliss et al [46] asked adult participants in a community sample (four times per day) their agreement with the statement, "In the last 15 min I have had mental images of myself planning/preparing to harm myself or make a suicide attempt." 72% within-person variance was reported.

Cloos et al [19] measured different aspects of mental imagery once daily, in a small sample of young women with NSSI, most of whom were also diagnosed with a personality disorder. Participants were asked 20 items taken from the Self-harm Images Interview (SHII), measuring compellingness (79% within-person variance); vividness (71%); controllability (78%); nowness (71%); distress (67%); and comfort (56%).

Physical pain sensitivity

Six studies (reported in five papers) measured perceptions of pain or pain tolerance either daily [26,37,76], four times per day [46], seven times per day [26] or using an event-contingent design [71].

Krall et al [26] reported two studies. In the first, a community sample of young adults were

asked “over the course of the day, how much did you feel physical pain”, using a scale from 0 to 10, with 61% within-person variance reported. In the second, a largely female sample of outpatient adults with BPD were asked seven times per day “right now, how much do you feel physical pain”, using a scale from 0 to 5, with 76% within-person variance reported.

In a mixed sample of young people who reported NSSI in the past 2 weeks, Selby et al [71] used an event-contingent design. If participants reported having engaged in NSSI at any assessment (up to 5 times per day), they were asked to rate their experience of physical pain before the NSSI episode (using a 0 to 10 scale). For pre-NSSI pain, 74% within-person variance was reported.

Bayliss et al [46] asked adult participants in a community sample their agreement with the statement, “In the last 15 min I could handle pain more easily than other people” and reported 29% within-person variance, conceptualising this item as ‘dispositional capability for suicide’.

Perceived pain tolerance was measured once daily by Spangenberg et al [37] using the item “Today I would have taken a lot of (physical) pain”, with 48% within-person variance reported in an adult sample of psychiatric inpatients with a current unipolar depressive disorder. Wolford-Clevenger et al [76] measured daily perceived pain tolerance in a (predominantly White, predominantly female) community sample of young adults using a single item, but combined this with an item measuring daily fearlessness about death to produce a measure of ‘capability for suicide’ (no ICC available).

Fearlessness about death

Four studies measured fearlessness about death [37,46,70, see also [76], above). Fearlessness about death was measured once daily by Spangenberg et al [37] using the item “Today I was not at all afraid to die”, with 53% within-person variance reported in an adult sample of psychiatric inpatients with a current unipolar depressive disorder. Bayliss et al [46] asked adult participants in a community sample their agreement with the statement, “In the last 15 min I have not been afraid of death” and reported 31% within-person variance, conceptualising this item as ‘acquired capability for suicide’.

Rogers [70] used the items “I am not at all afraid to die” and “The pain involved in dying frightens me” from the Acquired Capability for Suicide Scale—Fearlessness about Death (ACSS-FAD), using a five point scale from “not at all like me” to “very much like me”. Twelve percent within-person variance was reported when assessed six times per day in a community sample of adults with current suicidal ideation.

Access to means

Only two studies [46,70] measured access to means, operationalised as ‘physical distance to methods’ [70] or ‘practical capability for suicide’ [46]. In an adult community sample with current suicidal ideation, participants were asked six times per day to indicate on a scale from 0 to 100 how physically close they were to the primary suicide method they were considering (from a list of 16 methods), with 34% within-person variance reported. Bayliss et al [46] asked adult participants in a community sample their agreement with the statement, “In the last 15 min I could access the method/means I would use to kill myself” and reported 45% within-person variance, conceptualising this item as ‘practical capability for suicide’.

What is the relationship between the different IMV constructs and suicidal and non-suicidal thoughts and behaviours in daily life?

39/58 (67%) papers tested associations between IMV constructs and SHTBs in daily life; eight of these tested concurrent associations only; 16 tested lagged associations only; 15 studies tested both concurrent and lagged associations. Where lagged associations were reported, lags varied from a few hours to a day. Studies varied in which SHTBs were tested, including suicidal ideation, suicidal urge intensity, NSSI, NSSI urge, and suicidal behaviours.

Table 5. Summary of papers reporting associations between IMV constructs and SHTBs in daily life

Authors	IMV Constructs measured	SHTBs measured	Concurrent associations	Lagged associations
Aadahl et al., 2021 [43]	Defeat	Suicidal ideation	ß =0.21 (95%CI= 0.11, 0.31), P<.001	-
	Hopelessness		ß =0.18 (95%CI= 0.08, 0.27), P<.001	
Al-Dajani & Czyz, 2022 [30]	Perceived burdensomeness	Suicidal urge intensity	b=0.45, SE=0.05, P<.000	b=0.14, SE=0.05, P=.008
	Peer belongingness		b=-0.12, SE= 0.03, P<.000	b=-0.04, SE=0.03, P=.139
	Family belongingness		b=-0.14, SE=0.03, P<.000	b=0.02, SE=0.04, P=.677
Al-Dajani et al., 2022 [32]	Coping	Suicidal urge intensity	-	b=-0.02, SE=0.02, P=.238
Ammerman et al., 2017 [45]	Impulsivity	NSSI	b=0.62, SE=0.30, P<.05	-
Baryshnikov et al., 2024 [22]	Hopelessness	Suicidality	-	ß=0.71 (95%CI= 0.62, 0.81)
Bayliss et al., 2024 [46]	Mental imagery	Suicidal ideation	OR=5.15 (95%CI= 4.04, 6.57), P<.001	OR=1.38 (95%CI= 1.08, 1.77), P<.01
	Fearlessness about death		OR=1.29 (95%CI= 0.95, 1.75), P=.11	OR=1.22 (95%CI= 0.89, 1.68), P=.22
	Pain sensitivity		OR=0.82 (95%CI= 0.61, 1.10), P=.19	OR=0.93 (95%CI= 0.68, 1.26), P=.71
	Access to means		OR=0.82 (95%CI= 0.63, 1.07), P=.14	OR=0.92 (95%CI= 0.71, 1.19), P=.42
Ben-Zeev et al., 2012 [47]	Helplessness	Suicidal ideation	-	b=0.033, P=.092
	Hopelessness			b =0.006, P=.643
Burke et al., 2021 [48]	Urgency (Impulsivity)	NSSI urge	-	b=1.39 (95%CI= 0.78, 2.00), P<.001
Christensen et al., 2023 [49]	Social support	NSSI urge	-	OR=0.49 (95%CI= 0.32, 0.78), P=.002
Coppersmith et al., 2019 [50]	Social support	Suicidal ideation	b=-0.41 (95%CI= -0.52, -0.30), P<.001	b=0.00 (95%CI= -0.04, 0.05), P=.859
Czyz et al., 2019a [33]	Hopelessness	Suicidal ideation frequency;	SI frequency: b=0.37, ß=0.26, P<.001; SI duration: b=-0.37, ß	SI frequency: b=0.01, ß=0.01, P=.870; SI duration: b=-0.01, ß =-

Authors	IMV Constructs measured	SHTBs measured	Concurrent associations	Lagged associations
		duration, urge severity	=0.22, P<.001; SI urge severity: b=0.46, ß =0.20, P<.001	0.01, P=.912; SI urge severity: b=0.10, ß =0.04, P=.468
	Perceived burdensomeness		SI frequency: b=0.11, ß=0.15, P=.003; SI duration: b=0.16, ß=0.19, P<.001; SI urge severity: b=0.25, ß=0.21, P<.001	SI frequency: b=0.06, ß=0.08, P=.158; SI duration: b=0.10, ß=0.12, P=.038; SI urge severity: b=0.13, ß=0.12, P=.053
	Connectedness		SI frequency: b=-0.16, ß=-0.19, P<.001; SI duration: b=-0.18, ß=-0.18, P<.001; SI urge severity: b=-0.27, ß=-0.20, P<.001	SI frequency: b=-0.06, ß=-0.07, P=.174; SI duration: b=-0.07, ß=-0.07, P=.162; SI urge severity: b=-0.09, ß=-0.07, P=.213
Czyz et al., 2019b [34]	Engagement in coping strategies (number of strategies)	NSSI	b=-0.08, SE=0.18, P=.671	-
Defayette et al., 2023 [52]	Thwarted belongingness (social exclusion)	Suicidal ideation	b=0.04 (95%CI= −0.001, 0.07), P=.059, d=0.58	b=−0.003 (95%CI= -0.02, 0.01), P=.66
Gerner et al., 2023 [54]	Thwarted belongingness	Suicidal ideation	b=0.15 (95%CI= 0.11, 0.19), P<.001	b=0.06 (95%CI= 0.02, 0.11), P<.01
	Perceived burdensomeness		b=0.08 (95%CI= 0.04, 0.12), P<.001	b=0.03 (95%CI= -0.01, 0.07), P>0.05
	Hopelessness		b=0.25 (95%CI= 0.22, 0.28), P<.001	b=0.14 (95%CI= 0.09, 0.20), P<.001
Glenn et al., 2022 [55]	Thwarted belongingness	Suicidal thoughts	-	TB (FAMILY): ß =0.26 (P<.05) TB (FRIENDS): ß =0.31 (P<.05)
Hallard et al., 2021 [56]	Rumination	Suicidal ideation	-	ß =.20 (95%CI= 0.12, 0.27), P<.001
Hallensleben et al., 2019 [36]	Hopelessness	Suicidal ideation	b=0.41 (95%CI= 0.35, 0.47), P<.001	b=0.08 (95%CI= 0.02, 0.18), P=.007
	Perceived burdensomeness		b=0.09 (95%CI= 0.05, 0.13), P<.001	b=0.09 (95%CI= 0.03, 0.15), P=.001
	Thwarted belongingness		b=0.04 (95%CI= 0.00, 0.08), P=.014	b=0.00 (95%CI= -0.03, 0.04), P=.99
Hughes et al., 2019 [58]	Rumination (repetitive negative thoughts)	NSSI thoughts and behaviours	-	NSSI thought intensity rating: ß=0.01, t=6.75, P<.001 NSSI behaviour frequency: ß =0.03, t=7.73, P<.001
Jacobucci et al., 2023 [59]	Perceived burdensomeness	Suicidal ideation	-	ß=0.16 (95%CI= 0.01, 0.32)
	Thwarted belongingness		-	ß=0.18 (95%CI= 0.02, 0.34)
Kaurin et al., 2022 [61]	Impulsivity (during a social interaction)	Suicidal ideation	b=.01 (95%CI= −0.00, 0.01); ß= .068	
Kaurin et al., 2023 [38]	Impulsivity	Suicidal ideation	b=0.03 (95%CI= 0.01, 0.05)	-
Kellerman et	Social support	NSSI	-	AOR=0.67 (95%CI= 0.50,

Authors	IMV Constructs measured	SHTBs measured	Concurrent associations	Lagged associations
al., 2022 [24]	from staff			0.90), P=.007
	Social support from other patients			AOR=0.83 (95%CI= 0.61, 1.12), P=.231
	Social support from family members			AOR=0.68 (95%CI= 0.52, 0.89), P=.005
	Social support from friends			AOR=1.02 (95%CI= 0.77-1.36), P=.866
Kleiman et al., 2017 [25]	Hopelessness	Suicidal ideation	b=0.70, (95%CI= 0.62, 0.78), SE=0.04, P<.001	(controlling for SI at T) b=0.07, (95%CI= -0.05, 0.20), SE=0.07, P=.265
	Loneliness		b=0.26, (95%CI= 0.19, 0.33), SE=0.04, P<.001	(controlling for SI at T) b=-0.04, (95%CI= -0.14, 0.07), SE=0.05, P=.513
	Perceived burdensomeness		b=0.33, (95%CI=0.25, 0.40), SE=0.04, P<.001	(controlling for SI at T) b=0.03, (95%CI= -0.08, 0.14), SE=0.06, P=.615
	Hopelessness	Suicidal ideation	b=0.92, (95%CI= 0.76, 1.08), SE=0.08, P<.001	(controlling for SI at T) b=-0.03, (95%CI=-0.24, 0.19), SE=0.11, P=.806
	Loneliness		b=0.16, (95%CI= 0.01, 0.31), SE=0.08, P=.041	(controlling for SI at T) b=-0.10, (95%CI= -0.29, 0.09), SE=0.10, P=.316
Kudinova et al., 2023 [62]	Humiliation	NSSI	-	b=0.19, P>0.05
Kuehn, 2021 [63]	Coping	NSSI and suicidal thoughts	Suicidal thoughts: OR= 1.31 (95%CI=1.15, 1.49)	Suicidal thoughts: OR= 1.31 (95%CI= 0.93, 1.84)
	Impulsivity		NSSI: OR = 1.12 (95%CI= 0.97, 1.32) Suicidal thoughts: OR = 0.98 (95%CI= 0.80, 1.19)	-
	Humiliation		-	NSSI: OR = 0.99 (95%CI= 0.83, 1.16) Suicidal thoughts: OR = 1.19 (95%CI= 1.05, 1.32)
Lucht et al., 2022 [35]	Impulsivity	Suicidal ideation	ß=0.12 95%CI= -0.10, 0.35), P=.271	
Mournet et al., 2022 [41]	Loneliness	Suicidal ideation	OR=1.355 (95%CI= 1.22, 1.50), P<.001	OR=1.248 (95%CI= 1.12, 1.39), P<.001
	Perceived burdensomeness		OR=1.289 (95%CI= 1.19, 1.40), P<.001	OR=1.103 (95%CI= 1.01, 1.21), P=.029
Peters et al., 2022 [27]	Social connectedness (i.e., thwarted belongingness)	Suicidality	Correlation = 0.09 (P>0.05)	-
Rogers, 2023 [70]	Rumination	Suicidal behaviours	OR=3.53 (95%CI=0.82, 15.30), P=.091	OR=2.38 (95%CI=0.17, 32.44), P=.515
	Suicide-Specific Rumination		OR=3.85 (95%CI=0.96, 15.46), P=.058	OR=2.26 (95%CI=0.21, 24.00), P=.499
	Thwarted belongingness		OR=1.87 (95%CI=0.35, 9.93), P=.461	OR=1.85 (95%CI=0.08, 40.39), P=.695

Authors	IMV Constructs measured	SHTBs measured	Concurrent associations	Lagged associations
	Perceived burdensomeness		OR=3.28 (95%CI=0.76, 14.09), P=.111	OR=2.01 (95%CI=0.15, 26.46), P=.594
	Hopelessness		OR=3.99 (95%CI=1.00, 15.89), P=.050	OR=2.31 (95%CI=0.24, 22.58), P=.472
	Fearlessness about death		OR=1.81 (95%CI=0.56, 5.87), P=.321	OR=1.61 (95%CI=0.20, 14.08), P=.636
	Access to means (physical)		OR=1.37 (95%CI=0.36, 5.25), P=.642	OR=1.41 (95%CI=0.17, 11.59), P=.748
	Access to means (psychological)		OR=2.73 (95%CI=1.04, 7.14), P=.042	OR=2.12 (95%CI=0.38, 11.72), P=.388
Stanley et al., 2021 [73]	Coping strategies (engagement and effectiveness)	Suicidal ideation	-	Distraction/Positive Activity-Based CoPing Factor: b=-0.08, P<.001 Mindfulness-Oriented CoPing Factor: b=-0.03, P=.03
Tsypes et al., 2022 [39]	Reasons for living (future thoughts)	Suicidal ideation	ß =-0.13, (95%CI= -0.18, -0.08)	ß=-0.05, (95%CI= -0.09, -0.01)
Turner et al., 2016 [28]	Perceived social support	NSSI	-	When NSSI has been disclosed, OR=6.87 (95%CI= 3.47, 13.58), t=5.66, P<.001 When NSSI has not been revealed, OR=0.73 (95%CI= 0.34, 1.54), t=-0.86, P>0.05 No NSSI, OR=1.05 (95%CI= 0.94, 1.17), t=0.83, P>0.05
Turner et al., 2019 [29]	Problem-focused coping	Intense NSSI urges	OR=0.92, (95%CI= 0.83, 1.03)	OR=0.91, (95%CI= 0.79, 1.04)
	Avoidant coping		OR=1.15, (95%CI= 1.03, 1.29)	OR=0.96, (95%CI= 0.84, 1.10)
	Perceived social support		OR=0.87, (95%CI= 0.78, 0.97)	OR=0.92, (95%CI= 0.87, 0.98) (lagged, same day) OR=0.98, (95%CI= 0.86-1.11) (lagged, next day)
van Ballegooijen et al., 2022 [75]	Entrapment	Suicidal ideation	Corr=0.27 (P<.001)	Lag 1 (2-4h): Corr=0.10 (P=.01) Lag 2 (5-7h) Corr=0.10 (P=.03) Lag 3 (8-10h) Corr=0.11 (P=.02) Lag 4 (11-13h) Corr=0.12 (P=.04)
	Defeat		Corr=0.15 (P<.001)	Lag 1 (2-4h): Corr=0.02 (P=.64) Lag 2 (5-7h) Corr=-0.02 (P=.62)

Authors	IMV Constructs measured	SHTBs measured	Concurrent associations	Lagged associations
				Lag 3 (8-10h) Corr=0.02 (P=.70) Lag 4 (11-13h) Corr=0.04 (P=.50)
Victor et al., 2019 [20]	Criticism (thwarted belongingness)	NSSI urges, suicidal urges	-	NSSI urges: ß =0.02, (95%CI= -0.07, 0.11) Suicidal urges: ß =0.10, (95%CI= -0.01, 0.21)
	Rejection (thwarted belongingness)			NSSI urges: ß =0.20, (95%CI= 0.11, 0.27) Suicidal urges: ß =0.07, (95%CI= -0.05, 0.18)
Wolford-Clevenger et al., 2020 [76]	Thwarted belongingness	Suicidal ideation, suicidal behaviour	-	Passive SI: ß=0.03, SE=0.004, t=6.91, P<.001 Active SI: B=0.003, SE=0.002, t=1.95, P=.05
	Perceived burdensomeness			Passive SI: ß=0.04, SE=0.005, t=7.69, P<.001 Active SI: B=0.005, SE=0.002, t=2.57, P=.01
	Hopelessness (future thoughts)			Active SI: ß=0.02, SE=0.003, t=5.29, P<.001
	Pain tolerance			Suicidal behaviour: ß=0.0001, SE=0.0002, t=0.30, P=.76
	Fearlessness about death			Suicidal behaviour: ß=0.0001, SE=0.0002, t=0.46, P=.64
Wolford-Clevenger et al., 2021 [21]	Hopelessness (future thoughts)	Suicidal ideation	-	b=0.26, SE=0.07, t=3.48, P<.001

ß= standardized coefficient; b=unstandardized coefficient

Motivational phase

Two papers measured associations between defeat and SHTBs; one of these tested both

concurrent and lagged associations [75] and one concurrent only [43]. Both papers reported evidence for a concurrent positive relationship between defeat and SHTBs, but there was no evidence for a lagged association [75].

One paper reported associations between entrapment and SHTBs. Van Ballegooijen et al [75] reported a significant positive association between entrapment and suicidal ideation both concurrently and lagged.

Two papers tested lagged associations between shame and NSSI [62] or suicidal thoughts [63]. Shame predicted increased suicidal thoughts but did not predict NSSI.

Threat-to-self moderators

Three papers measured associations between rumination and SHTBs; one of these tested both concurrent and lagged associations [70] and two lagged only [56,58]. A significant association between rumination and suicidal ideation or NSSI thoughts and behaviours was found in lagged models [56,58]. However, Rogers [70] found no evidence of concurrent or lagged associations between rumination or suicide-specific rumination and suicidal behaviours.

Six papers measured associations between different aspects of coping and SHTBs. One paper reported concurrent associations only; two papers lagged only and three both. One paper found evidence only of increased odds of NSSI urges for those reporting concurrent avoidant coping [29] and one reported negative lagged associations between engagement with positive activity-based coping techniques (distraction) and suicidal ideation [73]. Kuehn [63] found that increased use of disengagement coping strategies predicted increased suicidal thoughts in concurrent but not lagged models.

Motivational moderators

Fifteen papers measured associations between thwarted belongingness and SHTBs; 9 of these measured both concurrent and lagged associations, one concurrent only and five lagged only. Seven papers found evidence of concurrent associations between thwarted belongingness and SHTBs, and six found evidence of lagged associations (eight studies found no evidence of lagged associations). Papers varied in conceptualisation of thwarted belongingness, with some measuring belongingness to family and friends separately [30,55], one paper measuring social connectedness [27], one measuring rejection [20], one social exclusion [52] and one loneliness [41]. Wolford-Clevenger et al., [76] found small but significant lagged associations with both passive and active suicidal ideation. Victor et al. [20] found evidence of lagged associations with NSSI but not suicidal urges.

Nine papers measured associations between perceived burdensomeness and SHTB, with all but two measuring both concurrent and lagged associations. Perceived burdensomeness predicted suicidal urge intensity [30] and suicidal ideation [36,41,76] in both concurrent and lagged associations. In Czyz et al [33], perceived burdensomeness was associated with suicidal ideation frequency, duration and urge severity in concurrent models but only with duration in lagged models. In Kleiman et al [25] and Gerner et al [54], perceived burdensomeness predicted suicidal ideation in concurrent but not lagged models. Jacobucci et al [59] reported evidence of an association between perceived burdensomeness and suicidal ideation in lagged models and Rogers [70] found no evidence of concurrent or lagged associations with suicidal

behaviours.

Thirteen papers measured associations between future thoughts (generally conceptualised as 'hopelessness') and SHTBs; eight of these tested both concurrent and lagged associations. Hopelessness predicted suicidal ideation in both concurrent and lagged models [21,22,30,36,54,76]. However, no lagged association was found between hopelessness and suicidal ideation in four studies [25,33,47,70].

Eight papers measured associations between perceived social support and SHTBs, with considerable variation in how social support was conceptualised. Turner et al, [29] reported negative associations between perceived social support and NSSI urges in concurrent and lagged, same day models, but not lagged, next day models. In Turner et al., [28], perceived social support following disclosure of NSSI positively predicted subsequent NSSI. Social support predicted a lagged decrease in NSSI urge in Christensen et al., [49]. In a daily diary study of hospitalized adolescents, Kellerman et al [24] found decreased odds of NSSI in lagged models for social support from staff and family members but not other patients or friends. Coppersmith et al. [50] found negative concurrent – but not lagged – associations between social support and suicidal ideation.

Volitional moderators

Six papers measured associations between impulsivity and SHTBs; four of these were concurrent only and one lagged only. Ammerman et al., [45] and Kaurin et al [38] found evidence of a positive concurrent association between impulsivity and NSSI or suicidal ideation (respectively), and Burke et al., [48] found evidence of a positive lagged association between impulsivity (conceptualised as urgency) and NSSI urges. However, three papers [35,61,63] found no evidence of a concurrent association between impulsivity (or impulsivity during social interactions [61]) and suicidal ideation [35,61] or NSSI [63].

Two papers measured – and did not find evidence of – either concurrent or lagged associations between pain sensitivity and fearlessness about death, and suicidal behaviour [76] or suicidal ideation [46].

Rogers [70] found evidence of a concurrent but not lagged association between 'psychological access to means' and suicidal behaviours, but no evidence of associations for fearlessness about death or physical access to means. Bayliss et al. [46] did not find evidence of either concurrent or lagged associations between access to means and suicidal ideation.

One paper [46] reported both concurrent and lagged associations between mental imagery and suicidal ideation.

Quality of evidence

As there are currently no gold standards for conducting EMA research, we assessed studies against quality criteria for reporting EMA studies. The reporting quality of studies varied considerably, though most were fully compliant with only a small minority of the quality criteria. Criteria with most compliance included referencing EMA (or equivalent) in the title and key words; briefly introducing and justifying the use of EMA; reporting the full text of items

and response options; and describing data preparation and data analysis in detail (see Table 6). Criteria with poorest compliance included justification of sample size; justification of the sample design (e.g., random, event-based) and number of assessments; describing any design feature to address potential sources of bias or participant burden (e.g., EMA questions appearing in different orders); reporting the number of EMA prompts that were planned to be delivered and the number that were actually received by participants (and any reasons for why prompts were not sent out); reporting whether EMA compliance is related to demographic or time-varying variables.

Table 6. Quality assessment summary[a]

Section	**Reporting criteria**	**Number of papers with full compliance (%)**
Title/abstract	Include EMA (or equivalent) in title and key words	34 (58%)
Introduction	Briefly introduce the concept of EMA and reasons for using	41 (69%)
Methods	Detail training of participants for EMA protocol	19 (32%)
	Describe procedures used to enhance compliance and participation	35 (60%)
	Describe technology used (hardware and software)	29 (49%)
	Justify sample size	10 (17%)
	Explain rationale for sampling density (assessments per day) and scheduling	14 (24%)
	Report full text of items, rating timeframes, response options/scaling	35 (60%)
	Report psychometric properties and origins of items	15 (25%)
	Preparation for data analyses: describe centering of predictor variables and at what level; report covariates included in the models	36 (62%)
	Describe levels of analysis (momentary, day, person); describe modeling and statistical software used	44 (76%)
Results	Describe the final data set: number of reports (total; person average; group average), days in study and retention rates, rates of delayed or suspended responding	18 (31%)
	Report the amount of time from prompt signal to answering of prompt	0 (0%)
	Report compliance rate both by monitoring days and waves, if applicable. Indicate reasons for noncompliance, if known	8 (14%)
	Report whether EMA compliance is related to demographic or time-varying	9 (15%)

	variables	
Discussion	Discuss EMA specific limitations of the study (e.g., reactivity, use of technology, use of unvalidated measures, software/hardware limitations, compliance)	19 (32%)
Transparency and reproducibility	A locked version of the hypotheses/research questions/analysis plan/methods was registered prior to data access and analysis	2 (3%)
	Materials (e.g. full ESM questionnaire, any other questionnaires, instructions to participants) are available	1 (2%)
	Code used to conduct analysis is available online	6 (10%)
	Data are publicly available or are stored in a restricted access repository	4 (7%)

[a] full criteria available in the appendix

No study fully reported the amount of time from prompt signal to answering of prompt. There was generally low use of open science practices, with only 2/58 papers explicitly pre-registering hypotheses and 1/58 publishing study materials. 8/58 papers made their analytic code either fully or partially publicly available, and 4/58 papers made their data open access (other studies either reported data being available on request or did not include a data availability statement). It is, however, worth noting that such open science practices are recent responses to the replication crisis and would not be expected in papers published before 2016. A detailed summary table of quality assessment data is available in supplementary material.

Discussion

Principal Results

There has been a recent proliferation in EMA studies of SHTB. We set out to summarise the state of the EMA literature pertaining to the constructs described within the IMV model. We selected the IMV model because it is one of the leading theoretical frameworks for understanding suicidal behaviour, which incorporates the majority of constructs contained within the other theoretical models such as the Interpersonal Theory of Suicide [77].

Fifty-eight papers were included in this review. The IMV constructs measured most frequently were thwarted belongingness (24/58, 41% studies), thoughts about the future (20/58, 34% studies) and perceived burdensomeness (16/58, 27% studies). The higher number of studies focusing on thwarted belongingness and perceived burdensomeness likely reflect the key role of these constructs within the Interpersonal Theory of Suicide [77]. The least frequently measured constructs were humiliation, social problem-solving, mental imagery, physical pain sensitivity, and fearlessness about death. No included papers measured memory biases, goals, norms, or resilience using EMA.

A majority of included papers were assessed to be fully compliant with a number of reporting quality criteria, including referencing EMA (or equivalent) in the title and key words; briefly introducing and justifying the use of EMA; reporting the full text of items and response options; and describing data preparation and data analysis in detail. However, there was poor compliance

with over half the 25 criteria against which the reporting quality of included papers were assessed.

Results predominantly showed at least moderate within-person variability across all IMV constructs included in this review, whether assessed once or multiple times daily, highlighting the utility of intensive longitudinal study designs. Although some constructs from the IMV model were well researched, namely thwarted belongingness, future thoughts and perceived burdensomeness, less – or no – information was available for other concepts such as defeat, humiliation, social problem-solving, memory biases, resilience, access to means, fearlessness about death and exposure to suicide.

We did not find evidence of patterns in within-person variability as a function of whether the samples were drawn from community or clinical populations, or on the number of daily assessments. It is worth noting that most community samples were 'high-risk' populations with a recent history of SHTBs, who may not have differed substantially from clinical populations. Our ability to make comparisons between sampling schemes was also limited by a quarter of included studies not reporting within-person variance.

We found evidence across several studies of concurrent associations between IMV constructs and SHTBs, and some evidence of lagged associations between entrapment, rumination, future thoughts (or 'hopelessness'), perceived burdensomeness, impulsivity, thwarted belongingness, rumination and SHTBs. However, not all findings were consistent, possibly due to heterogeneity across the studies included in our review, in terms of populations studied, study design, operationalisation of both IMV constructs and SHTBs, and analytical approach. Whilst the cross-lagged panel model (CLPM) – used in some studies included in this review – is a popular tool in this and other fields, it may often not be the correct tool [78]. The importance of disaggregation when analysing EMA data to study within-person processes has been recognised and we are likely to see a continued transition to alternative, superior models, such as the random intercepts cross-lagged panel model (RI-CLPM). Failure to disaggregate within- and between-person variability is likely to lead to much higher lagged effects, particularly when studying stable, trait-like constructs. Our review shows there is scope for further investigation of proximal relationships between IMV constructs and SHTBs, particularly with regard to the motivational phase (defeat, humiliation and entrapment), threat-to-self moderators (social problem-solving, coping, memory biases, rumination) and volitional moderators (access to means, planning, impulsivity, physical pain sensitivity, fearlessness about death, imagery) within the model.

Assessment of the reporting quality of included studies suggested little routine use of open science principles – even in studies published since the replication crisis – reflecting the situation in the suicide research field more broadly [79]. Open science practices can improve the transparency, reproducibility, and replicability of scientific research [80]. We recommend that future EMA studies in the field consider pre-registration of hypotheses using the registration template for ESM research [79], and making available data, study materials and analytic code. Other key areas for improvement include justifying sample size, e.g., by reporting power analyses [81], sample design and the number of assessments used in a study, consideration of potential sources of bias or participant burden when designing EMA studies, and more comprehensive reporting of EMA compliance, including whether compliance is related to demographic or time-varying variables. This is crucial as aspects of EMA study design, such as long questionnaire length, are associated with increased burden, which affects the quality and quantity of EMA data [82].

Comparison with Prior Work

Our findings are broadly consistent with a recent systematic review of interpersonal processes and SHTBs in daily life [15], in which the authors highlight a lack of consistency in operationalisation of key constructs [13]. Efforts to improve transparency and harmonization of measurement include the ESM Item Repository [83], a searchable and public bank of items used in previous EMA studies, to which researchers can contribute their items.

Also consistent with previous reviews of the EMA SHTB literature [8,11,13,15], our findings indicate that EMA is a useful methodological approach to providing rich information about individuals' experiences of both IMV constructs and SHTBs in daily life. The same reviews have similarly noted the challenges to synthesis of findings due to heterogeneity in study design.

Strengths and limitations

Our review is the first to comprehensively synthesise the EMA literature on key constructs within the IMV model of suicide [3], including a narrative synthesis of both within-person variance of constructs, and their associations with SHTBs. It also adds to the findings from a recent systematic review of cross-sectional, case-control and longitudinal studies of the IMV model [5]. The broad scope of the review, in addition to methodological differences between studies prohibited a meta-analysis of findings. Future meta-analyses of variability within key IMV constructs may be feasible with more focused and specific inclusion criteria.

We conducted a thorough search of five databases, as well as citation searching, and used blinded double screening of abstracts against inclusion and exclusion criteria. We made extra efforts to include unpublished research by searching the PMC Europe database of preprints, therefore limiting the effect of possible publication bias on our results. An additional search within three months of submission for publication ensures that the review is as up-to-date as possible, as the EMA literature is prolific. We limited the search to papers in English language following consultation with colleagues, but acknowledge that this may have resulted in the loss of papers published in other languages.

Implications

Our findings suggest that EMA methods can be valuable in providing real-time information about key risk factors for SHTBs, as outlined in the IMV model [3]. EMA may also be of potential value within clinical support settings, providing clinicians with detailed insight into an individual's mental states and daily experiences of constructs described by the IMV model. Enhanced understanding of these risk factors in daily life may inform individualised interventions.

Future research

Further research is needed to better understand how some IMV constructs – including defeat, humiliation, social problem-solving, memory biases, resilience, access to means, fearlessness about death and exposure to suicide – vary in daily life, over what timescale, and whether there are proximal associations with SHTB. Many of the factors we investigated are conceptualised by the IMV model as moderators, however all studies in this review focused on individual relationships with SHTB. Further research is needed to explore moderation to specifically test the hypotheses

outlined in the IMV model.

We found large heterogeneity in populations sampled, including gender (for example two studies sampled only female participants [19,20] and one study sampled only transgender or gender diverse participants [21]), ethnicity (for example one study sampled only Hispanic or Latino adults [72]) and mental health status (some studies sampled only those with a diagnosed mental health disorder or with recent experience of SHTBs). While beyond the scope of this review, future EMA studies or reviews might consider socio-demographic differences in within-person variability of IMV constructs.

Conclusions

Overall, the existing evidence suggests there is within-person fluctuation in the IMV constructs included in this review, suggesting it is possible to study them using EMA methods. We also found evidence of concurrent relationships between almost all constructs and SHTBs in daily life, with some evidence that entrapment, shame, rumination, thwarted belongingness, hopelessness, social support and impulsivity are additionally associated with SHTBs in lagged (i.e. longitudinal) relationships. Whilst EMA methods show promise in providing valuable information about individuals' experiences of both IMV constructs and SHTBs in daily life, there is currently large methodological heterogeneity and paucity of quality in studies using this approach. Efforts to enhance the quality of reporting and to advance transparency and harmonization within the field may improve future synthesis of findings.

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Conflicts of Interest

None declared.

Abbreviations

EMA: Ecological momentary assessment
ICC: Intraclass coefficient
IMV: Integrated Motivational-Volitional model of suicide

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Supplementary Files

Multimedia Appendixes

Table S1 Proportion of within-person variance reported for each IMV construct, by sample type and number of assessments per day.
URL: http://asset.jmir.pub/assets/b8c81ad01db19e79774491809fe9102c.docx

Reporting Quality Assessment Summary.
URL: http://asset.jmir.pub/assets/f3c3efb41954f324abe1232a9e3de4a1.xlsx