Dynamics of despair: examining suicidal ideation using real-time methodologies
Kivelä, L.M.M.

This dissertation examines the temporal dynamics of suicidal ideation in daily life using real-time assessment methods, including actigraphy and ecological momentary assessment (EMA). Suicidal ideation can be highly variable, and increased insight into these fluctuations can aid us in understanding how an individual may transition into moments of heightened suicidal ideation in real-time. Further, it has been proposed that variability in itself may serve as a phenotypic marker for increased suicide risk. Hence, obtaining a better understanding of the correlates and predictors of this variability is important for improved risk detection.

DYNAMICS OF DESPAIR

LIIA M.M. KIVELÄ
Universiteit Leiden

DYNAMICS OF DESPAIR | LIIA M.M. KIVELÄ

LIIA M.M. KIVELÄ

DYNAMICS OF DESPAIR

Examining Suicidal Ideation Using Real-Time Methodologies

Dynamics of Despair:

Examining Suicidal Ideation
Using Real-Time Methodologies

Liia Matilda Maria Kivelä

COVER DESIGN by Natasha Sotti
Printed by Gildeprint

ISBN: 978-94-6496-270-3

Dynamics of Despair:

Examining Suicidal Ideation
Using Real-Time Methodologies

Proefschrift

ter verkrijging van
de graad van doctor aan de Universiteit Leiden,
op gezag van rector magnificus prof.dr.ir. H. Bijl,
volgens besluit van het college voor promoties
te verdedigen op donderdag 9 januari 2025
klokke 11:30 uur

door

Liia Matilda Maria Kivelä
geboren te Espoo, Finland
in 1992

Promotor(es):
Dr. N. Antypa
Prof.dr. A.J.W. van der Does

Promotiecommissie:
Prof.dr. H.E. Hulst (Wetenschappelijk Directeur Psychologie/voorzitter)
Prof.dr. B.M. Elzinga
Prof.dr. A.M. van Hemert
Dr. D.P. de Beurs (Universiteit van Amsterdam)
Prof.dr. R. Gilissen

Funding for the research reported in this dissertation was provided by the Netherlands Organisation for Scientific Research (N.W.O) Research Talent Grant (406.18.521). N.W.O. had no role in the study design, collection, analysis or interpretation of the data, or writing of the dissertation.

“A hundred times I was upon the point
of killing myself; but still I loved life.
This ridiculous foible is perhaps one
of our most fatal characteristics;
for is there anything more absurd than
to wish to carry continually a burden
which one can always throw down?
to detest existence and yet
to cling to one’s existence?”

M. DE VOLTAIRE

Candide, or Optimism (1759)

Table of Contents

CHAPTER 01 Introduction

CHAPTER 02 Literature Review
Don’t Miss the Moment: A Systematic Review of Ecological Momentary Assessment in Suicide Research

CHAPTER 03 Application
Examination of Acceptability, Feasibility, and Iatrogenic Effects of Ecological Momentary Assessment of Suicidal Ideation

CHAPTER 04 Emotion & Cognition
Examining Contemporaneous and Temporal Associations of Real-Time Suicidal Ideation Using Network Analysis

CHAPTER 05 Sleep
Sleep, Hopelessness, and Suicidal ideation: An Ecological Momentary Assessment and Actigraphy Study

CHAPTER 06 Suicide Attempt
Digital Phenotypes of Real-Time Suicidal Ideation: Correlates and Consequences

CHAPTER 07 Discussion

SUMMARY

DUTCH SUMMARY (NEDERLANDSE SAMENVATTING)

LIST OF PUBLICATIONS

CURRICULUM VITAE

ACKNOWLEDGEMENTS

CHAPTER 01:

Introduction

Introduction

In past times, the act of suicide was often seen as a societal or political statement, unrelated to any internal struggles of the mind. In ancient Rome, *Romana mors*, or "Roman death", gave people the chance to choose between an honorable and dishonorable death. This path was chosen by army officials facing defeat, aristocrats faced with the prospect of public humiliation, and political opponents facing death or imprisonment (Hill, 2004). How suicide was viewed among commoners is unknown. In this context, suicide was seen as a direct, rational response to external events, and an act that was rarely executed *"while the balance of mind was disturbed"* (Hill, 2004, p. 2). As such, the perception at the time was that the contemplation of suicide was marked by dispassion rather than mental anguish, and that the path to suicide was characteristically direct and straightforward, with a distinctive cause behind it. This conceptualization persisted into the 19th century, with the French philosopher Émile Durkheim in his writings depicting the causes behind suicide to be societal, rather than individual (Berkman et al., 2000; Stack, 2000).

Although honor suicides still exist in certain cultures (see e.g., Russell et al., 2017), in contemporary Western society, suicide is rather understood to arise from a complex interplay of not only societal, but also biological and psychological influences. Meanwhile, the continuum from initial *suicidal ideation* (i.e., thoughts or contemplations of death and suicide (Harmer et al., 2024)) to the final act of suicide is considered to be much broader than depicted in many historical accounts. This complexity and continuity are reflected in many theoretical frameworks of suicidal ideation and behavior, including Rubinstein's *Diathesis-Stress Model* (Rubinstein, 1986) and Mann's *Psychobiological Model* (Mann & Arango, 1992), both of which posit that underlying vulnerability (such as genetics, childhood trauma, or maladaptive personality traits) may be activated by current stressors (such as adversity or illness) to produce suicidal ideation. Further psychological and physiological processes, still, are needed to understand how an individual may experience the transition from suicidal ideation to behavior, as depicted by the *Interpersonal Psychological Theory of Suicide (IPTS)* (Van Orden et al., 2010). These processes may include, for example, reduced fear of death and increased physical pain tolerance. The necessity for such *capability for suicide* is also highlighted by the *Integrated Motivational-Volitional (IMV) Model of Suicidal Behavior* (O'Connor & Kirtley, 2018). This model details that access to means and planning of the suicidal act are necessary prerequisites to suicidal behavior. As such, determinants of suicidal ideation and behavior may be dependent on the stage of the suicidal process.

As depicted above, stressful life events (Choi et al., 2023; Classen & Dunn, 2012; Næss et al., 2021) and psychiatric illness (Bostwick & Pankratz, 2000; Isometsä, 2014; Lynch et al., 2020; Paris, 2019) are predictors of suicidal ideation and behavior. While these predictors may increase the risk of suicidal ideation in general, more proximal experiences determine changes in the level of ideation in the present. These experiences include, for example, maladaptive cognitions such as hopelessness, loneliness and burdensomeness (Ribeiro & Joiner, 2009; Van Orden et al., 2010). Hopelessness, specifically, has a characteristically central role in the suicidal mind (Beck, 1990; Ribeiro et al., 2018). Such maladaptive cognitions also form the crux of the IPTS (Ribeiro & Joiner, 2009; Van Orden et al., 2010), which describes how feelings of disconnection, loneliness and burdensomeness may stem, for example, from recent negative life events such as the loss of employment, important relationships, or health. More distal forces (such as traumatic life events) therefore interact with current cognitive and psychological processes in the emergence of suicidal thought (Bryan & Rudd, 2016; Rudd, 2006; Rudd et al., 2006).

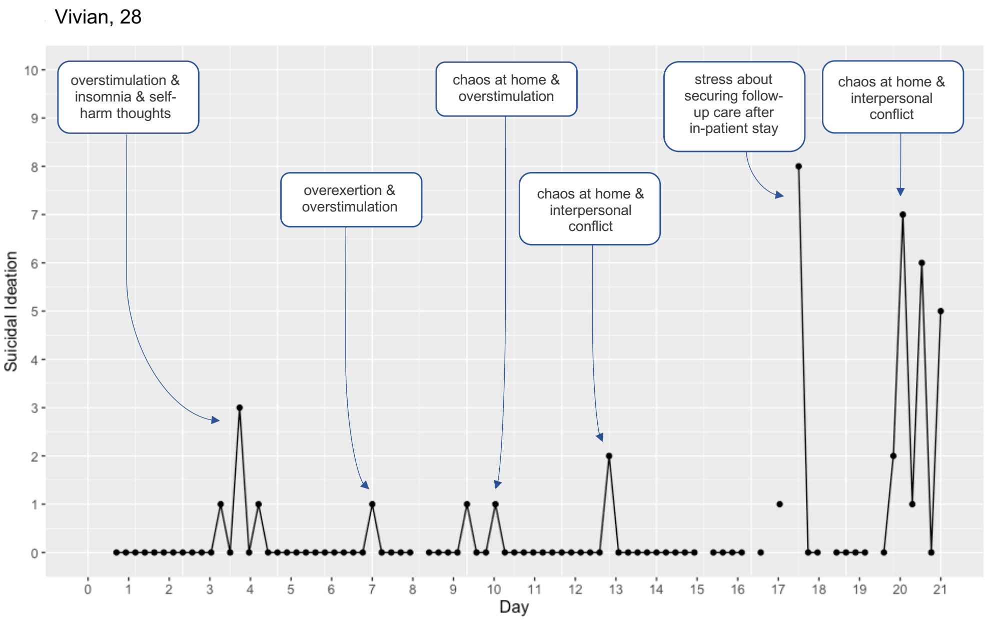
More recently, dynamic cognitive-emotional and behavioral processes, such as emotional dysregulation (Turton et al., 2021), insufficient or maladaptive coping (Ong & Thompson, 2019), and dysregulated sleep (Allen et al., 2019; Bernert et al., 2007, 2017), have also been implicated in suicidal crises. These disturbances may again be caused by external events (Baumeister et al., 2002; Dvir et al., 2014) as well as by existing psychopathology (Franzen & Buysse, 2008; Sansone & Sansone, 2010; Turton et al., 2021). Models of the transition from ideation to action also highlight the influence of dynamic and proximal, rather than static and distal risk factors. Such a division is made in the *Fluid Vulnerability Theory* (Rudd, 2008), which states that it is this distinction that differentiates between chronic and acute suicide risk. That is, as one moves closer to the act of suicide, more dynamic and proximal processes (such as ongoing disturbances in cognition, affect, or behavior) become increasingly important, instead of more static and chronic risk factors, such as history of trauma or long-term psychiatric illness (Berman, 2018; Bryan & Rudd, 2016). Considering the low base rate of suicide among individuals with these chronic risk factors, increased focus on proximal determinants within these populations may be necessary to differentiate those most at risk in the near term (Rudd et al., 2006). Taken all together, suicidal ideation may arise from a combination of dynamically interactive influences stemming from early vulnerability, recent stressors, and ongoing cognitive-psycho-behavioral processes. For example, when daily life stressors overwhelm someone with neurodevelopmental vulnerability and current mental health struggles (see ***Case Study 1***), or when a series of recent adverse events chips away at the resilience of someone with a history of early trauma (see ***Case Study 2***).

Meanwhile, the progression from ideation to action is far from a quick jump (Anestis et al., 2014) (see ***Case Study 3***), and further includes the transition from more passive suicidal ideation ("I don't want to be alive anymore"), to more active suicidal thoughts ("I want to kill myself"), and intent ("I *will* kill myself"). The final stages of suicidal ideation further require additional steps including the planning of the exact suicidal act (Wastler et al., 2023; Witte et al., 2006), and other preparations thereafter (O'Connor & Kirtley, 2018). Still, most individuals experiencing suicidal ideation will ultimately not attempt or die by suicide (Nock et al., 2008), even after progressing to the later stages of ideation. Instead, individuals may continue to experience thoughts of death or suicide over months, years, or even decades (Borges et al., 2008), severely affecting quality of life. This makes suicidal ideation, in itself, a distinct and pervasive disturbance, and one worthy of continued research attention.

Case Study 1: Vivian, 28

Vivian, 28, lives in a large city in the Netherlands. Typically, she lives together with her husband and two children, but currently she is completing a 6-month in-patient treatment program following a recent diagnosis of Autism Spectrum Disorder (ASD). While she has trained as an executive assistant, she is currently on occupational disability. In addition to her ASD diagnosis two years prior, she was also more recently diagnosed with Attention Deficit Hyperactivity Disorder (ADHD). In her teens, she was misdiagnosed with Borderline Personality Disorder (BPD) due to her frequent emotional outbursts resulting from ASD-related overstimulation, as well as history of chronic suicidal ideation. A diagnostic clinical interview further indicated that Vivian met criteria for both current and past Major Depressive Disorder (MDD), and confirmed the absence of BPD. Currently, Vivian is taking selective norepinephrine reuptake inhibitor (SNRI) medication for her ADHD, as well as benzodiazepines and quetiapine (an anti-psychotic) for sleep issues. Vivian reports having struggled with suicidal thoughts "her whole life – I always thought that if things get really bad, I can always kill myself." She describes engaging in suicidal ideation as a form of coping and escapism. She also has a history of three prior suicide attempts that resulted in hospital admissions. Previously, her attempts to seek help for *her suicidal crises often went unaddressed by mental health professionals who labeled her behavior as attention seeking due to her previous BPD diagnosis.*

As part of the SAFE study, Vivian records her suicidal ideation and associated mood, thoughts, and behaviors for three weeks using a mobile phone application. Following the assessment period, Vivian attends a meeting during which she receives a summary report of her data. The report indicates that Vivian predominantly experienced mild and infrequent suicidal ideation. Correspondingly, Vivian indicates that her suicidal ideation has substantially improved after starting treatment. Lately, her suicidal ideation predominantly consists of fleeting thoughts, whereas previously her ideation was obsessive and pervasive. Most of these momentary instances occurring at the treatment facility typically happened late at night when Vivian was unable to sleep. These sleepless moments usually followed a day of being overstimulated due to high external demands and sensory input, which made Vivian feel overwhelmed. In these moments, Vivian reported "getting stuck --- stuck in my head", and falling back into old patterns of thoughts of self-harm and suicide. In these moments, she relied on her medication as well as coping strategies acquired as part of Dialectical Behavioral Therapy (DBT) to prevent her ideation from intensifying or escalating.



While at home, Vivian's suicidal ideation was often triggered by chaotic environments and changing plans, which further lead to conflict with her husband, and outbursts by her children. When Vivian received her own ASD diagnosis two years prior, her two children also received the same diagnosis. Now, in instances where her children struggle with their triggers, Vivian's own related difficulties hinder her ability to optimally respond to her children. These instances make her feel increasingly overwhelmed, overstimulated, and further escalate chaos at the family home. After these instances, Vivian frequently finds herself lying in bed late at night, unable to sleep, stuck in negative thoughts.

Lately, Vivian has been increasingly worried about the end of her in-patient treatment program and securing follow-up care, and concerned about her return to the family home full time. She is especially worried about the family's financial status, and is currently waiting on a decision from social services regarding the extension of her disability leave and benefits – a process that is both slow, and discouraging.

Note: Certain identifiable characteristics have been changed to protect the anonymity of the individuals depicted in the case studies.

Temporal Dynamics of Suicidal Ideation

Long-Term Course Suicidal ideation can be highly persistent, but also substantially variable over time. Approximately 30% of individuals with significant suicidal ideation can be characterized as having persistent suicidal ideation (Kivelä et al., 2019; Smith et al., 2020; Wilcox et al., 2010), and may continue to experience ideation over a decade (Borges et al., 2008), or beyond. However, even when persistent, the level of ideation can vary over time, and be separated by periods marked by the absence of suicidal desire (Borges et al., 2008). Suicidal ideation has been characterized as varying in a "waxing and waning manner" (Oquendo & Baca-Garcia, 2014), fluctuating in both intensity and changing in composition (i.e., the degree of passive vs. active ideation or intent). Indeed, most people (>75%) with chronic suicidal ideation tend to report ideation intermittently rather than consistently, when followed over many years (Handley et al., 2013). Suicidal ideation characteristically tends to re-emerge at times of psychological pain or hardship (Handley et al., 2013), and may be accompanied by relapses in other psychiatric conditions, such as depression (Kivelä et al., 2019; Williams et al., 2006).

However, people may also continue to struggle with suicidal thoughts throughout remission from other mental health conditions (Heuschen et al., 2022), and not all people reporting suicidal ideation or behavior present with a diagnosable mental disorder (Milner et al., 2013). For example, remitted depressed patients with a history of suicidal ideation during a previous depressive episode present with a cognitive profile characterized by hopelessness and a heightened likelihood of experiencing suicidal thoughts when experiencing low mood, even during times of recovery (Antypa et al., 2010).

Predicting Risk Due to the diversity in risk factors and the multitude of potential pathways to eventual suicide, making assessments of an individuals' risk status remains a challenge to both mental health professionals as well as researchers. Based on two meta-analyses of longitudinal cohort studies of suicide risk published in 2017 and 2016, respectively, the authors of the two studies conclude that little improvement in prediction accuracy has been achieved over the past five decades of research (Franklin et al., 2017; Large et al., 2016). Further, they estimate that based on risk assessments performed in accordance with the currently established risk factors, 95% of individuals labelled as high-risk will eventually not die by suicide, whereas up to 50% of suicide mortality emerges from populations thought to be low-risk (Large et al., 2016). The authors propose that one reason for this poor predictive value of established risk factors is the lack of knowledge about the short-term dynamics of suicidal ideation, as less than 1% of the reviewed literature had focused on a timeframe of a month or less (Franklin et al., 2017). Therefore, our understanding of the days and hours leading up to suicidal crises has largely remained in the dark, at least with regard to the evidence provided by systematic empirical research, even though clinicians have long recognized the importance of this time period. A third review at the time concluded that *"the current state of affairs* [in suicide research] *is the consequence of our failure to explicitly consider the temporal dynamics that characterize various risk factors"* (Bryan & Rudd, 2016) (p. 22). That is, what exactly leads to the emergence or heightening of suicidal ideation in critical moments? And to what extent do these *warnings signs* – that is, factors indicating imminent changes in someone's risk status (Rudd, 2008; Rudd et al., 2006) – differ from the well-known, chronic risk-factors identified through the vast literature of past longitudinal studies? A better understanding of these more immediate, temporal indicators requires a switch in perspective from the distal to the proximal.

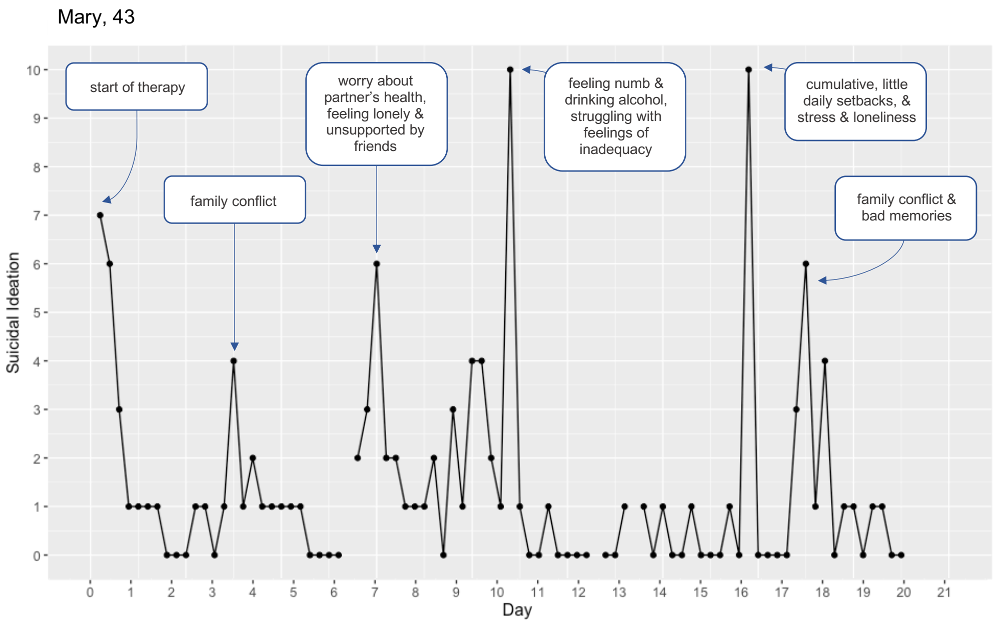
Short-Term Variability Although much neglected until recent years, initial reports about the short-term dynamics of suicidal ideation exist from two decades ago. Witte and colleagues (2006) were among the first to describe such patterns, reporting that the short-term course of suicidal ideation was neither stable nor linear, rather exhibiting a significant amount of variation from one day to the next. Prior to this, suicidal ideation had been thought to remain rather stable over the short-term period (days, weeks, and even months). This was based on findings such as that the test-retest reliability of widely used suicidal ideation measures (incl. the Suicide Probability Scale, SPS) is rather high (ranging from α = .94 after 10 days to α =.70 after 6 months) (Cull & Gill, 1995). However, such measures will invariably *remove* any evidence of short-term variability, focusing instead on average scores over extended time periods (i.e., typically a week or more) (Witte et al., 2006). Instead, since then it has been found that *"daily variability in suicidal ideation appears the norm, rather than the exception"* (Witte et al., 2006, p. 1038). Further, it has been demonstrated that variability in suicidal ideation is higher in suicide attempters than non-attempters – and high*est* in those with a history of multiple attempts (Witte et al., 2006). Subsequently, it has been proposed that suicidal ideation variability may represent a distinctive risk factor for future suicidal behavior (Witte et al., 2006). Although such declarations still warrant further research, it appears that suicidal ideation variability is a potentially relevant, and until recently largely unexplored, characteristic of ideation. As such, it may be relevant to consider variability alongside other suicidal ideation characteristics, such as its overall severity. Highly variable suicidal ideation, it is argued, may be perceived as more distressing by individuals than a chronically high level of ideation (Witte et al., 2005, 2006). Indeed, highly labile emotions tend to be perceived as more intense, and more frequent, than emotions that are more stable over time (Diener et al., 1991; Diener & Larsen, 1984). Finally, similar variability has been observed in the two best-known correlates of suicidal ideation: depressive symptoms and hopelessness (Witte et al., 2006). These findings represent the first indicators that known longitudinal suicide risk factors may also be synergistically involved in the short-term occurrence of suicidal ideation.

Case Study 2: Mary, 43

Mary, 43, grew up in France, but now lives alone in a Dutch town. She has recently experienced a number of significant adverse life events: she was let go from her long-term job and is currently unemployed, and a year prior, her husband suffered a stroke that left him hospital-bound and with limited communicational capabilities. Following these stressful events, Mary sought therapy for her trauma and associated depression. However, this experience has left her increasingly distressed, as she felt like the therapist that she saw was frightened by her experiences and emotions. This has left Mary feeling increasingly helpless. Furthermore, in conversations with her previous therapist, Mary had disclosed of her suicide plan. She describes this as a backup plan, one to be put into action in the future if the situation called for it, but one that she had no immediate plans to enact. However, after sharing these thoughts with her therapist, she now feels like that plan is no longer available to her, making her feel even more hopeless, trapped, and without the possibility of escape. Mary reports that her therapist had diagnosed her with Complex Post-Traumatic Stress Disorder (C-PTSD) and Major Depressive Disorder (MDD). She had also previously been diagnosed with PTSD in her teens due to childhood trauma, and has struggled with problematic alcohol use in recent years.

As part of the SAFE study, Mary records her suicidal ideation and associated mood, thoughts, and behaviors for three weeks using a mobile phone application. Following the assessment period, Mary attends a meeting during which she receives a summary report of her data. The report indicates that Mary, on average, experienced frequent mild-to-moderate suicidal ideation, with a few distinctive peak moments. Her experiences of suicidal ideation were characterized by increased feelings of loneliness and hopelessness, and decreased optimism, such as following her recent experience with her previous therapist. However, Mary also reported feeling numb and disconnected from her emotions: "I know I am sad, I have an indescribable grief with me every minute of the day. And I am also well aware of my loneliness. But I barely feel it." Following her husband's stroke, Mary is also cognizant that she has been secluding herself and struggles to reach out to friends, after feeling like her friends were initially unsupportive following the stroke.

[continues on next page]



During the assessment period, Mary also reports a number of stressful life events, including a medical setback concerning her husband, as well as reconnecting with her family. She calls her family dynamics "disturbing". However, Mary's peak suicidal ideation moments appeared to occur following multiple, compounding, but relatively lower-level stressors during the day, such as small daily setbacks, reminders of painful past experiences, and discouraging news about her husband's situation. In these moments, Mary was also more likely to reach for alcohol and cigarettes to regulate her mood, although she had recently stopped using both substances.

Note: Certain identifiable characteristics have been changed to protect the anonymity of the individuals depicted in the case studies.

Technological Advancements in the Study of Suicidal Ideation

Ecological Momentary Assessment (EMA) Since the initial studies using daily symptom measures on paper-and-pen diaries (Witte et al., 2005, 2006), the expansion of consumer-based technology (mobiles phones, tablets, and wearables such as smartwatches) has provided new avenues for the naturalistic collection of data related to suicidal ideation in daily life (Gratch et al., 2021; Myin-Germeys et al., 2009; van Berkel et al., 2018). What was once referred to as "diary studies" is now called *Ecological Momentary Assessment (EMA)*, comprising research methods where participants provide data on their experiences as part of their everyday lives, in real-time, and most frequently via the help of a mobile phone app (Shiffman et al., 2008). In addition to having increased convenience to the user (who does not need to carry additional paper diaries with them) such sampling methods also work to reduce retrospective completion of entries, instead focusing fully on the participant's immediate, momentary experiences. As such, EMA has the potential to provide data characterized by both high reliability as well as ecological validity (Bos, 2021; Myin-Germeys et al., 2009; Shiffman et al., 2008). Through such mobile phone apps, participants may track their suicidal ideation, and input data on related risk and protective factors and other daily occurrences as they happen. This mode of data collection is especially relevant for examining the types of proximal and/or dynamic predictors that may either be forgotten in the retrospect (if present only momentarily), or under- or overreported (if highly variable). Such predictors may include, for example, affect dynamics (Gross, 2002; Trull et al., 2015), cognitive appraisal (Van Orden et al., 2010), or changes in sleep (Bernert et al., 2017).

While a more comprehensive review of the literature on EMA in suicide research is provided in **Chapter 2**, a few pioneering studies are described here. Prior to the broader application of EMA in suicide research, the feasibility and safety of using EMA in populations with suicidal ideation were first examined (Husky et al., 2014). This revealed high compliance and agreement to participate, signaling that EMA is well-accepted and -tolerated in this population. EMA was also declared safe, after no reactive effects on either negative affect or suicidal ideation were found in response to the measures. While the application of EMA is growing rapidly, however, a closer examination of potential *iatrogenic* (i.e., negative reactive) effects is warranted. As an extension to these findings, we examine the acceptability, feasibility and safety of EMA, as well as participants' subjective experiences as relating to completing such assessments, in **Chapter 3**.

The short-term dynamics of suicidal ideation and its risk factors hopelessness, loneliness and burdensomeness were also examined through EMA (Kleiman et al., 2017). In line with the early findings reporting substantial day-to-day variability in suicidal ideation (Witte et al., 2006), similar variability was also found within-days (Kleiman et al., 2017). Further, the finding that known suicidal ideation risk factors exhibit similar variability in tandem with suicidal ideation was replicated (Kleiman et al., 2017). Subsequent studies have replicated findings on these temporal patterns both between- (Czyz et al., 2019) and within-days (Hallensleben et al., 2018; Rizk et al., 2019), and have examined the role of additional suicidal ideation risk factors, such as anger (Armey et al., 2020) and aggression (Ben-Zeev et al., 2017), emotion regulation (Rizk et al., 2019; Victor et al., 2019), and coping (Czyz et al., 2020; Stanley et al., 2021). Due to the multitude of suicide risk and protective factors, as well as the need to consider multiple, interacting risk factors in predicting suicidal ideation, studies examining broader arrays of such factors concomitantly are needed. In **Chapter 4**, we contribute to this literature by examining the cognitive-affective antecedents and consequences of real-time suicidal ideation, and model these interconnections using network analysis (Borsboom et al., 2021). Further, in **Chapter 5**, we extend these predictors to include sleep parameters.

More recently, increased temporal variability in suicidal ideation was found to increase future suicide risk, similar to the early findings indicating heightened suicidal ideation variability among those with a history of suicidal behavior (Witte et al., 2006). Specifically, higher variability in suicidal ideation (as measured with EMA during hospitalization) was found to associate with an increased risk of suicide attempt in the month post-discharge (Wang et al., 2021). While promising, these early findings warrant replication, especially over longer time intervals. In **Chapter 6**, we examine subtypes (i.e., *digital phenotypes*) of suicidal ideation based on momentary suicidal ideation dynamics (including intensity, frequency, and variability of ideation), and further examine if these characteristics can be used to predict the risk of suicide attempt over 12-months.

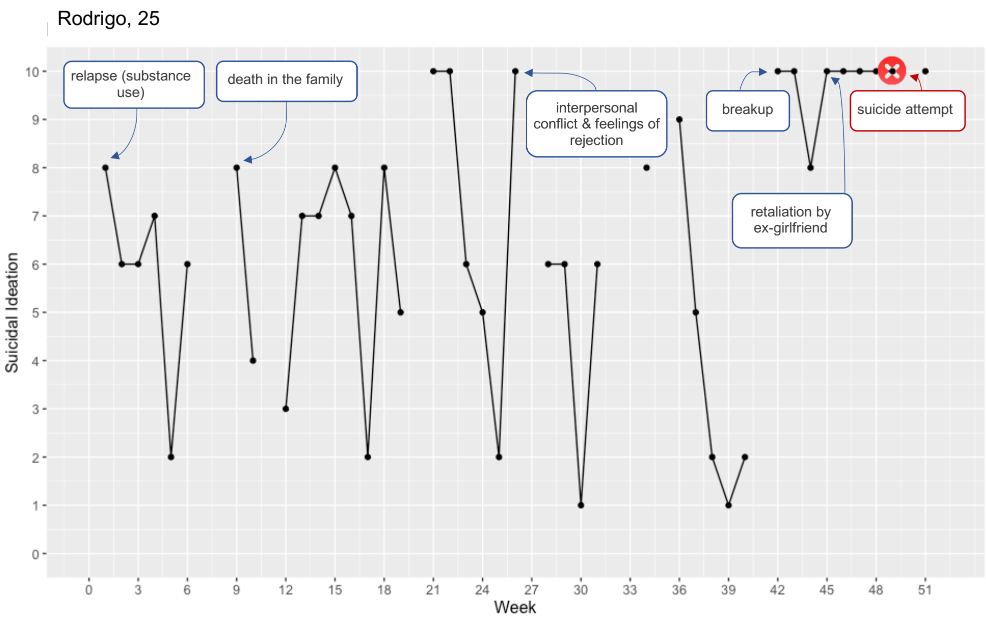
Actigraphy Together with the growing use of EMA in suicide research, further strives have been made to employ additional real-time monitoring techniques, especially those able to obtain objective data on suicide warning signs. Specifically, *actigraphy*, used to collect real-time data on sleep, activity patterns, and light exposure (Ancoli-Israel et al., 2015; Sadeh, 2011), has recently been implemented in suicide research. Sleep specifically has relevance as a potential warning sign for suicide, as prior studies have demonstrated that sleep disturbances outperform depressive symptoms in explaining current suicidal ideation (Bernert et al., 2007), as well as in predicting ideation in the short-term (Bernert et al., 2017). The identification of overt and objective indices of suicide risk also provides opportunities for outside intervention if such signs are noticed by mental health professionals or close others. This is especially relevant as those planning suicide in the near-term may often explicitly deny having suicidal intent (Berman, 2018), making it crucial to understand external signs that may signal imminent risk. Current sleep problems, which may be present in over 75% of cases of recent suicide deaths (Berman, 2018), may represent such a sign. To test this hypothesis, we examine the value of actigraphic sleep registration in predicting short-term changes in suicidal ideation in **Chapter 5**.

Case Study 3: Rodrigo, 25

Rodrigo, 25, is from Southern Europe and is currently completing an internship in the Netherlands. Throughout his life, he has struggled with emotional dysregulation, and in his early twenties, received diagnoses for both Borderline Personality Disorder (BPD) and Bulimia Nervosa (BN). A diagnostic clinical interview further indicated the presence of current Post-Traumatic Stress Disorder (PTSD), and past substance dependence issues. For his symptoms, Rodrigo is currently prescribed with anti-psychotic medication and antidepressants (a selective serotonin reuptake inhibitor, SSRI). Rodrigo also reports four prior suicide attempts, with the latest occurring approximately 12 months ago.

As part of the SAFE study, Rodrigo records his suicidal ideation and associated mood, thoughts, and behaviors for three weeks using a mobile phone application. Following the assessment period, Rodrigo attends a meeting during which he receives a summary report of his data. The report indicates that Rodrigo experienced frequent suicidal ideation that varied in intensity from mild to severe, often changing drastically from once assessment point to the next. During this time period, Rodrigo was impacted by disagreements with his girlfriend and family, and specifically struggled with feelings of rejection and fears of abandonment when he felt growing disconnection from his girlfriend. These events also corresponded with Rodrigo's peak-intensity suicidal ideation moments, and were associated with feelings of sadness and hopelessness, and to a lesser degree, anger and shame. Rodrigo also reported struggling with overeating and overspending.

Following the three-week daily assessment period, Rodrigo continues to log his experiences trough the app once per week over the following 12 months. Over the course of the year, Rodrigo reports a number of additional stressors, including the death of a close family member, experiences of discrimination, dysfunctional dynamics with his girlfriend, and conflict with family members. During this time, he also experiences a relapse with his substance use, receives a diagnosis of Major Depressive Disorder (MDD), and gets prescribed sedative-hypnotic medication for his struggles with insomnia. Additionally, in his app entries he reports using other prescription and recreational *substances, such as benzodiazepines, amphetamines, and cannabis. At the time, he writes: "I bought [dextroamphetamine pills] just for fun to have. I don't have any intentions of killing myself with it. I just like to feel the control of knowing I can do whatever I want if I want to". Rodrigo meets regularly with his psychologist and psychiatrist during this time.*



In the following months, Rodrigo undergoes a breakup with his girlfriend. Afterwards, he professes fears about his ex-girlfriend breaking into his apartment to damage his property, and reports that his ex-girlfriend was spreading rumors about him to his friends and family. This led Rodrigo to feel increasingly isolated from people close to him. Rodrigo also discloses a past history of his girlfriend being violent, further fueling his fears of potential retaliation following the breakup. Subsequently, Rodrigo grows increasingly reliant on substances, and reports turning to food, cigarettes, and sex as forms of coping with his increasing distress. He also reports feeling increasingly manic and obsessive. Two weeks later, Rodrigo attempts suicide and spends a period of time in an intensive care unit, and subsequently in an in-patient treatment facility.

Note: Certain identifiable characteristics have been changed to protect the anonymity of the individuals depicted in the case studies.

The SAFE Study – Suicidal ideation Assessment: Fluctuation monitoring with Ecological momentary assessment

The SAFE study (Suicidal ideation Assessment: Fluctuation monitoring with Ecological momentary assessment) was designed to 1) examine the short-term (hourly, daily) course of suicidal ideation and its associated predictors, and to 2) study the long-term (weekly, monthly) trajectory of ideation, and risk factors precipitating suicide attempts in the prospective. *Figure 1* presents a graphical overview of the SAFE study.

The target population for the study comprised individuals with a past-year history of active suicidal ideation (Columbia Suicide Severity Rating Scale (CSSRS) (Posner et al., 2011) score of >= 3, or >= 2 if symptoms were present in the past two months) and/or a suicide attempt, therefore capturing individuals with varying levels of severity of ideation. During initial intake proceedings, participants completed in-depth clinical interviews and symptom questionnaire measures of current psychopathology and past history of suicidal ideation and behavior. During the first part of the study, a **21-day assessment period** with EMA and actigraphy, participants completed four daily prompts on their mobile phone (Figure 2a), capturing reports of suicidal ideation, as well as associated behavioral (activity, social contact, coping, substance use, sleep), affective (positive and negative affective states) and cognitive (positive and negative thoughts) risk factors. Additionally, participants wore an actigraphy watch (Figure 2b) that measured their sleep and activity levels throughout the day and night. After the daily assessment period, participants could receive a summary report of their data, detailing observed patterns with regard to high/low-risk suicidal ideation moments in their daily life, aimed at increasing the individual's insights about the dynamics of their ideation (as described in ***Case Studies 1-3***). Following the daily assessment period, participants continued into a **1-year monitoring period**, during which they continued to report on their suicidal ideation and associated experiences through the mobile phone app, now additionally including reports of depressive symptoms as well as the occurrence of suicide attempts. An overview of all measures completed by the participants over the course of the study is included in the Appendix.

Following the introductory **Chapter 1** and a systematic review of the literature in **Chapter 2**, **Chapters 3-6** in the dissertation present findings from the SAFE study: **Chapters 3, 4 and 5** report findings from the 21-day assessment period, and **Chapter 6** also includes data from the 1-year monitoring period. Finally, **Chapter 7** provides a discussion of the works presented, the strengths and limitations of the methodologies used, as well as directions for future research and clinical practice. *Figure 3* presents a graphical depiction of the contents of the dissertation and themes discussed in each chapter.

Figure 1. A Graphical Overview of the SAFE Study (Suicidal ideation Assessment: Fluctuation monitoring with Ecological Momentary Assessment)

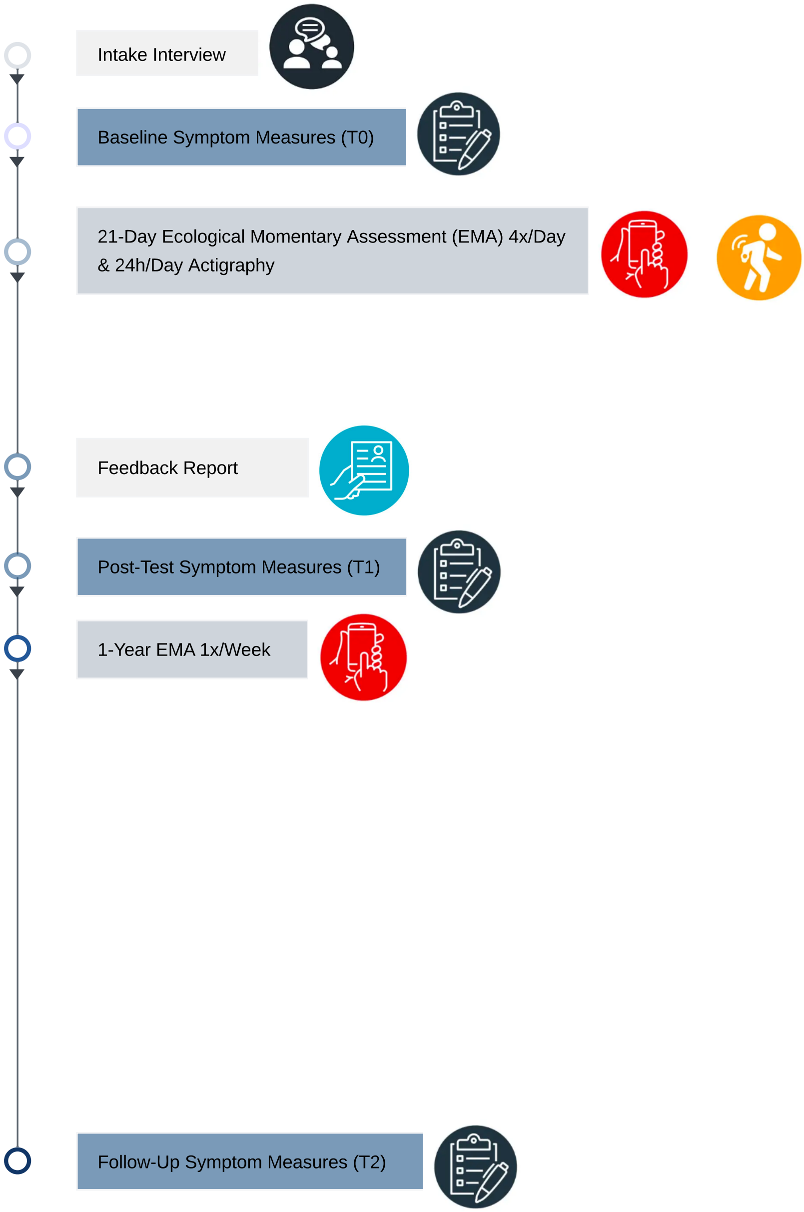
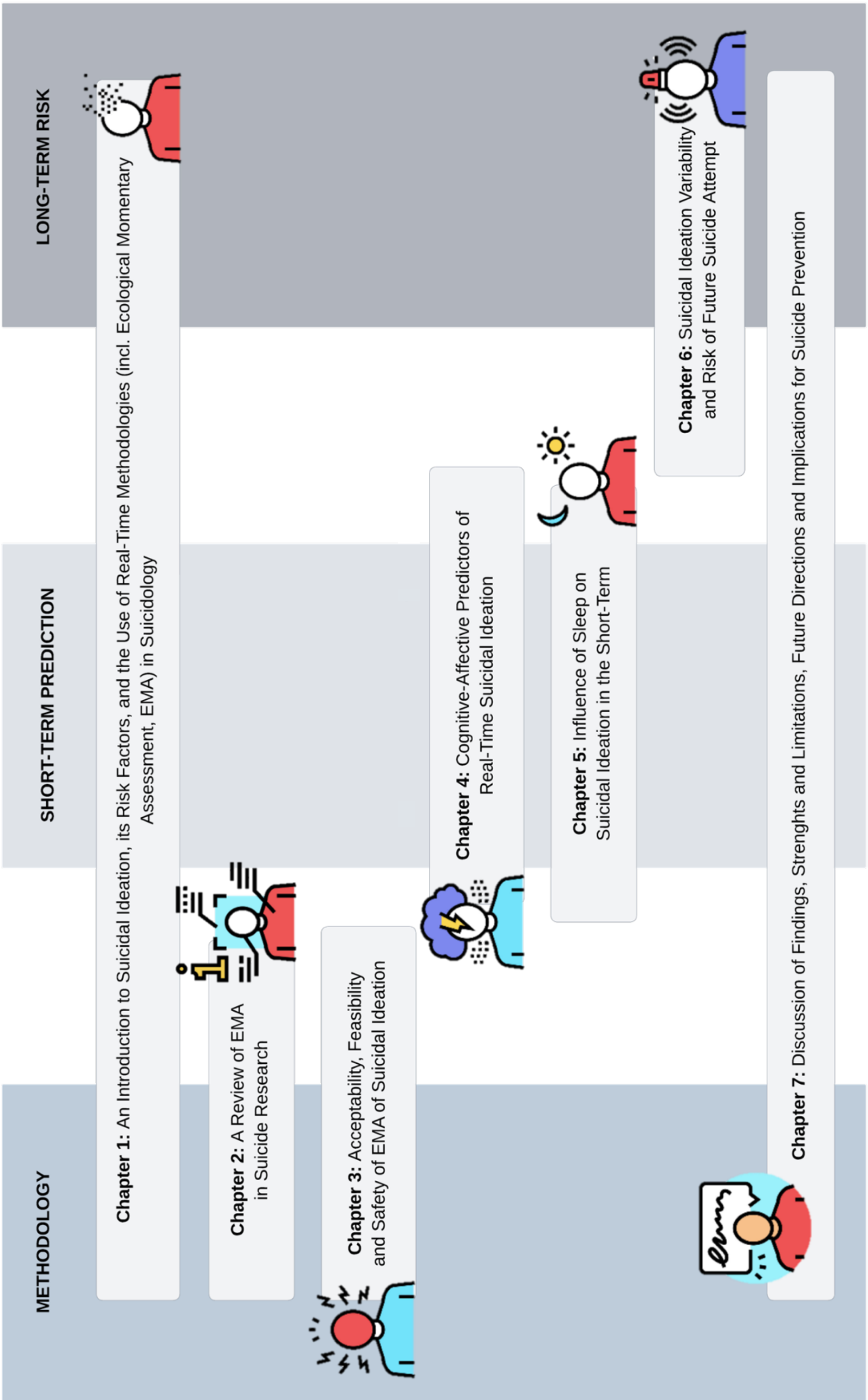


Figure 2. Visualizing the Use of the Ecological Momentary Assessment (EMA) Application (left) and Actigraphy Device (MotionWatch 8 ©) (right)

Figure 3. A Graphical Depiction of the Chapters in the Dissertation



References

Allen, N. B., Nelson, B. W., Brent, D., & Auerbach, R. P. (2019). Short-term prediction of suicidal thoughts and behaviors in adolescents: Can recent developments in technology and computational science provide a breakthrough? *Journal of Affective Disorders*, *250*, 163–169.

Ancoli-Israel, S., Martin, J. L., Blackwell, T., Buenaver, L., Liu, L., Meltzer, L. J., Sadeh, A., Spira, A. P., & Taylor, D. J. (2015). The SBSM guide to actigraphy monitoring: Clinical and research applications. *Behavioral Sleep Medicine*, *13 Suppl 1*, S4–S38. https://doi.org/10.1080/15402002.2015.1046356

Anestis, M. D., Soberay, K. A., Gutierrez, P. M., Hernández, T. D., & Joiner, T. E. (2014). Reconsidering the link between impulsivity and suicidal behavior. *Personality and Social Psychology Review*, *18*(4), 366–386. https://doi.org/10.1177/1088868314535988

Antypa, N., Van der Does, A. J. W., & Penninx, B. W. J. H. (2010). Cognitive reactivity: Investigation of a potentially treatable marker of suicide risk in depression. *Journal of Affective Disorders*, *122*(1–2), 46–52. https://doi.org/10.1016/j.jad.2009.06.013

Armey, M. F., Brick, L., Schatten, H. T., Nugent, N. R., & Miller, I. W. (2020). Ecologically assessed affect and suicidal ideation following psychiatric inpatient hospitalization. *General Hospital Psychiatry*, *63*, 89–96.

Baumeister, R. F., Twenge, J. M., & Nuss, C. K. (2002). Effects of social exclusion on cognitive processes: Anticipated aloneness reduces intelligent thought. *Journal of Personality and Social Psychology*, *83*(4), 817–827. https://doi.org/10.1037/0022-3514.83.4.817

Beck, A. T. (1961). An inventory for measuring depression. *Archives of General Psychiatry*, *4*(6), 561–571. https://doi.org/10.1001/archpsyc.1961.01710120031004

Beck, A. T., Brown, G., Berchick, J., Stewart, B. L., & Steer, R. A. (1990). Relationship between hopelessness and ultimate suicide: A replication with psychiatric outpatients. *American Journal of Psychiatry*, *147*(2), 190–195. https://doi.org/10.1176/ajp.147.2.190

Beck, A. T., Kovacs, M., & Weissman, A. (1979). Assessment of suicidal intention: The Scale for Suicide Ideation. *Journal of Consulting and Clinical Psychology*, *47*(2), 343–352.

Ben-Zeev, D., Scherer, E. A., Brian, R. M., Mistler, L. A., Campbell, A. T., & Wang, R. (2017). Use of multimodal technology to identify digital correlates of violence among inpatients with serious mental illness: A pilot study. *Psychiatric Services*, *68*(10), 1088–1092. https://doi.org/10.1176/appi.ps.201700077

Berkman, L. F., Glass, T., Brissette, I., & Seeman, T. E. (2000). From social integration to health: Durkheim in the new millennium. *Social Science & Medicine*, *51*(6), 843–857. https://doi.org/10.1016/S0277-9536(00)00065-4

Berman, A. L. (2018). Risk factors proximate to suicide and suicide risk assessment in the context of denied suicide ideation. *Suicide and Life-Threatening Behavior*, *48*(3), 340–352. https://doi.org/10.1111/sltb.12351

Bernert, R. A., Hom, M. A., Iwata, N. G., & Joiner, T. E. (2017). Objectively assessed sleep variability as an acute warning sign of suicidal ideation in a longitudinal evaluation of young adults at high suicide risk. *Journal of Clinical Psychiatry*, *78*(6), e678–e687. https://doi.org/10.4088/JCP.16m11193

Bernert, R. A., Joiner, T. E., & Joiner, T. (2007). Sleep disturbances and suicide risk: A review of the literature. *Neuropsychiatric Disease and Treatment, 3*(6), 735–743.

Borges, G., Angst, J., Nock, M. K., Ruscio, A. M., & Kessler, R. C. (2008). Risk factors for the incidence and persistence of suicide-related outcomes: A 10-year follow-up study using the National Comorbidity Surveys. *Journal of Affective Disorders*, *105*(1–3), 25–33. https://doi.org/10.1016/j.jad.2007.01.036

Borsboom, D., Deserno, M. K., Rhemtulla, M., Epskamp, S., Fried, E. I., McNally, R. J., Robinaugh, D. J., Perugini, M., Dalege, J., Costantini, G., Isvoranu, A.-M., Wysocki, A. C., van Borkulo, C. D., van Bork, R., & Waldorp, L. J. (2021). Network analysis of multivariate data in psychological science. *Nature Reviews Methods Primers*, *1*(1), 58. https://doi.org/10.1038/s43586-021-00055-w

Bos, F. M. (2021). *Ecological momentary assessment as a clinical tool in psychiatry: Promises, pitfalls, and possibilities.* University of Groningen.

Bostwick, J. M., & Pankratz, V. S. (2000). Affective disorders and suicide risk: A reexamination. *American Journal of Psychiatry*, *157*(12), 1925–1932. https://doi.org/10.1176/appi.ajp.157.12.1925

Bryan, C. J., & Rudd, M. D. (2016). The importance of temporal dynamics in the transition from suicidal thought to behavior. *Clinical Psychology: Science and Practice*, *23*(1), 21–25. https://doi.org/10.1111/cpsp.12135

Carney, C. E., Buysse, D. J., Ancoli-Israel, S., Edinger, J. D., Krystal, A. D., Lichstein, K. L., & Morin, C. M. (2012). The Consensus Sleep Diary: Standardizing prospective sleep self-monitoring. *Sleep*, *35*(2), 287–302. https://doi.org/10.5665/sleep.1642

Chaudhury, S. R., Galfalvy, H., Biggs, E., Choo, T.-H., Mann, J. J., & Stanley, B. (2017). Affect in response to stressors and coping strategies: An ecological momentary assessment study of borderline personality disorder. *Borderline Personality Disorder and Emotion Dysregulation*, *4*(1), 8. https://doi.org/10.1186/s40479-017-0059-3

Choi, N. G., Marti, C. N., & Choi, B. Y. (2023). Suicide from intimate partner and other relationship conflicts: Demographic and clinical correlates. *Journal of Mental Health*, *33*(1), 84–91. https://doi.org/10.1080/09638237.2023.2245886

Classen, T. J., & Dunn, R. A. (2012). The effect of job loss and unemployment duration on suicide risk in the United States: A new look using mass-layoffs and unemployment duration. *Health Economics*, *21*(3), 338–350. https://doi.org/10.1002/hec.1719

Cull, G. K., & Gill, W. S. (1995). *Suicide Probability Scale manual*. Western Psychological Services.

Czyz, E. K., Horwitz, A. G., Arango, A., & King, C. A. (2019). Short-term change and prediction of suicidal ideation among adolescents: A daily diary study following psychiatric hospitalization. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *60*(7), 732–741. https://doi.org/10.1111/jcpp.12974

Czyz, E. K., Yap, J. R. T., King, C. A., & Nahum-Shani, I. (2020). Using intensive longitudinal data to identify early predictors of suicide-related outcomes in high-risk adolescents: Practical and conceptual considerations. *Assessment*. https://doi.org/10.1177/1073191120939168

Diener, E., & Larsen, R. J. (1984). Temporal stability and cross-situational consistency of affective, behavioral, and cognitive responses. *Journal of Personality and Social Psychology*, *47*(4), 871–883. https://doi.org/10.1037/0022-3514.47.4.871

Diener, E., Sandvik, E., & Pavot, W. (1991). Happiness is the frequency, not the intensity, of positive versus negative affect. In F. Strack, M. Argyle, & N. Schwarz (Eds.), *Subjective well-being: An interdisciplinary perspective. International series in experimental social psychology* (1st ed., Vol. 21, pp. 119–139). Pergamon Press.

Dvir, Y., Ford, J. D., Hill, M., & Frazier, J. A. (2014). Childhood maltreatment, emotional dysregulation, and psychiatric comorbidities. *Harvard Review of Psychiatry*, *22*(3), 149–161. https://doi.org/10.1097/HRP.0000000000000014

Endicott, J., Nee, J., Harrison, W., & Blumenthal, R. (1993). Quality of Life Enjoyment and Satisfaction Questionnaire: A new measure. *Psychopharmacology Bulletin*, *29*(2), 321–326.

Falck, R. S., Barha, C. K., Chan, P. C. Y., & Liu-Ambrose, T. (2020). Refining sleep measurement using the Motionwatch8: How many days of monitoring do we need to get reliable estimates of sleep quality for older adults with mild cognitive impairment? *Sleep Science and Practice*, *4*, 11. https://doi.org/10.1186/s41606-020-00048-w

Falck, R. S., Best, J. R., Li, M. C. R., Eng, J. J., & Liu-Ambrose, T. (2019). Revisiting the MotionWatch8©: Calibrating cut-points for measuring physical activity and sedentary behavior among adults with stroke. *Frontiers in Aging Neuroscience*, *11*. https://doi.org/10.3389/fnagi.2019.00203

Falck, R. S., Crockett, R. A., Davis, J. C., Khan, K. M., & Liu-Ambrose, T. (2021). Shining the light on the MotionWatch8 light sensor for sleep and aging research: What can we measure and what are we missing? *Journal of Alzheimer's Disease Reports*, *5*(1), 55–63. https://doi.org/10.3233/ADR-200242

First, M. B. (2015). Structured Clinical Interview for the *DSM* (SCID). In *The Encyclopedia of Clinical Psychology* (pp. 1–6). John Wiley & Sons, Inc. https://doi.org/10.1002/9781118625392.wbecp351

Franklin, J. C., Ribeiro, J. D., Fox, K. R., Bentley, K. H., Kleiman, E. M., Huang, X., Musacchio, K. M., Jaroszewski, A. C., Chang, B. P., & Nock, M. K. (2017). Risk factors for suicidal thoughts and behaviors: A meta-analysis of 50 years of research. *Psychological Bulletin*, *143*(2), 187–232. https://doi.org/10.1037/bul0000084

Gratch, I., Choo, T. H., Galfalvy, H., Keilp, J. G., Itzhaky, L., Mann, J. J., Oquendo, M., & Stanley, B. (2021). Detecting suicidal thoughts: The power of ecological momentary assessment. *Depression and Anxiety*, *38*(1), 8–16.

Gross, J. J. (2002). Emotion regulation: Affective, cognitive, and social consequences. *Psychophysiology*, *39*(3), 281–291. https://doi.org/10.1017/S0048577201393198

Hallensleben, N., Spangenberg, L., Forkmann, T., Rath, D., Hegerl, U., Kersting, A., Kallert, T. W., & Glaesmer, H. (2018). Investigating the dynamics of suicidal ideation: Preliminary findings from a study using ecological momentary assessments in psychiatric inpatients. *Crisis*, *39*(1), 65–69. https://doi.org/10.1027/0227-5910/a000464

Hamilton, M. (1960). A rating scale for depression. *Journal of Neurology, Neurosurgery and Psychiatry*, *23*, 56–61.

Handley, T. E., Attia, J. R., Inder, K. J., Kay-Lambkin, F. J., Barker, D., Lewin, T. J., & Kelly, B. J. (2013). Longitudinal course and predictors of suicidal ideation in a rural community sample. *Australian and New Zealand Journal of Psychiatry*, *47*(11), 1032–1040. https://doi.org/10.1177/0004867413495318

Harmer, B., Lee, S., Duong, T. vi H., & Saadabadi, A. (2024). *Suicidal Ideation*. StatPearls Publishing.

Heuschen, C. B. B. C. M., Mocking, R. J. T., Zantvoord, J. B., Figueroa, C. A., Schene, A. H., Denys, D. A. J. P., Ruhé, H. G., Bockting, C. L. H., & Lok, A. (2022). Suicidal ideation in remitted major depressive disorder predicts recurrence. *Journal of Psychiatric Research*, *151*, 65–72. https://doi.org/10.1016/j.jpsychires.2022.04.005

Hill, T. D. (2004). *Ambitiosa mors: Suicide and the self in roman thought and literature*. Routledge.

Husky, M., Olié, E., Guillaume, S., Genty, C., Swendsen, J., & Courtet, P. (2014). Feasibility and validity of ecological momentary assessment in the investigation of suicide risk. *Psychiatry Research*, *220*(1–2), 564–570. https://doi.org/10.1016/j.psychres.2014.08.019

Husky, M., Swendsen, J., Ionita, A., Jaussent, I., Genty, C., & Courtet, P. (2017). Predictors of daily life suicidal ideation in adults recently discharged after a serious suicide attempt: A pilot study. *Psychiatry Research*, *256*, 79–84. https://doi.org/10.1016/j.psychres.2017.06.035

Isometsä, E. (2014). Suicidal behaviour in mood disorders: Who, when, and why? *The Canadian Journal of Psychiatry*, *59*(3), 120–130. https://doi.org/10.1177/070674371405900303

Jahng, S., Solhan, M. B., Tomko, R. L., Wood, P. K., Piasecki, T. M., & Trull, T. J. (2011). Affect and alcohol use: An ecological momentary assessment study of outpatients with borderline personality disorder. *Journal of Abnormal Psychology*, *120*(3), 572–584. https://doi.org/10.1037/a0024686

Kivelä, L., Krause-Utz, A., Mouthaan, J., Schoorl, M., de Kleine, R., Elzinga, B., Eikelenboom, M., Penninx, B. W., van der Does, W., & Antypa, N. (2019). Longitudinal course of suicidal ideation and predictors of its persistence – A NESDA study. *Journal of Affective Disorders*, *257*, 365–375. https://doi.org/10.1016/j.jad.2019.07.042

Kleiman, E. M., Turner, B. J., Fedor, S., Baele, E. E., Huffman, J. C., & Nock, M. K. (2017). Examination of real-time fluctuations in suicidal ideation and its risk factors: Results from two ecological momentary assessment studies. *Journal of Abnormal Psychology*, *126*(6), 726–738. https://doi.org/10.1037/abn0000273.supp

Large, M., Kaneson, M., Myles, N., Myles, H., Gunaratne, P., & Ryan, C. (2016). Meta-analysis of longitudinal cohort studies of suicide risk assessment among psychiatric patients: Heterogeneity in results and lack of improvement over time. *PLOS One*, *11*(6), e0156322. https://doi.org/doi: 10.1371/journal.pone.0156322

Lievaart, M., Franken, I. H. A., & Hovens, J. E. (2016). Anger assessment in clinical and nonclinical populations: Further validation of the State-Trait Anger Expression Inventory-2. *Journal of Clinical Psychology*, *72*(3), 263–278. https://doi.org/10.1002/jclp.22253

Lynch, F. L., Peterson, E. L., Lu, C. Y., Hu, Y., Rossom, R. C., Waitzfelder, B. E., Owen-Smith, A. A., Hubley, S., Prabhakar, D., Keoki Williams, L., Beck, A., Simon, G. E., & Ahmedani, B. K. (2020). Substance use disorders and risk of suicide in a general US population:

A case control study. *Addiction Science & Clinical Practice*, *15*(1), 14. https://doi.org/10.1186/s13722-020-0181-1

Mann, J. J., & Arango, V. (1992). Integration of neurobiology and psychopathology in a unified model of suicidal behavior. *Journal of Clinical Psychopharmacology*, *12*(2 Suppl), S2–S7. https://doi.org/10.1097/00004714-199204001-00001

Milner, A., Sveticic, J., & De Leo, D. (2013). Suicide in the absence of mental disorder? A review of psychological autopsy studies across countries. *International Journal of Social Psychiatry*, *59*(6), 545–554. https://doi.org/10.1177/0020764012444259

Morey, L. (1991). *Personality Assessment Inventory: Professional manual*. Psychological Assessment Resources.

Morin, C. M., Belleville, G., Bélanger, L., & Ivers, H. (2011). The Insomnia Severity Index: Psychometric indicators to detect insomnia cases and evaluate treatment response. *Sleep*, *34*(5), 601–608.

Myin-Germeys, I., Oorschot, M., Collip, D., Lataster, J., Delespaul, P., & van Os, J. (2009). Experience sampling research in psychopathology: Opening the black box of daily life. *Psychological Medicine*, *39*(9), 1533–1547. https://doi.org/10.1017/S0033291708004947

Næss, E. O., Mehlum, L., & Qin, P. (2021). Marital status and suicide risk: Temporal effect of marital breakdown and contextual difference by socioeconomic status. *SSM - Population Health*, *15*, 100853. https://doi.org/10.1016/j.ssmph.2021.100853

Nock, M. K., Borges, G., Bromet, E. J., Alonso, J., Angermeyer, M., Beautrais, A., Bruffaerts, R., Wai, T. C., De Girolamo, G., Gluzman, S., De Graaf, R., Gureje, O., Haro, J. M., Huang, Y., Karam, E., Kessler, R. C., Lepine, J. P., Levinson, D., Medina-Mora, M. E., Ono, Y., Posada-Villa, J., & Williams, D. (2008). Cross-national prevalence and risk factors for suicidal ideation, plans and attempts. *British Journal of Psychiatry*, *192*(2), 98–105. https://doi.org/10.1192/bjp.bp.107.040113

O'Connor, R. C., & Kirtley, O. J. (2018). The integrated motivational–volitional model of suicidal behaviour. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *373*(1754), 20170268. https://doi.org/10.1098/rstb.2017.0268

Ong, E., & Thompson, C. (2019). The importance of coping and emotion regulation in the occurrence of suicidal behavior. *Psychological Reports*, *122*(4), 1192–1210. https://doi.org/10.1177/0033294118781855

Oquendo, M. A., & Baca-Garcia, E. (2014). Suicidal behavior disorder as a diagnostic entity in the DSM-5 classification system: Advantages outweigh limitations. *World Psychiatry*, *13*(2), 128–130. https://doi.org/10.1002/wps.20116

Paris, J. (2019). Suicidality in borderline personality disorder. *Medicina*, *55*(6), 223. https://doi.org/10.3390/medicina55060223

Posner, K., Brown, G. K., Stanley, B., Brent, D. A., Yershova, K. V., Oquendo, M. A., Currier, G. W., Melvin, G. A., Greenhill, L., Shen, S., & Mann, J. J. (2011). The Columbia–Suicide Severity Rating Scale: Initial validity and internal consistency findings from three multisite studies with adolescents and adults. *American Journal of Psychiatry*, *168*(12), 1266–1277. https://doi.org/10.1176/appi.ajp.2011.10111704

Ribeiro, J. D., Huang, X., Fox, K. R., & Franklin, J. C. (2018). Depression and hopelessness as risk factors for suicide ideation, attempts and death: Meta-analysis of longitudinal studies. *British Journal of Psychiatry*, *212*(5), 279–286. https://doi.org/10.1192/bjp.2018.27

Ribeiro, J. D., & Joiner, T. E. (2009). The interpersonal-psychological theory of suicidal behavior: Current status and future directions. *Journal of Clinical Psychology*, *65*(12), 1291–1299. https://doi.org/10.1002/jclp.20621

Ribeiro, J. D., Witte, T. K., Van Orden, K. A., Selby, E. A., Gordon, K. H., Bender, T. W., & Joiner, T. E. (2014). Fearlessness about death: The psychometric properties and construct validity of the revision to the Acquired Capability for Suicide Scale. *Psychological Assessment*, *26*(1), 115–126. https://doi.org/10.1037/a0034858

Rizk, M. M., Choo, T. H., Galfalvy, H., Biggs, E., Brodsky, B. S., Oquendo, M. A., Mann, J. J., & Stanley, B. (2019). Variability in suicidal ideation is associated with affective instability in suicide attempters with borderline personality disorder. *Psychiatry*, *82*, 173–178.

Rubinstein, D. H. (1986). A stress–diathesis theory of suicide. *Suicide and Life-Threatening Behavior*, *16*(2), 182–197. https://doi.org/10.1111/j.1943-278X.1986.tb00351.x

Rudd, M. D. (2006). Fluid Vulnerability Theory: A cognitive approach to understanding the process of acute and chronic suicide Risk. In T.E. Ellis (Eds.), *Cognition and suicide: Theory, research, and therapy.* (pp. 355–368). American Psychological Association. https://doi.org/10.1037/11377-016

Rudd, M. D. (2008). Suicide warning signs in clinical practice. *Current Psychiatry Reports*, *10*(1), 87–90. https://doi.org/10.1007/s11920-008-0015-4

Rudd, M. D., Berman, A. L., Joiner, T. E., Nock, M. K., Silverman, M. M., Mandrusiak, M., Van Orden, K., & Witte, T. (2006). Warning signs for suicide: Theory, research, and clinical applications. *Suicide and Life-Threatening Behavior*, *36*(3). https://doi.org/10.1521/suli.2006.36.3.255

Russell, R., Metraux, D., & Tohen, M. (2017). Cultural influences on suicide in Japan. *Psychiatry and Clinical Neurosciences*, *71*(1), 2–5. https://doi.org/10.1111/pcn.12428

Sadeh, A. (2011). The role and validity of actigraphy in sleep medicine: An update. *Sleep Medicine Reviews*, *15*(4), 259–267. https://doi.org/10.1016/j.smrv.2010.10.001

Sheehan, D. V, Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T., Baker, R., & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *The Journal of Clinical Psychiatry*, *59 Suppl 20*, 22–57.

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology, 4*, 1–32. https://doi.org/10.1146/annurev.clinpsy.3.022806.091415

Smith, N. B., Sippel, L. M., Rozek, D. C., Spangler, P. T., Traber, D., Straud, C. L., Hoff, R., & Harpaz-Rotem, I. (2020). Courses of suicidal ideation among military veterans in residential treatment for posttraumatic stress disorder. *Depression and Anxiety*, *37*(3), 273–284. https://doi.org/10.1002/da.22993

Solis, E., Antypa, N., Conijn, J. M., Kelderman, H., & Van der Does, W. (2017). Psychometric properties of the Leiden Index of Depression Sensitivity (LEIDS). *Psychological Assessment*, *29*(2), 158–171. https://doi.org/10.1037/pas0000326

Stack, S. (2000). Suicide: A 15-year review of the sociological literature. Part I: Cultural and economic factors. *Suicide & Life-Threatening Behavior*, *30*(2), 145–162.

Stanley, B., Martínez-Alés, G., Gratch, I., Rizk, M., Galfalvy, H., Choo, T. H., & Mann, J. J. (2021). Coping strategies that reduce suicidal ideation: An ecological momentary assessment study. *Journal of Psychiatric Research*, *133*, 32–37. https://doi.org/10.1016/j.jpsychires.2020.12.012

Trull, T. J., Lane, S. P., Koval, P., & Ebner-Priemer, U. W. (2015). Affective dynamics in psychopathology. *Emotion Review*, *7*(4), 355–361. https://doi.org/10.1177/1754073915590617

Turton, H., Berry, K., Danquah, A., & Pratt, D. (2021). The relationship between emotion dysregulation and suicide ideation and behaviour: A systematic review. *Journal of Affective Disorders Reports*, *5*, 100136. https://doi.org/10.1016/j.jadr.2021.100136

van Berkel, N., Ferreira, D., & Kostakos, V. (2018). The experience sampling method on mobile devices. *ACM Computing Surveys*, *50*(6), 1–40. https://doi.org/10.1145/3123988

Van Orden, K. A., Cukrowicz, K. C., Witte, T. K., & Joiner, T. E. (2012). Thwarted belongingness and perceived burdensomeness: Construct validity and psychometric properties of the Interpersonal Needs Questionnaire. *Psychological Assessment*, *24*(1), 197–215. https://doi.org/10.1037/a0025358

Van Orden, K. A., Witte, T. K., Cukrowicz, K. C., Braithwaite, S. R., Selby, E. A., & Joiner, T. E. (2010). The Interpersonal Theory of Suicide. *Psychological Review*, *117*(2), 575–600. https://doi.org/10.1037/a0018697

Victor, S. E., Scott, L. N., Stepp, S. D., & Goldstein, T. R. (2019). I want you to want me: Interpersonal stress and affective experiences as within-person predictors of nonsuicidal self-injury and auicide urges in daily life. *Suicide and Life-Threatening Behavior*, *49*(4), 1157–1177. https://doi.org/10.1111/sltb.12513

Wang, S. B., Coppersmith, D. D. L., Kleiman, E. M., Bentley, K. H., Millner, A. J., Fortgang, R., Mair, P., Dempsey, W., Huffman, J. C., & Nock, M. K. (2021). A pilot study using frequent inpatient assessments of suicidal thinking to predict short-term postdischarge suicidal behavior. *JAMA Network Open*, *4*(3), e210591. https://doi.org/10.1001/jamanetworkopen.2021.0591

Wastler, H. M., Khazem, L. R., Ammendola, E., Baker, J. C., Bauder, C. R., Tabares, J., Bryan, A. O., Szeto, E., & Bryan, C. J. (2023). An empirical investigation of the distinction between passive and active ideation: Understanding the latent structure of suicidal thought content. *Suicide and Life-Threatening Behavior*, *53*(2), 219–226. https://doi.org/10.1111/sltb.12935

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070. https://doi.org/10.1037/0022-3514.54.6.1063

Wilcox, H. C., Arria, A. M., Caldeira, K. M., Vincent, K. B., Pinchevsky, G. M., & O'Grady, K. E. (2010). Prevalence and predictors of persistent suicide ideation, plans, and attempts during college. *Journal of Affective Disorders*, *127*(1–3). 287–294. https://doi.org/10.1016/j.jad.2010.04.017

Williams, J. M. G., Crane, C., Barnhofer, T., Van der Does, A. J. W., & Segal, Z. V. (2006). Recurrence of suicidal ideation across depressive episodes. *Journal of Affective Disorders*, *91*(2–3), 189–194. https://doi.org/10.1016/j.jad.2006.01.002

Witte, T. K., Fitzpatrick, K. K., Joiner, T. E., & Schmidt, N. B. (2005). Variability in suicidal ideation: A better predictor of suicide attempts than intensity or duration of ideation? *Journal of Affective Disorders*, *88*(2), 131–136. https://doi.org/10.1016/j.jad.2005.05.019

Witte, T. K., Fitzpatrick, K. K., Warren, K. L., Schatschneider, C., & Schmidt, N. B. (2006). Naturalistic evaluation of suicidal ideation: Variability and relation to attempt status. *Behaviour Research and Therapy*, *44*(7), 1029–1040. https://doi.org/10.1016/j.brat.2005.08.004

Appendix

Table S1. An Overview of the Measures Included in the SAFE study (Suicidal ideation Assessment: Fluctuation monitoring with Ecological Momentary Assessment)

INSTRUMENT	CONSTRUCT	SOURCE
INTAKE INTERVIEW	Sociodemographics	Interview
	Past & current psychiatric diagnoses	Mini-International Neuropsychiatric Interview (M.I.N.I. version 5.0) (Sheehan et al., 1998) & Structured Clinical Interview for DSM-5 Personality Disorders subscale for Borderline Personality Disorder (SCID-5-PD-BPD) (First, 2015)
	Physical illness	Interview
	Medications	Interview
	Suicidal ideation & attempt history	Columbia Suicide Severity Rating Scale (CSSRS) (Posner et al., 2011)
BASELINE QUESTIONNAIRES (T0)	Suicidal ideation	Beck Scale for Suicide Ideation (BSSI) (Beck et al., 1979)
	Depressive symptoms	Beck Depression Inventory (BDI-I) (Beck, 1961)
	Anxiety symptoms	Hamilton Anxiety and Depression Scale – Anxiety Subscale (HADS-A) (Hamilton, 1960)
	Insomnia symptoms	Insomnia Severity Index (ISI) (Morin et al., 2011)
	Borderline personality traits	Personality Assessment Inventory – Borderline Scale (PAI-BOR) (Morey, 1991)
	Trait anger	State-Trait Anger Expression Inventory – Trait subscale (STAXI-T) (Lievaart et al., 2016)
	Cognitive reactivity	Leiden Index of Depression Sensitivity – Revised (LEIDS-R) (Solis et al., 2017)
	Quality of life	Quality of Life Enjoyment and Satisfaction Questionnaire –

		Short Form (Q-LES-Q-SF) (Endicott et al., 1993)
ECOLOGICAL MOMENTARY ASSESSMENT (EMA) – 21 DAYS	Location, social contact & current activity	Adapted from Husky et al. (2017) (see Chapter 3 - Appendix for full list of EMA items)
	Positive & negative affective states	Adapted from the Positive and Negative Affect Scales (PANAS) (Watson et al., 1988)
	Cognitions	Adapted from the Interpersonal Needs Questionnaire (INQ) (van Orden et al., 2012)
	Suicidal ideation & acquired capability	Adapted from the BSSI, CSSRS and Acquired Capability for Suicide Scale (ACSS) (Ribeiro et al., 2014)
	Impactful events	Adapted from Chaudhury et al., (2017)
	Coping	Adapted from Chaudhury et al., (2017)
	Substance use	Adapted from Jahng et al. (2011)
	Sleep	Adapted from the Consensus Sleep Diary – Morning section (CSD-M) (Carney et al., 2012)
ACTIGRAPHY	Sleep	MotionWatch8© (CamnTech, Cambridge, UK) (Falck et al., 2019, 2020, 2021)
	Activity	“
	Light exposure	“
POST-TEST QUESTIONNAIRES (T1)	Suicidal ideation	“
	Depressive symptoms	“
	Anxiety symptoms	“
	Insomnia symptoms	“
	Participant feedback on EMA/actigraphy	Custom questionnaire (see Chapter 3 - Appendix)
ECOLOGICAL MOMENTARY ASSESSMENT (EMA) – 1 YEAR	Positive & negative affective states	“
	Cognitions	“

	Suicidal ideation & acquired capability & suicide attempts	“
	Depressive symptoms	Adapted from the BDI
	Impactful events	“
	Coping	“
	Substance use	“
	Sleep	“
FOLLOW-UP QUESTIONNAIRES (T2)	Suicidal ideation	“
	Depressive symptoms	“
	Anxiety symptoms	“
	Insomnia symptoms	“
	Borderline personality traits	“
	Trait anger	“
	Cognitive reactivity	“
	Quality of life	“

CHAPTER 02:

Literature Review

Don’t Miss the Moment: A Systematic Review of Ecological Momentary Assessment in Suicide Research

Published as:

Kivelä, L., van der Does, W., Riese, H., & Antypa, N. (2022). Don’t Miss the Moment: A Systematic Review of Ecological Momentary Assessment in Suicide Research. *Frontiers in Digital Health, 4*, 876595. https://doi.org/10.3389/fdgth.2022.876595

Abstract

Background: Suicide and suicide-related behaviors are prevalent yet notoriously difficult to predict. Specifically, short-term predictors and correlates of suicide risk remain largely unknown. Ecological momentary assessment (EMA) may be used to assess how suicidal thoughts and behaviors (STBs) unfold in real-world contexts. **Methods:** We conducted a systematic literature review of EMA studies in suicide research to assess (1) how EMA has been utilized in the study of STBs (i.e., methodology, findings), and (2) the feasibility, validity and safety of EMA in the study of STBs. **Results:** We identified 45 articles, detailing 23 studies. Studies mainly focused on examining how known longitudinal predictors of suicidal ideation perform within shorter (hourly, daily) time frames. Recent studies have explored the prospects of digital phenotyping of individuals with suicidal ideation. The results indicate that suicidal ideation fluctuates substantially over time (hours, days), and that individuals with higher mean ideation also have more fluctuations. Higher suicidal ideation instability may represent a phenotypic indicator for increased suicide risk. Few studies succeeded in establishing prospective predictors of suicidal ideation beyond prior ideation itself. Some studies show negative affect, hopelessness and burdensomeness to predict increased ideation within-day, and sleep characteristics to impact next-day ideation. The feasibility of EMA is encouraging: agreement to participate in EMA research was moderate to high (*Med* = 77%), and compliance rates similar to those in other clinical samples (*Med* response rate = 70%). More individuals reported suicidal ideation through EMA than traditional (retrospective) self-report measures. Regarding safety, no evidence was found of systematic reactivity of mood or suicidal ideation to repeated assessments of STBs. **Conclusions:** Suicidal ideation can fluctuate substantially over short periods of time, and EMA is a suitable method for capturing these fluctuations. Some specific predictors of subsequent ideation have been identified, but these findings warrant further replication. While repeated EMA assessments do not appear to result in systematic reactivity in STBs, participant burden and safety remains a consideration when studying high-risk populations. Considerations for designing and reporting on EMA studies in suicide research are discussed.

Introduction

Ecological momentary assessment (EMA) refers to data collection methods were momentary information is collected in real life (Shiffman et al., 2008). EMA is also known as experience sampling method (ESM) (Larson & Csikszentmihalyi, 2014) or ambulatory assessment (AA) (Trull & Ebner-Priemer, 2014). These three terms emphasize the defining features of this methodology: catching individuals in their natural environments while they go about their daily lives, and probing them about their experiences as they unfold in the moment. Indeed, the most prominent strengths of EMA are its ecological validity and the ability to perform repeated assessments (Davidson et al., 2017; Shiffman et al., 2008). Technological advancements have further increased the feasibility of EMA measures: as opposed to undergoing assessments that are either based on retrospective self-report or performed in non-representative laboratory settings, participants may now provide time- and context-specific data through their smartphones (Kaplan & Stone, 2013; Shiffman et al., 2008; Trull & Ebner-Priemer, 2014).

While paper-and-pen diaries and later handheld computers or personal digital assistants (PDAs) were first used to collect EMA data, many studies now use mobile phone applications specifically designed for EMA purposes (Myin-Germeys et al., 2018). These applications function as electronic diaries that may be used to prompt participants to record their mood, cognitions, behavior, context (incl. social interactions) and other experiences, typically either through text entries, event logs or rating scales (Myin-Germeys et al., 2018). Such electronic EMA assessments typically use either *signal-contingent* or *event-contingent* sampling, prompting participants to fill out assessments either when alerted by the device, or when certain events naturally occur in their daily lives. These methods may also be combined (Janssens et al., 2018; Myin-Germeys et al., 2018; Shiffman et al., 2008). Signal-contingent sampling schedules can further be divided into *fixed* and *(pseudo)randomized* schedules. EMA assessments sent out on fixed schedules prompt participants at the same time(s) each day, while randomized schedules send out prompts at random times throughout the day; pseudorandomized schedules divide each 24-hour period into blocks, and random prompts are sent out per block. Pseudorandomization offers advantages over full randomization, as it ensures that assessments are sufficiently paced out within the day, but also that participants do not systematically miss prompts due pre-determined commitments like work or school schedules, or learn to anticipate prompts (Shiffman, 2009).

EMA has been increasingly adopted in the study of psychopathology. This may be a promising approach since insights into the psychological states and behavior patterns in the daily life of the patient can be targeted in therapy (Riese & Wichers, 2021). Recent reviews have outlined the applicability of EMA in a number of clinical populations, including patients with depression (Bos et al., 2019; Colombo et al., 2019) and anxiety disorders (Walz et al., 2014), eating disorders (Smith et al., 2019), borderline personality disorder (Santangelo et al., 2014), and psychotic disorders (Bell et al., 2017). These reviews indicate that EMA is an acceptable and feasible data collection method in psychiatric samples as well, and that it may be used to assess a range of experiences from affect (Ebner-Priemer & Trull, 2009) to self-harm (Rodríguez-Blanco et al., 2018) and substance use (Serre et al., 2015). Indeed, EMA can hold many advantages over traditional self-report measures for these purposes. Psychiatric disorders, such as depression (Dalgleish & Watts, 1990; Williams et al., 2007) and schizophrenia (Forbes et al., 2009), are often characterized by memory biases. Retrospective accounts of certain behaviors, such as substance use, are also characteristically unreliable (Shiffman, 2009). Individuals may also be more willing to disclose sensitive information, such as accounts of drug use or self-harm, when they can do so remotely without face-to-face contact with the researcher (Gnambs & Kaspar, 2014). Further, EMA is an especially suitable method for assessing symptoms that are dynamic in nature (such as affective instability) (Myin-Germeys et al., 2018; Trull et al., 2015), which may be time or context dependent, and for which global retrospective measures provide only approximations (Shiffman et al., 2008). However, the benefits of EMA should be considered together with its possible limitations, which may include increased burden and time commitment from participants, and potential reactivity to repeated assessments of negative experiences (Bos, 2021).

Meanwhile, EMA remains a relatively underused data collection method in suicide research, although its features make it suitable for the assessment of suicidal thoughts and behaviors (STBs) (Davidson et al., 2017; De Beurs et al., 2015; Nock, 2016). Suicide and suicide-related phenomena (ideation i.e., thoughts or fantasies about one's death (Ringel, 1976), attempts) represent a major cause of mortality and disability worldwide (Borges et al., 2010; Nock et al., 2008). Several risk-factors for suicide are known, including psychiatric and demographic variables such as depression, gender and stress (Borges et al., 2010; Nock et al., 2008; Van Orden et al., 2010). However, these factors have quite limited clinical use: they are poor predictors of short-term behavior, or are non-modifiable (e.g., gender, past STBs). Their base rate is also much higher than that of suicide, and basing clinical decisions on these risk factors would result in an abundance of false positives (Franklin et al., 2017; Large et al., 2011, 2016), and many interventions are generic and are not very efficacious (Chesin & Stanley, 2013). Meanwhile, acute warning signs of suicide risk remain less well studied and understood (Rudd et al., 2006). Two recent meta-analyses concluded that there has been no improvement in the prediction of suicide risk in the past fifty years (Franklin et al., 2017; Large et al., 2016). Many have called for a shift of focus towards prospectively predicting STBs in the short term (within days or even hours) (Chesin & Stanley, 2013; Davidson et al., 2017; Glenn & Nock, 2014). Both suicidal ideation and its risk factors can fluctuate substantially over short periods of time (days and hours) (Witte et al., 2006). Indeed, it has been suggested that (between-day) *variability* in suicidal ideation may be a better predictor of suicide than its intensity or duration (Witte et al., 2005, 2006).

In summary, the study of STBs needs a new focus and methodology, for which EMA holds promise. Its limited use so far in suicide research may reflect concerns about the potentially adverse effects of repeated probing of suicidal thoughts and urges in at-risk groups. It has been demonstrated that asking individuals about their suicidal thoughts and behaviors does not induce suicidal ideation in asymptomatic individuals, nor does it increase risk in those affected. In fact, it may even serve to lessen ideation and general distress in high-risk individuals (Gould et al., 2005; Smith et al., 2010). Limited evidence exists, however, on the question of whether this also holds for as frequently repeated assessments as with EMA schedules. The validity of EMA measures of STBs is also uncertain. Self-reports of suicidal behavior can be very unstable over time due to erroneous recall (Eikelenboom et al., 2014). Further, only a limited number of items can be used to cover a certain construct in EMA protocols (Myin-Germeys et al., 2018) – sometimes only a single item is used (see e.g., Husky et al. (2017)).

The aim of this systematic review was to determine: (i) how EMA has been used to operationalize and measure STBs (incl. methodology, aim, findings), and (ii) the feasibility, validity and safety of EMA in research on STBs. We exclude studies on non-suicidal self-injury (NSSI) (recently reviewed by Rodríguez-Blanco et al. (2018)) and studies using paper-and-pen diaries, as these data are frequently compromised by retrospective responding (Stone et al., 2003).

Methods

The review was conducted in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009).

Search Profile

The databases Web of Science (www.webofknowledge.com) and PubMed (https://www.ncbi.nlm.nih.gov) were searched for articles in December 2021, using the search term: "((EMA) OR ("ecological momentary assessment") OR (ESM) OR ("experience sampling method") OR ("ambulatory assessment") OR ("ambulatory monitoring") OR ("real time monitoring") OR ("electronic diary")) AND (("suicide") OR ("suicidal"))". As shown in Figure 1, the search produced 372 results. After excluding duplicate records, 280 remained. Of these, 40 met the inclusion criteria given below. Another 5 articles were identified through alternate sources (i.e., review papers and other articles), resulting in a total of 45 articles for the present review.

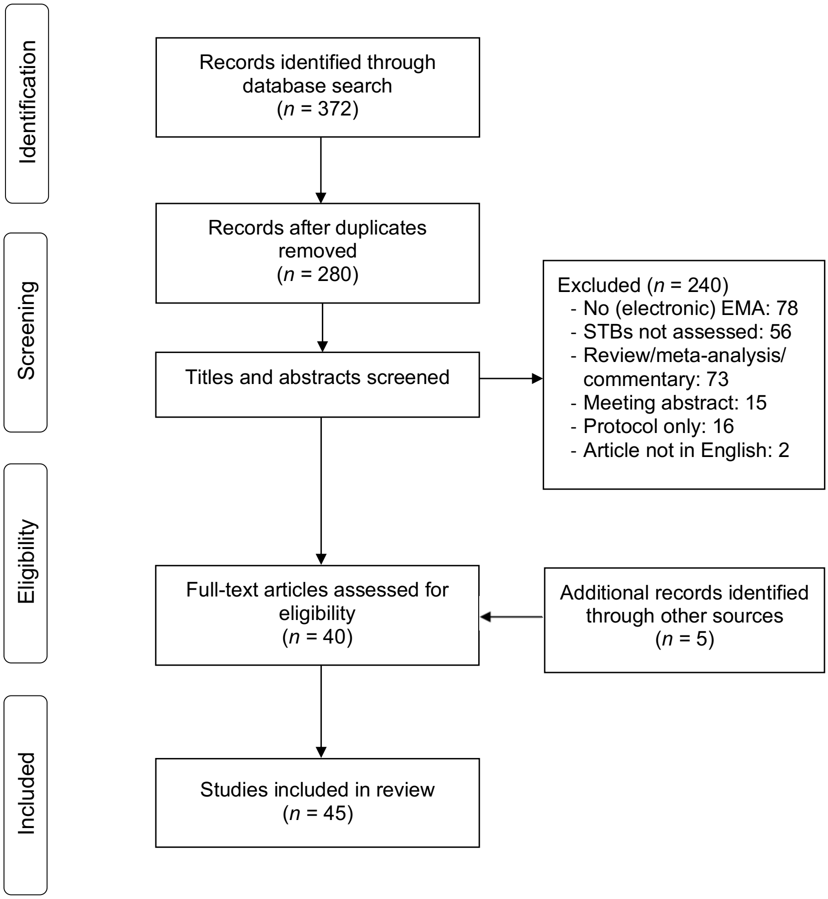
Inclusion and Exclusion Criteria

We included articles reporting on (1) studies using electronic EMA (PDAs, mobile phones, smartwatches), and excluded studies using paper-and-pen diaries. We also included studies using web-based survey software (such as Qualtrics, www.qualtrics.com) if mobile phones or other devices were used to alert and direct the participants to the survey. We further only included (2) studies where EMA was used to assess STBs (≥ 1 item assessing STBs). We excluded studies focusing solely on non-suicidal self-injury (NSSI), but included studies where both NSSI and STBs were assessed. Articles were also excluded if (1) the article was a meta-analysis, (systematic) review, editorial, or commentary, or (2) the article was not written in English.

Data Abstraction

For each article we recorded the (1) author(s) and publication year, (2) sample characteristics, (3) aim of the study, (4) variable(s) measured through EMA, (5) how STBs were operationalized (i.e., the number and type of EMA items assessing STBs), (6) duration of the EMA assessment period, (7) sampling method (i.e., schedule and number of prompts per day), (8) device and software used, (9) methodological characteristics (incl. acceptance i.e., agreement to participate, attrition, compliance i.e., average response rates, and reactivity), and (10) main findings (as relating to STBs), including any adverse events. When reported, we also recorded any procedures used to ensure participant safety during the EMA assessment period.

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Flow Diagram of Included Studies



Results

In total, 45 articles reporting on 23 studies were included in the review (some studies were reported in more than one article; overlap between samples is indicated where applicable). Of these, 33 articles were reports where EMA was used to measure STBs (Table 1), and nine specifically addressed methodological issues (acceptability, feasibility and validity) of using EMA to measure STBs (Table 2).

Characteristics of EMA Studies Measuring STBs

Samples Sample sizes ranged from 13 to 457 (*Med* = 53, *n* = 23). Most studies (78%, *n* = 18) were conducted in adult, and less frequently in adolescent samples (22%, *n* = 5) (Czyz et al., 2018; Glenn et al., 2020; Nock et al., 2009; Vine et al., 2020). Participants were typically recruited from high-risk populations, such as psychiatric inpatients or those recently discharged from the hospital. Most frequent primary co-morbid diagnoses were depressive disorders (Forkmann et al., 2018; Gratch et al., 2021; Torous et al., 2015) and borderline personality disorder (BPD) (Kaurin et al., 2020; Law et al., 2015; Rizk et al., 2019); however, inclusion was typically based on (recent) history of self-reported STBs to ensure sufficient number of observations of STBs during the assessment period.

Schedules The duration of EMA monitoring ranged from 4 to 60 days (*Med* = 14, *n* = 23). The number of (scheduled) EMA prompts per day ranged from 1 to 11 (*Med* = 5, *n* = 21). All studies used some form of signal-contingent sampling: (pseudo)random sampling schedules were most frequently used (57%, *n* = 13) (Al-Dajani & Uliaszek, 2021; Armey et al., 2020; Glenn & Nock, 2014; Gratch et al., 2021; Hallard et al., 2021; Husky et al., 2017; Kleiman et al., 2017; Littlewood et al., 2019; Oquendo et al., 2020; Rizk et al., 2019; Rogers, 2021; Torous et al., 2015; Wang et al., 2021), followed by fixed sampling (26%, *n* = 6) (Czyz et al., 2018, 2021; Law et al., 2015; Nock et al., 2009; Peters et al., 2020; Vine et al., 2020), and protocols that combined both fixed and (pseudo)random sampling (13%, *n* = 3) (Hallensleben et al., 2019; Kleiman et al., 2017; Victor et al., 2019). Fixed schedules were almost exclusively used in studies with once-daily prompts (as well as three older studies with PDAs (Husky et al., 2014; Law et al., 2015; Nock et al., 2009)), whereas pseudo-random schedules were typically used for repeated within-day assessments. Approximately one fourth (26%; *n* = 6) of studies supplemented signal-contingent sampling with event-contingent sampling (i.e., participants were encouraged to self-initiate additional entries when experiencing STBs (Al-Dajani & Uliaszek, 2021; Armey et al., 2020; Glenn & Nock, 2014; Kleiman et al., 2017; Nock et al., 2009)), but none of the studies used event-contingent sampling alone. Studies frequently (57%, *n* = 13) (Al-Dajani & Uliaszek, 2021; Armey et al., 2020; Czyz et al., 2018; Glenn et al., 2020; Gratch et al., 2021; Hallard et al., 2021; Husky et al., 2014; Kleiman et al., 2017; Littlewood et al., 2019; Rizk et al., 2019; Victor et al., 2019; Wang et al., 2021)) reported that participants could provide input about their daily schedules (incl. sleep and wake times), allowing EMA prompt windows to be adjusted for each participant, and a minimum time window (30-60 minutes) between prompts was established with (pseudo)random schedules to achieve better temporal coverage.

Measured Variables and Operationalization of STBs While all studies included EMA items on suicidal ideation, four studies (18%) also assessed the occurrence of suicide attempts via EMA (Czyz et al., 2018; Law et al., 2015; Nock et al., 2009; Rogers, 2021) (see Table 1 and Table 2 for full list of measured variables and SI item descriptions). The number of EMA items on STBs ranged from 1 to 9 (*Med* = 2, *n* = 22). The items were typically rated on a 5-point Likert-scale; seven (32%) studies used binary items, or a combination of an initial binary item on the presence of STBs, followed by ratings on frequency, intensity and/or duration (18%, *n* = 4). Items were often based on established self-report questionnaires or structured interviews, such as the Beck Scale for Suicide Ideation (BSSI) (Beck et al., 1979) or the Columbia Suicide Severity Rating Scale (C-SSRS) (Posner et al., 2011), and rephrased to reflect the time period of the EMA or otherwise adapted for the purposed of the study.

Several studies used gate questions to limit the number of questions presented pertaining to STBs. Such gate questions either first inquired about the presence of (any) negative thoughts prior to direct questioning of suicidal ideation (see e.g., Husky et al., 2014), or limited follow-up questions on the intensity, frequency and/or duration of ideation only to those instances where suicidal ideation was first endorsed (see e.g., Armey et al., 2020; Czyz, Horwitz, et al., 2019; Glenn & Nock, 2014; Nock et al., 2009). Two studies used a turn-over system where a subset of questions was randomly presented at a certain time point to limit repetition (Porras-Segovia et al., 2020; Torous et al., 2015). Studies were heterogenous in their operationalization of STBs, and no clear delineation emerged over time on preferred methodologies or use of specific EMA items.

The most frequently measured predictor variables included contextual factors (incl. location, activity, social company), affect, and constructs from the Interpersonal Psychological Theory of Suicide (IPTS: hopelessness, burdensomeness and thwarted belongingness (Chu et al., 2017)). Protective factors, such as coping and social support, were less frequently assessed.

Main findings

Prevalence of STBs In adolescent samples, suicidal ideation was reported by 34-82% of the sample during EMA (*Med* = 71%, *n* = 3), and overall, 2-39% of observations had suicidal ideation ratings > 0 (*Med* = 25%, *n* = 3). These thoughts occurred once a week on average, and typically lasted 1 to 30 minutes (based on a binary measure of ideation (Nock et al., 2009)). In adult samples, ideation was reported by 26-100% of the participants (*Med* = 97%, *n* = 7), and 1-82% of observations had suicidal ideation ratings > 0 (*Med* = 22%, *n* =

7). While the majority of studies recruited participants with heightened risk profiles (such as those recently discharged after a suicide attempt), prevalence rates in two community-based samples with current self-reported ideation were comparable to the pooled prevalence rates (86-100% participants and 20-22% of all entries indicated suicidal ideation) (Al-Dajani & Uliaszek, 2021; Rogers, 2021). When examined separately, higher levels of passive (*M* = 4.54, *SD* = 2.25, Range 2-10) than active (*M* = 3.18, *SD* = 1.50, Range 2-10) suicidal ideation were reported (Hallensleben et al., 2019).

Contextual factors of suicidal thoughts among adolescents included being alone, experiencing arguments/conflict or recalling negative memories (Nock et al., 2009). Among adolescents with a history of NSSI, suicidal ideation frequently co-occurred with NSSI (Czyz et al., 2021). Among adults, being alone, at home or at work, and inactivity increased the probability of suicidal ideation, while being with family and friends or engaged in leisure activities decreased the probability of ideation (Husky et al., 2017). Although negative daily life events were generally not associated with suicidal ideation, negative interpersonal events increased the probability of ideation (Husky et al., 2017; Kaurin et al., 2020), whereas perceived social support decreased its probability (Coppersmith et al., 2019). Affective precipitants (incl. negative affect, feelings of pressure, anger/irritability) were associated with increased occurrence of ideation (Armey et al., 2020; Nock et al., 2009).

Variability of STBs Most individuals experienced substantial variability in suicidal ideation both between- (Czyz, Horwitz, et al., 2019) and within-days (Hallensleben et al., 2019; Kleiman et al., 2017; Rizk et al., 2019). Within-day, approximately one third of ratings differed from the previous one by at least one (within-person) standard deviation, illustrating both sharp increases and decreases in ideation in a time frame of hours (4-8h) (Kleiman et al., 2017). Those with higher mean ideation (per person, across EMA period) experienced more variability (Kleiman et al., 2017; Oquendo et al., 2020; Peters et al., 2020). Risk factors (negative affect, hopelessness, loneliness, burdensomeness, connectedness, thwarted belongingness) occurred with similar variability, and were concurrently associated with suicidal ideation (Aadahl et al., 2021; Czyz, Horwitz, et al., 2019; Hallensleben et al., 2019; Kleiman et al., 2017; Victor et al., 2021). General affective instability (i.e., tendency to experience frequent, sudden changes in mood) was associated with suicidal ideation variability among female BPD patients (Rizk et al., 2019), and inpatient individuals diagnosed with MDD or bipolar disorder (Peters et al., 2020). Generally, baseline clinical characteristics, such as severity of depressive symptoms (retrospective self-report of symptoms over the past two weeks (Hallensleben et al., 2018)) were not differentially associated with suicidal ideation variability. The test-retest reliability of EMA-assessed within-person suicidal ideation variability (as estimated by the Root Mean Square of the Successive Differences, RMSSD) was high across 24 months (Oquendo et al., 2020). Suicidal ideation variability (here operationalized as the individual's likelihood of experiencing extreme changes in suicidal ideation from one assessment point to the next) was also predictive of the occurrence of a suicide attempt at 1-month follow-up post-discharge, based on a pilot study of 83 adults hospitalized for a suicidal crisis (Wang et al., 2021).

Prediction of STBs Most reports failed to establish independent temporal predictors of suicidal ideation severity: of twelve articles fitting temporal prediction models (Coppersmith et al., 2019; Czyz et al., 2018; Glenn et al., 2021; Hallensleben et al., 2019; Kaurin et al., 2021; Kleiman et al., 2017; Littlewood et al., 2019; Rath et al., 2019; Schatten et al., 2021; Stanley et al., 2021; Victor et al., 2019), four failed to establish significant predictors after accounting for ideation at the previous time point (Coppersmith et al., 2019; Czyz et al., 2018; Kleiman et al., 2017), and five did not control for prior ideation (Glenn et al., 2021; Kaurin et al., 2021; Littlewood et al., 2019; Schatten et al., 2021; Victor et al., 2019). Across studies, prior suicidal ideation therefore remained the strongest (or only) predictor of subsequent ideation (i.e., suicidal ideation at time t significantly predicting ideation at $t + 1$). Regarding other predictors, the most consistent evidence was found for momentary negative affect, hopelessness and burdensomeness. These variables predicted increased momentary suicidal ideation within-day (Hallensleben et al., 2019; Kleiman et al., 2017; Rath et al., 2019; Victor et al., 2019). One study indicated that active coping reduced the intensity of ideation at the subsequent assessment two hours later (Stanley et al., 2021). Between days, short sleep duration (both objective and subjective), poor subjective sleep quality and increased sleep latency (i.e., time to fall asleep) predicted (mean) next-day suicidal ideation (Kaurin et al., 2021; Littlewood et al., 2019). Negative interpersonal events were also associated with increased next-day suicidal ideation (Glenn et al., 2021). The probability of finding influential predictors was further lower with increasing intervals. Studies examining day-to-day rather than within-day changes in suicidal ideation were less likely to report positive findings (Coppersmith et al., 2019; Czyz et al., 2018). This may be due to reduced temporal granularity of data due to aggregate daily ratings.

Table 1. Overview of Manuscripts Reporting on Studies Using EMA to Assess Suicidal Thoughts and Behaviors (STBs)

Author	Sample	Aim	Measured variables	STB items	Duration	Sampling method	Device	Compliance	Main findings
Nock et al. (2009)	*n* = 30 adolescents/ young adults w/ history of NSSI thoughts	Antecedents and functions of self-injurious thoughts and behaviors	Context, affect, coping, substance use, binging/ purging, STBs & NSSI thoughts and behaviors	1(–4) item(s): "Think of doing these? [ ] Attempt suicide." (If *yes*: "How intense did the urge get?", "How long did you think about it?", "Did you attempt suicide?"	14 days	(Fixed) signal-contingent 2x/day + event-contingent	Personal digital assistants (PDAs)	83% (filled in complete EMA)	SI most often occurred when alone, and was preceded by worry, feelings of pressure, bad memories, and arguments with others; SI was generally mild-to-moderate in intensity and longer in duration than NSSI thoughts
Ben-Zeev et al. (2017)	*n* = 27 adult psychiatric inpatients	Real-time correlates of violent ideation and behavior	Context, affect, delusions, substance cravings/ withdrawal, violent ideation/	1 item: "Are you thinking of ending your life?"	7 days	Signal-contingent 6x/day	Customized Android smartphones	n/a	SI was associated with concurrent violent ideation and other-directed

			behavior, SI						aggressive behavior
Husky et al. (2017)	*n* = 42 adult recent suicide attempters	Predictors of SI in daily life	Activity, location, social interactions, stressful events, affect, negative thoughts (incl. SI and NSSI thoughts)	1 item: presence/ absence of SI and/or NSSI	7 days	(Random) signal-contingent 5x/day	Personal digital assistants (PDAs)	74% (average response rate)	Inactivity, being at home/work, and feeling sad or anxious increased the probability of SI; being with close others decreased the probability of SI
Kleiman et al. (2017)									
Study 1	*n* = 54 adult recent suicide attempters	Variability of SI and risk factors	Hopelessness, loneliness, burdensome-ness, SI	3 items: “How intense is your desire to kill yourself right now?”, “How strong is your intention to kill yourself right now?”, “How strong is your	28 days	(Random) signal contingent 4x/day + event-contingent	Smartphones (mEMA software)	63% (average response rate)	Higher mean SI was associated with higher SI variability; hopelessness, loneliness and burdensomeness covaried with SI, but did not

				ability to resists the urge to kill yourself right now?"					prospectively predict SI
Study 2	n = 36 adult psychiatric inpatients	Variability of SI and risk factors	Hopelessness, loneliness, SI	3 items: As above	Duration of inpatient stay (M = 10 days)	(Random) signal contingent 4x/day + event-contingent	Android smartphones (MovisensXS software)	62% (average response rate)	Hopelessness and loneliness substantially (co)varied with SI, but did not prospectively predict SI
Hallensleben et al. (2018)*	n = 20 adult psychiatric inpatients	Modeling variability of SI	SI	4 items: *Passive ideation* incl. "At the moment I feel that life is not worth living.", *Active ideation* incl. "At the moment I'm thinking about killing myself."	6 days	(Random) signal-contingent 10x/day	Android smartphones (MovisensXS software)	n/a	SI variability was not significantly associated with baseline clinical characteristics (incl. depression severity)
Kleiman et al. (2018a)**	n = 43 adult recent	Affective antecedents and	Affect, SI	3 items: "How intense is your desire to kill	28 days	(Random) signal-contingent 4x/day + event contingent	Smartphones (mEMA software)	n/a	NA decreased and PA increased at the

	suicide attempters	consequences of SI			yourself right now?", "How strong is your intention to kill yourself right now?", "How strong is your ability to resists the urge to kill yourself right now?"					next time point following instances of SI
Kleiman et al. (2018b)										
*Study 1***	n = 51 adult recent suicide attempters	Phenotyping of suicidal ideators	SI		3 items: "How intense is your desire to kill yourself right now?", "How strong is your intention to kill yourself right now?", "How strong is your ability to resists the urge to kill	28 days	(Random) signal-contingent 4x/day	Smartphones (mEMA software)	n/a	Five subtypes of SI: (1) low mean, low variability, (2) low mean, moderate variability, (3) moderate mean, high variability, (4) high mean, low variability, and

				yourself right now?"					(5) high mean, high variability
*Study 2****	n = 32 adult psychiatric inpatients	Phenotyping of suicidal ideators	SI	3 items; As above	Duration of inpatient stay (M = 9 days)	(Random) signal-contingent 4x/day	Android smartphones (MovisensXS software)	n/a	The finding of five subtypes of SI from Study 1 was replicated
Littlewood et al. (2018)	n = 51 adults w/ current SI	Temporal relations of sleep and SI	Sleep, feelings of entrapment, SI	1 item: "Right now I am feeling suicidal."	7 days	(Random) signal-contingent 6x/day	Smart-watch (PRO-Diary watch)	85% (average response rate)	Sleep duration, subjective sleep quality predicted next-day SI; daytime SI did not predict sleep the subsequent night
Coppersmith et al. (2019)**	n = 53 adult recent suicide attempters	Variability of SI and social support	Social support, SI	3 items: assessing (1) wish to live, (2) wish to die, and (3) desire to die by suicide, incl. "I have *no / a weak / a moderate to*	28 days	(Fixed) signal-contingent 1x/day	Smartphones (mEMA software)	71% (average response rate)	Perceived social support was negatively associated with same-day SI, but did not predict next-day SI

				strong wish to live."					
Czyz et al. (2019a)	$n = 34$ adolescents w/ a history of STBs	Proximal outcomes of a suicide intervention	Self-efficacy, safety plan use, coping, SI	1(–4) item(s): "At any point in the last 24h, did you have any thoughts of killing yourself?", "How many times did you have thoughts of killing yourself?", "How long did these thoughts last?", "How strong was the urge to act on your thoughts of suicide?"	28 days	(Fixed) signal-contingent 1x/day	Text messages (TelEMA software) with link to online questionnaire (Qualtrics software)	n/a	Intervention group reported higher self-efficacy to resist urge to suicide, more sustained safety plan use, and more self-reliant coping
Czyz et al. (2019b)****	$n = 34$ adolescents w/ a history of STBs	Co-occurrence and function of NSSI and	Coping, NSSI and SI	1(–4) item(s): As above	28 days	(Fixed) signal-contingent 1x/day	Text messages (TelEMA software) with link to online	n/a	SI and NSSI co-occurred on 58% of days, and on 98% of

		SI					questionnaire (Qualtrics software)		these days NSSI was reported as a coping mechanism for SI
Czyz et al. (2019c)****	*n* = 34 adolescents w/ a history of STBs	Variability and predictors of daily SI	Hopelessness, connectedness, burdensome-ness, SI	1(–4) item(s): As above	28 days	(Fixed) signal-contingent 1x/day	Text messages (TelEMA software) with link to online questionnaire (Qualtrics software)	69%	Connectedness, burdensome-ness and loneliness were associated with same-day, but not next-day, SI
Hallensleben et al. (2019)	*n* = 74 adult psychiatric inpatients	Variability and predictors of passive and active SI	Depressed mood, hopelessness, thwarted belongingness, burdensome-ness, SI	4 items; *Passive ideation* incl. "Life is not worth living for me.", "There are more reasons to die than to live." *Active ideation* incl. "I think about taking	6 days	(Random) signal-contingent 10x/day	Android smartphones (MovisensXS software)	n/a	Passive and active SI associated with hopelessness, depressed mood, burdensome-ness and thwarted belongingness; hopelessness and burdensome-

				my life.", "I want to die."					ness prospectively predicted SI at the next time point
Rath et al. (2019)*	*n* = 74 adult psychiatric inpatients	Network modeling of SI and risk factors	Depressed mood, hopelessness, thwarted belongingness, burdensome-ness, PA, anxiety, SI	4 items: "Life is not worth living for me.", "There are more reasons to die than to live.", "I think about taking my life.", "I want to die."	6 days	(Random) signal-contingent 10x/day	Android smartphones (MovisensXS software)	n/a	SI was concurrently associated with all risk factors; SI and perceived burdensome-ness predicted SI at the subsequent time point
Rizk et al. (2019)	*n* = 38 female adults w/ BPD and history of STBs	Variability of SI and its relation to affective instability	SI	9 items; assessing the wish live, wish to die, wish to escape, thoughts about dying, thoughts about suicide, urge to die by	7 days	(Random) signal-contingent 6x/day	Personal digital assistants (PDAs)	n/a	Baseline affective instability predicted SI variability, independent of (baseline) depression severity

				suicide, thoughts about hurting self, urge to hurt self, and reasons for living					
Spangenberg et al. (2019)*	n = 74 adult psychiatric inpatients	Temporal stability of capability for suicide	Capability for suicide, SI	4 items (SI): “Life is not worth living for me.”, “There are more reasons to die than to live.”, “I think about taking my life.”, “I want to die.” 3 items (Capability for suicide): “Today I would have taken a lot of (physical) pain.”, “Today I was not at all afraid to die.”,	6 days	(Random) signal-contingent 10x/day + (Fixed) signal-contingent 1x/day	Android smartphones (MovisensXS software)	90% (random alerts), 95% (fixed alerts) (average response rate)	Substantial fluctuations in daily capability for suicide; daily SI was prospectively associated with suicide capability at the end of the day

				"Today I could have killed myself if I wanted to."					
Victor et al. (2019)	*n* = 62 female adults w/ history SI	Effects of internalizing and externalizing NA on SI	Internalizing & externalizing NA, rejection, criticism, SI and NSSI thoughts	1 item; "Since the last prompt, have you felt the urge or wanted to make a suicide attempt?"	21 days	(Random) signal-contingent 6x/day + (Fixed) signal-contingent 1x/day	Text messages with link to an online questionnaire	75% (average response rate)	Within-person changes in internalizing NA predicted SI at the next assessment; feelings of rejection and criticism were indirectly associated with SI through increased internalizing NA
Armey et al. (2020)	*n* = 151 adults w/ history of STBs	Associations of SI, affect and anger	Affect, anger/ irritability, SI	1(–2) item: "Since your last completed questionnaire, have you thought about	21 days	(Random) signal-contingent 5x/day + event-contingent	Smartphones (mEMA software)	44% (average response rate)	Higher NA and lower PA associated with increased odds of SI; increased within-person

				hurting or killing yourself?" (If *yes*, follow-up question on frequency)					anger/ irritability associated with increased odds of SI
Czyz et al. (2020)****	*n* = 32 adolescents w/ a history of STBs	Identifying early signs of suicide crises (attempt, hospitali-zation)	Self-efficacy, hopelessness, connectedness, burdensome-ness, psychological pain, SI	1(–2) item(s): "At any point in the last 24 hr, did you have any thoughts of killing yourself?" (If *yes*: "How long did these thoughts last?")	14 days	(Fixed) signal-contingent 1x/day	Text messages (TelEMA software) with link to online questionnaire (Qualtrics software)	76% (average response rate)	The strongest single predictors of suicide crises were duration of SI & self-efficacy
Hadzic et al. (2020)*	*n* = 74 adult psychiatric inpatients	Association of trait impulsivity w/ variability in SI	SI	4 items: "Life is not worth living for me.", "There are more reasons to die than to live.", "I think about taking my life.", "I want to die."	6 days	(Random) signal-contingent 10x/day	Android smartphones (MovisensXS software)	n/a	Trait impulsivity associated with variability in passive, but not active, SI

Kaurin et al. (2020)	n = 153 adults w/ BPD & n = 52 healthy controls	Associations of interpersonal stressors, affect, impulsivity and SI	Social interactions, affect, impulsivity, SI	2 items: "Have you wished you were dead or wished you could go to sleep and not wake up?", "Have you actually had any thoughts of killing yourself?"	21 days	n/a	Smartphones (Metric Wire application)	n/a	Interpersonal stressors associated with SI indirectly through higher NA and lower PA
Oquendo et al. (2020)	n = 51 adults with MDD	Associations of affective instability, trait impulsivity and aggression, childhood trauma, stressful events & SI	Stressful evets, SI	9 items: "Thoughts about dying?", "A wish to live?", "A wish to die?", "A wish to sleep and not wake up?", "A wish to escape?", "Reasons for living?", "Thoughts about hurting	42 days (7 days at baseline, 3, 6, 12, 18 and 24 months follow-up)	(Random) signal-contingent 6x/day	Smartphones/ iPods (Harvest Your Data platform)	74%	High SI variability was associated with greater SI reactivity to stressors; degree of SI variability was stable over 24-months follow-up

				yourself?", "An urge to hurt yourself?", "Thoughts about killing yourself?"					
Peters et al. (2020)	$n = 39$ adult psychiatric inpatients	Correlates of SI variability	Depressed mood, anger/ irritability, social connected-ness, SI	1 item: "How suicidal are you right now?"	Duration of inpatient stay (M = 12 days)	(Fixed) signal-contingent 3x/day	Smartphones (Ethica platform)	Range 40-100% (daily average response rate)	SI severity and depressed mood variability were associated with greater SI variability, while general affective instability was not
Vine et al, (2020)	$n = 162$ adolescents in current psychiatric treatment	Associations of dissociative experiences with SI	Dissociative experiences, affect, SI	2 items: "Thoughts about killing yourself or hurting yourself?", "Told someone you were going	4 days	(Fixed) signal-contingent 2x/day (weekdays) & 3x/day (weekends)	Smartphones	89% (reached target compliance rate of 80%)	SI was significantly associated with dissociative experiences, but only for female adolescents

				to kill yourself or hurt yourself?”					
Aadahl et al. (2021)****	*n* = 24 adults w/ current SI	Associations of meta-cognitive beliefs and SI	Defeat, entrapment, hopelessness, SI	2 items: “I want to die.”, “I was thinking about killing myself.”	6 days	(Random) signal-contingent 7x/day	Text messages with link to online questionnaire	49% (average response rate)	NA, hopelessness and defeat associated with SI
Al-Dajani et al. (2021)	*n* = 39 community sample of adults w/ current SI	Function and consequences of SI	Affect, function of SI, SI	1(–3) item(s) (SI): “Since you last took this survey, did you experience a suicidal thought?” (If *yes*: “I thought that suicide can be a way to solve the problem I am facing.”, “Thinking of suicide was a way to escape/avoid	14 days	(Random) signal-contingent 4x/day + event-contingent	Smartphones (Experience Sampler application)	68% (average response rate)	NA increased after instances of SI; seeing suicide as a solution (vs. escape) lead to a broader NA response following instances of SI

				the emotion I was feeling."					
Cobo et al. (2021)	*n* = 36 adult psychiatric patients w/ history of STBs	SI before and during COVID-19 lockdown	NA, sleep, appetite, SI	2 items: "Wish to die", "Wish to live"	n/a	n/a	Smartphones (MEmind application)	n/a	SI ("Wish to die") decreased during the COVID-19 lockdown
Hallard et al. (2021)	*n* = 24 adults w/ current SI	Associations with cognitive control strategies, rumination and SI	Worry, rumination, self-punishment, distraction, social control, reappraisal, SI	2 items: "I want to die.", "I was thinking about killing myself."	6 days	(Random) signal-contingent 7x/day	Text messages with link to online questionnaire	49% (average response rate)	Maladaptive cognitive control strategies (worry, punishment) and rumination associated with SI
Czyz et al. (2021)	*n* = 74 adolescents w/ a history of STBs	Daily associations of NSSI and SI	NSSI and SI	1(–3) item(s): "At any point in the last 24 hr, did you have any thoughts of killing yourself?" (If *yes*: "How long did these	28 days	(Fixed) signal-contingent 1x/day	Text messages with link to online questionnaire	74% (average response rate)	NSSI and SI co-occurred 78% of the time; longer and more intense SI increased the odds of engagement in NSSI; more

				thoughts last?", "How strong was the urge to act on your thoughts of suicide?")					engagement in NSSI was associated with higher odds of suicide attempt
Glenn et al. (2021)	*n* = 48 adolescents	Short-term associations of negative interpersonal events and SI	Interpersonal events, thwarted belongingness and SI	4 items: "How intense is your desire to kill yourself right now?", "How strong is your intent to kill yourself right now?", "How able are you to keep yourself safe right now?", "How strong is your desire to live right now?"	28 days	(Random) signal-contingent + interval-contingent 4x/day	Smartphones (mEMA software)	n/a	Thwarted belongingness mediated the association between negative interpersonal events and next-day SI
Kaurin et al. (2021)*******	*n* = 153 adults w/ BPD &	Associations of sleep and next-day SI	Sleep, SI	6 items: "Have you wished you were dead or	21 days	(Random) signal-contingent 6x/day	Smartphones (Metric Wire application)	n/a	Increased sleep latency was associated with

	$n = 52$ healthy controls			wished you could go to sleep and not wake up?", "Have you actually had any thoughts of killing yourself?", "Have you been thinking about how you might do this?", "Have you had these thoughts and had some intention of acting on them?", "Do you intend to carry out this plan?"					greater next-day SI
Porras-Segovia et al. (2021)********	$n = 110$ adult psychiatric patients w/	Associations of NA,	Sleep, appetite, NA, SI	2 items: "Wish to die", "Wish to live"	*Med* = 90 days	(Fixed & random) signal-contingent	Smartphones (MEmind application)	53%	Concurrent associations between

	history of STBs	appetite, sleep and SI							disturbed sleep and SI
Schatten et al. (2021)****	*n* = 34 adolescent w/ a history of STBs	Affective predictors of same- and next-day suicidal ideation	Affect, SI	1 item: "At any point in the last 24h, did you have any thoughts of killing yourself?"	28 days	(Fixed) signal-contingent 1x/day	Text messages (TelEMA software) with link to online questionnaire (Qualtrics software)	69%	Misery, anger and happiness were associated with same-day SI; happiness predicted next-day SI
Stanley et al. (2021)*****	*n* = 50 adults w/ BPD and history of STBs	Effectiveness of coping on SI	Coping, SI	9 items; assessing the wish to live, wish to die, wish to escape, thoughts about dying, thoughts about suicide, urge to die by suicide, thoughts about hurting self, urge to hurt self, and	7 days	(Random) signal-contingent 6x/day	Personal digital assistants (PDAs)	70% (average response rate)	Distraction/ positive activity-based coping strategies (e.g., keeping busy, socializing, doing something good for self) reduced intensity of SI at next time point

				reasons for living					
Victor et al. (2021)********	*n* = 161 female adults w/ history SI	Associations between affect, NSSI and SI	Affect, NSSI, SI	1 item; "Since the last prompt, have you felt the urge or wanted to make a suicide attempt?"	21 days	(Random) signal-contingent 6x/day + (Fixed) signal-contingent 1x/day	Text messages with link to an online questionnaire	n/a	NA (mean and variability) was associated with SI
Wang et al. (2021)***	*n* = 83 adult psychiatric inpatients	Predicting suicide attempts from SI variability	SI	3 items; "How intense is your desire to kill yourself right now?", "How strong is your intention to kill yourself right now?", "How strong is your ability to resists the urge to kill yourself right now?"	Duration of inpatient stay (M = 7 days)	(Random) signal-contingent 4–6x/day	Smartphones (MovisensXS & Beiwe software)	n/a	Instability (rapid changes) in SI strongly predicted suicide attempt at 1-month follow-up

Note: SI = Suicidal ideation; STBs = Suicidal thoughts and behaviors; NSSI = Non-suicidal self-injury; BPD = Borderline personality disorder; MDD = Major depressive disorder; PA = Positive affect; NA = Negative affect; * sample from Hallensleben et al. (2019), ** Kleiman et al. (2017) (Study 1), *** Kleiman et al. (2017) (Study 2), **** Czyz et al. (2018), ***** Rizk et al. (2019), ****** Hallard et al. (2021), ******* Kaurin et al. (2020), ******** Cobo et al. (2021), ********* Victor et al. (2019)

Table 2. Overview of Manuscripts Assessing the Feasibility and Validity of Using EMA to Assess Suicidal Thoughts and Behaviors (STBs)

Author	Sample	Aim	Measured variables	STBs items	Duration	Sampling method	Device	Main findings
Husky et al. (2014)†	$n = 20$ adult past suicide attempters, $n = 42$ recent suicide attempters, $n = 13$ healthy controls, $n = 21$ affective controls	Feasibility and validity of EMA in individuals at risk of suicide	Activity, location, social interactions, hopelessness, affect (incl. SI & NSSI thoughts)	1 item: presence/ absence of SI and/or NSSI thoughts	7 days	(Fixed) signal contingent 5x/day	Personal digital assistants (PDAs)	**Acceptance:** range 88% (recent suicide attempters) – 67% (past suicide attempters), **Compliance:** range 86% (healthy controls) – 74% (recent suicide attempters) (average response rate), **Reactivity**: no effect of study duration on intensity or duration of NA & no effect on frequency of SI, **Validity:** baseline depression scores predicted EMA NA (incl. SI)
Law et al. (2015)	Adults w/ and w/o BPD: $n = 119$ control EMA & $n = 129$ EMA w/ SI items	Reactive effects of repeated assessment of STBs	BPD symptoms, affect, STBs	2 items: "I tried to kill myself in the last 60 minutes.", "I thought about committing suicide in the last 60 minutes."	14 days	(Fixed) signal-contingent 5x/day	Personal digital assistants (PDAs)	**Retention:** 96%, **Compliance:** 78% (suicide EMA) vs. 80% (control EMA) (average response rate), **Reactivity:** No reactive effects of repeated assessment of STBs on the occurrence of SI, self-harm or suicide attempts for either BPD or non-BPD sample

Torous et al. (2015)	*n* = 13 adults w/ MDD	Feasibility and validity of EMA of depressive symptoms	Depressive symptoms (PHQ-9)	1 item: "I would be better off dead or hurting myself."	30 days	(Random) signal-contingent 3x/day	Smartphones (Mindful Moods app)	**Acceptance:** 93%, **Compliance:** 78% (average response rate), **Validity:** EMA depression scores (incl. SI) correlated highly with the PHQ-9 (r = .84), but more SI was reported through EMA
Czyz et al. (2018)††	*n* = 34 adolescents w/ history of STBs	Feasibility of using EMA in adolescents at risk of suicide	STBs, experience with EMA	2(–6) item(s): "At any point in the last 24 hours did you have any thoughts of killing yourself?" (If *yes*: "How many times did you have thoughts of killing yourself?", "How long did these thoughts last?"), "At any point in the last 24 hours, did you try to kill yourself or make yourself not alive	28 days	(Fixed) signal-contingent 1x/day	Text messages (TelEMA software) with link to online questionnaire (Qualtrics software)	**Acceptance:** 77%, **Retention:** 69%, **Compliance:** Average 69% (Week 1: 80%, Week 4: 60%) (average response rate), **Validity:** SI endorsed by 71% in EMA vs. 45% in retrospective interview

				anymore?" (If *yes*: "What did you do?", "Did you do this as a way of ending your life?")				
Forkmann et al. (2018)†††	n = 74 adult psychiatric inpatients w/ depression and history of SI	Psycho-metric properties of EMA SI items	PA, anxiety, depression, burdensome-ness, thwarted belongingness, hopelessness, SI	4 items: *Passive ideation* incl. "At the moment I feel that life is not worth living." *Active ideation* incl. "At the moment I'm thinking about killing myself."	6 days	(Random) signal-contingent 10x/day	Android smart-phones (MovisensXS software)	**Acceptance:** 47%, **Retention:** 94%, **Compliance:** 90% (average response rate), **Validity:** EMA SI correlated strongly with retrospective questionnaire (BSSI) (Passive SI: r = .73, Active SI: r = .76), **Reliability:** Passive SI: α = .80, Active SI: α = .79 (within-person), Passive SI: α = .97, Active SI: α = .92 (between-person)
Glenn et al. (2020) ††††††	n = 53 adolescents and their parents	Feasibility and accepta-bility of EMA in high risk adolescents	Sleep, affect, cognitions, substance use, interpersonal negative events, SI	6 items: "How intense is your desire to die right now?", "How strong is your intent to kill yourself right	28 days	(Random) signal-contingent + interval-contingent 5x/day	Smartphones (mEMA software)	**Acceptance:** 25%, **Compliance:** Average 63% (Week 1: 87%, Week 4: 45%) (average response rate)

				now?", "How able are you to keep yourself safe right now?", "Are you thinking about attempting suicide (hurting yourself to die)?", "Did you do anything to hurt yourself (with or without wanting to die) today?" (If *yes*, follow-up questions on intensity and duration)				
Gratch et al. (2020)††††	*n* = 51 adults with MDD	Validity of EMA-assessed SI	SI	9 items: "Thoughts about dying?", "A wish to live?", "A wish to die?", "A wish to sleep and not wake up?", "A	7 days	(Random) signal-contingent 6x/day	Smartphones/ iPods (Harvest Your Data platform)	**Compliance:** 73% (average response rate), **Validity:** Worst point EMA SI correlated with retrospective questionnaire (BSSI; $r = .73$); 58% reporting SI in EMA did not do so on the BSSI

				wish to escape?", "Reasons for living?", "Thoughts about hurting yourself?", "An urge to hurt yourself?", "Thoughts about killing yourself?"				
Porras-Segovia et a. (2020)†††††	*n* = 120 adult psychiatric patients w/ history of STBs & *n* = 337 student controls	Feasibility of EMA in psychiatric patients and controls	NA, sleep, appetite, SI	2 items: "Wish to die", "Wish to live"	60 days	n/a	Smartphones (MEmind application)	**Acceptance:** 64% psychiatric patients vs. 69% controls, **Retention:** 68% (controls) vs. 80% (psychiatric patients), **Compliance:** 68% psychiatric patients vs. 75% controls (average response rate)
Rogers et al. (2021)	*n* = 237 community sample of adults w/ current SI	Feasibility and acceptability of EMA in a high-risk community sample	Affect, hopelessness, loneliness, agitation, irritability, rumination, thwarted belongingness,	Incl. SI thoughts, intent & desire, suicide plans, preparations, attempt	14 days	(Random) signal-contingent 6x/day	Smartphones (Ethica platform)	**Compliance:** 69% (average response rate), **Retention:** 60%

	social interactions, stressful events, sleep, SI	

Note: SI = Suicidal ideation; STBs = Suicidal thoughts and behaviors; NSSI = Non-suicidal self-injury; BPD = Borderline personality disorder; MDD = Major depressive disorder; PA = Positive affect; NA = Negative affect; PHQ-9 = Patient Health Questionnaire-9; BSSI = Beck Suicide Severity Index; † sample corresponds to Husky et al. (2017), †† Czyz et al. (2019), ††† Hallensleben et al. (2019), †††† Oquendo et al. (2020), ††††† Cobo et al. (2021), †††††† Glenn et al. (2021) reported in Table 1

The Methodology of Using EMA to Assess STBs

In order to examine the feasibility of using EMA in suicide research we reviewed reports of acceptance and compliance across studies, as well as detail previously used measures to ensure participant safety during EMA periods. Reports of adverse events are further examined to estimate the safety of repeated assessments of STBs.

Acceptance and Compliance Acceptance rates ranged between 25-93% (*Med* = 77%, *n* = 10). Comparing three subgroups, acceptance was highest among outpatients with a recent history of a suicide attempt (88%), as compared to clinical controls (i.e., 68% outpatients without a history of suicide attempts), and healthy controls (77%) (Husky et al., 2014). Acceptance was lower in inpatient samples (47-77%, *Med* = 50%, *n* = 3).

Compliance ranged from 44-90% (*Med* = 70%, *n* = 19). Compliance in clinical subgroups (Range 74-82%) was lower than that in a non-clinical control group (86%) (Husky et al., 2014). A similar pattern emerged when comparing psychiatric patients (65%) and student controls (75%) (Porras-Segovia et al., 2020). Compliance rates were not significantly related to suicide history or current depressive symptom or suicidal ideation severity (Glenn & Nock, 2014; Hallard et al., 2021; Oquendo et al., 2020; Peters et al., 2020; Rogers, 2021). Compliance rates declined over time (i.e., participants exhibited fatigue effects) (Czyz et al., 2018; Forkmann et al., 2018; Glenn et al., 2020). In a four-week study, compliance decreased by twenty percentage points from the first to the fourth week of EMA (Czyz et al., 2018). However, this effect was not replicated by all: rather than declining in a linear manner, one study reported that compliance rates did not decrease over time (Peters et al., 2020), fluctuated before stabilizing after approximately two weeks (Torous et al., 2015), or that compliance increased over time during a one-week EMA study (Husky et al., 2014). Compliance rates did not differ between studies employing once-daily (Range 69-74%, *Med* = 72%, *n* = 2), or multiple daily assessments (Range 44-90%, *Med* = 70%, *n* = 17). Response rates were higher in the afternoons (Torous et al., 2015) and on weekend days (Forkmann et al., 2018). Practice effects were also observed by participants' response times decreasing over time (Husky et al., 2014).

Attrition was low (Range 4-40%, *Med* = 6%, *n* = 10). In line with findings of lower compliance rates among psychiatric patients, dropout was higher among clinical cases than controls (Porras-Segovia et al., 2020). The highest attrition rate (40%) was reported in an anonymous online study with no personal contact (Rogers, 2021).

Validity EMA measures were associated with traditional self-report and interview measures. Baseline depression severity (Hamilton Depression Rating Scale, HAMD (Hamilton, 1960)) predicted EMA-assessed sad mood and negative thoughts (incl. suicidal ideation) (Husky et al., 2014). The correlation between depression scores (incl. a suicidal ideation item) derived from the traditionally administered Patient Health Questionnaire-9 (PHQ-9; Kroenke et al., 2001) and EMA administered PHQ-9 was $r = .84$ (Torous et al., 2015). EMA-measured momentary suicidal ideation correlated highly[1] with the BSSI (passive ideation: $r = .73$, active ideation: $r = .76$ (Forkmann et al., 2018)). Correlations were higher for items assessing active ("Wish to die" $r = .76$) rather than passive ideation ("Wish to live" $r = .37$) (Gratch et al., 2021). A one-item EMA measure ("How suicidal are you right now?") correlated highly with the BSSI ($r = .71$) and moderately with the Beck Depression Inventory (BDI; Beck, 1961) ($r = .41$) (Peters et al., 2020). Variability in momentary SI correlated moderately with the Suicide Behaviors Questionnaire - Revised (SBQ-R (Osman et al., 2001)) ($r = .41$), the BSSI ($r = .49$), and the Capability for Suicide Questionnaire (GCSQ (86)) ($r = .30$) (Hadzic et al., 2020).

More severe depressive symptoms were reported through EMA than with a traditional retrospective questionnaire, and EMA reports of suicidal ideation were notably higher than questionnaire scores for 69% of the participants (Torous et al., 2015). In an adolescent sample, suicidal ideation was reported in EMA by 71% of the participants, and in 45% of the interviews post-EMA (Czyz et al., 2018). Among adults, 58% of participant reporting SI in EMA did not do so in an interview post-EMA (Gratch et al., 2021).

Reactivity in Momentary Affect and STBs A feasibility study in adult suicide attempters (recent or past attempt history), clinical controls (i.e., depressed patients without suicide attempt history), and healthy controls, found no effects of study duration on the intensity of negative affect or frequency of suicidal ideation, indicating no symptom worsening with repeated prompts (Husky et al., 2014). However, there was a decrease in positive affect among recent and past suicide attempters, *and* a decrease in hopelessness among recent suicide attempters with increasing study duration (across seven days) (Husky et al., 2014). In another study comparing two 14-day EMA protocols (one with items on suicidal ideation, and a control EMA protocol), there were no differences in the occurrence of suicidal ideation, self-harm or suicide attempts between the two conditions for either clinical (patients with BPD) or non-clinical controls based on weekly retrospective measures (Law et al., 2015). In a sample of adolescents assessed after 1-month of EMA, most participants reported that they generally felt no change in mood after filling out EMA (69%) or that they felt better (28%); one participant reported that

[1] Interpretation of correlation coefficients based on $r = .50$ indicating large, $r = .30$ medium, and $r = .10$ small correlations (Cohen, 1988).

they had worse mood after completing EMA (Czyz et al., 2018). The clinicians of another adolescent sample reported the study, on average, to have had ‘neutral’ to ‘somewhat positive’ impact on their patients (incl. increased awareness into one’s condition (Czyz et al., 2021)). Following a 6-day EMA assessment with 10 prompts per day, 16% of a sample of depressed inpatients reported that they had felt stressed and/or burdened by the assessments (Forkmann et al., 2018), but no further details were provided. Among 237 high risk adults from the community, 9% reported they had experienced the EMA as “occasionally ’distressing’”, ‘emotionally taxing,’ and, ‘triggering bad thoughts,’” (p. 6), in comparison to 3% who reported a decrease in the frequency of and urge to act on suicidal thoughts due to study participation (Rogers, 2021). In general, participants reported their experiences overall as neutral-to-positive but time consuming (or burdensome), and that they would be open to participating in similar research in the future (Czyz et al., 2018; Forkmann et al., 2018; Glenn et al., 2020).

Adverse Events Ten studies reported whether any suicide attempts occurred during the study period: in four studies no such events occurred (Forkmann et al., 2018; Kleiman et al., 2017; Nock et al., 2009). Three studies followed adolescents who were recently discharged from inpatient treatment after a suicide attempt or severe ideation. In 28 days, the incidence of suicide attempts was 6% (Czyz et al., 2019), 8% (Czyz et al., 2021), and 9% (Glenn et al., 2020). In a sample of 50 adult BPD patients, 10% attempted suicide over 7 days (Stanley et al., 2021), and in a study of 248 adults with and without BPD, approximately 5% of participants made a suicide attempt during the *entire* study period (including a six-month follow-up) (Law et al., 2015). In a community sample of 237 adults with current suicidal ideation, 3% attempted suicide during the 2-week study (Rogers, 2021). In comparison, in similar high-risk populations (with last-year suicidal ideation or attempt) the estimated 1-year prevalence of suicide attempts is between 13% and 20% (Han et al., 2015; Parra-Uribe et al., 2017), with the risk being higher for those with recent attempt history (Parra-Uribe et al., 2017). Risk is further heightened among those with an earlier age of occurrence of first attempt, as well as those with BPD (features) (Aouidad et al., 2020). No suicide mortality was reported in any of the reviewed studies.

Safety Measures Eight studies reported implementing some type of safety measures in their EMA protocols. Four studies implemented automatic messages sent out by the EMA device. In one study each EMA assessment began with a message reminding the participant to contact a mental health professional or emergency personnel in case of a crisis (Law et al., 2015), and three others used similar messages that were presented if the participant’s responses indicated momentary suicidal ideation (Armey et al., 2020; Czyz et al., 2018; Husky et al., 2017). Three studies employed ongoing monitoring of the participants' responses (Czyz et al., 2018, 2021; Nock et al., 2009). In a study using PDAs, participants were instructed to upload their data on a server each night for evaluation, and research personnel phoned participants in case responses indicated imminent risk or if no data had been uploaded for 72 hours (Nock et al., 2009). Another study reported twice-daily (manual) checks on the participants entries; 32% of the adolescent participants were contacted for a risk assessment during the 4-week study (Czyz et al., 2021). In another study, the EMA software was programmed to send out automatic email alerts to the study's on-call clinician if the participant endorsed a suicide attempt or severe ideation with suicidal intent and/or a plan, in which case the clinician made contact with the participant; less than 1% of the responses recorded met this threshold and required contact by the study personnel (Czyz et al., 2018). Two studies required that each participant had an individualized safety plans in place established by their treating physician (Armey et al., 2020; Glenn et al., 2020), and another study instructed participants on how to make one prior to participation (Rogers, 2021). In two studies, research personnel conducted an unspecified suicide risk assessment halfway through the 2-week EMA period (Al-Dajani & Uliaszek, 2021), and in the other study participants completed the CSSRS at baseline and at follow-up and test assistants referred acute cases to the emergency department (Cobo et al., 2021). Of note is that while only 36 % (n = 8) of studies reported on safety procedures, 80% (n = 4) of studies in adolescent samples had safety measures in place. None of the studies conducted in inpatient settings employed additional safety measures.

Discussion

Applicability of EMA in Suicide Research

Among the 23 reviewed studies, substantial variability existed in the operationalization of STBs. This ranged from single-item binary measures of general self-harm ideation (Husky et al., 2017) to multi-item batteries assessing the intensity, frequency and duration of specific suicidal thoughts (see e.g., Czyz et al. (2019); Oquendo et al. (2020)). General guidelines for EMA research emphasize that items should be formulated in a way that allows for the assessment of the natural fluctuations in momentary experience, while limiting potential floor and ceiling effects (Hektner et al., 2007). Binary items generally lack these characteristics. Single-item measures may also not be sufficient in capturing the wide spectrum of ideation, such as distinguishing passive from active ideation and intent. Further, suicidal ideation alone is not the only permissive characteristic preceding suicidal acts; a transition from ideation to attempt requires *acquired capability,* that is, additional cognitive and behavioral processes, such as decreased fear of death and increased pain tolerance (Van Orden et al., 2010). These latter characteristics can also fluctuate substantially from day to day (Spangenberg et al., 2019).

The strength of EMA for suicide research remains in its ability to capture more variable aspects of suicide risk that may be difficult to grasp by traditional retrospective questionnaires. From our review we conclude that suicidal ideation exhibits substantial variability over time, often increasing or decreasing sharply within only a few hours in an individual (see e.g., Kleiman et al., 2017)). Witte and colleagues (Witte et al., 2005, 2006) have proposed that such variability in suicidal ideation may provide a more reliable index of suicide risk than the severity or duration of ideation alone. This notion is tentatively supported by findings of higher suicidal ideation variability among patients with more severe suicidal ideation (Kleiman et al., 2017; Oquendo et al., 2020; Peters et al., 2020), as well as those with a prior suicide attempt history (Peters et al., 2020), and by higher EMA suicidal ideation variability predicting attempts at 1-month follow-up (Wang et al., 2021). In line with these findings, a previous review of EMA studies on NSSI also identified affective variability as a risk factor for engaging in self-harm behavior (Rodríguez-Blanco et al., 2018). While these preliminary findings warrant further replication, they indicate that suicidal ideation variability may represent a promising marker for suicide risk.

In addition to suicidal ideation itself, a number of its risk factors (incl. negative affect, hopelessness, loneliness, burdensomeness, thwarted belongingness) were also found to exhibit similar variability patterns and associate with momentary ideation. However, fewer studies so far have succeeded in establishing prospective predictors of suicidal ideation. A similar pattern is observable in the EMA literature on NSSI, where most studies have elucidated on the immediate context, rather than precipitants, of self-harm behavior (Rodríguez-Blanco et al., 2018). Kaurin and colleagues (Kaurin et al., 2020) outlined the ongoing discourse in EMA literature over the relative value of time-lagged versus concurrent (or *contemporaneous*) modeling approaches. While longitudinal modeling is often regarded as superior in traditional research designs, contemporaneous associations derived from EMA data reflect associations beyond simple co-occurrences; rather, they reflect systematic covariances between variables, and can signal the presence of temporal associations occurring very close in time. Hence, these findings indicate that a number of known longitudinal predictors of suicidal ideation are also involved in its imminent emergence over shorter time frames. Considering emerging evidence that suicidal ideation variability may represent an important marker for acute risk, increased understanding of the factors underlying these fluctuations is of great importance.

Table 3. Considerations for Designing and Reporting EMA Studies in Suicide Research

DESIGN		
1.	**Manage burden**	Assessments should be quick and easy to complete in daily life. More frequent prompts over shorter time periods do not necessarily reduce compliance, while longer assessment periods may. Feedback from participants over preferred sampling windows may reduce the burden of ill-timed prompts and increase compliance.
2.	**Sensitivity to change**	EMA items should be able to capture (more fine-tuned) changes in symptoms over time; binary items often lack this sensitivity.
3.	**Complexity of suicide risk**	Single item measures may fail to capture important determinants of suicide risk. Assessments should be comprehensive in capturing different aspects of ideation (incl. passive, active ideation, intent), and differentiate suicidal ideation from non-suicidal self-injurious thoughts.
4.	**Consider add-on ambulatory measures**	Supplementing self-report EMA with ambulatory sensors (such as GPS and actigraphy) can provide objective data without increasing participant burden.
5.	**Optimize incentives**	Monetary rewards are relatively uninfluential in increasing compliance rates; alternative personalized incentives (incl. receiving feedback on EMA responses) may be considered.
6.	**Ensure safety**	Safety plans and clear guidelines on seeking help should always be implemented. Additional measures (e.g., ongoing monitoring) may be necessary for certain populations (incl. adolescents).
REPORTING		
7.	**Reporting of adverse events**	Adverse events should be assessed and transparently reported so that potential reactivity and the efficacy of different safety procedures can be evaluated.
8.	**Established EMA items**	Databases of established EMA items are lacking. Clear reporting on item formulation and psychometric properties is needed. Questions from traditional questionnaire measures may not directly translate to the purposes of EMA.

9.	**Data quality**	Factors that may impact data quality and interpretation (incl. attrition, compliance, patterns of missing data) need adequate reporting.

Feasibility and Safety of EMA in Suicide Research

Acceptability and Compliance While our review supports the general acceptability of EMA in suicide research, the burden of EMA measures may be less tolerable for those currently experiencing very severe symptoms, analog to findings in individuals with depressive disorders (van Genugten et al., 2020). Meanwhile, compliance was good and not substantially lower than in other clinical (Johnson et al., 2009) or non-clinical populations (see e.g., Courvoisier et al., 2012). This is in line with reports that EMA compliance is not significantly influenced by demographic or clinical characteristics (Hartley et al., 2014).

Regardless, maintaining compliance with EMA remains a challenge, especially when assessment periods grow long, as compliance decreases over time with each subsequent week of EMA (see e.g., Czyz et al., 2018; Glenn et al., 2020)). Meanwhile, compliance rates did not appear lower in studies using multiple measures per day (vs. once-daily ratings). It has also previously been reported that more frequent assessments may not reduce compliance (Jones et al., 2019), or may even increase compliance (Wen et al., 2017), as long as questionnaires are kept brief (Eisele et al., 2020). Shorter time intervals between prompts can also increase compliance (Rintala et al., 2020). However, overly lengthy measures can induce fatigue and reduce compliance, as well as impact data quality due to increased careless responding or skipping questions (Daniëls et al., 2021; Eisele et al., 2020). Based on our review, researchers may be advised to prioritize more frequent, but brief assessments over short time periods to establish higher compliance; future research should aim to more systematically examine how increasing the number of daily prompts affects compliance rates, in order to establish optimal sampling schedules that balance temporal coverage with participant burden. Researchers may also consider implementing incentives for compliance. Many of the reviewed studies used monetary rewards for increasing or sustaining compliance (see e.g., Glenn & Nock, 2014; Rogers, 2021). However, monetary incentives are reported as relatively unimpactful in increasing compliance, based on a review of 481 EMA studies (Ottenstein & Werner, 2021). Alternative incentives, such as personalized feedback based on EMA data, may be regarded as more valuable (Folkersma et al., 2021).

In line with the observation that all of the reviewed studies used signal-contingent sampling (either alone or in conjunction with event-contingent sampling), we may also recommend this approach for future research, as signal-contingent sampling more optimally allows for the examination of the variability in experience of STBs. Finally, further research is needed to generalize these recommendations to other age groups (such as the elderly) and non-Western societies. As the reviewed studies exclusively focused on adolescents and adults (who may already be more accustomed to using technology to track their lives), it remains to be established whether such electronic symptom self-monitoring would be perceived as equally acceptable, and helpful, by older populations.

Validity While EMA measures showed high correlations with traditional self-report, more individuals reported suicidal ideation through EMA, and more severe instances of ideation were detected through EMA than retrospective measures. We further found that EMA reports of active suicidal ideation were more highly correlated with retrospective measures than those of passive ideation (Gratch et al., 2021). It is tempting to speculate that EMA has increased sensitivity in detecting momentary, fleeting, and/or passive instances of ideation. However, the possibility that part of this increased reporting is due to reactivity to the EMA questions (i.e., symptom increases due to enhanced focus on them) cannot be disregarded (Barta et al., 2012; Bos, 2021), although the current evidence does not support such assessment reactivity (see below).

Adverse Events Our review did not uncover systematic (negative) mood reactivity to EMA, and importantly, there was no evidence of reactivity on STBs specifically (Husky et al., 2014; Law et al., 2015). These findings are in line with reports of no symptom reactivity in other patient populations, such as those with chronic pain (Cruise et al., 1996) and mood disorders (Husky et al., 2014). Some behaviors, like alcohol use among substance dependent patients, may be more subject to reactive effects than cognitive or affective symptoms (Johnson et al., 2009). However, these conclusions are tentative at best due to the low number of studies directly assessing reactivity, and the general lack of control groups across studies. Further, available studies were seriously limited in their assessment and reporting of adverse events (suicide attempts, mortality) occurring during the study period. Future research should more transparently examine and describe these events if, and when, they occur.

Safety Considerations A defining strength of smartphone-based EMA for suicide research is that it enables the real-time monitoring of participants' responses. However, it remains to be determined how such risk detection can be done with optimal sensitivity and specificity. Changes in symptoms over time, especially drastic changes over short periods of time (within days, hours), may provide a better indication of risk than absolute ratings at any single time point (Rudd et al., 2006). Further, participants may not always provide accurate reports of their experiences for fear of intervention, as many people planning suicide explicitly deny such intentions (Busch et al., 2003). EMA safety protocols should consequently also involve contact with participants lost to attrition, and additional contact should be made not only when participants indicate severe symptomatology, but also when EMA prompts are systematically missed (as also previously done by e.g., Nock et al., 2009).

Limitations

Across the reviewed studies, there was considerable heterogeneity in study characteristics and their reporting thereof. This, together with the diversity in aims and samples across studies, prevented us from conducting meta-analyses. Little rationale was provided for the selection of the EMA items used (or if pilots were run to established the item set for the population under study) with the exception of questions adapted from established self-report questionnaires. However, these questions may not always optimally translate to EMA, as they can lack sufficient sensitivity to variability, especially over shorted time frames. Notably, three (14%) studies did not provide EMA item descriptions, two (9%) did not report sampling frequency, and three (14%) did not report sampling technique (i.e., fixed or random). Further, there was insufficient reporting of other study characteristics: 12 (55%) studies did not report acceptability, three (14%) did not report any index of compliance (with further inconsistencies in how compliance was defined), 14 (63%) did not report on attrition, 12 (55%) did not report adverse events, and 11 (50%) did not report whether any safety measures were implemented. Additional characteristics that may impact data quality and inference, such as amount and patterns of missing data, and information on average time intervals between prompts, as well as delay from alert to response, were rarely reported. A recent review of EMA of NSSI noted similar study heterogeneity and lack of reporting on compliance (Rodríguez-Blanco et al., 2018). Reviewers evaluating EMA studies for publication should require these to be reported. Finally, how to adequately measure EMA item reliability and validity remains to be established (although first initiatives have started, such as the Experience Sampling Method (ESM) Item Repository (https://osf.io/kg376/)). Correlations with retrospective measures, or moment-to-moment reliability statistics may not provide adequate indications of good psychometric fit, as EMA ratings are *expected* to vary over time rather than stay constant.

Future Directions

Based on the reviewed studies, in Table 3 we provide an overview of considerations for designing and reporting on EMA studies in suicide research. Directions for future research are discussed further below.

EMA in Clinical Practice While only one of the reviewed studies employed EMA to assess the effectiveness of an intervention (Czyz et al., 2019), EMA also has broad potential in applicability in clinical practice (Bos, 2021). Beyond EMA interventions (Berrouiguet et al., 2018; McDevitt-Murphy et al., 2018), EMA assessments in themselves may serve a therapeutic purpose: feedback from participants indicates that EMA made them more reflective, introspective, and mindful of their experiences (see e.g., Rogers, 2021). Further, for patients experiencing (persistent) suicidal ideation, demonstrating that ideation is variable, and hence malleable, may provide relief. In accordance with the finding that suicidal ideation variability may serve as a potential marker for increased suicide risk, this characteristic of ideation may be an especially valuable target for EMA monitoring and/or interventions in clinical practice. First applications of using EMA in clinical practice to monitor and manage symptoms are already underway (Porras-Segovia et al., 2020). The extensive nature of EMA data also allows for more opportunities for single-case data analysis that may be used to examine individual symptom profiles or identify person-specific triggers (Bentley et al., 2019) – an important goal in the treatment of the very heterogeneous group of patients experiencing STBs (Harmer et al., 2021). However, despite these considerable inter-individual differences, most studies reviewed here solely examined group-level associations, while in clinical practice, the focus is on individual patients (Zuidersma et al., 2020). Hence, the precise utility of this methodology in clinical practice in relation to STBs remains to be established.

Digital Phenotyping The prospect of digital phenotyping of suicidal ideators (such as identifying those with high/low variability) based on EMA data has been discussed by many (see e.g., Ballard et al., 2021; Barrigon et al., 2019), but so far implemented by few (Cobo et al., 2021; Kleiman et al., 2018; Rath et al., 2019). EMA data has revealed notable inter-individual differences in suicide symptom profiles (Rath et al., 2019), highlighting the importance of identifying meaningful subtypes of suicidal ideators that could improve risk assessments and choice of treatment targeting specific symptom profiles. However, the network theory is subject to certain pitfalls that still need to be solved before it can be implemented in clinical practice (Bos, 2021; von Klipstein et al., 2020). Next steps in EMA research may also involve intensive longitudinal assessments over longer time periods (i.e., months) in order to more reliably establish such phenotypes. Further, determining the value of such phenotyping would require additional follow-up assessments connecting these symptom profiles to overt outcomes (i.e., suicide attempt, mortality) over time.

Conclusions

Currently, sociodemographic and clinical risk-factors, such as a current mental health diagnosis or previous attempt history, are considered the best predictors of future suicidal behavior – “the best” in this instance indicating the best of the worst, with currently established longitudinal risk factors being no better than chance at differentiating between those at high vs. low risk (Large et al., 2016). More recently, real-time methodologies have identified new potential targets for risk-detection, namely rapid changes in momentary affect, interpersonal experiences, and sleep (Allen et al., 2019). However, these observations still warrant replication. The use of EMA in suicide research has grown rapidly in the past years, and review of the literature suggests that the fluctuating nature of suicidal ideation makes it an especially suited target for EMA, which may provide unique insights into the temporal correlates and imminent warning signs of increased suicide risk. Retrospective reports can be unreliable, especially when individuals are asked to recall fleeting or highly variable experiences (Armey et al., 2020), but EMA may have increased sensitivity in detecting these momentary experiences. Meanwhile, it has been proposed that identifying instability in suicidal ideation offers promise in improving the detection of those most at risk of suicide (Witte et al., 2005, 2006), and attempts have been made to create new categorizations of suicidal ideators based on real-time data (Kleiman al., 2018). Such risk profiling may hence represent next steps not only in EMA research, but in the improved treatment of patients with suicidal ideation.

References

Aadahl, V., Wells, A., Hallard, R., & Pratt, D. (2021). Metacognitive beliefs and suicidal ideation: An experience sampling study. *International Journal of Environmental Research and Public Health*, *18*(23), 12336. https://doi.org/10.3390/ijerph182312336

Al-Dajani, N., & Uliaszek, A. A. (2021). The after-effects of momentary suicidal ideation: A preliminary examination of emotion intensity changes following suicidal thoughts. *Psychiatry Research*, *302,* 114027. https://doi.org/10.1016/j.psychres.2021.114027

Allen, N. B., Nelson, B. W., Brent, D., & Auerbach, R. P. (2019). Short-term prediction of suicidal thoughts and behaviors in adolescents: Can recent developments in technology and computational science provide a breakthrough? *Journal of Affective Disorders*, *250*, 163–169.

Aouidad, A., Cohen, D., Mirkovic, B., Pellerin, H., Garny de La Rivière, S., Consoli, A., Gérardin, P., & Guilé, J. M. (2020). Borderline personality disorder and prior suicide attempts define a severity gradient among hospitalized adolescent suicide attempters. *BMC Psychiatry*, *20*(1), 525. https://doi.org/10.1186/s12888-020-02930-4

Armey, M. F., Brick, L., Schatten, H. T., Nugent, N. R., & Miller, I. W. (2020). Ecologically assessed affect and suicidal ideation following psychiatric inpatient hospitalization. *General Hospital Psychiatry*, *63*, 89–96.

Ballard, E. D., Gilbert, J. R., Wusinich, C., & Zarate, C. A. (2021). New methods for assessing rapid changes in suicide risk. *Frontiers in Psychiatry*, 12, 598434. https://doi.org/10.3389/fpsyt.2021.598434

Barrigon, M. L., Courtet, P., Oquendo, M., & Baca-García, E. (2019). Precision medicine and suicide: An opportunity for digital health. *Current Psychiatry Reports, 21*(12), 131. https://doi.org/10.1007/s11920-019-1119-8

Barta, W. D., Tennen, H., & Litt, M. D. (2012). Measurement reactivity in diary research. In M. R. Mehl & T. S. Conner (Eds.), *Handbook of research methods for studying daily life* (pp. 108–123). The Guilford Press.

Beck, A. T. (1961). An inventory for measuring depression. *Archives of General Psychiatry*, *4*(6), 561–571. https://doi.org/10.1001/archpsyc.1961.01710120031004

Beck, A. T., Kovacs, M., & Weissman, A. (1979). Assessment of suicidal intention: The Scale for Suicide Ideation. *Journal of Consulting and Clinical Psychology*, *47*(2), 343–352.

Bell, I. H., Lim, M. H., Rossell, S. L., & Thomas, N. (2017). Ecological momentary assessment and intervention in the treatment of psychotic disorders: A systematic review. *Psychiatric Services*, *68*(11), 1172–1181). https://doi.org/10.1176/appi.ps.201600523

Bentley, K. H., Kleiman, E. M., Elliott, G., Huffman, J. C., & Nock, M. K. (2019). Real-time monitoring technology in single-case experimental design research: Opportunities and challenges. *Behaviour Research and Therapy*, *117*, 87–96. https://doi.org/10.1016/j.brat.2018.11.017

Ben-Zeev, D., Scherer, E. A., Brian, R. M., Mistler, L. A., Campbell, A. T., & Wang, R. (2017). Use of multimodal technology to identify digital correlates of violence among inpatients with serious mental illness: A pilot study. *Psychiatric Services*, *68*(10), 1088–1092. https://doi.org/10.1176/appi.ps.201700077

Berrouiguet, S., Perez-Rodriguez, M. M., Larsen, M., Baca-García, E., Courtet, P., & Oquendo, M. (2018). From eHealth to iHealth: Transition to participatory and personalized medicine in mental health. *Journal of Medical Internet Research*, *20*(1), e1. https://doi.org/10.2196/jmir.7412

Borges, G., Nock, M. K., Abad, J. M. H., Hwang, I., Sampson, N. A., Alonso, J., Andrade, L. H., Angermeyer, M. C., Beautrais, A., Bromet, E., Bruffaerts, R., de Girolamo, G., Florescu, S., Gureje, O., Hu, C., Karam, E. G., Kovess-Masfety, V., Lee, S., Levinson, D., Medina-Mora, M.E., Ormel, J., Posada-Villa, J., Sagar, R., Tomov, T., Uda, H., Williams, D.R., & Kessler, R. C. (2010). Twelve-month prevalence of and risk factors for suicide attempts in the world health organization world mental health surveys. *Journal of Clinical Psychiatry*, *71*(12), 1617–1628. https://doi.org/10.4088/JCP.08m04967blu

Bos, F. M. (2021). *Ecological momentary assessment as a clinical tool in psychiatry: Promises, pitfalls, and possibilities.* University of Groningen.

Bos, F. M., Snippe, E., Bruggeman, R., Wichers, M., & van der Krieke, L. (2019). Insights of patients and clinicians on the promise of the experience sampling method for psychiatric care. *Psychiatric Services*, *70*(11), 983–991. https://doi.org/10.1176/appi.ps.201900050

Busch, K. A., Fawcett, J., & Jacobs, D. G. (2003). Clinical correlates of inpatient suicide. *Journal of Clinical Psychiatry*, *64*(1), 14–19.

Chesin, M., & Stanley, B. (2013). Risk assessment and psychosocial interventions for suicidal patients. *Bipolar Disorders*, *15*(5), 584–593. https://doi.org/10.1111/bdi.12092

Chu, C., Buchman-Schmitt, J. M., Stanley, I. H., Hom, M. A., Tucker, R. P., Hagan, C. R., Rogers, M. L., Podlogar, M. C., Chiurliza, B., Ringer, F. B., Michaels, M. S., Patros, C. H. G., & Joiner, T. E. (2017). The interpersonal theory of suicide: A systematic review and meta-analysis of a decade of cross-national research. *Psychological Bulletin*, *143*(12), 1313–1345. https://doi.org/10.1037/bul0000123

Cobo, A., Porras-Segovia, A., Pérez-Rodríguez, M. M., Artés-Rodríguez, A., Barrigón, M. L., Courtet, P., & Baca-García, E. (2021). Patients at high risk of suicide before and during a COVID-19 lockdown: ecological momentary assessment study. *BJPsych Open*, *7*(3), e82. https://doi.org/10.1192/bjo.2021.43

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences*. Routledge. https://doi.org/10.4324/9780203771587

Colombo, D., Fernández-Álvarez, J., Patané, A., Semonella, M., Kwiatkowska, M., García-Palacios, A., Cipresso, P., Riva, G., & Botella, C. (2019). Current state and future directions of technology-based ecological momentary assessment and intervention for major depressive disorder: A systematic review. *Journal of Clinical Medicine*, *8*(4), 465. https://doi.org/10.3390/jcm8040465

Coppersmith, D. D. L., Kleiman, E. M., Glenn, C. R., Millner, A. J., & Nock, M. K. (2019). The dynamics of social support among suicide attempters: A smartphone-based daily diary study. *Behaviour Research and Therapy*, *120,* 103348. https://doi.org/10.1016/j.brat.2018.11.016

Courvoisier, D. S., Eid, M., & Lischetzke, T. (2012). Compliance to a cell phone-based ecological momentary assessment study: The effect of time and personality characteristics. *Psychological Assessment*, *24*(3), 713–720. https://doi.org/10.1037/a0026733

Cruise, C. E., Broderick, J., Portera, L., Kae1l, A., & Stone, A. A. (1996). Reactive effects of diary self-assessment in chronic pain patients. *Pain*, *67*(2–3), 253–258.

Cwik, J. C., Forkmann, T., Glaesmer, H., Paashaus, L., Schönfelder, A., Rath, D., Prinz, S., Juckel, G., & Teismann, T. (2020). Validation of the German capability for suicide questionnaire (GCSQ) in a high-risk sample of suicidal inpatients. *BMC Psychiatry*, *20*(1), 412. https://doi.org/10.1186/s12888-020-02812-9

Czyz, E. K., Glenn, C. R., Arango, A., Koo, H. J., & King, C. A. (2021). Short-term associations between nonsuicidal and suicidal thoughts and behaviors: A daily diary study with high-risk adolescents. *Journal of Affective Disorders*, *292*, 337–344. https://doi.org/10.1016/j.jad.2021.05.104

Czyz, E. K., Glenn, C. R., Busby, D., & King, C. A. (2019). Daily patterns in nonsuicidal self-injury and coping among recently hospitalized youth at risk for suicide. *Psychiatry Research*, *281,* 112588. https://doi.org/10.1016/j.psychres.2019.112588

Czyz, E. K., Horwitz, A. G., Arango, A., & King, C. A. (2019). Short-term change and prediction of suicidal ideation among adolescents: a daily diary study following psychiatric hospitalization. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *60*(7), 732–741. https://doi.org/10.1111/jcpp.12974

Czyz, E. K., King, C. A., & Biermann, B. J. (2019). Motivational interviewing-enhanced safety planning for adolescents at high suicide risk: A pilot randomized controlled trial. *Journal of Clinical Child and Adolescent Psychology*, *48*(2), 250–262. https://doi.org/10.1080/15374416.2018.1496442

Czyz, E. K., King, C. A., & Nahum-Shani, I. (2018). Ecological assessment of daily suicidal thoughts and attempts among suicidal teens after psychiatric hospitalization: Lessons about feasibility and acceptability. *Psychiatry Research*, *267*, 566–574. https://doi.org/10.1016/j.psychres.2018.06.031

Czyz, E. K., Yap, J. R. T., King, C. A., & Nahum-Shani, I. (2020). Using intensive longitudinal data to identify early predictors of suicide-related outcomes in high-risk adolescents: Practical and conceptual considerations. *Assessment, 28*(8), 1949–1959. https://doi.org/10.1177/1073191120939168

Dalgleish, T., & Watts, F. N. (1990). Biases of attention and memory in disorders of anxiety and depression. *Clinical Psychology Review*, *10*, 589–604.

Daniëls, N. E. M., Hochstenbach, L. M. J., van Zelst, C., van Bokhoven, M. A., Delespaul, P. A. E. G., & Beurskens, A. J. H. M. (2021). Factors that influence the use of electronic diaries in health care: Scoping review. *JMIR mHealth and uHealth*, *9*(6), e19536. https://doi.org/10.2196/19536

Davidson, C. L., Anestis, M. D., & Gutierrez, P. M. (2017). Ecological momentary assessment is a neglected methodology in suicidology. *Archives of Suicide Research*, *21*(1), 1–11. https://doi.org/10.1080/13811118.2015.1004482

De Beurs, D., Kirtley, O., Kerkhof, A., Portzky, G., & O'Connor, R. C. (2015). The role of mobile phone technology in understanding and preventing suicidal behavior. *Crisis*, *36*(2), 79–82. https://doi.org/10.1027/0227-5910/a000316

Ebner-Priemer, U. W., & Trull, T. J. (2009). Ambulatory assessment: An innovative and promising approach for clinical psychology. *European Psychologist*, *14*(2), 109–119. https://doi.org/10.1027/1016-9040.14.2.109

Eikelenboom, M., Smit, J. H., Beekman, A. T. F., Kerkhof, A. J. F. M., & Penninx, B. W. J. H. (2014). Reporting suicide attempts: Consistency and its determinants in a large mental health study. *International Journal of Methods in Psychiatric Research*, *23*(2), 257–266. https://doi.org/10.1002/mpr.1423

Eisele, G., Vachon, H., Lafit, G., Kuppens, P., Houben, M., Myin-Germeys, I., & Viechtbauer, W. (2020). The effects of sampling frequency and questionnaire length on perceived burden, compliance, and careless responding in experience sampling data in a student population. *Assessment, 29*(2), 136–151. https://doi.org/10.1177/1073191120957102

Folkersma, W., Veerman, V., Ornée, D. A., Oldehinkel, A. J., Alma, M. A., & Bastiaansen, J. A. (2021). Patients' experience of an ecological momentary intervention involving self-monitoring and personalized feedback for depression. *Internet Interventions*, *26,* 100436. https://doi.org/10.1016/j.invent.2021.100436

Forbes, N. F., Carrick, L. A., McIntosh, A. M., & Lawrie, S. M. (2009). Working memory in schizophrenia: A meta-analysis. *Psychological Medicine*, *39*(6), 889–905. https://doi.org/10.1017/S0033291708004558

Forkmann, T., Spangenberg, L., Rath, D., Hallensleben, N., Hegerl, U., Kersting, A., & Glaesmer, H. (2018). Assessing suicidality in real time: A psychometric evaluation of self-report items for the assessment of suicidal ideation and its proximal risk factors using ecological momentary assessments. *Journal of Abnormal Psychology*, *127*(8), 758–769. https://doi.org/10.1037/abn0000381.supp

Franklin, J. C., Ribeiro, J. D., Fox, K. R., Bentley, K. H., Kleiman, E. M., Huang, X., Musacchio, K. M., Jaroszewski, A. C., Chang, B. P., & Nock, M. K. (2017). Risk factors for suicidal thoughts and behaviors: A meta-analysis of 50 years of research. *Psychological Bulletin*, *143*(2), 187–232. https://doi.org/10.1037/bul0000084

Glenn, C. R., Kleiman, E. M., Kandlur, R., Esposito, E. C., & Liu, R. T. (2021). Thwarted belongingness mediates interpersonal stress and suicidal thoughts: An intensive longitudinal study with high-risk adolescents. *Journal of Clinical Child and Adolescent Psychology, 51*(3), 295–311. https://doi.org/10.1080/15374416.2021.1969654

Glenn, C. R., Kleiman, E. M., Kearns, J. C., Santee, A. C., Esposito, E. C., Conwell, Y., & Alpert-Gillis, L. J. (2020). Feasibility and acceptability of ecological momentary assessment with high-risk suicidal adolescents following acute psychiatric care. *Journal of Clinical Child and Adolescent Psychology, 51*(1), *32*–48. https://doi.org/10.1080/15374416.2020.1741377

Glenn, C. R., & Nock, M. K. (2014). Improving the short-term prediction of suicidal behavior. *American Journal of Preventive Medicine*, *47*(3 Suppl. 2), S173–S180. https://doi.org/10.1016/j.amepre.2014.06.004

Gnambs, T., & Kaspar, K. (2014). Disclosure of sensitive behaviors across self-administered survey modes: A meta-analysis. *Behavior Research Methods*, *47*(4), 1237–1259. https://doi.org/10.3758/s13428-014-0533-4

Gould, M. S., Marrocco, F. A., Kleinman, M., Thomas, J. G., Mostkoff, K., Cote, J., & Davies, M. (2005). Evaluating iatrogenic risk of youth suicide screening programs a randomized controlled trial. *JAMA*, *293*(13), 1635–1643. https://jamanetwork.com/

Gratch, I., Choo, T. H., Galfalvy, H., Keilp, J. G., Itzhaky, L., Mann, J. J., Oquendo, M., & Stanley, B. (2021). Detecting suicidal thoughts: The power of ecological momentary assessment. *Depression and Anxiety*, *38*(1), 8–16.

Hadzic, A., Spangenberg, L., Hallensleben, N., Forkmann, T., Rath, D., Strauß, M., Kersting, A., & Glaesmer, H. (2020). The association of trait impulsivity and suicidal ideation and its fluctuation in the context of the Interpersonal Theory of Suicide. *Comprehensive Psychiatry*, *98,* 152158. https://doi.org/10.1016/j.comppsych.2019.152158

Hallard, R. I., Wells, A., Aadahl, V., Emsley, R., & Pratt, D. (2021). Metacognition, rumination and suicidal ideation: An experience sampling test of the self-regulatory executive function model. *Psychiatry Research*, *303,* 114083. https://doi.org/10.1016/j.psychres.2021.114083

Hallensleben, N., Glaesmer, H., Forkmann, T., Rath, D., Strauss, M., Kersting, A., & Spangenberg, L. (2019). Predicting suicidal ideation by interpersonal variables, hopelessness and depression in real-time: An ecological momentary assessment study in psychiatric inpatients with depression. *European Psychiatry*, *56*, 43–50. https://doi.org/10.1016/j.eurpsy.2018.11.003

Hallensleben, N., Spangenberg, L., Forkmann, T., Rath, D., Hegerl, U., Kersting, A., Kallert, T. W., & Glaesmer, H. (2018). Investigating the dynamics of suicidal ideation: Preliminary findings from a study using ecological momentary assessments in psychiatric inpatients. *Crisis*, *39*(1), 65–69. https://doi.org/10.1027/0227-5910/a000464

Hamilton, M. (1960). A rating scale for depression. *Journal of Neurology, Neurosurgery and Psychiatry*, *23*, 56–61.

Han, B., Compton, W. M., Gfroerer, J., & McKeon, R. (2015). Prevalence and correlates of past 12-month suicide attempt among adults with past-year suicidal ideation in the United States. *The Journal of Clinical Psychiatry*, *76*(3), 295–302. https://doi.org/10.4088/JCP.14m09287

Harmer, B., Lee, S., Duong, T. V. H., & Saadabadi, A. (2021). *Suicidal ideation.* StatPearls Publishing.

Hartley, S., Varese, F., Vasconcelos e Sa, D., Udachina, A., Barrowclough, C., Bentall, R. P., Lewis, S. W., Dunn, G., Haddock, G., & Palmier-Claus, J. (2014). Compliance in experience sampling methodology: The role of demographic and clinical characteristics. *Psychosis*, *6*(1), 70–73. https://doi.org/10.1080/17522439.2012.752520

Hektner, J., Schmidt, J., & Csikszentmihalyi, M. (2007). *Experience Sampling Method*. SAGE Publications. https://doi.org/10.4135/9781412984201

Husky, M., Olié, E., Guillaume, S., Genty, C., Swendsen, J., & Courtet, P. (2014). Feasibility and validity of ecological momentary assessment in the investigation of suicide risk. *Psychiatry Research*, *220*(1–2), 564–570. https://doi.org/10.1016/j.psychres.2014.08.019

Husky, M., Swendsen, J., Ionita, A., Jaussent, I., Genty, C., & Courtet, P. (2017). Predictors of daily life suicidal ideation in adults recently discharged after a serious suicide attempt: A pilot study. *Psychiatry Research*, *256*, 79–84. https://doi.org/10.1016/j.psychres.2017.06.035

Janssens, K. A. M., Bos, E. H., Rosmalen, J. G. M., Wichers, M. C., & Riese, H. (2018). A qualitative approach to guide choices for designing a diary study. *BMC Medical Research Methodology*, *18*(1), 140. https://doi.org/10.1186/s12874-018-0579-6

Johnson, E. I., Grondin, O., Barrault, M., Faytout, M., Helbig, S., Husky, M., Granholm, E. L., Loh, C., Nadeau, L., Wittchen, H. U., & Swendsen, J. (2009). Computerized ambulatory monitoring in psychiatry: A multi-site collaborative study of acceptability, compliance, and reactivity. *International Journal of Methods in Psychiatric Research*, *18*(1), 48–57. https://doi.org/10.1002/mpr.276

Jones, A., Remmerswaal, D., Verveer, I., Robinson, E., Franken, I. H. A., Wen, C. K. F., & Field, M. (2019). Compliance with ecological momentary assessment protocols in substance users: a meta-analysis. *Addiction*, *114*(4), 609–619. https://doi.org/10.1111/add.14503

Kaplan, R. M., & Stone, A. A. (2013). Bringing the laboratory and clinic to the community: Mobile technologies for health promotion and disease preventiona. *Annual Review of Psychology*, *64,* 471–498. https://doi.org/10.1146/annurev-psych-113011-143736

Kaurin, A., Dombrovski, A. Y., Hallquist, M. N., & Wright, A. G. C. (2020). Momentary interpersonal processes of suicidal surges in borderline personality disorder. *Psychological Medicine, 52*(13), 2702–2712. https://doi.org/10.1017/S0033291720004791

Kaurin, A., Hisler, G., Dombrovski, A. Y., Hallquist, M. N., & Wright, A. G. C. (2021). Sleep and next-day negative affect and suicidal ideation in borderline personality disorder. *Personality Disorders: Theory, Research, and Treatment, 13*(2), 160–170. https://doi.org/10.1037/per0000496

Kleiman, E. M., Coppersmith, D. D. L., Millner, A. J., Franz, P. J., Fox, K. R., & Nock, M. K. (2018). Are suicidal thoughts reinforcing? A preliminary real-time monitoring study on the potential affect regulation function of suicidal thinking. *Journal of Affective Disorders*, *232*, 122–126. https://doi.org/10.1016/j.jad.2018.02.033

Kleiman, E. M., Turner, B. J., Fedor, S., Baele, E. E., Huffman, J. C., & Nock, M. K. (2017). Examination of real-time fluctuations in suicidal ideation and its risk factors: Results from two ecological momentary assessment studies. *Journal of Abnormal Psychology*, *126*(6), 726–738. https://doi.org/10.1037/abn0000273.supp

Kleiman, E. M., Turner, B. J., Fedor, S., Beale, E. E., Picard, R. W., Huffman, J. C., & Nock, M. K. (2018). Digital phenotyping of suicidal thoughts. *Depression and Anxiety*, *35*(7), 601–608. https://doi.org/10.1002/da.22730

Kroenke, K., Spitzer, R. L., & Williams, J. B. W. (2001). The PHQ-9: Validity of a brief depression severity measure. *Journal of General Internal Medicine*, *16*(9), 606–613.

Large, M., Kaneson, M., Myles, N., Myles, H., Gunaratne, P., & Ryan, C. (2016). Meta-analysis of longitudinal cohort studies of suicide risk assessment among psychiatric patients: Heterogeneity in results and lack of improvement over time. *PLOS One*, *11*(6), e0156322. https://doi.org/doi: 10.1371/journal.pone.0156322

Large, M., Ryan, C., & Nielssen, O. (2011). The validity and utility of risk assessment for inpatient suicide. *Australasian Psychiatry*, *19*(6), 507–512. https://doi.org/10.3109/10398562.2011.610505

Larson, R., & Csikszentmihalyi, M. (2014). The experience sampling method. *Flow and the Foundations of Positive Psychology*. Springer Netherlands. https://doi.org/10.1007/978-94-017-9088-8_2

Law, M. K., Furr, R. M., Arnold, E. M., Mneimne, M., Jaquett, C., & Fleeson, W. (2015). Does assessing suicidality frequently and repeatedly cause harm? A randomized control study. *Psychological Assessment*, *27*(4), 1171–1181. https://doi.org/10.1037/pas0000118

Littlewood, D. L., Kyle, S. D., Carter, L. A., Peters, S., Pratt, D., & Gooding, P. (2019). Short sleep duration and poor sleep quality predict next-day suicidal ideation: An ecological momentary assessment study. *Psychological Medicine*, *49*(3), 403–411. https://doi.org/10.1017/S0033291718001009

McDevitt-Murphy, M. E., Luciano, M. T., & Zakarian, R. J. (2018). Use of ecological momentary assessment and intervention in treatment with adults. *FOCUS*, *16*(4), 370–375. https://doi.org/10.1176/appi.focus.20180017

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., Altman, D., & The PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine*, 6(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097

Myin-Germeys, I., Kasanova, Z., Vaessen, T., Vachon, H., Kirtley, O., Viechtbauer, W., & Reininghaus, U. (2018). Experience sampling methodology in mental health research: new insights and technical developments. *World Psychiatry*, *17*(2), 123–132. https://doi.org/10.1002/wps.20513

Nock, M. K. (2016). Recent and needed advances in the understanding, prediction, and prevention of suicidal behavior. *Depression and Anxiety*, *33*(6), 460–463). https://doi.org/10.1002/da.22528

Nock, M. K., Borges, G., Bromet, E. J., Cha, C. B., Kessler, R. C., & Lee, S. (2008). Suicide and suicidal behavior. *Epidemiologic Reviews*, *30*(1), 133–154. https://doi.org/10.1093/epirev/mxn002

Nock, M. K., Pristein, M. J., & Sterba, S. K. (2009). Revealing the form and function of self-injurious thoughts and behaviors: A real-time ecological assessment study among adolescents and young adults. *Journal of Abnormal Psychology*, *118*(4), 816–827.

Oquendo, M. A., Galfalvy, H. C., Choo, T. H., Kandlur, R., Burke, A. K., Sublette, M. E., Miller, J. M., Mann, J. J., & Stanley, B. H. (2020). Highly variable suicidal ideation: a phenotypic marker for stress induced suicide risk. *Molecular Psychiatry, 26,* 5079–5086. https://doi.org/10.1038/s41380-020-0819-0

Osman, A., Bagge, C. L., Gutierrez, P. M., Konick, L. C., Kopper, B. A., & Barrios, F. X. (2001). The Suicidal Behaviors Questionnaire-Revised (SBQ-R): Validation with clinical and nonclinical samples. *Assessment*, *8*(4), 443–454. https://doi.org/10.1177/107319110100800409

Ottenstein, C., & Werner, L. (2021). Compliance in Ambulatory Assessment Studies: Investigating Study and Sample Characteristics as Predictors. *Assessment, 29*(8), 1765–1776. https://doi.org/10.1177/10731911211032718

Parra-Uribe, I., Blasco-Fontecilla, H., Garcia-Parés, G., Martínez-Naval, L., Valero-Coppin, O., Cebrià-Meca, A., Oquendo, M. A., & Palao-Vidal, D. (2017). Risk of re-attempts and suicide death after a suicide attempt: A survival analysis. *BMC Psychiatry*, *17*(1), 163. https://doi.org/10.1186/s12888-017-1317-z

Peters, E. M., Dong, L. Y., Thomas, T., Khalaj, S., Balbuena, L., Baetz, M., Osgood, N., & Bowen, R. (2020). Instability of suicidal ideation in patients hospitalized for depression: An exploratory study using smartphone ecological momentary assessment. *Archives of Suicide Research*, *26*(1), 56–69. https://doi.org/10.1080/13811118.2020.1783410

Porras-Segovia, A., Cobo, A., Díaz-Oliván, I., Artés-Rodríguez, A., Berrouiguet, S., Lopez-Castroman, J., Courtet, P., Barrigón, M. L., Oquendo, M. A., & Baca-García, E. (2021). Disturbed sleep as a clinical marker of wish to die: A smartphone monitoring study over three months of observation. *Journal of Affective Disorders*, *286*, 330–337. https://doi.org/10.1016/j.jad.2021.02.059

Porras-Segovia, A., Molina-Madueño, R. M., Berrouiguet, S., López-Castroman, J., Barrigón, M. L., Pérez-Rodríguez, M. S., Marco, J. H., Díaz-Oliván, I., de León, S., Courtet, P., Artés-Rodríguez, A., & Baca-García, E. (2020). Smartphone-based ecological momentary assessment (EMA) in psychiatric patients and student controls: A real-world feasibility study. *Journal of Affective Disorders*, *274*, 733–741. https://doi.org/10.1016/j.jad.2020.05.067

Posner, K., Brown, G. K., Stanley, B., Brent, D. A., Yershova, K. V., Oquendo, M. A., Currier, G. W., Melvin, G. A., Greenhill, L., Shen, S., & Mann, J. J. (2011). The Columbia–Suicide Severity Rating Scale: Initial validity and internal consistency findings from three multisite studies with adolescents and adults. *American Journal of Psychiatry*, *168*(12), 1266–1277. https://doi.org/10.1176/appi.ajp.2011.10111704

Rath, D., de Beurs, D., Hallensleben, N., Spangenberg, L., Glaesmer, H., & Forkmann, T. (2019). Modelling suicide ideation from beep to beep: Application of network analysis to ecological momentary assessment data. *Internet Interventions*, *18,* 100292. https://doi.org/10.1016/j.invent.2019.100292

Riese, H., & Wichers, M. (2021). Comment on: Eronen MI (2019). The levels problem in psychopathology. *Psychological Medicine*, *51*(3), 525–526. https://doi.org/10.1017/S0033291719003623

Ringel, E. (1976). The Presuicidal Syndrome. *Suicide and Life-Threatening Behavior*, *6*(3), 131–149. https://doi.org/10.1111/j.1943-278X.1976.tb00328.x

Rintala, A., Wampers, M., Myin-Germeys, I., & Viechtbauer, W. (2020). Momentary predictors of compliance in studies using the experience sampling method. *Psychiatry Research*, *286,* 112896. https://doi.org/10.1016/j.psychres.2020.112896

Rizk, M. M., Choo, T. H., Galfalvy, H., Biggs, E., Brodsky, B. S., Oquendo, M. A., Mann, J. J., & Stanley, B. (2019). Variability in suicidal ideation is associated with affective instability in suicide attempters with borderline personality disorder. *Psychiatry*, *82*, 173–178.

Rodríguez-Blanco, L., Carballo, J. J., & Baca-García, E. (2018). Use of ecological momentary assessment (EMA) in non-suicidal self-injury (NSSI): A systematic review. *Psychiatry Research*, *263,* 212–219. https://doi.org/10.1016/j.psychres.2018.02.051

Rogers, M. L. (2021). Feasibility and acceptability of ecological momentary assessment in a fully online study of community-based adults at high risk for suicide. *Psychological Assessment, 33*(12), 1215–1225. https://doi.org/10.1037/pas0001054

Rudd, M. D., Berman, A. L., Joiner, T. E., Nock, M. K., Silverman, M. M., Mandrusiak, M., Van Orden, K., & Witte, T. (2006). Warning signs for suicide: Theory, research, and clinical applications. *Suicide and Life-Threatening Behavior*, *36*(3), 255–262. https://doi.org/10.1521/suli.2006.36.3.255

Santangelo, P., Bohus, M., & Ebner-Priemer, U. W. (2014). Ecological momentary assessment in borderline personality disorder: A review of recent findings and methodological challenges. *Journal of Personality Disorders*, *28*(4), 555–576. https://doi.org/10.1521/pedi_2012_26_067

Schatten, H. T., Brick, L. A., Holman, C. S., & Czyz, E. (2021). Differential time varying associations among affective states and suicidal ideation among adolescents following hospital discharge. *Psychiatry Research*, *305,* 114174. https://doi.org/10.1016/j.psychres.2021.114174

Serre, F., Fatseas, M., Swendsen, J., & Auriacombe, M. (2015). Ecological momentary assessment in the investigation of craving and substance use in daily life: A systematic review. *Drug and Alcohol Dependence*, *148,* 1–20. https://doi.org/10.1016/j.drugalcdep.2014.12.024

Shiffman, S. (2009). How many cigarettes did you smoke? Assessing cigarette consumption by global report, time-line follow-back, and ecological momentary assessment. *Health Psychology*, *28*(5), 519–526. https://doi.org/10.1037/a0015197

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology*, 4, 1–32. https://doi.org/10.1146/annurev.clinpsy.3.022806.091415

Smith, K. E., Mason, T. B., Juarascio, A., Schaefer, L. M., Crosby, R. D., Engel, S. G., & Wonderlich, S. A. (2019). Moving beyond self-report data collection in the natural environment: A review of the past and future directions for ambulatory assessment in eating disorders. *International Journal of Eating Disorders*, *52*(10), 1157–1175). https://doi.org/10.1002/eat.23124

Smith, P., Poindexter, E., & Cukrowicz, K. (2010). The effect of participating in suicide research: Does participating in a research protocol on suicide and psychiatric symptoms increase suicide ideation and attempts? *Suicide and Life-Threatening Behavior*, *40*(6), 535–543. https://doi.org/10.1521/suli.2010.40.6.535

Spangenberg, L., Glaesmer, H., Hallensleben, N., Rath, D., & Forkmann, T. (2019). (In)stability of capability for suicide in psychiatric inpatients: Longitudinal assessment using ecological momentary assessments. *Suicide and Life-Threatening Behavior*, *49*(6), 1560–1572. https://doi.org/10.1111/sltb.12547

Stanley, B., Martínez-Alés, G., Gratch, I., Rizk, M., Galfalvy, H., Choo, T. H., & Mann, J. J. (2021). Coping strategies that reduce suicidal ideation: An ecological momentary assessment study. *Journal of Psychiatric Research*, *133*, 32–37. https://doi.org/10.1016/j.jpsychires.2020.12.012

Stone, A. A., Shiffman, S., Schwartz, J. E., Broderick, J. E., & Hufford, M. R. (2003). Patient compliance with paper and electronic diaries. *Controlled Clinical Trials*, *24*(2), 182–199. https://doi.org/10.1016/S0197-2456(02)00320-3

Torous, J., Staples, P., Shanahan, M., Lin, C., Peck, P., Keshavan, M., & Onnela, J.-P. (2015). Utilizing a personal smartphone custom app to assess the Patient Health Questionnaire-9 (PHQ-9) depressive symptoms in patients with major depressive disorder. *JMIR Mental Health*, *2*(1), e8. https://doi.org/10.2196/mental.3889

Trull, T. J., & Ebner-Priemer, U. (2014). The role of ambulatory assessment in psychological science. *Current Directions in Psychological Science*, *23*(6), 466–470. https://doi.org/10.1177/0963721414550706

Trull, T. J., Lane, S. P., Koval, P., & Ebner-Priemer, U. W. (2015). Affective dynamics in psychopathology. *Emotion Review*, *7*(4), 355–361. https://doi.org/10.1177/1754073915590617

van Genugten, C. R., Schuurmans, J., Lamers, F., Riese, H., Penninx, B. W. J. H., Schoevers, R. A., Riper, H. M., & Smit, J. H. (2020). Experienced burden of and adherence to smartphone-based ecological momentary assessment in persons with affective disorders. *Journal of Clinical Medicine*, *9*(2), 322. https://doi.org/10.3390/jcm9020322

Van Orden, K. A., Witte, T. K., Cukrowicz, K. C., Braithwaite, S. R., Selby, E. A., & Joiner, T. E. (2010). The Interpersonal Theory of Suicide. *Psychological Review*, *117*(2), 575–600. https://doi.org/10.1037/a0018697

Victor, S. E., Brown, S. L., Scott, L. N., Hipwell, A. E., & Stepp, S. D. (2021). Prospective and concurrent affective dynamics in self-injurious thoughts and behaviors: An examination in young adult women. *Behavior Therapy*, *52*, 1158–1170.

Victor, S. E., Scott, L. N., Stepp, S. D., & Goldstein, T. R. (2019). I want you to want me: Interpersonal stress and affective experiences as within-person predictors of nonsuicidal self-injury and suicide urges in daily life. *Suicide and Life-Threatening Behavior*, *49*(4), 1157–1177. https://doi.org/10.1111/sltb.12513

Vine, V., Victor, S. E., Mohr, H., Byrd, A. L., & Stepp, S. D. (2020). Adolescent suicide risk and experiences of dissociation in daily life. *Psychiatry Research*, *287,* 112870. https://doi.org/10.1016/j.psychres.2020.112870 von Klipstein, L., Riese, H., van der Veen, D. C., Servaas, M. N., & Schoevers, R. A. (2020). Using person-specific networks in psychotherapy: Challenges, limitations, and how we could use them anyway. *BMC Medicine*, *18*(1), 345. https://doi.org/10.1186/s12916-020-01818-0

Walz, L. C., Nauta, M. H., & aan het Rot, M. (2014). Experience sampling and ecological momentary assessment for studying the daily lives of patients with anxiety disorders: A systematic review. *Journal of Anxiety Disorders*, 28(8), 925–937. https://doi.org/10.1016/j.janxdis.2014.09.022

Wang, S. B., Coppersmith, D. D. L., Kleiman, E. M., Bentley, K. H., Millner, A. J., Fortgang, R., Mair, P., Dempsey, W., Huffman, J. C., & Nock, M. K. (2021). A pilot study using frequent inpatient assessments of suicidal thinking to predict short-term postdischarge suicidal behavior. *JAMA Network Open*, *4*(3), e210591. https://doi.org/10.1001/jamanetworkopen.2021.0591

Wen, C. K. F., Schneider, S., Stone, A. A., & Spruijt-Metz, D. (2017). Compliance with mobile ecological momentary assessment protocols in children and adolescents: A systematic review and meta-analysis. *Journal of Medical Internet Research*, *19*(4), e132. https://doi.org/10.2196/jmir.6641

Williams, J. M. G., Barnhofer, T., Crane, C., Hermans, D., Raes, F., Watkins, E., & Dalgleish, T. (2007). Autobiographical memory specificity and emotional disorder. *Psychological Bulletin*, *133*(1), 122–148. https://doi.org/10.1037/0033-2909.133.1.122

Witte, T. K., Fitzpatrick, K. K., Joiner, T. E., & Schmidt, N. B. (2005). Variability in suicidal ideation: A better predictor of suicide attempts than intensity or duration of ideation? *Journal of Affective Disorders*, *88*(2), 131–136. https://doi.org/10.1016/j.jad.2005.05.019

Witte, T. K., Fitzpatrick, K. K., Warren, K. L., Schatschneider, C., & Schmidt, N. B. (2006). Naturalistic evaluation of suicidal ideation: Variability and relation to attempt status. *Behaviour Research and Therapy*, *44*(7), 1029–1040. https://doi.org/10.1016/j.brat.2005.08.004

Zuidersma, M., Riese, H., Snippe, E., Booij, S. H., Wichers, M., & Bos, E. H. (2020). Single-subject research in psychiatry: Facts and fictions. *Frontiers in Psychiatry*, 11, 539777. https://doi.org/10.3389/fpsyt.2020.539777

CHAPTER 03:

Application

Examination of Acceptability, Feasibility and Iatrogenic Effects of Ecological Momentary Assessment (EMA) of Suicidal Ideation

Published as:

Kivelä, L., Fiß, F., van der Does, W., & Antypa, N. (2023). Examination of Acceptability, Feasibility and Iatrogenic Effects of Ecological Momentary Assessment (EMA) of Suicidal Ideation. *Assessment, 31*(6), 1292-1308. https://doi.org/10.1177/10731911231216053

Abstract

Background: Ecological momentary assessment (EMA) can be used to examine the dynamics of suicidal ideation in daily life. While the general acceptability and feasibility of EMA in suicide research has been established, further examination of potential iatrogenic effects (i.e., negative reactivity) and identifying those more likely to react negatively is needed. **Methods:** Participants (*N* = 82) with current suicidal ideation completed 21 days of EMA (4x/day) and filled in *M* = 78% (*Med* = 84%) of the EMA. **Results:** No positive or negative affect reactivity was observed in EMA ratings over the study period. Retrospectively, most participants rated their experience as positive (69%); 22% indicated mood worsening, and 18% suicidal ideation reactivity. Those with more borderline personality traits, PTSD, and higher depressive, anxiety and suicidal ideation symptoms, were more likely to report iatrogenic effects. **Conclusions:** In conclusion, while high compliance rates and lack of affect reactivity during EMA indicate that EMA is well tolerated in suicide research, a minority of participants may report subjective mood effects in retrospect.

Introduction

Ecological momentary assessment (EMA) is an emerging methodology in suicide research (Davidson et al., 2017). EMA encompasses data collection methods where participants are repeatedly prompted to report on their experiences, as part of their normal daily lives and in real-time, using electronic devices (Shiffman et al., 2008). Data may thus be collected in a way that increases ecological validity, minimizes recall bias, and enhances the temporal granularity of the information collected. Recent reviews (Gee et al., 2020; Kivelä et al., 2022; Sedano-Capdevila et al., 2021) have demonstrated that EMA can be used for the real-time assessment of suicidal ideation and its associated momentary risk factors. EMA allows for the assessment of more dynamic characteristics of suicidal ideation, such as hourly and daily fluctuations in the intensity of ideation, as well as risk-factors that may be time- or context-dependent (Myin-Germeys et al., 2018). While the use of EMA in suicide research is growing rapidly, few studies so far have directly examined the feasibility and acceptability of EMA in suicide research, especially in terms of potential iatrogenic effects (i.e., negative reactivity to EMA). More data are also needed on the subjective experience of participants in such studies. Specifically, there may be concern about the burden imposed on already vulnerable populations, as well as the potentially harmful effects of repeated assessments of suicidal ideation (Bos, 2021).

The possible iatrogenic effects of suicide assessments have been a long-time concern of both clinicians and researchers. A 2009 survey of medical ethics committee members revealed that 65% believed that participating in suicide-related research would be detrimental to patients (Lakeman & FitzGerald, 2009). However, the consensus from the general literature indicates that inquiring people about their suicidal ideation, even when done repeatedly or intensively, does not increase suicidal ideation, or trigger suicidal or self-harm behavior (Bender et al., 2019; Gould et al., 2005; Hom et al., 2018; Schatten et al., 2022; Smith et al., 2010). Some studies have shown that such assessments may even serve to lessen ideation and associated distress: for example, in a study involving interview and questionnaire measures, as well as exposure to suicide-related stimuli as part of an emotional picture processing task, participants reported reductions in suicidal ideation at 1-month follow-up (Schatten et al., 2022). A 2018 review and meta-analysis of 13 studies examining iatrogenic effects of suicide assessments also concluded that no significant negative outcomes resulted from participation (DeCou & Schumann, 2018). However, these findings may not extend to study designs where measures of suicidal ideation can be repeated up to a hundred times over the span of days and weeks. Another concern therefore regards the compliance of patients to EMA designs, whether influenced by negative reactivity to the assessments, or the general burden of such intensive research designs.

Studies to date appear to support the feasibility, acceptability and safety of EMA in suicide research. In the first study examining the feasibility of EMA-based suicidal ideation assessments, Husky et al. (2014) found study acceptability (i.e., agreement to participate) to be higher among recent suicide attempters (88%) than healthy controls (77%), although compliance among cases (74%) was lower than controls (86%). Subsequent studies have largely supported these early findings: based on a review of twenty-three EMA studies examining suicidal ideation, median acceptability was 77%, and compliance (i.e., average response rate) was 70% (Kivelä et al., 2022). Excellent retention rates were also reported (*Med* = 94%) (Kivelä et al., 2022). These numbers mirror those derived from EMA studies in other clinical populations (Johnson et al., 2009).

However, fewer studies have directly examined iatrogenic effects of EMA. Most studies have concluded on the acceptability of EMA based on objective indices, such as high retention and compliance rates. Husky and colleagues (2014) also examined reactive effects, and found that the intensity and frequency of negative affect and suicidal ideation did not increase as a function of study duration, indicating no negative reactivity to repeated assessments. However, this study only lasted seven days, while EMA studies may frequently use weeks-to-months long assessments (range in prior EMA studies on suicidal ideation 4 – 60 days; Kivelä et al., 2022). Another study comparing a 14-day EMA protocol on suicidal ideation to a control protocol (14-days of EMA on negative psychological experiences with no suicide-related items) found no differences in the occurrence of suicidal ideation, attempts or self-harm between the two groups; these findings were replicated both among clinical cases (borderline personality disorder) and controls (Law et al., 2015). Further, the effects of frequency of EMA on suicidal ideation severity were examined in a sample of 101 adults with past-week active suicidal ideation; no negative effects were observed (Coppersmith et al., 2022). However, more nuanced effects may occur. For example, while Husky and colleagues (2014) found no effects on the key outcomes of negative affect and suicidal ideation, decreases in both positive affect *and* hopelessness were observed. Consequently, both potential negative as well as positive reactive effects to EMA need to be further evaluated.

With regard to participants' subjective experience with EMA studies, most participants have rated their experiences as "neutral-to-positive" based on two studies, one in a sample of 34 adolescents who completed once-daily EMA for 21 days (Czyz et al., 2018), and another in a sample of 237 high-risk adults from the community who completed EMA six times per day over 14 days (Rogers, 2021). Participants in both studies predominantly indicated that they would participate in similar research again (Czyz et al., 2018; Rogers, 2021). However, subsets of participants reported having experienced the EMA protocol as stressful and/or burdensome (16%) (Forkmann et al., 2018), occasionally distressing and/or triggering bad thoughts (9%) (Rogers, 2021), or having made them feel worse (3%) (Czyz et al., 2018). Notably, to the best of our knowledge, no previous study has examined the characteristics of participants who are more likely to report negative reactivity from EMA assessments. Consequently, predictors of iatrogenic effects warrant further examination.

The aim of the present study was to enrich the current literature on the acceptability, feasibility and safety of EMA in suicide research by presenting data from the SAFE study, a longitudinal cohort study in individuals with current suicidal ideation, in which mobile-phone based EMA (4x/day) was administered over three weeks. Specifically, we aimed to replicate prior findings indicating that EMA of suicidal ideation does not result in systematic iatrogenic effects on suicide outcomes (Coppersmith et al., 2022; Husky et al., 2014; Law et al., 2015). Further, we comprehensively assessed participants' subjective experiences as relating to study participation (extending on Czyz et al., 2018; Forkmann et al., 2018; Rogers, 2021). While prior studies have indicated no systematic reactivity with EMA on suicidal ideation or behavior specifically (Coppersmith et al., 2022; Husky et al., 2014; Law et al., 2015), reactivity on other outcomes (such as reduced positive affect; Husky et al., 2014) has been reported and warrants further examination. We therefore aimed to further replicate the prior findings indicating that EMA of suicidal ideation does not result in suicidal reactivity, and explore effects on other (positive/negative) affect outcomes. Furthermore, identifying (groups of) participants who might be more at risk to react negatively is of both research and clinical value, since some participants do self-report iatrogenic effects (Czyz et al., 2018; Rogers, 2021), indicating the need to better characterize this subgroup at risk. In sum, while the application of EMA in suicide research is ever-growing, only a few studies have reported on reactive effects, and participant characteristics associated with an increased likelihood of reporting iatrogenic effects have not previously been examined. This information is important to ensure that the field progresses in a safe manner. To this extent, we examined 1) acceptability and feasibility (incl. agreement to participate, attrition, compliance), 2) predictors of compliance (i.e., how baseline characteristics affect response rates), and 3) iatrogenic effects (i.e., whether systematic changes could be observed in participants' affect and/or suicidal ideation ratings over the study period, and which participants were most likely to be subject to reactivity). Finally, we explored participant feedback given at the end of the 3-week EMA period on their subjective experience with the assessments.

Methods

Participants

Eligible participants were 18 years or older with a recent (past year) history of a suicide attempt and/or active suicidal ideation (based on a reduced version of the Columbia Suicide Severity Rating Scale (CSSRS) (Posner et al., 2011) comprised of the first five questions, with cutoff scores of >= 3, or >=2 if symptoms were present in the past two months). Participants had a sufficient proficiency in written and spoken English and/or Dutch; possessed an Android or iOS compatible smartphone; and were registered with a local (Dutch) general practitioner (GP). Exclusion criteria included a current diagnosis of bipolar disorder, a psychotic disorder, or (severe) substance dependence (based on DSM-5 criteria).

Instruments

Intake Interview Data on participants' sociodemographic characteristics, and medical and psychiatric history (incl. medications) were collected through a custom semi-structured interview. A reduced version of the CSSRS was used to assess the participants' recent (past year) history of suicidal ideation; additional questions were included on lifetime history of suicide attempts. The MINI Neuropsychiatric interview (version 5.0) (Sheehan et al., 1998) and the Structured Clinical Interview for DSM-5 Personality Disorders subscale for Borderline Personality Disorder (SCID-PD-BPD) (First, 2015) were used to establish current diagnoses.

Ecological Momentary Assessment (EMA) Each EMA assessment included the same core set of questions, with additional questions on sleep parameters included as part of the morning assessment, and questions about napping included as part of the evening assessment. The full set of EMA questions, item formulation and rating scales can be found in the Appendix. The core set of questions covered the participants' current: 1) location, social company and activity, 2) affect (happiness, calmness, sadness, anxiety, anger, guilt, shame), 3) cognitions (hopelessness, loneliness, burdensomeness, optimism), 4) suicidal ideation (passive and active ideation, acquired capability), 5) impactful events (type and stressfulness of positive and negative impactful events), 5) coping (use of coping strategies), and 6) substance use (medication, alcohol, and recreational drugs). Morning assessment of the previous night's sleep included questions about the participants subjective sleep quality, timing of sleep, and experience of nighttime awakenings and nightmares; evening assessments inquired about napping during the day. Participants filled in 4x/day EMA over the first 20 days, and a final morning assessment on Day 21, resulting in a total of 81 scheduled entries. Additional data collected by the EMA app included response time (i.e., time from alert to response) and completion time (i.e., time to complete EMA once opened). EMA items used in the present analyses included suicidal ideation (mean of the three EMA items on desire to live, desire to die, and suicidal thoughts; *nb.* desire to live was reverse coded prior to calculating the mean score), positive affect (mean of the EMA items on happiness and calmness) and negative affect (mean of the EMA items on sadness, anxiety, anger, guilt and shame). Descriptives of the study variables are presented in Table 1.

Questionnaires At baseline, participants filled in additional state and trait measures. The Beck Scale for Suicide Ideation (BSSI) (Beck et al., 1979) is a 21-item measure of current (past week) suicidal ideation. Cronbach's alpha in our sample was .91. The Beck Depression Inventory (BDI-I) (Beck, 1961) is a 21-item measure of current (past week) depressive symptoms (Cronbach's alpha = .85). The Hamilton Anxiety and Depression Scale – Anxiety Subscale (HADS-A) (Zigmond & Snaith, 1983) is a 7-item measure of current (past week) anxiety symptoms (Cronbach's alpha = .65). The Insomnia Severity Index (ISI) (Bastien, 2001) is a 7-item measure of sleep complaints experienced in the previous two weeks (Cronbach's alpha = .79). The Quality of Life Enjoyment and Satisfaction Questionnaire – Short Form (Q-LES-Q-SF) (Endicott et al., 1993) is a 16-item measure assessing current (past week) life satisfaction with regard to relationships, work and health (Cronbach's alpha = .85). The Leiden Index of Depression Sensitivity – Revised (LEIDS-R) (Solis et al., 2017) is a 34-item measure on the propensity to cognitive reactivity (Cronbach's alpha = .85). The State-Trait Anger Expression Inventory (STAXI) (Zigmond & Snaith, 1983) is a 44-item measure on state and trait anger (expression); in the present study we used the 10-item trait subscale (Cronbach's alpha = .84). Lastly, the Personality Assessment Inventory – Borderline Scale (PAI-BOR) (Morey, 1991) is a 24-item measure of borderline personality traits (Cronbach's alpha = .83). The same questionnaires were repeated after the 21-day EMA period (apart from the LEIDS-R, STAXI, and PAI-BOR which are trait measures and were not expected to change within the study period); in addition, participants also filled in a custom questionnaire on their experience with the EMA procedure (see Appendix).

Table 1. Within-Person Descriptive Statistics of Study Variables

Variable	*M*	*SD*	Range	ICC	RMSSD
Suicidal ideation (mean)	3.04	1.97	0–9	0.71	1.18
Desire to live	4.28	2.25	0–9	0.69	1.50
Desire to die	3.09	2.59	0–10	0.70	1.58
Suicidal thoughts	1.57	1.79	0–8	0.53	1.29
Positive affect (mean)	5.13	1.29	2–8	0.43	1.54
Happy	4.93	1.52	0–8	0.46	1.68
Calm	5.33	1.25	2–9	0.30	2.04
Negative affect (mean)	2.92	1.62	0–7	0.61	1.27
Sad	3.54	1.72	0–7	0.41	2.11
Anxious	3.59	1.80	0–8	0.44	2.14
Angry	1.87	1.48	0–6	0.38	1.88
Guilty	2.84	2.30	0–9	0.61	1.79
Ashamed	2.76	2.44	0–10	0.65	1.67

Note: *M* = Mean, *SD* = Standard deviation, ICC = Intraclass correlation, RMSSD = Root mean square of successive differences; based on scheduled entries $k = 5{,}196$

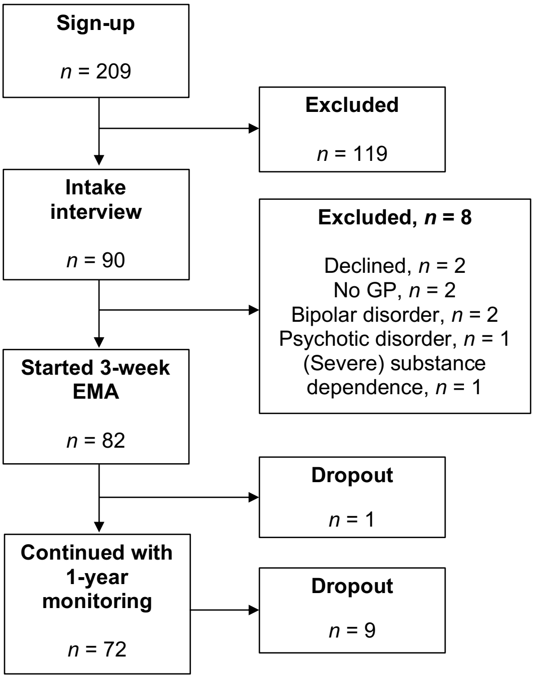
Procedure

Recruitment Participants for the study were recruited through fliers distributed in the community and on social media, as well as the Leiden University Medical Center (LUMC) Department of Psychiatry, Leiden University Treatment and Expertise Center (LUBEC), and other collaborating treatment centers in the area of Leiden and The Hague. Fliers included a QR code to the study website, where potential participants could access full study information and complete an online “self-test” to check their eligibility. Interested participants could then fill in a contact form to be invited for an (online or in-person) intake interview. Recruitment started in August 2020 and ended in September 2022.

Intake Interview During the intake interview, participants received study information and signed written informed consent. The main inclusion and exclusion criteria for the study were then examined with the CSSRS, MINI and SCID-PD-BPD (see *Participants*). In case the participant was in need of immediate mental health support, they were referred for treatment or crisis management. No participants examined required such immediate intervention.

After meeting eligibility criteria and signing informed consent, and prior to receiving study instructions, a personalized suicide safety plan was created with each participant, detailing available resources and coping strategies available in the event of a suicidal crisis. Participants were also informed that the content of their entries in the EMA app would not be monitored in real time, and in the event of a crisis, the participants should contact their GP and/or treating specialist, or one of the listed support resources (including the suicide prevention line 113). In acute danger situations, participants were instructed to call the emergency number (112). A statement at the end of the safety plan urged participants to immediately contact the study personnel in case they felt that the study proceedings were negatively affecting their mood and/or functioning. No participants reached out to the study personnel to indicate such effects. Participants were also reminded of their right to drop out of the study at any point and without having to provide a reason. Further, the GP and/or treating specialist of all participants was informed of their involvement in the study via a standardized letter.

Figure 1. Participant flow



Note: EMA = Ecological Momentary Assessment, GP = General practitioner

Table 2. Sociodemographic and Clinical Characteristics of the Sample

Sample characteristic	*N* = 82
Gender (*N*, %)	
Female	63 (77%)
Male	11 (13%)
Non-binary/trans	8 (10%)
Age (*M*, *SD*)	27 (8.6)
Nationality (*N*, %)	
Dutch	45 (55%)
Other	37 (45%)
Education level (*N*, %)	
Low	11 (13%)
Middle	34 (42%)
High	37 (45%)
Employment (*N*, %)	
Employed	24 (29%)
Not employed	14 (17%)
Student	44 (54%)
Living situation (*N*, %)	
Alone	27 (33%)
With others	53 (65%)
Hospitalized	2 (2%)
Relationship status (*N*, %)	
In a relationship	29 (35%)
Single	53 (65%)
Children (*N*, %)	
Yes	8 (10%)
Current Psychiatric diagnosis* (*N*, %)	
MDD	41 (50%)
Other depressive disorders	22 (27%)
Anxiety disorders	47 (57%)
ASD	14 (17%)
ADHD	10 (12%)
Eating disorders	5 (7%)
OCD	7 (9%)
PTSD	18 (22%)
BPD	12 (15%)
Alcohol/substance abuse	7 (9%)
Psychoactive medication (*N*, %)	
Anxiolytics / sedatives	20 (24%)

Stimulants	10 (12%)
Antidepressants	33 (40%)
Current suicidal ideation (BSSI) (*M, SD*)[a]	15.3 (8.6)
Current depressive symptoms (BDI) (*M, SD*)[a]	25.5 (9.6)
Suicide attempt history (*N*, %)	
None	47 (57%)
Single attempt	10 (12%)
Multiple attempts	25 (31%)
Medical diagnosis (*N*, %)	
Yes	35 (43%)
Non-psychoactive medication (*N*, %)	
Yes	26 (32%)
Smoking (tobacco) (*N*, %)	
Yes	35 (43%)

Notes: Education level: Low = Elementary school / Vocational education, Middle = Secondary school, High = University / Applied College education; MDD = Major depressive disorder, ASD = Autism spectrum disorder, ADHD = Attention deficit hyperactivity disorder, OCD = Obsessive compulsive disorder, PTSD = Post-traumatic stress disorder, BPD = Borderline personality disorder; * all diagnoses are based on current diagnoses derived from the MINI/ SCID-PD-BPD, except for ASD which is based on participant self-report; [a] $n = 71$

Participants subsequently received an invitation for a post-test meeting organized approximately a week after the end of the EMA period. During this meeting participants returned the research materials and received instructions for the second phase of the study (as part of the SAFE study participants also underwent 24h actigraphy over the 3-week EMA period, followed by 1-year of weekly EMA questionnaires; these measures are not included in the present paper). The researcher also briefly discussed the EMA experience with the participant. Additionally, participants were informed during the intake interview that they would receive a personalized feedback report based on their data during the post-test meeting. None of the participants indicated during the intake that they did not wish to receive the report. However, one participant who dropped out during the EMA period, as well as five participants who opted not to continue into the second phase of the study, indicated that they did not wish to attend the post-test session or receive the feedback report. Therefore, seventy-six participants (93%) received a feedback report. For these participants, during the post-test meeting the researcher presented them with their personalized feedback report, and explained/discussed the report with the participant. Following the meeting, participants received an email with a link to another set of online questionnaires, comprised of the same core set of questionnaires filled in at baseline, with additional items included on the participants' experience with the EMA. Participants again were instructed to fill in the questionnaire within the following 72h, and received a reminder email if they did not do so. Participants received a monetary compensation (20€) after completing the 3-week EMA and returning the study materials; compensation was not based on the number of EMA completed. Travel/and or postage costs for study materials were compensated for all participants if applicable.

Statistical Analysis

All analyses were performed with SPSS. Descriptive statistics were used to present sample characteristics, EMA response rates, and to summarize participant feedback. Linear regression analyses, independent samples t-tests and Chi-squared tests were used to examine predictors and patterns of response rates. Paired samples t-tests were used to examine differences between baseline and post-EMA scores on questionnaire measures. Multilevel linear regression analyses (linear-mixed models) were used to assess reactivity in momentary positive and negative affect and suicidal ideation over time. The models included both a random intercept and a random slope, to account for heterogeneity in individual symptom trajectories. A first-order autoregressive (AR) covariance structure was used, which assumes that successive observations are more highly correlated than temporally more distal observations. In line with Husky and colleagues (2014), we used assessment number (1-81) and day number (1-21) as continuous predictors. In the analyses on the effects of assessment number, we specified a three-level structure whereby observations were nested within individuals and within days. In the analyses on the effects of day number, we specified a two-level structure whereby observations were nested within individuals. Finally, we performed post-hoc multilevel analyses with the three suicidal ideation items (wish to live, wish to die, suicidal thoughts) as separate outcomes, in accordance with findings that different aspects of suicidal thinking may present different temporal patters (Oakey-Frost et al., 2023). Significance was determined at alpha = .05. With 82 participants and 81 responses per participant as target, and based on the average EMA response rate (78%), we had power (.90) to detect small effects (d = .20) (Kleiman, 2017).

Results

Acceptability

A total of 209 participants signed up for the study and were invited for an intake interview. Of those, 90 attended the intake. Following the interview, eight participants were excluded because they declined to participate (*n* = 2), were not registered with a local GP (*n* = 2), or had probable bipolar disorder (*n* = 2), (primary) psychotic disorder[1] (*n* = 1), or (severe) substance dependence (*n* = 1). Consequently, 82 participants were enrolled in the study. This resulted in estimates of acceptability ranging from 39% (percentage of participants who signed up for the study and subsequently started the data collection period) to 98% (percentage of eligible participants who completed the intake and subsequently started the data collection period). One participant dropped out of the study during the 3-week EMA period, resulting in a retention rate of 99% (*n.b.* prior to dropping out, this participant achieved a response rate that was within the range of the completers, and hence this participant was retained in all analyses). Participant flow is presented in Figure 1, and an overview of the sociodemographic and clinical composition of the sample is reported in Table 2.

Seventy-one participants (87%) also filled in the baseline questionnaire, and fifty-nine participants (72%) filled in the post-test questionnaire. Those who did not fill in the baseline questionnaire were significantly more likely to have a suicide attempt history, $\chi^2(1) = 4.69$, $p = .030$, $V = 0.24$, and a diagnosis of ADHD $\chi^2(1) = 6.79$, $p = .009$, $V = 0.29$. Those who did not fill in the post-test questionnaire were more likely to be male, $\chi^2(2) = 7.45$, $p = .024$, $V = 0.30$. Conversely, those with a diagnosis of MDD, $\chi^2(1) = 4.27$, $p = .039$, $V = 0.23$, were *more* likely to fill in the post-test questionnaire; no other differences were observed on sociodemographic or clinical characteristics.

Following the three-week EMA period, 72 participants (89%) continued to the second phase of the study (i.e., a 1-year monitoring period with weekly EMA; results not reported here). There were no significant group differences between those who continued and those who did not on either sociodemographic or clinical characteristics (all *p*s > .05).

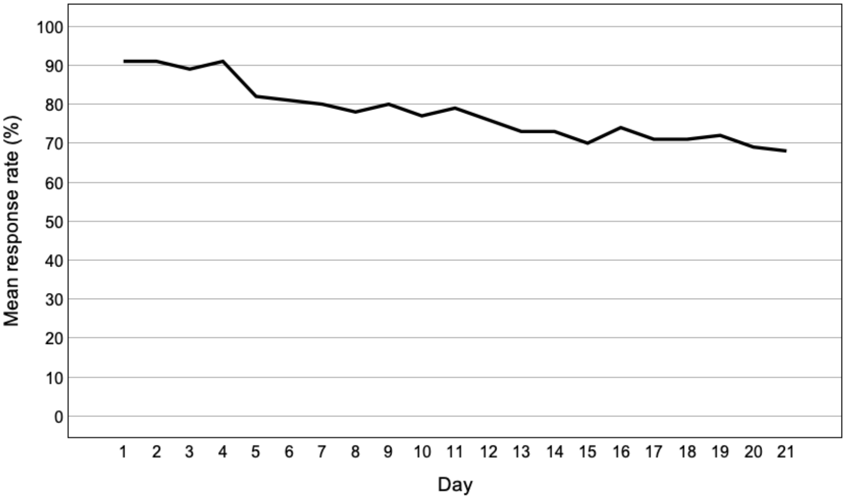
Feasibility

Participants on average filled in $M = 63$ ($Med = 68$) EMA entries out of the 81 scheduled alerts, with a mean response rate of 78% ($Med = 84\%$) and range from 14 to 81 (17-100%). In addition, participants on average filled in $M = 3$ ($Med = 2$) additional entries

[1] Participants with major depressive disorder (MDD) with psychotic features were included. Participants with primary psychotic disorders (as per DSM-5 definition) such as schizophrenia were excluded.

(Range 0-13), resulting in a total of $M = 66$ ($Med = 70$) EMA entries completed per participant overall (Range 16-88). In total, $K = 5{,}400$ unique assessments were completed by the sample as a whole, of which $k = 5{,}196$ were scheduled entries and $k = 204$ were additional entries initiated by the participants.

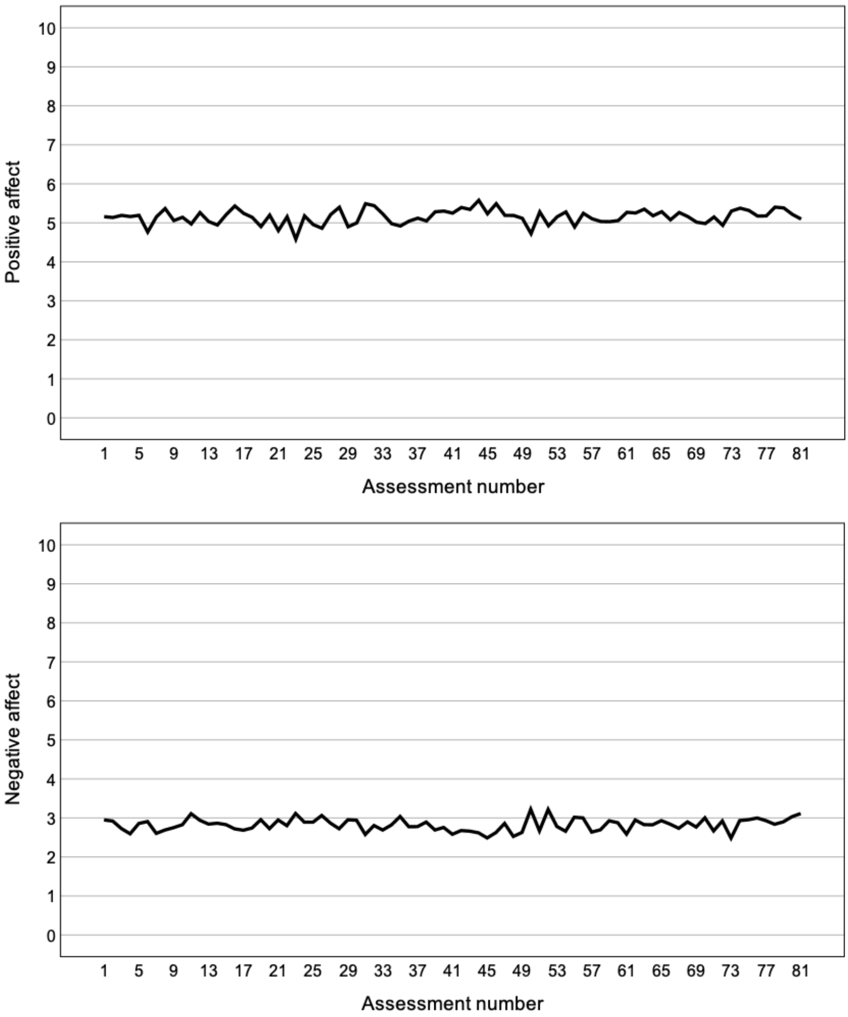
Figure 2. Percentage of Assessments Filled in as a Function of Day Number

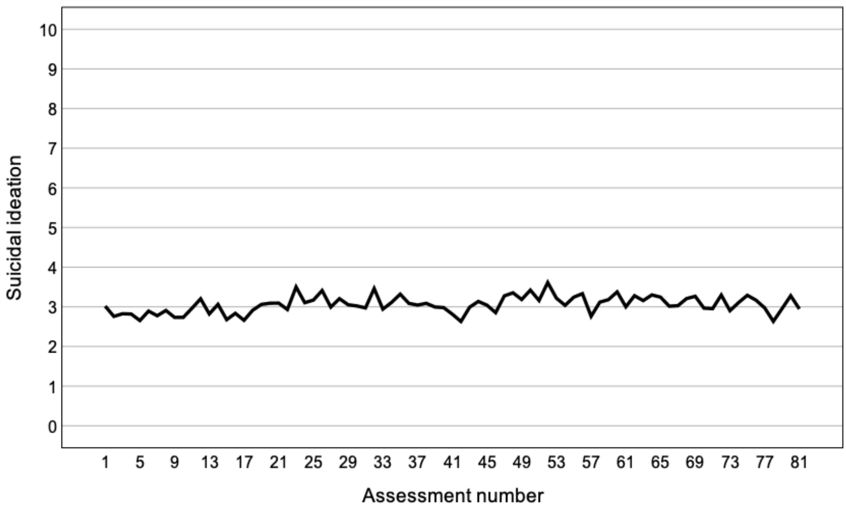


Participants on average filled in the EMA 38 minutes and 21 seconds after the alert, and took 2 minutes and 46 seconds to complete the assessment. The probability of filling in the (scheduled) EMA decreased over time, $\chi^2(1) = 113.37$, $p < .001$, OR = 1.06, $CI_{95\%}$ [1.05, 1.07], with response rates declining from 91% on Day 1 to 68% on Day 21 (Figure 2). Morning EMA alerts were significantly more likely to be missed, compared to day and evening alerts (76% of morning assessments filled in, 79% day and 79% evening, $\chi^2(2) = 10.77$, $p = .005$, $V = 0.04$). No differences were observed between weekdays versus weekends (78% response rate on weekdays and 78% on weekends, $p = .973$).

There was no influence of age ($p = .340$), gender ($p = .127$), living situation ($p = .597$), or education level ($p = .240$) on response rates; however, students had lower compliance than non-students ($M_{student} = 74\%$, $M_{other} = 83\%$), $t(79) = 2.12$, $p = .037$, $d = 0.47$. There was no influence of borderline personality traits (PAI-BOR; $p = .056$) or suicide attempt history ($p = .846$); however, those with a current diagnosis of an anxiety disorder had lower compliance ($M_{anxiety} = 75\%$, $M_{other} = 84\%$), $t(79) = 2.00$, $p = .049$, $d = 0.45$ (all other diagnoses $p > .05$). Baseline quality of life (Q-LES-Q-SR, $p = .833$), depressive symptom (BDI, $p = .628$), suicidal ideation (BSSI, $p = .223$), anxiety (HADS-A, $p = .302$) and insomnia symptom severity (ISI, $p = .743$) also did not impact compliance. However, those scoring higher on trait anger had lower compliance rates (STAXI, $B = -0.65$, $SE = 0.28$, $Beta = -0.27$, $p = .021$).

Figure 3. Mean Ratings of Positive Affect, Negative Affect and Suicidal Ideation as a Function of Assessment Number





Reactivity

There was no evidence of systematic affect reactivity i.e., increases or decreases in participants' EMA-rated momentary positive affect (B = 0.01, SE = 0.09, p = .996), negative affect (B = 0.01, SE = *0.10,* p = .959) or suicidal ideation (B = 0.01, SE = 0.14, p = .973) as a function of assessment number (Figure 3) [2]. Similar findings emerged when examining desire to live (B = 0.01, SE = 0.16, p = .971), desire to die (B = 0.01, SE = 0.18, p = .978) and suicidal thoughts separately (B = −0.01, SE = 0.12, p = .971). There were also no increases or decreases in EMA-rated positive affect (B = -0.01, SE = 0.08, p = .970), negative affect (B = 0.02, SE = 0.10, p = .833) or suicidal ideation (B = 0.02, SE = 0.14, p = .901) as a function of assessment day. Similar findings emerged when examining desire to live (B = 0.02, SE = 0.16, p = .891), desire to die (B = 0.02, SE = 0.18, p = .918) and suicidal thoughts separately (B = −0.01, SE = 0.12, p = .963). Baseline and post-EMA questionnaire comparisons showed a decrease in overall suicidal ideation severity on the BSSI: $M_{baseline}$ = 16.40 (SD = 9.17), $M_{post\text{-}EMA}$ = 15.05 (SD = 8.64), t(54) = 2.20, p = .032, d = 0.30. No differences were observed on the BDI, HADS, ISI or Q-LES-Q (all p's > .05).

[2] Analyses on response rates and reactivity were based on scheduled alerts only in order to keep the number as well as timing of the entries consistent across participants.

Table 3. Summary of Participant Feedback After the 21-Day EMA Period

Question	*N* = 58
Overall experience	
Positive	40 (69%)
Neutral	13 (22%)
Negative	5 (9%)
Burdensomeness	
Not burdensome	42 (72%)
Neutral	6 (10%)
Burdensome	10 (17%)
Stressfulness	
Not stressful	43 (74%)
Neutral	9 (16%)
Stressful	6 (10%)
Duration of EMA period	
Just right	48 (83%)
Neutral	2 (3%)
Too long	8 (14%)
Frequency of EMA	
Just right	37 (64%)
Neutral	8 (14%)
Too many	13 (22%)
Number of questions per EMA	
Just right	37 (64%)
Neutral	14 (24%)
Too many	7 (12%)
Number of answer options	
Too few	20 (35%)
Just right	38 (65%)
Too many	-
Reason for missing alerts	
I did not miss any alerts	2 (3%)
Burden too high	9 (15%)
Technical problems	12 (20%)
Too busy	39 (66%)
Phone not accessible/available	12 (20%)
Other	17 (29%)
Change in daily behavior / schedules	
Did not change behavior / schedule	51 (88%)
Neutral	2 (3%)

Changed behavior / schedule	5 (9%)
Improved mood after EMA	
No	36 (62%)
Neutral	9 (16%)
Yes	13 (22%)
Worsened mood after EMA	
No	34 (59%)
Neutral	11 (19%)
Yes	13 (22%)
Triggered suicidal ideation after EMA	
No	35 (61%)
Neutral	12 (21%)
Yes	10 (18%)
Worsened suicidal ideation after EMA	
No	43 (74%)
Neutral	9 (16%)
Yes	6 (10%)

Note: EMA = Ecological Momentary Assessment

Participant Feedback After 21-Day EMA

Based on participant feedback (n = 58; Table 3), the most frequently reported reasons for missing EMA were being otherwise engaged/busy (66%), not having access to phone (20%), and technical issues with the app (20%). Many also reported having missed morning and/or evening assessments due to being asleep (17%).

Most participants (69%) reported their experience with the EMA as positive overall (22% neutral and 9% negative). 17% reported the EMA to have been burdensome (10% neutral, 72% not burdensome), and 10% stressful (16% neutral, 74% not stressful); of those who reported the EMA to have been stressful (n = 6), two participants indicated the source of the stress to have been the burden of filling in the assessments, one the content of the EMA, and three indicated stress from both the burden and content. Additionally, out of a number of descriptive items provided to the participants (selecting multiple items allowed), 48% described the study as “insightful”, 15% “fun/exciting” and 10% “relaxing”. Meanwhile, 12% described the EMA period as “depressing” and 10% “annoying”. The experience for many was multifaceted (e.g., *“A lot of work, but also provided insights and sometimes it gave comfort.”*).

When asked if participants had changed their daily behavior and/or schedules in some way due to study participation, most (88%) reported no change (3% neutral, 9%

changed behavior). Those who indicated (at least some) behavioral change, reported spending more time on their phone (n = 3) and waking up earlier so not to miss the morning assessments (n = 5), or generally having made positive changes to their sleep (n = 1). Ten participants indicated having been more attentive/in tune with their experiences and emotions (*"I took more time out of my day to assess how I was feeling."*), of which three indicated having engaged in (positive) behavioral change due to this awareness (*"I --- was more aware of how bad things were and therefore tried to get into a healthier pattern.", "I became more aware of my daily rhythms and tried to implement more structure into my days."*).

Most participants reported neither positive mood effects (62% no improvement in mood, 16% neutral, 22% improved mood) nor negative mood effects (59% no worsening of mood, 19% neutral, 22% worsened mood) resulting from the EMA. 18% reported a triggering effect of the EMA on their suicidal ideation (21% neutral, 61% no triggering effect), and 10% reported a worsening in their suicidal ideation (16% neutral, 74% no worsening effect). Those with more borderline personality traits (PAIBOR, B = 0.06, SE = 0.02, $Beta$ = 0.34, p = .013) and those with a PTSD diagnosis (B = 1.17, SE = 0.55, $Beta$ = 0.28, p = .037) were more likely to report a triggering effect of the EMA on their suicidal ideation. Those with higher suicidal ideation (BSSI, B = 0.06, SE = 0.03, $Beta$ = , p = .030), depressive (BDI, B = 0.05, SE = 0.02, $Beta$ = 0.29, p = .033) and anxiety symptoms (HADS, B = 0.16, SE = 0.06, $Beta$ = 0.34, p = .013), and those with more borderline personality traits (PAIBOR, B = 0.05, SE = 0.02, $Beta$ = 0.28, p = .041), were more likely to report suicidal ideation worsening from the EMA; no other participant characteristics were associated with increased suicidal ideation or negative affect reactivity.

When examining the EMA ratings of the subgroup of participants who reported mood worsening (n = 13), no increase in negative affect was observed over the EMA period (B = 0.01, SE = 0.26, p = .967). When examining the EMA scores of the subgroup of participants who reported triggering (n = 10) or worsening of suicidal ideation (n = 6), no increase in suicidal ideation was observed over the EMA period (triggering: B = -0.02, SE = 0.35, p = .958; worsening: B = -0.01, SE = 0.53, p = .994). Notably, all participant who filled in the feedback survey (including those who reported iatrogenic effects) continued into the second phase of the study.

Discussion

In the present study, we examined the acceptability and feasibility of EMA in patients with suicidal ideation, with a focus on iatrogenic effects and identifying subgroups of patients who may be more affected by negative reactivity. Overall, our findings support the acceptability, feasibility and safety of EMA among patients with current suicidal ideation. While we failed to uncover systematic iatrogenic effects in EMA-rated affect and suicidal ideation, a distinctive subgroup of participants (characterized by higher depression, anxiety and suicidal ideation severity, as well as comorbid PTSD and BPD traits) self-reported experiencing negative reactivity from the EMA, based on participant feedback after the 21-day EMA period. These findings are discussed further below.

Acceptability

With 39% of those signing up for the study ultimately starting the EMA, our acceptability rate was fairly low. Online-based recruitment is likely to attract a higher number of people curious about the study rather than serious intent to participate. Studies approaching potential participants in inpatient or outpatient settings tend to report higher acceptability rates (see e.g., Husky et al., 2014; Torous et al., 2015). Meanwhile, 98% of participants who attended the intake interview and were deemed eligible to participate started the EMA period. Our 99% retention rate was also higher than that reported in the literature (60-96%) (Czyz et al., 2018; Forkmann et al., 2018; Law et al., 2015; Porras-Segovia et al., 2020; Rogers, 2021). These numbers are likely influenced by participant self-selection; those following up with the intake interview were likely to have already carefully considered the burden of participation, and were more intrinsically motivated to take part in the study.

Feasibility

We achieved excellent compliance rates, with people on average filling in 78% (*Med* = 84%) of the scheduled EMAs. As such, our compliance rate was higher than the average in previous studies (*Med* = 70%) (Kivelä et al., 2022). Reasons for our high compliance are again likely to include participant characteristics and self-selection, as well as the nature of the incentives used in the study; participants were aware that they would receive a personalized feedback report which was dependent on the (amount and quality) of their EMA responses. Notably, we did not employ additional feedback or rewards for increased compliance, such as periodically providing participants with feedback on their response rate, or offering additional monetary rewards for high compliance (as done previously by e.g., Glenn et al., 2020; Rogers, 2021). Indeed, monetary rewards tend to have fairly small effects on compliance (Ottenstein & Werner, 2021), whereas more personalized rewards (such as feedback reports) may be more effective in increasing participants' engagement with the study (Folkersma et al., 2021). Participants were also informed they would receive a phone call from the study personnel if they did not fill in any EMA for 72 hours; desire to avoid this phone call may have further increased participants' compliance. However, our decision not to monitor the *content* of participants' responses in real-time may also have influenced responses and response patterns: while response monitoring is generally recommended (especially when studying adolescents) it is also understood that such monitoring may lead to underreporting of suicidal ideation, or even additional missing data in case participants stop completing the surveys at times of severe ideation in order to prevent unwanted intervention by research staff (Bentley et al., 2021).

While previous studies have concluded that participant characteristics, such as suicide attempt history or current depression or suicidal ideation severity, do not influence response rates (Glenn et al., 2020; Hallard et al., 2021; Oquendo et al., 2020; Peters et al., 2020; Rogers, 2021), we identified several characteristics that were predictive of lower compliance. Our finding that students had lower compliance than non-students is contrary to Porras-Segovia and colleagues (2020), who reported higher compliance among student controls than psychiatric patients. However, most of our student participants also had current psychiatric diagnoses, therefore hindering direct comparisons with the previous study. Further, we also found lower compliance among those with an anxiety disorder, as well as those scoring higher on trait anger. Lower compliance among patients with anxiety disorders may be explained by anxious individuals' propensity to experiential avoidance (i.e., avoidance of distressing emotional experiences) (Hayes-Skelton & Eustis, 2020), which may have reduced their willingness to attend to their internal states as prompted by the EMA. Meanwhile, trait anger is correlated with both low agreeableness and low conscientiousness (Pease & Lewis, 2015), which can logically be expected to also extend to lower study compliance.

It is more difficult to infer how our study design may have impacted compliance. At 21 days, our assessment period was fairly long (average study duration in previous studies *Med* = 14), while the number of assessments per day (4) was slightly below average (*Med* = 5) (Kivelä et al., 2022). However, with up to 40 questions per EMA prompt our protocol was fairly intensive. Most previous studies achieving comparable compliance rates (> 70%) employed shorter assessment periods (<= 2 weeks) (Husky et al., 2017; Littlewood et al., 2019; Nock et al., 2009; Oquendo et al., 2020; Spangenberg et al., 2019) or only collected EMA once per day (Coppersmith et al., 2019; Czyz et al., 2020). However, Victor and colleagues (2019) reached similar compliance in an EMA study of young women with a history of self-injurious thoughts, which employed seven daily prompts over 21 days. Finally, unlike many other studies Kleiman et al., 2017; Littlewood et al., 2019; Rizk et al., 2019) that allowed participants to adjust the EMA prompt windows to their daily schedules (e.g., wake up and bedtimes), we employed the same assessment schedule for all (7am – 10pm), in order to create comparable timeframes between participants that would allow us to examine time-of-day effects in future analyses. However, in order to provide the participants with some additional flexibility in terms of their response times, we allowed for a time window of three hours in the mornings, and two hours during the daytime and evenings, for the participants to complete the EMA following the initial alert. Regardless, this may have led to the lower compliance we observed to morning assessments (with non-morning types being more likely to miss early alerts), although it has also previously been reported that adherence to morning surveys tends to be lower than that to daytime assessments (Jacobucci et al., 2023; Torous et al., 2015). We also experienced decreasing compliance over time, with compliance rates declining from 91% to 68% between the first and last day of the assessment period, indicating some fatigue effects. Decreasing compliance with increasing study duration is a consistent finding in the literature (Czyz et al., 2018; Forkmann et al., 2018; Glenn et al., 2020), with a distinctive drop after three weeks (Jacobucci et al., 2023). For example, in a study by Czyz and colleagues (2018), compliance decreased from 80% on week 1 to 60% on week 4, and in a study by Glenn and colleagues (2022) from 87% on week 1 to 45% on week 4. Notably, both previous studies used adolescent samples.

Of note is also that we experienced some technical issues with the EMA app several times over the 26-months of data collection, but unfortunately were unable to account for the exact amount of missing data that was due to technical issues (rather than non-compliance). However, 20% of participants reported having been impacted by technical issues; some also reported that frustration with the technical issues reduced their engagement with the study and therefore lead to additional missed entries.

Reactivity Importantly, no suicide attempts or deaths occurred during the EMA period. Examination of changes in participants' EMA-reported positive and negative affect and suicidal ideation over the study period indicated no (negative or positive) affect reactivity. This is in line with prior studies showing no increases in negative affect, suicidal ideation or other suicide outcomes in response to EMA measures (Coppersmith et al., 2022; Husky et al., 2014; Law et al., 2015). While these prior studies showed no reactivity in active suicidal ideation (thoughts about, and desire and intent for suicide) we also considered more passive aspects of ideation (will to live, desire to die), which neither exhibited reactive effects. However, 22% of participants retrospectively indicated having experienced mood worsening during the study period, with 18% of participants having experienced the EMA as triggering their suicidal ideation and 10% as worsening their ideation. These numbers seem to largely align with previous studies: 16% of depressed inpatients reported having experienced EMA as stressful and/or burdensome (Forkmann et al., 2018), and 9% of a community-based sample with current suicidal ideation stated the assessments to have been "occasionally 'distressing', 'emotionally taxing' and 'triggering bad thoughts'" (Rogers, 2021). When examining the characteristics of those who were more likely to report iatrogenic effects, we found increased symptom severity (depression, anxiety and suicidal ideation), as well as comorbid PTSD and BPD traits, to distinguish those who were more likely to report reactivity. Individuals experiencing more severe current symptoms may find the study proceedings as more taxing or more confrontational, due to the higher number of negative emotional experiences they would be forced to face. Individuals with BPD traits specifically (Sansone & Sansone, 2010; Sauer et al., 2014), as well as those with PTSD (Badour & Feldner, 2013; Sauer et al., 2014), are also more likely to experience problems with emotion regulation, including emotional (hyper)reactivity. Further, this emotional (hyper)reactivity does not only concern negative, but may even result from neutral environmental stimuli (Sansone & Sansone, 2010). Individuals higher in BPD traits are also less likely to engage in emotional acceptance (Chapman et al., 2013), and may hence experience their emotions as more distressing. Meanwhile, an EMA study showed avoidance to be the most frequently used emotion regulation strategy by patients with PTSD, and that maladaptive emotion regulation prospectively predicted increases in PTSD symptoms (Short et al., 2018). Consequently, patients with PTSD may be more distressed by facing their (negative) emotions.

It should also be noted that the participants' self-report with regard to these iatrogenic effects was completed, on average, one to two weeks after the end of the EMA period and concerned the assessment period as a whole, and we did not include questions as part of the EMA itself to inquire whether participants felt iatrogenic effects *in the moment*. As such, it is impossible to assess if participants experienced this subjective reactivity in *real time*, and these reports may further be influenced by retrospective memory biases. For example, an EMA study on PTSD symptoms concluded that retrospective symptom reports post-EMA more closely corresponded to worst-point EMA scores, rather than average ratings throughout the EMA period (Schuler et al., 2021). Patients with depression are also known to exhibit negative memory biases, with the strength of such biases being associated with symptom severity (Duyser et al., 2020).

Individuals with borderline personality traits also have a tendency to recall negative experiences in a manner where the reported severity of the experience increases over time (Maraz et al., 2022). We also did not ask whether participants experienced *decreased* suicidal ideation after filling in EMA, so our questionnaire was biased towards participants reporting more negative rather than positive reactive effects. Further, all participants who filled in the feedback survey (including those reporting iatrogenic effects) continued into the second phase of the study. As part of their safety plan, participants were also urged to immediately contact the study personnel in case they felt that the study proceedings were negatively affecting their mood and/or functioning; none of the participants made contact for this reason. Hence, in concordance with our findings of no systematic reactivity in the participants' EMA scores, it appears that for those reporting iatrogenic effects the negative reactivity was unlikely to have been systematic, or substantially distressing. In line with participant reports that they experienced the EMA as increasing their awareness of their emotions and daily experiences (e.g., *"I --- was more aware of how bad things were and therefore tried to get into a healthier pattern."*), it may be that, for better or worse, this increased attention and awareness may also have led to increased focus on negative emotions. Hence, the EMA may have forced some participants to confront emotions they were trying to ignore or suppress, resulting in temporary mood and/or suicidal ideation worsening after filling in the assessments. Alternatively, these reports may simply reflect participants' increased attention to their thoughts and emotions that were already there (including suicidal ideation), rather than actual increases in the intensity of said experiences. As EMA has been shown to increase emotional self-awareness (Kauer et al., 2012), this awareness might be perceived as the triggering or worsening of suicidal ideation by EMA. Correspondingly, prior research has demonstrated that neither suicidal ideation (Coppersmith et al., 2019; Husky et al., 2014) nor suicidal behavior (Law et al., 2015) increase in response to EMA. Other participants also reported that having to fill in certain responses, such as repeatedly reporting that they were alone when filling in the EMA, sometimes made them feel sad, illustrating how even innocuous questions may sometimes be triggering. A further point of consideration that has recently been brought forward as explaining effects that may appear iatrogenic concerns the emotion regulation function of suicidal thinking (Coppersmith et al., 2023; Kleiman et al., 2018). This emotion regulation function may explain why certain participants (i.e., those using suicidal thinking as a form of maladaptive coping) may experience increases in suicidal thinking over time. This is based on findings that those who report engaging in suicidal thinking as a form of emotion regulation are more likely to report more frequent and severe suicidal thoughts (Coppersmith et al., 2023).

Finally, we observed a decrease in overall suicidal ideation severity from baseline to post-EMA (on the BSSI). This finding is contrary to our findings of no systematic change in the participants EMA-rated suicidal ideation. To the best of our knowledge, no previous EMA study has reported decreases in suicidal ideation following study participation. However, studies employing other cross-sectional and longitudinal designs have shown that participating in suicide research may serve to lessen suicidal ideation (Schatten et al., 2022; Smith et al., 2010). However, our finding of reduced suicidal ideation on the BSSI is likely to also be influenced by the lower compliance to the post-test questionnaire (71%), with those in a better mental state perhaps being more willing to fill in the additional assessment. An alternative explanation concerns potential intervention effects resulting from the feedback reports presented to the participants after their EMA period (and prior to filling in the post-EMA questionnaire, which included feedback about the study). It is possible that, rather than the EMA procedure itself, the insights resulting from the feedback report and related discussions with the research personnel may have led to symptom relief. Unfortunately, we did not formally evaluate the participants' reactions to the feedback reports, as the study was designed as an observational rather than an intervention study, and the feedback reports were merely intended as additional incentives for participants, and neither the EMA assessments nor the feedback reports were expected to lead to treatment effects. However, with 22% of participants reporting *improved* mood in response to the EMA, it is clear that reactive effects may also appear in a positive direction.

Strengths of our study include a diverse high-risk sample, as we employed minimal exclusion criteria related to comorbidities, medication use etc. As such our findings have greater generalizability to the heterogeneous group of patients experiencing suicidal ideation. Further, as we achieved higher retention and compliance rates than expected, we had excellent power for our analyses. Finally, we paid special attention not only to objective iatrogenic effects, but also participants' subjective experiences in undergoing intensive longitudinal assessments on suicidal ideation.

Limitations of the present study include the relatively small sample; although our sample size is somewhat higher than the average in past studies (*Med* = 52) (Kivelä et al., 2022), larger-scale studies are needed to replicate these early findings. Further, although we achieved excellent compliance with the EMA, compliance with other study proceedings (such as the baseline and post-test questionnaires) was lower. Hence, the subsample of participants who reported on their experience with the EMA may not be representative of the full sample, and most importantly may neglect to take into account those who experienced more substantive negative effects. Finally, the exclusion of participants with current bipolar, psychotic, or severe substance abuse disorders limits the generalizability of our results when considering patients with the aforementioned comorbidities.

In conclusion, high feasibility numbers should not blind researchers to the fact that a distinctive minority may report negative reactivity in response to repeated daily assessments of suicidal ideation. These retrospective reports did not, however, correspond with systematic reactive changes in momentary mood and/or suicidal ideation during the EMA. Regardless, increased attention in future research should be paid to identifying subgroups of patients who may be more likely to report negative effects. Based on our findings, this may include those with higher baseline symptom severity (depression, anxiety, suicidal ideation) as well as comorbidity with either PTSD or BPD traits. Participants in similar studies should be transparently informed that they may experience mood effects – whether those be positive or negative.

References

Badour, C. L., & Feldner, M. T. (2013). Trauma-related reactivity and regulation of emotion: Associations with posttraumatic stress symptoms. *Journal of Behavior Therapy and Experimental Psychiatry*, *44*(1), 69–76. https://doi.org/10.1016/j.jbtep.2012.07.007

Bastien, C. (2001). Validation of the Insomnia Severity Index as an outcome measure for insomnia research. *Sleep Medicine*, *2*(4), 297–307. https://doi.org/10.1016/S1389-9457(00)00065-4

Beck, A. T. (1961). An inventory for measuring depression. *Archives of General Psychiatry*, *4*(6), 561–571. https://doi.org/10.1001/archpsyc.1961.01710120031004

Beck, A. T., Kovacs, M., & Weissman, A. (1979). Assessment of suicidal intention: The Scale for Suicide Ideation. *Journal of Consulting and Clinical Psychology*, *47*(2), 343-352.

Bender, T. W., Fitzpatrick, S., Hartmann, M.-A., Hames, J., Bodell, L., Selby, E. A., & Joiner, T. E. (2019). Does it hurt to ask? An analysis of iatrogenic risk during suicide risk assessment. *Neurology, Psychiatry and Brain Research*, *33*, 73–81. https://doi.org/10.1016/j.npbr.2019.07.005

Bentley, K. H., Maimone, J. S., Kilbury, E. N., Tate, M. S., Wisniewski, H., Levine, M. T., Roberg, R., Torous, J. B., Nock, M. K., & Kleiman, E. M. (2021). Practices for monitoring and responding to incoming data on self-injurious thoughts and behaviors in intensive longitudinal studies: A systematic review. *Clinical Psychology Review*, *90*, 102098. https://doi.org/10.1016/j.cpr.2021.102098

Bos, F. M. (2021). *Ecological momentary assessment as a clinical tool in psychiatry: Promises, pitfalls, and possibilities.* University of Groningen.

Chapman, A. L., Dixon-Gordon, K. L., & Walters, K. N. (2013). Borderline personality features moderate emotion reactivity and emotion regulation in response to a fear stressor. *Journal of Experimental Psychopathology*, *4*(5), 451–470. https://doi.org/10.5127/jep.031612

Coppersmith, D. D. L., Fortgang, R. G., Kleiman, E. M., Millner, A. J., Yeager, A. L., Mair, P., & Nock, M. K. (2022). Effect of frequent assessment of suicidal thinking on its incidence and severity: High-resolution real-time monitoring study. *British Journal of Psychiatry*, *220*(1), 41–43. https://doi.org/10.1192/bjp.2021.97

Coppersmith, D. D. L., Kleiman, E. M., Glenn, C. R., Millner, A. J., & Nock, M. K. (2019). The dynamics of social support among suicide attempters: A smartphone-based daily diary study. *Behaviour Research and Therapy*, *120*. https://doi.org/10.1016/j.brat.2018.11.016

Coppersmith, D. D. L., Millgram, Y., Kleiman, E. M., Fortgang, R. G., Millner, A. J., Frumkin, M. R., Bentley, K. H., & Nock, M. K. (2023). Suicidal thinking as affect regulation. *Journal of Psychopathology and Clinical Science*, *132*(4), 385–395. https://doi.org/10.1037/abn0000828

Czyz, E. K., King, C. A., & Nahum-Shani, I. (2018). Ecological assessment of daily suicidal thoughts and attempts among suicidal teens after psychiatric hospitalization: Lessons about feasibility and acceptability. *Psychiatry Research*, *267*, 566–574. https://doi.org/10.1016/j.psychres.2018.06.031

Czyz, E. K., Yap, J. R. T., King, C. A., & Nahum-Shani, I. (2020). Using intensive longitudinal data to identify early predictors of suicide-related outcomes in high-risk adolescents: Practical and conceptual considerations. *Assessment*, *28*(8), 1949-1959. https://doi.org/10.1177/1073191120939168

Davidson, C. L., Anestis, M. D., & Gutierrez, P. M. (2017). Ecological momentary assessment is a neglected methodology in suicidology. *Archives of Suicide Research*, *21*(1), 1–11. https://doi.org/10.1080/13811118.2015.1004482

DeCou, C. R., & Schumann, M. E. (2018). On the iatrogenic risk of assessing suicidality: A meta-analysis. *Suicide and Life-Threatening Behavior*, *48*(5), 531–543. https://doi.org/10.1111/sltb.12368

Duyser, F. A., van Eijndhoven, P. F. P., Bergman, M. A., Collard, R. M., Schene, A. H., Tendolkar, I., & Vrijsen, J. N. (2020). Negative memory bias as a transdiagnostic cognitive marker for depression symptom severity. *Journal of Affective Disorders*, *274*, 1165–1172. https://doi.org/10.1016/j.jad.2020.05.156

Endicott, J., Nee, J., Harrison, W., & Blumenthal, R. (1993). Quality of Life Enjoyment and Satisfaction Questionnaire: A new measure. *Psychopharmacology Bulletin*, *29*(2), 321–326.

First, M. B. (2015). *Structured Clinical Interview for the DSM (SCID).* John Wiley & Sons. https://doi.org/10.1002/9781118625392.wbecp351

Folkersma, W., Veerman, V., Ornée, D. A., Oldehinkel, A. J., Alma, M. A., & Bastiaansen, J. A. (2021). Patients' experience of an ecological momentary intervention involving self-monitoring and personalized feedback for depression. *Internet Interventions*, *26,* 100436. https://doi.org/10.1016/j.invent.2021.100436

Forkmann, T., Spangenberg, L., Rath, D., Hallensleben, N., Hegerl, U., Kersting, A., & Glaesmer, H. (2018). Assessing suicidality in real time: A psychometric evaluation of self-report items for the assessment of suicidal ideation and its proximal risk factors using ecological momentary assessments. *Journal of Abnormal Psychology*, *127*(8), 758–769. https://doi.org/10.1037/abn0000381.supp

Gee, B. L., Han, J., Benassi, H., & Batterham, P. J. (2020). Suicidal thoughts, suicidal behaviours and self-harm in daily life: A systematic review of ecological momentary assessment studies. *Digital Health, 6*, 205520762096395. https://doi.org/10.1177/2055207620963958

Glenn, C. R., Kleiman, E. M., Kearns, J. C., Santee, A. C., Esposito, E. C., Conwell, Y., & Alpert-Gillis, L. J. (2020). Feasibility and acceptability of ecological momentary assessment with high-risk suicidal adolescents following acute psychiatric care. *Journal of Clinical Child and Adolescent Psychology, 51*(1), 32-48. https://doi.org/10.1080/15374416.2020.1741377

Gould, M. S., Marrocco, F. A., Kleinman, M., Thomas, J. G., Mostkoff, K., Cote, J., & Davies, M. (2005). Evaluating iatrogenic risk of youth suicide screening programs. *JAMA*, *293*(13), 1635. https://doi.org/10.1001/jama.293.13.1635

Hallard, R. I., Wells, A., Aadahl, V., Emsley, R., & Pratt, D. (2021). Metacognition, rumination and suicidal ideation: An experience sampling test of the self-regulatory executive function model. *Psychiatry Research*, *303*, 114083. https://doi.org/10.1016/j.psychres.2021.114083

Hayes-Skelton, S. A., & Eustis, E. H. (2020). Experiential avoidance. *Clinical handbook of fear and anxiety: Maintenance processes and treatment mechanisms.* (p. 115–131). American Psychological Association. https://doi.org/10.1037/0000150-007

Hom, M. A., Stanley, I. H., Rogers, M. L., Gallyer, A. J., Dougherty, S. P., Davis, L., & Joiner, T. E. (2018). Investigating the iatrogenic effects of repeated suicidal ideation screening on suicidal and depression symptoms: A staggered sequential study. *Journal of Affective Disorders*, *232*, 139–142. https://doi.org/10.1016/j.jad.2018.02.022

Husky, M., Olié, E., Guillaume, S., Genty, C., Swendsen, J., & Courtet, P. (2014). Feasibility and validity of ecological momentary assessment in the investigation of suicide risk. *Psychiatry Research*, *220*(1–2), 564–570. https://doi.org/10.1016/j.psychres.2014.08.019

Husky, M., Swendsen, J., Ionita, A., Jaussent, I., Genty, C., & Courtet, P. (2017). Predictors of daily life suicidal ideation in adults recently discharged after a serious suicide attempt: A pilot study. *Psychiatry Research*, *256*, 79–84. https://doi.org/10.1016/j.psychres.2017.06.035

Jacobucci, R., Ammerman, B. A., & McClure, K. (2023, June 5). Examining missingness at the momentary level in clinical research using ecological momentary assessment: Implications for suicide research. https://doi.org/10.31234/osf.io/7yfhp

Johnson, E. I., Grondin, O., Barrault, M., Faytout, M., Helbig, S., Husky, M., Granholm, E. L., Loh, C., Nadeau, L., Wittchen, H. U., & Swendsen, J. (2009). Computerized ambulatory monitoring in psychiatry: A multi-site collaborative study of acceptability, compliance, and reactivity. *International Journal of Methods in Psychiatric Research*, *18*(1), 48–57. https://doi.org/10.1002/mpr.276

Kauer, S., Reid, S., Crooke, A., Khor, A., Hearps, S., Jorm, A., Sanci, L., Patton, G. (2012). Self-monitoring using mobile phones in the early stages of adolescent depression: Randomized controlled trial. *Journal of Medical Internet Research, 14*(3), e67.

Kivelä, L., van der Does, W. A. J., Riese, H., & Antypa, N. (2022). Don't miss the moment: A systematic review of ecological momentary assessment in suicide research. *Frontiers in Digital Health*, *4,* 876595. https://doi.org/10.3389/fdgth.2022.876595

Kleiman, E. M., Coppersmith, D. D. L., Millner, A. J., Franz, P. J., Fox, K. R., & Nock, M. K. (2018). Are suicidal thoughts reinforcing? A preliminary real-time monitoring study on the potential affect regulation function of suicidal thinking. *Journal of Affective Disorders*, *232*, 122–126. https://doi.org/10.1016/j.jad.2018.02.033

Kleiman, E. M., Turner, B. J., Fedor, S., Baele, E. E., Huffman, J. C., & Nock, M. K. (2017). Examination of real-time fluctuations in suicidal ideation and its risk factors: Results from two ecological momentary assessment studies. *Journal of Abnormal Psychology*, *126*(6), 726–738. https://doi.org/10.1037/abn0000273.supp

Lakeman, R., & FitzGerald, M. (2009). The ethics of suicide research. *Crisis*, *30*(1), 13–19. https://doi.org/10.1027/0227-5910.30.1.13

Law, M. K., Furr, R. M., Arnold, E. M., Mneimne, M., Jaquett, C., & Fleeson, W. (2015). Does assessing suicidality frequently and repeatedly cause harm? A randomized control study. *Psychological Assessment*, *27*(4), 1171-1181. https://doi.org/10.1037/pas0000118

Littlewood, D. L., Kyle, S. D., Carter, L. A., Peters, S., Pratt, D., & Gooding, P. (2019). Short sleep duration and poor sleep quality predict next-day suicidal ideation: An ecological momentary assessment study. *Psychological Medicine*, *49*(3), 403–411. https://doi.org/10.1017/S0033291718001009

Maraz, A., Nagy, T., & Ziegler, M. (2022). Negativity in delayed affective recall is related to the borderline personality trait. *Scientific Reports*, *12*(1), 3505. https://doi.org/10.1038/s41598-022-07358-2

Morey, L. (1991). *Personality Assessment Inventory: Professional manual*. Psychological Assessment Resources.

Myin-Germeys, I., Kasanova, Z., Vaessen, T., Vachon, H., Kirtley, O., Viechtbauer, W., & Reininghaus, U. (2018). Experience sampling methodology in mental health research: new insights and technical developments. *World Psychiatry*, *17*(2), 123-132. https://doi.org/10.1002/wps.20513

Nock, M. K., Pristein, M. J., & Sterba, S. K. (2009). Revealing the form and function of self-injurious thoughts and behaviors: A real-time ecological assessment study among adolescents and young adults. *Journal of Abnormal Psychology*, *118*(4), 816–827.

Oakey-Frost, N., Moscardini, E., Cowan, T., Cohen, A., & Tucker, R. (2023). The temporal dynamics of wish to live, wish to die, and their short-term prospective relationships with suicidal desire. *Behavior Therapy, 54*(3), 584-594.

Oquendo, M. A., Galfalvy, H. C., Choo, T. H., Kandlur, R., Burke, A. K., Sublette, M. E., Miller, J. M., Mann, J. J., & Stanley, B. H. (2020). Highly variable suicidal ideation: A phenotypic marker for stress induced suicide risk. *Molecular Psychiatry, 26*, 5079-5086. https://doi.org/10.1038/s41380-020-0819-0

Ottenstein, C., & Werner, L. (2021). Compliance in ambulatory assessment studies: Investigating study and sample characteristics as predictors. *Assessment, 29*(8), 1765-1776. https://doi.org/10.1177/10731911211032718

Pease, C. R., & Lewis, G. J. (2015). Personality links to anger: Evidence for trait interaction and differentiation across expression style. *Personality and Individual Differences*, *74*, 159–164. https://doi.org/10.1016/j.paid.2014.10.018

Peters, E. M., Dong, L. Y., Thomas, T., Khalaj, S., Balbuena, L., Baetz, M., Osgood, N., & Bowen, R. (2020). Instability of suicidal ideation in patients hospitalized for depression: An exploratory study using smartphone ecological momentary assessment. *Archives of Suicide Research*, *26*(1), 56-69. https://doi.org/10.1080/13811118.2020.1783410

Porras-Segovia, A., Molina-Madueño, R. M., Berrouiguet, S., López-Castroman, J., Barrigón, M. L., Pérez-Rodríguez, M. S., Marco, J. H., Díaz-Oliván, I., de León, S., Courtet, P., Artés-Rodríguez, A., & Baca-García, E. (2020). Smartphone-based ecological momentary assessment (EMA) in psychiatric patients and student controls: A real-world feasibility study. *Journal of Affective Disorders*, *274*, 733–741. https://doi.org/10.1016/j.jad.2020.05.067

Posner, K., Brown, G. K., Stanley, B., Brent, D. A., Yershova, K. v., Oquendo, M. A., Currier, G. W., Melvin, G. A., Greenhill, L., Shen, S., & Mann, J. J. (2011). The Columbia–Suicide Severity Rating Scale: Initial validity and internal consistency findings from three multisite studies with adolescents and adults. *American Journal of Psychiatry*, *168*(12), 1266-1277. https://doi.org/10.1176/appi.ajp.2011.10111704

Rizk, M. M., Choo, T. H., Galfalvy, H., Biggs, E., Brodsky, B. S., Oquendo, M. A., Mann, J. J., & Stanley, B. (2019). Variability in suicidal ideation is associated with affective instability in suicide attempters with borderline personality disorder. *Psychiatry*, *82*, 173–178.

Rogers, M. L. (2021). Feasibility and acceptability of ecological momentary assessment in a fully online study of community-based adults at high risk for suicide. *Psychological Assessment, 33*(12), 1215–1225. https://doi.org/10.1037/pas0001054

Sansone, R. A., & Sansone, L. A. (2010). Emotional hyper-reactivity in borderline personality disorder. *Psychiatry*, *7*(9), 16–20.

Sauer, C., Arens, E. A., Stopsack, M., Spitzer, C., & Barnow, S. (2014). Emotional hyper-reactivity in borderline personality disorder is related to trauma and interpersonal themes. *Psychiatry Research*, *220*(1–2), 468–476. https://doi.org/10.1016/j.psychres.2014.06.041

Schatten, H. T., Allen, K. J. D., Carl, E. C., Miller, I. W., & Armey, M. F. (2022). Evaluating potential iatrogenic effects of a suicide-focused research protocol. *Crisis*, *43*(6), 508–515. https://doi.org/10.1027/0227-5910/a000823

Schuler, K., Ruggero, C. J., Mahaffey, B., Gonzalez, A., L. Callahan, J., Boals, A., Waszczuk, M. A., Luft, B. J., & Kotov, R. (2021). When hindsight is not 20/20: Ecological momentary assessment of PTSD symptoms versus retrospective report. *Assessment*, *28*(1), 238–247. https://doi.org/10.1177/1073191119869826

Sedano-Capdevila, A., Porras-Segovia, A., Bello, H. J., Baca-García, E., & Barrigon, M. L. (2021). Use of ecological momentary assessment to study suicidal thoughts and behavior: A systematic review. *Current Psychiatry Reports*, *23*(7), 41. https://doi.org/10.1007/s11920-021-01255-7

Sheehan, D. V, Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T., Baker, R., & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *The Journal of Clinical Psychiatry*, *59 Suppl 20*, 22-57.

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology*, *4*, 1–32. https://doi.org/10.1146/annurev.clinpsy.3.022806.091415

Short, N. A., Boffa, J. W., Clancy, K., & Schmidt, N. B. (2018). Effects of emotion regulation strategy use in response to stressors on PTSD symptoms: An ecological momentary assessment study. *Journal of Affective Disorders*, *230*, 77–83. https://doi.org/10.1016/j.jad.2017.12.063

Smith, P., Poindexter, E., & Cukrowicz, K. (2010). The effect of participating in suicide research: Does participating in a research protocol on suicide and psychiatric symptoms increase suicide ideation and attempts? *Suicide and Life-Threatening Behavior*, *40*(6), 535–543. https://doi.org/10.1521/suli.2010.40.6.535

Solis, E., Antypa, N., Conijn, J. M., Kelderman, H., & Van der Does, W. (2017). Psychometric properties of the Leiden Index of Depression Sensitivity (LEIDS). *Psychological Assessment*, *29*(2), 158–171. https://doi.org/10.1037/pas0000326

Spangenberg, L., Glaesmer, H., Hallensleben, N., Rath, D., & Forkmann, T. (2019). (In)stability of capability for suicide in psychiatric inpatients: Longitudinal assessment using ecological momentary assessments. *Suicide and Life-Threatening Behavior*, *49*(6), 1560–1572. https://doi.org/10.1111/sltb.12547

Torous, J., Staples, P., Shanahan, M., Lin, C., Peck, P., Keshavan, M., & Onnela, J.-P. (2015). Utilizing a personal smartphone custom app to assess the Patient Health Questionnaire-9 (PHQ-9) depressive symptoms in patients with major depressive disorder. *JMIR Mental Health*, *2*(1), e8. https://doi.org/10.2196/mental.3889

Victor, S. E., Scott, L. N., Stepp, S. D., & Goldstein, T. R. (2019). I want you to want me: Interpersonal stress and affective experiences as within-person predictors of nonsuicidal self-injury and auicide urges in daily life. *Suicide and Life-Threatening Behavior*, *49*(4), 1157–1177. https://doi.org/10.1111/sltb.12513

Zigmond, A. S., & Snaith, R. P. (1983). The Hospital Anxiety and Depression Scale. *Acta Psychiatrica Scandinavica*, *67*(6), 361–370. https://doi.org/10.1111/j.1600-0447.1983.tb09716.x

Appendix

1. Daily Ecological Momentary Assessment (EMA) Questions (21-Day Assessment)

SLEEP*

Good morning!

1. How did you sleep last night? From 0 (very poorly) to 10 (very well).
2. What time did you go to bed? ____
3. What time did you try to get to sleep? ____
4. How long did it take you to fall asleep? ____
5. Did you wake up during the night? (if YES, go to A; if NO, go to 6)
    a. How long were you awake (in minutes)? ____
6. Did you have any nightmares? ____
7. What time did you wake up for the day? ____
8. What time did you get out of bed? ____Did you take any naps today? (if YES, go to A; if NO, go to ADDITIONAL SLEEP COMMENTS)**
    a. How many minutes in total did you spend napping? ______

ADDITIONAL SLEEP COMMENTS

9. Do you want to add any other comments/notes about your sleep? ______

***Only assessed at the first EMA beep of the day.**

****Only assessed at the last EMA beep of the day.**

CONTEXTUAL FACTORS

1. Where are you right now? (Select: at home; work; other:____)
2. What are you doing right now? ____
3. Currently I am... (Select: alone, with others)
    a. If "with others", Select: friends; family; other:____

IMPACTFUL EVENTS

1. Have you experienced any events*** that had an impact on you since the last questionnaire? (if YES, go to A; if NO, go to MOOD)
    a. Please indicate the type of event that had the most impact: (Select: had a disagreement with someone; been rejected by someone; been complimented or praised by someone; been

disappointed by someone; felt neglected by someone; experienced a loss of some sort; received good news; received bad news; been reminded of something painful from the past; been reminded of something pleasant from the past; other: something negative_____; other: something positive_____)

b. How stressful was the (most stressful) event? From 0 (not stressful at all) to 10 (very stressful).

*****These events may be either negative *or* positive.**

MOOD

1. At the moment, how *happy* do you feel? From 0 (not at all) to 10 (very much) (Positive mood)
2. At the moment, how *calm* do you feel? From 0 (not at all) to 10 (very much) (Positive mood)
3. At the moment, how *sad* do you feel? From 0 (not at all) to 10 (very much) (Negative mood)
4. At the moment, how *anxious* do you feel? From 0 (not at all) to 10 (very much) (Negative mood)
5. At the moment, how *angry* do you feel? From 0 (not at all) to 10 (very much) (Negative mood)
6. At the moment, how *guilty* do you feel? From 0 (not at all) to 10 (very much) (Negative mood)
7. At the moment, how *ashamed* do you feel? From 0 (not at all) to 10 (very much) (Negative mood)

COGNITIONS

1. At the moment, how *hopeless* do you feel? From 0 (not at all) to 10 (very much).
2. At the moment, how *optimistic* do you feel? From 0 (not at all) to 10 (very much).
3. At the moment, how *lonely* do you feel? From 0 (not at all) to 10 (very much).
4. At the moment, I feel like *I'm a burden to others in my life*. From 0 (not at all) to 10 (very much).

SUICIDAL IDEATION

1. At the moment, how strong is your desire to live? From 0 (none) to 10 (very strong) (Passive ideation).
2. At the moment, how strong is your desire to die, or to go to sleep and not wake up? From 0 (none) to 10 (very strong) (Passive ideation).
3. At the moment, do you actually have thoughts of killing yourself? From 0 (not at all) to 10 (very much) (Active ideation). (If ≥ 1, go to A; if = 0, go to COPING STRATEGIES)
    a. At the moment, how strong is your intention to act on these thoughts? From 0 (none) to 10 (very strong) (Active ideation).
    b. At the moment, how much can you resist the urge to kill yourself? From 0 (not at all) to 10 (very much)? (Acquired capability).
    c. At the moment, how afraid are you of dying? From 0 (not at all) to 10 (very much) (Acquired capability).
    d. At the moment, how afraid are you of the *pain* associated with dying? From 0 (not at all) to 10 (very much) (Acquired capability).

COPING STRATEGIES

1. If you have experienced negative mood/thoughts, did you do something to try to manage them? (If YES, go to A; if NO, go to SUBSTANCE USE)
    a. What did you do? (Select: keeping busy; socializing; calling/messaging a friend; calling/messaging a family member; positive thinking; doing something good for self; calming self/relaxation; finding perspective; sitting with feelings until they pass; other: _____)

SUBSTANCE USE

Since the last questionnaire have you used:

1. Medication (other than your daily prescriptions)? (If YES, go to A; if NO, go to ALCOHOL)
    a. Medication: Please specify: _____
2. Alcohol? (If YES, go to A; if NO, go to CANNABIS)
    a. How many drinks did you have?

3. Cannabis?
4. Other drugs? (If YES, go to A; if NO, go to FINAL COMMENTS)
    a. Other drugs: Please specify: _____

FINAL COMMENTS

1. Do you want to add any other comments/notes? _____

2. Experience with Ecological Momentary Assessment (EMA) Questionnaire – 21-Day Assessment

The following questions are about your experience measuring your mood / thoughts using the mobile phone (Ethica) app during the past three weeks.

1. How burdensome did you find the mobile phone assessments overall? From 0 (not at all) to 7 (very much)
2. The duration of the study (3 weeks) was... From 0 (just right) to 7 (too long)
3. The number of assessments per day (4) was... From 0 (just right) to 7 (too many)
4. The number of questions per assessment was... From 0 (just right) to 7 (too many)
5. Were there specific questions you found difficult or annoying to answer? _____
6. Were there specific questions that you hope would have been included? _____
7. How did you find the answer options / rating scales? [Selection answer option] 1 (There was always a suitable answer option available), 2 (There were not enough options / the scale was too limited), 3 (There were too many options / the scale was too broad)
8. If you missed assessments during the 3 weeks, did you miss them due to... [Selection answer option – you may choose multiple] 1 (I didn't miss any assessments), 2 (The burden of the assessments was too high), 3 (Technical problems / I didn't receive the alert), 4 (I was too busy / I didn't have time), 5 (I didn't have my mobile phone with me), 6 (Other: _____)
9. To what extent did you change your behavior / normal daily rhythms due to the assessments? From 1 (not at all) to 7 (very much)
    a. If yes, how did your behavior / daily rhythms change? _____
10. How stressful was filling in the assessments? From 1 (not at all) to 7 (very much)
    a. What part of the assessment did you find stressful? [Selection answer option] 1 (The process of filling in the assessments (i.e., time burden, missing assessments, difficulty using the app etc.)), 2 (The content of the questions (i.e., sensitive topics)), 3 (Both the process and content of the assessments.)

11. Do you think the assessments sometimes influenced your mood in a positive way (i.e., improved your mood / felt better after filling in the assessment)? From 1 (not at all) to 7 (very much)
12. Do you think the assessments sometimes influenced your mood in a negative way (i.e., worsened your mood / felt worse after filling in the assessment)? From 1 (not at all) to 7 (very much)
13. Do you think the assessments sometimes triggered suicidal thoughts (when you didn't have these thoughts prior to filling in the assessment)? From 1 (not at all) to 7 (very much)
14. Do you think the assessments sometimes worsened your suicidal thoughts (when you already had these thoughts prior to the assessment)? From 1 (not at all) to 7 (very much)
15. Would you describe your experience with using the app / filling in the assessments as ...? [Selection answer option – you may choose multiple] 1 (Fun/exciting), 2 (Relaxing), 3 (Insightful), 4 (Neutral), 5 (Depressing), 6 (Annoying), 7 (Stressful), 8 (Other: _____)
16. How would you rate your experience with the mobile phone app assessments overall? From 1 (very positive) to 7 (very negative)
17. Would you like to add any other comments? _____

CHAPTER 04:

Emotion & Cognition

Examining Contemporaneous and Temporal Associations of Real-Time Suicidal Ideation Using Network Analysis

Published as:

Kivelä, L., Fried, E., van der Does, W., & Antypa, N. (2023). Examining Contemporaneous and Temporal Associations of Real-Time Suicidal Ideation Using Network Analysis. *Psychological Medicine, 54*(12), 3357-3365. https://doi.org/10.1017/S003329172400151X

Abstract

Background: Suicidal ideation arises from a complex interplay of multiple interacting risk factors over time. Recently, ecological momentary assessment (EMA) has increased our understanding of factors associated with real-time suicidal ideation, as well as those predicting ideation at the level of hours and days. Here we used statistical network methods to investigate which cognitive-affective risk and protective factors are associated with the temporal dynamics of suicidal ideation. **Methods:** The SAFE study is a longitudinal cohort study of 82 participants with current suicidal ideation who completed 4x/day EMA over 21 days. We modelled contemporaneous (*t*) and temporal (*t + 1*) associations of three suicidal ideation components (passive ideation, active ideation, acquired capability) and their predictors (positive and negative affect, anxiety, hopelessness, loneliness, burdensomeness, optimism) using multilevel vector auto-regression models. **Results:** Contemporaneously, passive suicidal ideation was positively associated with sadness, hopelessness, loneliness, and burdensomeness, and negatively with happiness, calmness, and optimism; active suicidal ideation was positively associated with passive suicidal ideation, sadness, and shame; and acquired capability only with passive and active suicidal ideation. Acquired capability and hopelessness positively predicted passive ideation at *t +1*, which in turn predicted active ideation; acquired capability was positively predicted at *t + 1* by shame, and negatively by burdensomeness. **Conclusions:** Our findings show that systematic real-time associations exist between suicidal ideation and its predictors, and that different factors may uniquely influence distinct components of ideation. These factors may represent important targets for safety planning and risk detection.

Introduction

Suicidal ideation is influenced by multiple interacting risk and protective factors over time (de Beurs et al., 2021; Franklin et al., 2017; Goldston et al., 2016). Some risk factors, such as sociodemographic characteristics and childhood adversity, may exert their influences over one's lifetime (Nock et al., 2008), but are not useful in assessing imminent risk. The influence of other risk factors, such as stressful life events, although more temporally limited (Howarth et al., 2020), have shown poor sensitivity in identifying those most at risk. Some other factors, such as abrupt changes in sleep or affect (Allen et al., 2019), may have even more temporally specific effects, and help in identifying those with heightened imminent risk. Collectively, these latter factors are known as *acute warning signs* of suicide (Rudd et al., 2006), i.e., factors that are associated with suicide risk in the short term. The aim of the present study was to model real-time data on suicidal ideation and its warning signs in order to uncover patterns that characterize short-term changes in suicidal ideation.

Although familiar to health care professionals, acute warning signs have been given relatively little research attention (Rudd, 2008), probably because they are sometimes fleeting and therefore quite difficult to measure. However, the development of *Ecological Momentary Assessment (EMA)* (Davidson et al., 2017; Shiffman et al., 2008) and its increased application in suicide research have facilitated a stronger focus on these warning signs. EMA, which refers to real-time data collection methods in individuals' natural environments, allows for a fine-grained examination of the temporal effects of suicidal ideation, as well as its risk and protective factors (De Beurs et al., 2015; Kivelä et al., 2022; Nock, 2016). EMA data may be used to examine momentary correlates of high or low suicidal ideation, or to build prediction models that aim to forecast changes in suicidal ideation in the subsequent hours and days. Increased attention on this acute time frame is crucial, as it has previously gone largely neglected (De Beurs et al., 2015; Franklin et al., 2017; Glenn & Nock, 2014). Now, a more detailed examination of the temporal dynamics of suicidal ideation is needed, with a shift to identifying *state* rather than trait predictors of suicidal ideation.

EMA research on suicidal ideation allows researchers to focus on this clinically relevant timeframe (hours, days), and has already provided some new insights. We recently reviewed 23 studies that used EMA to assess suicidal ideation (Kivelä et al., 2022). These studies have demonstrated that many known long-term suicide risk factors are also momentary correlates of suicidal ideation. Among these are contextual factors (such as being alone) (Husky et al., 2017; Nock et al., 2009), interpersonal conflict (Kaurin et al., 2020; Nock et al., 2009), maladaptive coping and rumination (Hallard et al., 2021), increased negative affect (Armey et al., 2020; Husky et al., 2017), as well as hopelessness, burdensomeness and loneliness/thwarted belongingness (Czyz et al., 2019; Hallensleben et al., 2019; Kleiman et al., 2017). Fewer studies have examined prospective (short-term) associations with suicidal ideation. Consequently, few temporal predictors of ideation have been established. Suicidal ideation itself appears to be strongly autocorrelated within-day (Kleiman et al., 2017), but evidence for other temporal predictors is scarce, inconsistent, and requires further work. For example, hopelessness and burdensomeness (Hallensleben et al., 2019), negative affect (Armey et al., 2020; Victor et al., 2019), active coping (Stanley et al., 2021), as well as sleep duration (Littlewood et al., 2019) may be predictive of suicidal ideation in the short-term.

Further, only a limited number of EMA studies have clearly distinguished between different components of suicidal ideation. These include passive and active suicidal ideation (Wastler et al., 2023), as well as *acquired capability*, referring to increased internal preparedness for suicidal behavior, encompassing decreased fearlessness about death and increased pain tolerance (Van Orden et al., 2010). The identification of predictors of active suicidal ideation and acquired capability may be especially important, as these constructs are more closely related to the transition from ideation to action (Díaz-Oliván et al., 2021; Van Orden et al., 2010). From the few studies that have aimed to disentangle these components, differential findings have emerged. Perceived burdensomeness was found to concurrently associate with passive, but not active, suicidal ideation, while hopelessness, depressed mood and thwarted belongingness were related to both active and passive ideation (Hallensleben et al., 2019). Finally, higher daily levels of active ideation predicted higher acquired capability ratings at the end of the day (Spangenberg et al., 2019). These findings illustrate the importance of separating different components of suicidal ideation.

An emerging modeling technique, namely *network analysis*, allows for the synthesis of this information in a manner that enables researchers to model the complexity of systems with multiple outcomes and multiple interacting risk and protective factors over time (Borsboom et al., 2021; Bringmann et al., 2013; de Beurs, 2017; Fried & Cramer, 2017). As such, network modeling can address both of the current challenges in EMA suicide research: account for the complexity in both predictors and outcomes, and help explore short-term, temporal associations. Network models in time-series data can estimate potentially bidirectional associations not only between suicidal ideation and its risk factors, but between different suicidal ideation outcomes as well, in order to observe the full extent of both direct and indirect influences on suicidal ideation.

Further, in network models, risk factors such as loneliness or hopelessness reflect pieces in the greater network of the symptomatology of suicidal ideation, rather than simply being potential *causes* of suicidal ideation. In other words, suicidal ideation can both be influenced by, and further influence, these risk factors, and network modeling may be used to visualize these complex, bidirectional temporal relationships.

Network analysis is most often applied to complex time-series data, such as those collected via EMA. So far, only one study has applied network analysis to such data on suicidal ideation. Among 74 psychiatric inpatients who completed six days of EMA with 10 prompts per day, contemporaneous (i.e., concurrent) associations were found between suicidal ideation and hopelessness, thwarted belongingness, burdensomeness, positive and negative affect, and anxiety; however, only burdensomeness emerged as a significant temporal predictor of within-day suicidal ideation (Rath et al., 2019). As such, current EMA studies of real-time suicidal ideation (and network models emerging from such data) have not yet established robust short-term temporal predictors of ideation. Further, the distinction between different components of suicidal ideation, and how different risk and protective factors may differentially associate with these outcomes, have not been considered in such models.

The aim of the present study was to further investigate the temporal dynamics of different components of suicidal ideation. We applied network analysis to EMA data to examine how cognitive-affective risk and protective factors (incl. positive and negative affect, anxiety, hopelessness, loneliness, burdensomeness, optimism) are interconnected, and how they interact in the prediction of suicidal ideation (passive ideation, active ideation, and acquired capability) in the short-term. While the potential range of risk and protective factors impacting suicidal ideation is vast (de Beurs et al., 2021; Franklin et al., 2017; Goldston et al., 2016), past EMA studies have demonstrated that maladaptive cognitions (hopelessness, loneliness, burdensomeness) and affect variables specifically appear to form the most robust associations with real-time suicidal ideation (Kivelä et al., 2022). According to the Interpersonal Psychological Theory of Suicide (IPTS) (Van Orden et al., 2010), hopelessness, loneliness and burdensomeness are crucial for the development of suicidal ideation, and are also interconnected with other established risk factors (Kleiman et al., 2014). For example, a negative cognitive style (e.g., hopelessness-proneness), may be associated both with specific negative attributions ("I am alone", "I am a burden"), as well as other negative affective sequale (feelings of shame, anger, sadness etc.). Cognition and affect interact; affect can influence cognition and similarly, cognitions may trigger affective responses (Duncan & Barrett, 2007), resulting in bidirectional associations with suicidal ideation. Considering that no previous study has examined the combined real-time associations between these variables in relation to different components of suicidal ideation, we adopted an explorative framework and did not specify *a priori* predictions of differential associations with passive and active suicidal ideation, and acquired capability.

Methods

Design

Data were collected in the SAFE study, a longitudinal cohort study in individuals with current suicidal ideation, who completed 21 days of EMA 4x/day.

Ethical Approval

The study was approved by the Medical Ethics Committee – Leiden, Den Haag, Delft (The Netherlands) (METC-LDD) on 24.04.2020 (NL71510.058.19).

Participants

Participants (N = 82) for the study were adults with a history of a suicide attempt and/or active suicidal ideation in the past year (Columbia Suicide Severity Rating Scale (CSSRS) (Posner et al., 2011) score of >= 3, or >= 2 if ideation was present in the past two months). All participants endorsed past 12-month active suicidal ideation on the CSSRS, of which 26 (32%) reported that this ideation was still present within the past two months. All participants who endorsed a past 12-month suicide attempt (n = 17, 21%) also reported past 12-month active ideation. Additional inclusion criteria comprised of proficiency in written and spoken English and/or Dutch, being registered with a Dutch general practitioner (GP), and possession of an iOS or Android compatible smartphone. Exclusion criteria were a (current) diagnosis of bipolar disorder, a psychotic disorder, or severe substance dependence, or any other intellectual or physical impairment that would have prevented the participant from adequately following the study procedures. More information on study proceedings may be found in Kivelä et al. (2023).

Table 1. Ecological Momentary Assessment (EMA) Items

Parameter	Item	Scale
Suicidal ideation		
Passive ideation	At the moment, how strong is your desire to live?	0 (none) – 10 (very strong)*
	At the moment, how strong is your desire to die, or go to sleep and not wake up?	0 (none) – 10 (very strong)
Active ideation	At the moment, do you actually have thoughts of killing yourself?	0 (not at all) – 10 (very much)
	At the moment, how strong is your intention to act on these thoughts?	0 (none) – 10 (very strong)
Acquired capability	At the moment, how much can you resist the urge to kill yourself?	0 (not at all) – 10 (very much)*
	At the moment, how afraid are you of dying?	0 (not at all) – 10 (very much)*
	At the moment, how afraid are you of the pain associated with dying?	0 (not at all) – 10 (very much)*
Happy	At the moment, how happy do you feel?	0 (not at all) – 10 (very much)
Calm	At the moment, how calm do you feel?	0 (not at all) – 10 (very much)
Sad	At the moment, how sad do you feel?	0 (not at all) – 10 (very much)
Anxious	At the moment, how anxious do you feel?	0 (not at all) – 10 (very much)
Angry	At the moment, how angry do you feel?	0 (not at all) – 10 (very much)
Guilty	At the moment, how guilty do you feel?	0 (not at all) – 10 (very much)
Ashamed	At the moment, how ashamed do you feel?	0 (not at all) – 10 (very much)
Hopeless	At the moment, how hopeless do you feel?	0 (not at all) – 10 (very much)
Optimistic	At the moment, how optimistic do you feel?	0 (not at all) – 10 (very much)
Lonely	At the moment, how lonely do you feel?	0 (not at all) – 10 (very much)
Burdensome	At the moment, I feel like I'm a burden to others in my life.	0 (not at all) – 10 (very much)

Note: * positively worded items were reverse coded so that higher scores on all items reflect more severe suicidal ideation

Measures and Procedure

Participants were recruited through fliers distributed in the community (incl. social media), as well as collaborating mental health care providers in the area. Fliers included a QR code directing participants to the study website, where they could access full study information, and fill in a "self-test" to check their eligibility for the study. Interested participants could then fill in a contact form to be invited for an intake interview either on location (Leiden) or online. A total of 209 participants signed up for the study and were invited for the intake interview, of which 90 attended the interview.

During the intake, participants received information about the study and their role as a participant, and after signing written informed consent, completed a semi-structured interview covering information on their sociodemographic characteristics, and medical and psychiatric history. The MINI Neuropsychiatric Interview (v. 5) (Sheehan et al., 1998) and the Structured Clinical Interview for DSM-5 Personality Disorders subscale for Borderline Personality Disorder (SCID-PD-BPD) were used to establish current diagnoses, and an adapted version of the CSSRS (Posner et al., 2011) was used to assess the participants' past-year history of suicidal ideation, as well as their lifetime history of suicide attempts. Following the interview, eight participants were excluded ($n = 2$ because they declined to participate, and $n = 6$ on the basis of inclusion/exclusion criteria, see Kivelä et al., 2023 for more information on participant flow). Following eligibility assessment, and prior to receiving instructions for the EMA, a personalized suicide safety plan was drafted for each participant detailing their resources in the case of a suicidal crisis. Finally, participants were instructed on how to download the EMA app (created by Ethicadata.com), and the use of the app was illustrated by means of a demo questionnaire and written instructions provided to the participants.

During 21 days, participants received four daily (scheduled) EMA prompts on a signal-contingent, pseudo-random schedule. Prompts were sent out at randomized times within the windows of 7am-9am, 12pm-2pm, 4pm-6pm and 8pm-10pm. Following the alert, participants had 180 minutes to fill in the morning assessment, and 120 minutes to fill in the afternoon and evening assessments. Reminder alerts were sent out 30 minutes after the initial alert in case the EMA had not yet been completed. Additionally, participants could self-initiate (additional) entries at any time during the EMA period. The EMA items are presented in Table 1. Passive suicidal ideation was defined as the mean of two items, active suicidal ideation as the mean of two items, and acquired capability as the mean of three items.

Statistical Analysis

All analyses were conducted in R (version 4.0.2) using the *mlVAR* package (Epskamp et al., 2021) for fitting multilevel vector autoregression models. Assumptions for *mlVAR* models include equidistant observations, stationarity, and multivariate normality (Bringmann et al., 2013). In order to establish equidistant observations, we only estimated associations between successive observations within the same day (i.e., excluding associations between the last observation of day d and the first observation of the subsequent day $d + 1$, which would include a longer time lag than the other observations which were approximately equally spaced within the day). We examined stationarity, i.e.

the assumption that the means of all variables for all participants remain stable over time, using the Kwiatkowski-Phillips-Schmidt-Shin unit root test (KPSS) (Kwiatkowski et al., 1992); the test indicated that the assumption was met for
most variables, for most participants[1]. Detrending was applied to transform each variable time series for each participant in which the assumption was violated, whereby the non-stationary time series were replaced with the participant's within-person mean (as previously done by e.g., Jongeneel et al., 2020). The Kolmogorov-Smirnov test was used to assess multivariate normality; all variables violated ($p < .001$) the assumption, as is often the case in EMA data (see e.g., Veenman et al., 2022). While violations to normality do not prevent the fitting of VAR models, they may reduce the power to detect small relations.

Prior to fitting the models, we examined potential multicollinearity between passive suicidal ideation, active suicidal ideation, and acquired capability. All variance inflation factor (VIF) values were <=3 and tolerance => .30, indicating no multicollinearity. We used the *mlVAR* package to estimate (1) a contemporaneous model which presents concurrent associations between all variables at time *t*, and (2) a temporal model with a time lag to estimate associations between two subsequent assessments (*t* and *t +1*). In the contemporaneous model, all associations are controlled for the contemporaneous effects of all other variables in the model, as well as temporal effects and autocorrelations of all variables. In the temporal model, all associations are controlled for the temporal effects of the other variables in the model (i.e., unique partial contributions of each variable are estimated). We used orthogonal estimation, which is better suited for models with a larger number of variables (Epskamp et al., 2021). The *lmer* estimation method (which uses sequential univariate multilevel estimation) was used for all models. Results were visualized using the *qgraph* package (Epskamp et al., 2012); the network graphs present associations (edges) between variables (nodes) whereby the thickness of the edges indicates the strength of the association, and the color of the edges the direction of the association (*dashed red:* negative association; *blue:* positive association). Significance for all analyses was determined at alpha = .05.

[1] Happy was detrended for 25% of the participants, Calm for 23%, Sad for 20%, Anxious for 22%, Angry for 18%, Guilty for 32%, Shame for 32%, Hopeless for 24%, Optimistic for 24%, Loneliness for 15%, Burdensomeness for 32%, Passive suicidal ideation for 30%, Active suicidal ideation for 27%, and Acquired capability for 25% participants. Proportion of detrended time-series is similar to that in other EMA studies (see e.g., Jongeneel et al., 2020).

Results

Data Exploration

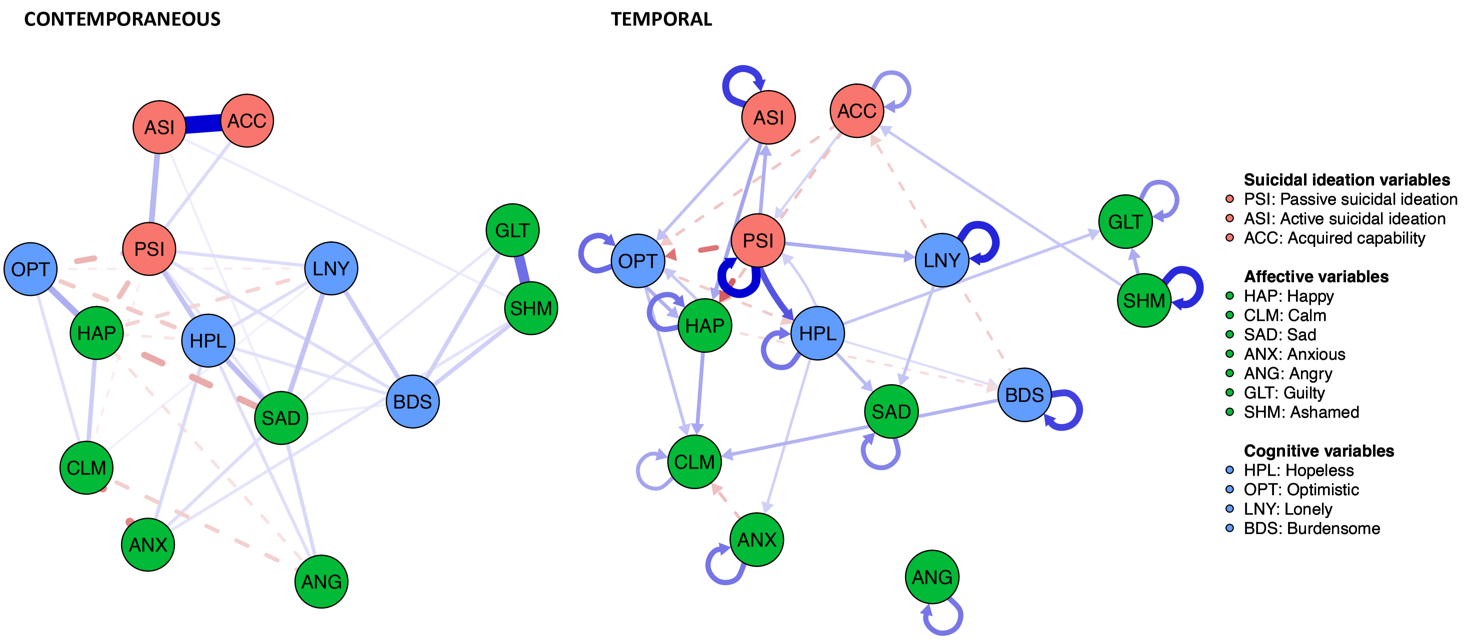
The full EMA dataset consisted of 5,400 observations, nested within 82 participants, and 21 days. Participants completed 66 surveys on average (*Med* = 70, Range = 16-88). After excluding participants with less than 20 observations, in line with guidelines for fitting *mlVAR* models (Epskamp, 2021), 5,349 observations nested within 79 participants, and 21 days remained. Participants on average filled in 65 of the 81 scheduled alerts (Range 22–81, total k = 5,145), as well as three additional entries (Range 0–13, total k = 201), resulting in a total of 68 entries per participant on average (Range 24–88, total K = 5,349). For fitting the contemporaneous *(t)* network model, we used all 5,349 (N = 79) individual observations. For the temporal *(t +1)* network model, we included 3,415 (N = 79) pairs of adjacent within-day observations (i.e., excluding any pairs of observations broken up by either missing data or transitions between days). Table 2 presents intra-individual means and standard deviations for all study variables as measured with the EMA. All participants indicated at least one observation of passive suicidal ideation (mean % of non-zero ratings = 91, Range 3 – 100). Seventy-two participants (91%) additionally indicated at least one observation of both active suicidal ideation and acquired capability during the study period (mean % of non-zero ratings = 41, Range 1 – 100).

Table 2. Intra-Individual Means and Standard Deviations

	Intra-individual	
	M	***SD***
Passive suicidal ideation	3.74	1.36
Active suicidal ideation	1.22	0.94
Acquired capability	2.10	1.46
Happy	4.90	1.58
Calm	5.30	1.81
Sad	3.54	1.98
Anxious	3.60	1.95
Angry	1.83	1.77
Guilty	2.80	1.67
Ashamed	2.71	1.61
Hopeless	3.76	1.87
Optimistic	4.18	1.59
Lonely	3.67	1.90
Burdensome	3.77	1.50

Note: Range for all variables 0-10

Figure 1. Contemporaneous (t) (left) and Temporal (t + 1) (right) Associations with Passive and Active Suicidal Ideation and Acquired Capability



Note: Dashed red: negative association, blue: positive association; only associations $p < .05$ are shown.

Sample Characteristics

The sample (N = 79) was primarily female (80%), with the remaining participants identifying either as male (11%) or non-binary/trans (9%). The mean age of the sample was 27 (SD = 8.6). The sample was comprised of Dutch (54%) and other nationals (46%). The most prevalent current (past month) diagnoses were major depressive disorder (51%) and other depressive disorders (28%), anxiety disorders (56%), post-traumatic stress disorder (23%), autism spectrum disorder (18%), and borderline personality disorder (15%). Current psychiatric medication use was reported by 60% of the sample, and 43% had a history of at least one prior suicide attempt. More detailed information on sample characteristics may be found in Kivelä et al. (2023).

Contemporaneous Associations with Passive and Active Suicidal Ideation and Acquired Capability

In the contemporaneous model (Figure 1, left), passive suicidal ideation was positively associated with sadness (r = .07, p < .001), hopelessness (r = .16, p < .001), loneliness (r = .11, p < .001), and burdensomeness (r = .09, p < .001), and negatively associated with happiness (r = –.18, p < .001), calmness (r = –.05, p = .017), and optimism (r = –.20, p < .001). Active suicidal ideation was positively associated with passive suicidal ideation (r = .20, p < .001), sadness (r = .05, p = .004) and shame (r = .05, p = .028). Acquired capability was positively associated with passive suicidal ideation (r = .10, p < .001) and active suicidal ideation (r = .69, p < .001).

Temporal Associations with Passive and Active Suicidal Ideation and Acquired Capability

In the temporal model (Figure 1, right), passive suicidal ideation (r = .30, p < .001), active suicidal ideation (r = .23, p < .001) and acquired capability (r = .13, p = .001) all exhibited significant positive autocorrelations. Increased hopelessness (r = .06, p = .003) and acquired capability (r = .13, p = .001) were predictive of higher levels of passive ideation at the subsequent time point. Passive ideation in turn predicted increased active ideation (r = .09, p = .002), hopelessness (r = .20, p < .001) and loneliness (r = .10, p = .006), and decreased happiness (r = –.19, p < .001) and optimism (r = –.16, p < .001) at the subsequent assessment point. None of the other variables (except for passive ideation, see above) prospectively predicted active ideation at the subsequent time point. However, active ideation in turn predicted increased happiness (r = .11, p = .003) and optimism (r = .07, p = .033) at the subsequent assessment point. Increased shame (r = .06, p = .004) and decreased burdensomeness (r = –.06, p = .021) were associated with heightened acquired capability at the subsequent time point. Acquired capability in turn predicted decreased happiness (r = −.07, p = .033) and optimism (r = −.07, p = .017) at the subsequent assessment point.

Discussion

Passive Suicidal Ideation

Momentary passive suicidal ideation correlated with sadness, hopelessness, loneliness and burdensomeness, in line with prior literature (Armey et al., 2020; Czyz et al., 2019; Hallensleben et al., 2019; Husky et al., 2017; Kleiman et al., 2017). It has previously been shown that perceived burdensomeness associates only with passive and not active suicidal ideation (Hallensleben et al., 2019). Here, we found all three constructs of the Interpersonal Theory of Suicide (IPTS; Van Orden et al., 2010) (i.e., hopelessness, loneliness and burdensomeness) to associate only with passive, but not active, ideation. Passive suicidal ideation also associated with reduced happiness, calmness and optimism, in line with prior reports of decreased positive affect (and happiness specifically) relating to momentary suicidal ideation (Husky et al., 2017; Rath et al., 2019). Our findings add to this literature by demonstrating concurrent, negative associations with another facet of positive affect: calmness. Indeed, retrospective reports by clinicians and family members have long described that individuals often appear agitated in the days preceding suicide (Sani et al., 2011). In line with our findings on momentary optimism, another study previously found positive thinking-based coping to decrease suicidal ideation in daily life (Stanley et al., 2021).

Passive ideation was prospectively predicted by increased hopelessness and acquired capability. Using EMA data, only one previous study has highlighted hopelessness as a prospective predictor of ideation: among psychiatric inpatients, hopelessness predicted both passive and active ideation within-day (Hallensleben et al., 2019). Meanwhile, others did not establish hopelessness as a prospective (short-term) predictor of ideation (Czyz et al., 2019; Kleiman et al., 2017). However, of note is that both studies examined active ideation only. Our findings therefore add to this literature by demonstrating that hopelessness may be uniquely associated with passive suicidal ideation. We propose that the different operationalization of suicidal ideation in prior studies may partly explain the contradictory findings.

Acquired capability also prospectively predicted increased passive ideation, which in turn predicted active ideation. It may be expected that a passive lack of will to live or a wish to die will over time develop into more concrete thoughts about death and/or suicide (Van Orden et al., 2010). Our findings illustrate that this transition may occur relatively quickly (in approx. 4 hours), although it is important to note that our sample was composed of individuals with a long-term (months, years) history of suicidal ideation. Hence, it is unlikely that someone experiencing first time passive ideation would progress to active ideation so rapidly, but rather our data reflects moment-to-moment changes in individuals who are already familiar with suicidal states.

Active Suicidal Ideation

Active ideation was concurrently associated only with sadness and shame (excluding the triadic associations between passive and active ideation, and acquired capability). Shame is specifically associated with the lethality of suicide attempts (Van Orden et al., 2010), which may explain its unique association with active suicide ideation. Further, shame is closely related to other forms of (non-suicidal) self-harm (Sheehy et al., 2019). This is proposed to result from the strong overlap between shame, self-hatred and the need to punish oneself (Sheehy et al., 2019) – or perhaps in the case of suicidal behavior, to completely eliminate oneself.

Somewhat paradoxically, active ideation also prospectively predicted *increased* happiness and optimism. This is in contrast to our findings on passive ideation and acquired capability, which were followed by negative mood consequences. We speculate that this pattern simply reflects the passing of a suicidal crisis leading to feelings of relief. However, others reporting similar findings propose that some people engage in suicidal thinking as a way of regulating their affect, and hence experience suicidal thoughts as comforting (Kleiman et al., 2018). While a subset of patients does report comfort from ideation (Crane et al., 2014), most people describe their suicidal thoughts as distressing, as also demonstrated by a previous EMA study which found increased negative affect following instances of suicidal thinking (Al-Dajani & Uliaszek, 2021). However, in case suicidal thinking does serve this relief function, it appears that it is active, rather than passive suicidal ideation that produces this effect. This finding also fits within the framework of suicide representing an escape from psychological pain (Baumeister, 1990).

Acquired Capability

Acquired capability was concurrently associated only with passive and active suicidal ideation. The finding that acquired capability was more strongly associated with active rather than passive ideation supports the notion that acquired capability and active ideation are more closely related, and together may be more influential in predicting suicidal acts (Van Orden et al., 2010). The lack of other concurrent associations is also in line with the IPTS, which posits that risk factors such as hopelessness and loneliness are crucial for the development of suicidal ideation, but are not necessarily directly related to acquired capability (Van Orden et al., 2010).

We did, however, find that increased shame and decreased burdensomeness prospectively predicted acquired capability. Shame and burdensomeness have many related characteristics. While shame is considered the emotion perhaps most related to self-hatred (Sheehy et al., 2019), the concept of burdensomeness includes beliefs such as that "the self is so flawed as to be a liability on others" (Van Orden et al., 2010, p. 12). Meanwhile, burdensomeness is more related to the perception of self in relation to others, while shame is more self-directed. Therefore, through repeated negative experiences with others, feelings of burdensomeness may over time become internalized into deeper feelings of shame and self-hatred. This may explain why further down in the pathway to suicide the role of burdensomeness may be reduced, while shame takes a more central role (Van Orden et al., 2010).

Limitations

Certain limitations should be considered when interpreting these findings. First, established power calculations for multilevel VAR models are lacking and it remains to be determined how many participants and time points are needed to obtain precise estimates. We acknowledge power as a potential limitation and urge future research to replicate these findings in larger samples. Second, due to the nature of network models that are highly parameterized, we did not include additional predictors in our models to balance comprehensiveness with statistical power. In line with the systems approach to understanding psychopathology, suicidal ideation is a multifaceted phenomenon, for which any one risk factor is likely to have only limited explanatory or predictive power (Fried, 2022; Fried & Robinaugh, 2020). We hope that future research identifies ways to obtain comprehensive system estimates for suicidal ideation, considering cognitive-affective (e.g., sadness), contextual (e.g., social contact) and behavioral (e.g., coping) components. Third, we must work towards a better understanding of the timeline within which different factors affect suicidal ideation in order to inform study designs: How do we space EMA prompts to optimally predict suicidal ideation? In our analyses, we observed relatively more concurrent rather than temporal associations. However, just because some variables did not emerge as temporal predictors does not necessarily mean that they are not prospectively associated with suicidal ideation – it only means that they are not associated with ideation within the very specific time frame (approx. 4 hours) that we had between observations in our study. Instead it is possible that some factors, such as sadness, may exert their influences much more rapidly, in which case these associations would emerge in the contemporaneous models. Other factors, such as shame, may need longer to result in suicidal ideation, and accumulate over time before their effects become apparent. Finally, our sample was predominantly female and skewed younger in age distribution. The influence of many of the examined risk factors may differ as a function of sociodemographic characteristics (e.g., factors such as loneliness may differentially affect different age groups and genders, see e.g., Boehlen et al., 2022). Gender differences also exists in interpersonal sensitivity, such as the experience of shame (Nyström et al., 2018).

Clinical Implications

Our findings on the differential associations between suicide risk factors on one hand, and passive and active suicidal ideation as well as acquired capability on the other, have clinical relevance. First, we observed unique associations of hopelessness, loneliness and burdensomeness with passive suicidal ideation, indicating that negative cognitive attributional styles may be more central for the foundational development of passive suicidal ideation. These factors may therefore represent important targets in the long-term therapeutic management of suicidality (Van Orden et al., 2012). However, our finding indicating that shame specifically was uniquely associated with active suicidal ideation, and further predicted short-term increases in acquired capability, indicates that for acute risk management, targeting other affective processes may be more crucial. Shame encompasses intense feelings of embarrassment and self-hatred (Lester, 1997), and may therefore represent an especially aversive internal state that is more likely to lead to active thoughts and preparedness to 'escape' the shame-inducing experience (Baumeister, 1990). Our findings therefore indicate that shame-reduction techniques (Goffnett et al., 2020) may also benefit the treatment of patients with suicidal ideation.

Conclusions

In conclusion, we observed differential associations of risk factors with passive and active suicidal ideation and acquired capability. Hopelessness, loneliness and burdensomeness were uniquely associated with passive but not active suicidal ideation, and shame with active suicidal ideation and acquired capability. Overall, our findings illustrate how ecological momentary assessment and network analysis may be used to better understand and visualize the cognitive-affective landscape from which suicidal ideation may emerge in real-time. Future research using real time assessments should aim to further distinguish the various risk and protective factors that may differentially characterize passive, active ideation and acquired capability outcomes. A clinical implication of our findings is that targeting shame may be especially relevant for suicide prevention, considering its unique contribution in explaining not only short-term increases in active suicidal ideation, but also the preparedness for suicidal acts.

References

Al-Dajani, N., & Uliaszek, A. A. (2021). The after-effects of momentary suicidal ideation: A preliminary examination of emotion intensity changes following suicidal thoughts. *Psychiatry Research*, *302*, 114027. https://doi.org/10.1016/j.psychres.2021.114027

Allen, N. B., Nelson, B. W., Brent, D., & Auerbach, R. P. (2019). Short-term prediction of suicidal thoughts and behaviors in adolescents: Can recent developments in technology and computational science provide a breakthrough? *Journal of Affective Disorders*, *250*, 163–169.

Armey, M. F., Brick, L., Schatten, H. T., Nugent, N. R., & Miller, I. W. (2020). Ecologically assessed affect and suicidal ideation following psychiatric inpatient hospitalization. *General Hospital Psychiatry*, *63*, 89–96.

Baumeister, R. F. (1990). Suicide as escape from self. *Psychological Review*, *97*(1), 90–113. https://doi.org/10.1037/0033-295X.97.1.90

Boehlen, F. H., Maatouk, I., Friederich, H.-C., Schoettker, B., Brenner, H., & Wild, B. (2022). Loneliness as a gender-specific predictor of physical and mental health-related quality of life in older adults. *Quality of Life Research*, *31*(7), 2023–2033. https://doi.org/10.1007/s11136-021-03055-1

Borsboom, D., Deserno, M. K., Rhemtulla, M., Epskamp, S., Fried, E. I., McNally, R. J., Robinaugh, D.J., Perugini, M., Dalege, J., Constantini, G., Isvoranu, A.M., Wysocki, A.C., van Borkulo, C.D., van Bork, R., & Waldorp, L. J. (2021). Network analysis of multivariate data in psychological science. *Nature Reviews Methods Primers*, *1*(1), 58. https://doi.org/10.1038/s43586-021-00055-w

Bringmann, L. F., Vissers, N., Wichers, M., Geschwind, N., Kuppens, P., Peeters, F., Borsboom, D., & Tuerlinckx, F. (2013). A network approach to psychopathology: New insights into clinical longitudinal data. *PLoS ONE*, *9*(4), e96588. https://doi.org/10.1371/journal.pone.0060188

Crane, C., Barnhofer, T., Duggan, D. S., Eames, C., Hepburn, S., Shah, D., & Williams, J. M. G. (2014). Comfort from suicidal cognition in recurrently depressed patients. *Journal of Affective Disorders*, *155*, 241–246. https://doi.org/10.1016/j.jad.2013.11.006

Czyz, E. K., Horwitz, A. G., Arango, A., & King, C. A. (2019). Short-term change and prediction of suicidal ideation among adolescents: a daily diary study following psychiatric hospitalization. *Journal of Child Psychology and Psychiatry and Allied Disciplines*, *60*(7), 732–741. https://doi.org/10.1111/jcpp.12974

Davidson, C. L., Anestis, M. D., & Gutierrez, P. M. (2017). Ecological momentary assessment is a neglected methodology in suicidology. *Archives of Suicide Research*, *21*(1), 1–11. https://doi.org/10.1080/13811118.2015.1004482 de Beurs, D. (2017). Network analysis: A novel approach to understand suicidal behaviour. *International Journal of Environmental Research and Public Health*, *14*(3), 219. https://doi.org/10.3390/ijerph14030219

de Beurs, D., Bockting, C., Kerkhof, A., Scheepers, F., O'Connor, R., Penninx, B., & van de Leemput, I. (2021). A network perspective on suicidal behavior: Understanding suicidality as a complex system. *Suicide and Life-Threatening Behavior*, *51*(1), 115–126. https://doi.org/10.1111/sltb.12676

de Beurs, D., Kirtley, O., Kerkhof, A., Portzky, G., & O'Connor, R. C. (2015). The role of mobile phone technology in understanding and preventing suicidal behavior. *Crisis*, *36*(2), 79–82. https://doi.org/10.1027/0227-5910/a000316

Díaz-Oliván, I., Porras-Segovia, A., Barrigón, M. L., Jiménez-Muñoz, L., & Baca-García, E. (2021). Theoretical models of suicidal behaviour: A systematic review and narrative synthesis. *The European Journal of Psychiatry*, *35*(3), 181–192. https://doi.org/10.1016/j.ejpsy.2021.02.002

Duncan, S., & Barrett, L. F. (2007). Affect is a form of cognition: A neurobiological analysis. *Cognition & Emotion*, *21*(6), 1184–1211. https://doi.org/10.1080/02699930701437931

Epskamp, S., Cramer, A. O. J., Waldorp, L. J., Schmittmann, V. D., & Borsboom, D. (2012). Qgraph: Network visualizations of relationships in psychometric data. *Journal of Statistical Software*, *48*(4), 1–18. https://doi.org/10.18637/jss.v048.i04

Epskamp, S., Deserno, M. K., & Bringmann, L. F. (2021). *mlVAR: Multi-level vector autoregression* [R package version 0.5.1].

Franklin, J. C., Ribeiro, J. D., Fox, K. R., Bentley, K. H., Kleiman, E. M., Huang, X., Musacchio, K.M., Jaroszewski, A.C., Chang, B.P., & Nock, M. K. (2017). Risk factors for suicidal thoughts and behaviors: A meta-analysis of 50 years of research. *Psychological Bulletin*, *143*(2), 187–232. https://doi.org/10.1037/bul0000084

Fried, E. I. (2022). Studying mental health problems as systems, not syndromes. *Current Directions in Psychological Science*, *31*(6), 500–508. https://doi.org/10.1177/09637214221114089

Fried, E. I., & Cramer, A. O. J. (2017). Moving forward: Challenges and directions for psychopathological network theory and methodology. *Perspectives on Psychological Science*, *12*(6), 999–1020. https://doi.org/10.1177/1745691617705892

Fried, E. I., & Robinaugh, D. J. (2020). Systems all the way down: Embracing complexity in mental health research. *BMC Medicine*, *18*(1), 205. https://doi.org/10.1186/s12916-020-01668-w

Glenn, C. R., & Nock, M. K. (2014). Improving the short-term prediction of suicidal behavior. *American Journal of Preventive Medicine*, *47*(3 Suppl. 2), S176–180. https://doi.org/10.1016/j.amepre.2014.06.004

Goffnett, J., Liechty, J. M., & Kidder, E. (2020). Interventions to reduce shame: A systematic review. *Journal of Behavioral and Cognitive Therapy*, *30*(2), 141–160. https://doi.org/10.1016/j.jbct.2020.03.001

Goldston, D. B., Erkanli, A., Daniel, S. S., Heilbron, N., Weller, B. E., & Doyle, O. (2016). Developmental trajectories of suicidal thoughts and behaviors from adolescence through adulthood. *Journal of the American Academy of Child & Adolescent Psychiatry*, *55*(5), 400-407.e1. https://doi.org/10.1016/j.jaac.2016.02.010

Hallard, R. I., Wells, A., Aadahl, V., Emsley, R., & Pratt, D. (2021). Metacognition, rumination and suicidal ideation: An experience sampling test of the self-regulatory executive function model. *Psychiatry Research*, *303*, 114083. https://doi.org/10.1016/j.psychres.2021.114083

Hallensleben, N., Glaesmer, H., Forkmann, T., Rath, D., Strauss, M., Kersting, A., & Spangenberg, L. (2019). Predicting suicidal ideation by interpersonal variables, hopelessness and depression in real-time: An ecological momentary assessment study in psychiatric inpatients with depression. *European Psychiatry*, *56*, 43–50. https://doi.org/10.1016/j.eurpsy.2018.11.003

Howarth, E. J., O'Connor, D. B., Panagioti, M., Hodkinson, A., Wilding, S., & Johnson, J. (2020). Are stressful life events prospectively associated with increased suicidal ideation and behaviour? A systematic review and meta-analysis. *Journal of Affective Disorders*, *266*, 731–742. https://doi.org/10.1016/j.jad.2020.01.171

Husky, M., Swendsen, J., Ionita, A., Jaussent, I., Genty, C., & Courtet, P. (2017). Predictors of daily life suicidal ideation in adults recently discharged after a serious suicide attempt: A pilot study. *Psychiatry Research*, *256*, 79–84. https://doi.org/10.1016/j.psychres.2017.06.035

Jongeneel, A., Aalbers, G., Bell, I., Fried, E. I., Delespaul, P., Riper, H., van der Gaag, M., & van den Berg, D. (2020). A time-series network approach to auditory verbal hallucinations: Examining dynamic interactions using experience sampling methodology. *Schizophrenia Research*, *215*, 148–156. https://doi.org/10.1016/j.schres.2019.10.055

Kaurin, A., Dombrovski, A. Y., Hallquist, M. N., & Wright, A. G. C. (2020). Momentary interpersonal processes of suicidal surges in borderline personality disorder. *Psychological Medicine, 52*(13), 2702–2712. https://doi.org/10.1017/S0033291720004791

Kivelä, L., van der Does, W. A. J., Riese, H., & Antypa, N. (2022). Don't miss the moment: A systematic review of ecological momentary assessment in suicide research. *Frontiers in Digital Health*, *4,* 876595. https://doi.org/10.3389/fdgth.2022.876595

Kivelä, L., Fiß, F., van der Does, W., & Antypa, N. (2023). Examination of acceptability, feasibility and iatrogenic effects of ecological momentary assessment (EMA) of suicidal ideation. *Assessment.* https://doi.org/10.1177/10731911231216053

Kleiman, E. M., Coppersmith, D. D. L., Millner, A. J., Franz, P. J., Fox, K. R., & Nock, M. K. (2018). Are suicidal thoughts reinforcing? A preliminary real-time monitoring study on the potential affect regulation function of suicidal thinking. *Journal of Affective Disorders*, *232*, 122–126. https://doi.org/10.1016/j.jad.2018.02.033

Kleiman, E. M., Law, K. C., & Anestis, M. D. (2014). Do theories of suicide play well together? Integrating components of the hopelessness and interpersonal psychological theories of suicide. *Comprehensive Psychiatry*, *55*(3), 431–438. https://doi.org/10.1016/j.comppsych.2013.10.015

Kleiman, E. M., Turner, B. J., Fedor, S., Baele, E. E., Huffman, J. C., & Nock, M. K. (2017). Examination of real-time fluctuations in suicidal ideation and its risk factors: Results from two ecological momentary assessment studies. *Journal of Abnormal Psychology*, *126*(6), 726–738. https://doi.org/10.1037/abn0000273.supp

Kwiatkowski, D., Phillips, P. C. B., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root. *Journal of Econometrics*, *54*(1–3), 159–178. https://doi.org/10.1016/0304-4076(92)90104-Y

Lester, D. (1997). The role of shame in suicide. *Suicide and Life-Threatening Behavior*, *27*(4), 352–361.

Littlewood, D. L., Kyle, S. D., Carter, L. A., Peters, S., Pratt, D., & Gooding, P. (2019). Short sleep duration and poor sleep quality predict next-day suicidal ideation: An ecological momentary assessment study. *Psychological Medicine*, *49*(3), 403–411. https://doi.org/10.1017/S0033291718001009

Nock, M. K. (2016). Recent and needed advances in the understanding, prediction, and prevention of suicidal behavior. *Depression and Anxiety*, *33*(6), 460–463). https://doi.org/10.1002/da.22528

Nock, M. K., Borges, G., Bromet, E. J., Alonso, J., Angermeyer, M., Beautrais, A., Bruffaerts, R., Chiu, W.T., de Girolamo, G., Gluzman, S., de Graaf, R., Gureje, O., Haro, J.M., Huang, Y., Karam, E., Kessler, R.C., Lepine, J.P., Levinson, D., Medina-Mora, M.E., Ono, Y., Posada-Villa, J., & Williams, D. (2008). Cross-national prevalence and risk factors for suicidal ideation, plans and attempts. *British Journal of Psychiatry*, *192*(2), 98–105. https://doi.org/10.1192/bjp.bp.107.040113

Nock, M. K., Pristein, M. J., & Sterba, S. K. (2009). Revealing the form and function of self-injurious thoughts and behaviors: A real-time ecological assessment study among adolescents and young adults. *Journal of Abnormal Psychology*, *118*(4), 816–827.

Nyström, M. B. T., Kjellberg, E., Heimdahl, U., & Jonsson, B. (2018). Shame and interpersonal sensitivity: Gender differences and the association between internalized shame coping strategies and interpersonal sensitivity. *Bulletin of the Menninger Clinic*, *82*(2), 137–155. https://doi.org/10.1521/bumc.2018.82.2.137

Posner, K., Brown, G. K., Stanley, B., Brent, D. A., Yershova, K. V., Oquendo, M. A., Currier, G.W., Melvin, G.A., Greenhill, L., Shen, S., & Mann, J. J. (2011). The Columbia–Suicide Severity Rating Scale: Initial validity and internal consistency findings from three multisite studies with adolescents and adults. *American Journal of Psychiatry*, *168*(12), 1266–1277. https://doi.org/10.1176/appi.ajp.2011.10111704

Rath, D., de Beurs, D., Hallensleben, N., Spangenberg, L., Glaesmer, H., & Forkmann, T. (2019). Modelling suicide ideation from beep to beep: Application of network analysis to ecological momentary assessment data. *Internet Interventions*, *18,* 100292. https://doi.org/10.1016/j.invent.2019.100292

Rudd, M. D. (2008). Suicide warning signs in clinical practice. *Current Psychiatry Reports*, *10*(1), 87–90. https://doi.org/10.1007/s11920-008-0015-4

Rudd, M. D., Berman, A. L., Joiner, T. E., Nock, M. K., Silverman, M. M., Mandrusiak, M., van Orden, K., & Witte, T. (2006). Warning signs for suicide: Theory, research, and clinical applications. *Suicide and Life-Threatening Behavior*, *36*(3), 255–262. https://doi.org/10.1521/suli.2006.36.3.255

Sani, G., Tondo, L., Koukopoulos, A., Reginaldi, D., Kotzalidis, G. D., Koukopoulos, A. E., Manfredi, G., Mazzarini, L., Pacchiarotti, I., Simonetti, A., Ambrosi, E., Angeletti, G., Girardi, P., & Tatarelli, R. (2011). Suicide in a large population of former psychiatric inpatients. *Psychiatry and Clinical Neurosciences*, *65*(3), 286–295. https://doi.org/10.1111/j.1440-1819.2011.02205.x

Sheehan, D. V, Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T., Baker, R., & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *The Journal of Clinical Psychiatry*, *59 Suppl. 20*, 22-33.

Sheehy, K., Noureen, A., Khaliq, A., Dhingra, K., Husain, N., Pontin, E. E., Cawley, R., & Taylor, P. J. (2019). An examination of the relationship between shame, guilt and self-harm: A systematic review and meta-analysis. *Clinical Psychology Review*, *73*, 101779. https://doi.org/10.1016/j.cpr.2019.101779

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology*, *4*(1), 1–32. https://doi.org/10.1146/annurev.clinpsy.3.022806.091415

Spangenberg, L., Glaesmer, H., Hallensleben, N., Rath, D., & Forkmann, T. (2019). (In)stability of capability for suicide in psychiatric inpatients: Longitudinal assessment using ecological momentary assessments. *Suicide and Life-Threatening Behavior*, *49*(6), 1560–1572. https://doi.org/10.1111/sltb.12547

Stanley, B., Martínez-Alés, G., Gratch, I., Rizk, M., Galfalvy, H., Choo, T. H., & Mann, J. J. (2021). Coping strategies that reduce suicidal ideation: An ecological momentary assessment study. *Journal of Psychiatric Research*, *133*, 32–37. https://doi.org/10.1016/j.jpsychires.2020.12.012

Van Orden, K. A., Talbot, N., & King, D. (2012). Using the Interpersonal Theory of Suicide to inform interpersonal psychotherapy with a suicidal older adult. *Clinical Case Studies*, *11*(5), 333–347. https://doi.org/10.1177/1534650112457710

Van Orden, K. A., Witte, T. K., Cukrowicz, K. C., Braithwaite, S. R., Selby, E. A., & Joiner, T. E. (2010). The Interpersonal Theory of Suicide. *Psychological Review*, *117*(2), 575–600. https://doi.org/10.1037/a0018697

Veenman, M., Janssen, L. H. C., Van Houtum, L. A. E. M., Wever, M. C. M., Verkuil, B., Epskamp, S., Fried, E.I., & Elzinga, B. M. (2024). A Network Study of Family Affect Systems in Daily Life. Multivariate Behavioral Research, 59(2), 371-405. https://doi.org/10.1080/00273171.2023.2283632

Victor, S. E., Scott, L. N., Stepp, S. D., & Goldstein, T. R. (2019). I want you to want me: Interpersonal stress and affective experiences as within-person predictors of non-suicidal self-injury and suicide urges in daily life. *Suicide and Life-Threatening Behavior*, *49*(4), 1157–1177. https://doi.org/10.1111/sltb.12513

Wastler, H. M., Khazem, L. R., Ammendola, E., Baker, J. C., Bauder, C. R., Tabares, J., Bryan, A.O., Szeto, E., & Bryan, C. J. (2023). An empirical investigation of the distinction between passive and active ideation: Understanding the latent structure of suicidal thought content. *Suicide and Life-Threatening Behavior*, *53*(2), 219–226. https://doi.org/10.1111/sltb.12935

CHAPTER 05:

Sleep

Sleep, Hopelessness and Suicidal Ideation: An Actigraphy and Sleep Diary Study

Published as:

Kivelä, L., van der Does, W., & Antypa, N. (2024). Sleep, Hopelessness and Suicidal Ideation: An Actigraphy and Sleep Diary Study. *Journal of Psychiatric Research, 177,* 46-52. https://doi.org/10.1016/j.jpsychires.2024.06.039

Abstract

Background: Recent research shows that sleep disturbances are linked to increased suicidal ideation. In the present longitudinal cohort study, we used subjective (ecological momentary assessment, EMA) and objective (actigraphy) measures to examine the effects of sleep parameters on next-day suicidal ideation. Further, we examined hopelessness as a mediator between insufficient sleep and increased suicidal ideation. **Methods:** Individuals with current suicidal ideation (N= 82) completed 21 days of EMA and actigraphy to estimate suicidal ideation, hopelessness and sleep parameters. Multilevel linear-mixed models were used to examine the effects of sleep parameters on next-day suicidal ideation, as well as for the mediating effect of hopelessness (in the morning) on the association between previous night's sleep and suicidal ideation levels the next day. **Results:** Significant concordance existed between subjective and objective sleep measures, with moderate-to-large correlations (r= .44 – .58). Lower subjective sleep quality and efficiency, shorter total sleep time and increased time awake after sleep onset were significantly associated with increased next-day suicidal ideation (controlling for previous-day suicidal ideation). Actigraphy-measured sleep fragmentation was also a significant predictor of next-day ideation. Hopelessness mediated the effects of the subjective sleep parameters on suicidal ideation, but did not account for the association with sleep fragmentation. **Conclusions:** Individuals' psychological complaints (hopelessness, suicidal ideation) were better predicted by subjective sleep complaints than by objective sleep indices. Increased hopelessness following from perceived insufficient sleep appears an important explanatory factor when considering the link between sleep disturbances and suicidal ideation.

Introduction

Sleep has broad implications not only for physical, but also psychological health (Robotham, 2011). Sleep disturbances are implicated in many mental disorders, including depression (Baglioni et al., 2011) and anxiety disorders (Staner, 2003). Sleep disturbances also represent a significant risk factor for all aspects of suicidality (incl. suicidal ideation (SI), behavior and mortality) (Pigeon et al., 2012). Based on a meta-analysis of 42 longitudinal studies, insomnia has been found to confer the most risk for SI, whereas nightmares are most strongly associated with suicide attempts (Harris et al., 2020). Further, insomnia predicts the persistence of SI above and beyond general depressive symptom severity (Kivelä et al., 2019) and other mental health problems (Batterham et al., 2021; Geoffroy et al., 2021; Simmons et al., 2020). This highlights the important role of disturbed sleep for suicidal outcomes.

Sleep disturbances in patients experiencing SI have primarily been assessed with subjective measures. A meta-analysis of 41 such longitudinal studies (Liu et al., 2020) reported a small-to-medium effect size of sleep disturbances on SI. For insomnia specifically, a small-to-medium effect size was reported, while hypersomnia yielded a non-significant negligible effect size. Nightmares were also associated with subsequent SI, with a small-to-medium effect size. In comparison, a recent meta-analysis of studies using objective measures identified only 11 studies – seven of which used actigraphy, six polysomnography and two electroencephalogram (EEG). It was concluded that short sleep duration had a small, significant association with current SI, but no associations were found for other potential markers (such as sleep efficiency or percentage of rapid eye movement (REM) sleep) (Romier et al., 2023). Subjective sleep disturbance therefore appears to be more strongly associated with SI than objective sleep indices, although the literature employing objective measures is still limited and mainly reliant on retrospective reports of SI.

While more studies are needed on the discrepancies between subjective and objective sleep measures, one of the current limitations in the field is the lack of studies examining short-term risk (Liu et al., 2020). A meta-analysis found follow-up length to be a significant moderator in the association between sleep disturbances and SI, with studies employing shorter follow-ups (a few weeks or months) yielding larger effect sizes (Liu et al., 2020). This indicates that sleep disturbances are an imminent and possibly potent risk factor for SI. However, few studies have examined the *immediate* effects of sleep on SI. Both subjective and objective sleep duration, but only subjective sleep quality predicted next-day SI in a 7-day actigraphy and ecological momentary assessment (EMA) study in adults (Littlewood 2019). In a 28-day actigraphy and EMA study in adolescents recently discharged from acute psychiatric care following a suicidal crisis, longer (subjective) sleep onset latency, nightmares and *higher* sleep quality related to greater next-day SI (Glenn et al., 2021). Meanwhile, only objective wake after sleep onset (WASO) was related to next-day SI, whereby, surprisingly, *less* WASO was related to *more* SI (Glenn et al., 2021).

Another target for further investigation are the causal mechanisms tying sleep disturbances to SI. Here, we examine hopelessness as a potential mediator, in line with our previous findings that hopelessness reactivity (i.e., the tendency to experience hopelessness in response to low mood) mediated the effect of insomnia on persistent SI over 9-years (Kivelä et al., 2019). Similar findings were reported in a cross-sectional study of 766 community adults, where hopelessness was found to mediate the association between insomnia and SI (Woosley et al., 2014). In another study, feelings of defeat, entrapment and hopelessness mediated the association between nightmares and SI (Littlewood et al., 2016). However, no previous study has examined whether this relationship also exists on a more immediate, night-to-day basis.

Theoretically, we propose that insufficient sleep may worsen affect (Medic et al., 2017), consequently leading to increased negative emotionality, including pessimism and hopelessness (McCall and Black, 2013), as lack of sleep may have a detrimental effect on one's ability to contain hopeless thoughts. Insomnia may also be more directly associated with hopeless cognitions about the effects of poor sleep, such as expectations of reduced daytime functioning and the persistence of sleep problems over time (McCall & Black, 2013). Such hopelessness about sleep has been referred to as insomnia catastrophizing, whereby individuals specifically ruminate on the worst-case consequences of poor sleep (Jansson-Fröjmark et al., 2020; Winsper and Tang, 2014). Hopelessness, in turn, is a well-established risk factor for both suicidal ideation and behavior (Kuo et al., 2004; Zhang et al., 2011).

The aim of the present study was to examine how subjective and objective sleep parameters relate to next-day SI in a cohort of participants with current suicidal ideation who were monitored for 21 days with EMA and actigraphy. We also explored feelings of hopelessness as a mediator in the association between sleep and suicidal ideation the next day.

Methods

Ethics

All procedures were conducted in accordance with the Helsinki Declaration of 1964 and its later amendments. The study was approved by the Medical Ethics Committee

– Leiden, Den Haag, Delft (METC-LDD) on 24.4.2020 with dossier number NL71510.058.19. All participants provided written informed consent.

Sample

The sample (*N* = 82) was derived from the SAFE study, a longitudinal cohort study in adults with a past-year history of a suicide attempt and/or active SI (as indicated by a score of >= 3 on the Columbia Suicide Severity Rating Scale (CSSRS) (Posner et al., 2011), or a score of >= 2 if symptoms were present in the past two months). Exclusion criteria included a current diagnosis of bipolar disorder, a psychotic disorder, severe substance dependence, or any physical or intellectual impairment that would meaningfully hinder the individual's participation in the study. More details about the SAFE study are reported elsewhere (Kivelä et al., 2023).

Procedure

Participants were recruited through social media and community advertisements, as well as referral from treatment providers in the surrounding areas. Participants attended an (in-person or online) intake interview where, after receiving study information and signing informed consent, the participant's history of SI was assessed via an adapted version of the CSSRS (composed of the first five questions on past-year SI, and additional questions on lifetime history of suicide attempts). Current diagnoses were established via the M.I.N.I. PLUS Neuropsychiatric interview (version 5.0) (Sheehan et al., 1998). Following diagnostics but prior to receiving study instructions, personalized safety plans were created for each participant. Participants then received instructions for the EMA and actigraphy (see *Instruments* below). Following the 21-day assessment period, another meeting was scheduled where participants returned the study materials and received a summary report of their data.

Instruments

Baseline Sociodemographics (age, gender), current medical diagnoses and medication use were collected via a custom semi-structured interview. Current depressive symptoms were assessed with the Beck Depression Inventory (BDI-I) (Beck, 1961), which includes 21 questions on depressive symptoms as present in the past week. Current SI was estimated with the Beck Scale for Suicide Ideation (BSSI) (Beck et al., 1979), which includes 21 items on past-week SI. Insomnia symptoms were established with the Insomnia Severity Index (ISI) (Morin et al., 2011), which includes seven items on sleep complaints in the past two weeks. For the ISI, scoring guidelines indicate 0-7 to reflect the absence of (clinically significant) insomnia, 8-14 subthreshold insomnia, 15-21 moderate, and 22-28 severe insomnia.

Ecological Momentary Assessment (EMA) EMA was used to assess SI, hopelessness and subjective sleep parameters over 21 days. Participants downloaded a mobile phone app produced by Ethica (a.k.a. Avicenna), and received alerts for four questionnaires per day. The questionnaires were released on a pseudo-random schedule between the hours of 7am and 10pm. Additionally, participants could self-initiate additional EMA at any time. Questions on SI were presented at all EMAs per day, and each assessment included three questions (*"At the moment… how strong is your desire to live?", "… how strong is your desire to die, or go to sleep and not wake up?", "… do you actually have thoughts of killing yourself?"*) rated on a scale from 0 (none/not at all) to 10 (very strong/very well). The positively worded item (desire to live) was reverse coded and a daily mean score of SI was calculated.

Hopelessness was estimated each morning with the question *"At the moment… how hopeless do you feel?"* rated on a scale from 0 (not at all) to 10 (very much).

Questions on subjective sleep were presented each morning (adapted from the Consensus Sleep Diary – Morning section) (CSD-M; Carney et al., 2012) and included subjective sleep quality (SSQ) *("How did you sleep last night?"* from 0 (very poorly) to 10 (very well)), timing of sleep (*"What time did you try to get to sleep?", "What time did you wake up for the day?", "What time did you get out of bed?"*), time to fall asleep *("How long did it take you to fall asleep (in minutes)?"*), night-time awakenings (*"Did you wake up during the night*?" *yes/no* And if *'yes'*: *"How long were you awake (in minutes)?"*) and nightmares (*"Did you have any nightmares?" yes/no*). Sleep parameters derived from EMA included SSQ, total sleep time (TST; defined as the time spent asleep between initiating sleep and awakening in the morning), sleep efficiency (SE; a percentage calculated by dividing TST with the overall time spent in bed, multiplied by 100), sleep onset latency (SOL; time between initiating sleep and actually falling asleep), wake after sleep onset (WASO; time spent awake between falling asleep at night and waking up in the morning) and nightmares.

Actigraphy Objective sleep data was collected with the MotionWatch 8 (CamnTech, Cambridge, UK). The watch includes a tri-axial accelerometer that samples activity in 30 second epochs, as well as a light sensor (data not reported). Participants were instructed to press a button on the watch when attempting to sleep at night, and when waking up in the morning. The data were uploaded into the MotionWare program

(CamnTech, Cambridge, UK), which produces estimates on sleep parameters based on algorithms that transform the activity data collected by the accelerometer. Parameters used in the present study included the fragmentation index (FI; a percentage reflecting the proportion of mobile/immobile epochs during the sleep period to estimate restlessness during the night) (Shrivastava et al., 2014), SE, TST, SOL and WASO. When event markers were missing, participants' EMA entries and visual inspection of the data were used to mark sleep periods; when both were missing, or event markers and self-reports deviated greatly, visual inspection (based on activity cessation and light data) was used to determine sleep periods. These pre-processing steps are in line with other studies using actigraphy (Falck et al., 2020) Bernert et al., 2017). The MotionWatch 8 has been validated for use with 85% per-epoch agreement of sleep/wake when compared to PSG (O'Hare et al., 2015), with a minimum of 14 nights of measurement recommended to establish reliable estimates (Ancoli-Israel et al., 2015).

Statistical Analysis

All analyses were conducted in IBM SPSS Statistics (version 29.0). Multilevel regression analyses (linear-mixed models) were used to examine the (main) effects of subjective and objective sleep measures on next-day suicidal ideation. Prior to the analyses, all continuous variables (predictors and outcome) were person-mean centered by subtracting a participant's mean score from each individual observation, in order to examine within-person effects. We considered all predictors as fixed effects, and specified a 2-level random intercept model whereby observations were nested within individuals. For repeated effects, we specified a first-order autoregressive covariance structure, which takes into account temporal dependencies and assumes higher correlations between two adjacent time points, with decreasing correlations between observations with increasing distance. Separate multilevel regression analyses were ran for all sleep parameters, as the assumption of no multicollinearity was violated.[1] Finally, we examined the mediating effect of hopelessness (in the morning) on the associations between the sleep parameters and next-day suicidal ideation, in accordance with the steps specified by Baron & Kenny (1986). All models were controlled for previous-day suicidal ideation. Significance was determined at $p < .05 / 11 = .005$ for all multilevel analyses, corrected by the total number of subjective and objective sleep parameters examined.

[1] No multicollinearity was observed between hopelessness and the sleep parameters (VIF = 1.42).

Table 1. Sociodemographic and clinical characteristics of the sample

	EMA $N = 82$	Actigraphy $n = 61$
Age (*M, SD*)	27 (8.6)	28 (8.6)
Gender - Female (*N*, %)	63 (77%)	45 (74%)
Depressive symptom severity (BDI) (*M, SD*)	25.5 (9.6)	25.3 (10.2)
Suicidal ideation severity (BSSI) (*M, SD*)	15.3 (8.6)	15.4 (8.7)
Suicidal ideation (EMA) (*M, SD*)	3.1 (2.0)	2.9 (2.0)
Current diagnoses (*N*, %)		
Depressive disorder	63 (77%)	48 (79%)
Anxiety disorder	47 (57%)	33 (54%)
PTSD	18 (22%)	10 (16%)
OCD	7 (9%)	6 (10%)
ADHD	10 (12%)	6 (10%)
Medication (*N*, %)		
Sedatives	20 (24%)	16 (26%)
Stimulants	10 (12%)	6 (10%)
Antidepressants	33 (40%)	27 (44%)
Concurrent medical diagnosis (*N*, %)	35 (43%)	28 (46%)
Non-psychoactive medication	26 (32%)	19 (31%)
Insomnia severity (ISI) (*M, SD*)	11.8 (5.0)	11.8 (5.4)

Note: EMA = Ecological Momentary Assessment, BDI = Beck Depression Inventory, BSSI = Beck Scale for Suicide Ideation, PTSD = Post-traumatic stress disorder, OCD = Obsessive compulsive disorder, ADHD = Attention deficit hyperactivity disorder, ISI = Insomnia Severity Index

Results

Sample Description

Participants ($N = 82$) provided self-report EMA data for $K = 16$ nights on average, resulting in $k = 1{,}304$ unique observations. For objective sleep parameters, 21 participants (26%) had no actigraphy data available. Approximately half of the missingness was attributable to participants not returning their watches, or watches getting lost in the mail ($n = 9$). Other participants had completely missing data due to either unknown technical issues or user error resulting in no data being recorded by the watch ($n = 12$). The remaining participants ($n = 61$) provided actigraphy data for $K = 18$ nights on average, resulting in $k = 1{,}114$ unique observations. No significant differences emerged between those with and without actigraphy data (see Appendix, Table S1). Sociodemographic and clinical characteristics of the sample are presented in Table 1. More detailed descriptions of the characteristics of the sample may be found in Kivelä et al. (2023).

Table 2. Intra-Individual Means and Standard Deviations of Subjective and Objective Sleep Parameters

	EMA $N = 82$	Actigraphy $n = 61$	Pearson r	t-test (df)	p-value
Subjective sleep quality (SSQ)					
M (SD)	5.6 (1.2)	-	-	-	-
Range	2.0–8.7	-			
Fragmentation index (FI)					
M (SD)	-	26.2 (9.1)	-	-	-
Range	-	9.2–54.4			
Sleep efficiency (SE)					
M (SD)	84% (7.4%)	77% (7.2%)	.51	6.58	.001
Range	56–97%	54–90%		(59)	
Total sleep time (TST)					
M (SD)	416 min (55 min)	395 min (52 min)	.58	2.87	.006
Range	255–527 min	201–473 min		(59)	
Sleep onset latency (SOL)					
M (SD)	23 min (18 min)	18 min (9 min)	.57	2.90	.005
Range	4–92 min	4–43 min		(59)	
Wake after sleep onset (WASO)					
M (SD)	20 min (18 min)	60 min (26 min)	.44	–12.00	< .001
Range	0–83 min	23–132 min		(60)	
Nightmares					
Percentage (%)	23%	-		-	-
Range	0–95%	-			

Note: EMA = Ecological Momentary Assessment; all correlation coefficients were significant with $p < .001$

Concordance Between Sleep Measures

Means and standard deviations of the subjective and objective sleep parameters, and correlations between them, are presented in Table 2. Subjective and objective estimates of SE, TST, SOL and WASO exhibited moderate-to-large correlations. Actigraphy measures indicated significantly shorter TST and SOL, lower SE and higher WASO compared to self-reports. Baseline insomnia severity (ISI) significantly predicted EMA-measured lower subjective SSQ ($B = -0.10$, $SE = 0.03$, $p < .001$, $R^2 = 0.15$), SE ($B = -0.59$, $SE = 0.17$, $p < .001$, $R^2 = 0.15$) and WASO ($B = 1.78$, $SE = 0.36$, $p < .001$, $R^2 = 0.26$), but not TST ($p = .091$), SOL ($p = .487$), nightmares ($p = .052$), or any of the objective sleep parameters (all *p*'s > .05). Baseline insomnia severity significantly predicted higher EMA-measured SI (B = 0.13, SE = 0.05, p = .005, R^2 = 0.11).

Subjective and Objective Sleep Parameters and Next-Day Suicidal Ideation

Lower subjective SSQ and SE, shorter TST and longer WASO were significantly associated with within-person increases in SI the following day, while SOL and nightmares were not. Out of the objective sleep parameters, only FI was significantly associated with next-day SI after correction for multiple testing (Table 3).

Table 3. Multilevel Regression of Subjective and Objective Sleep Parameters on Next-Day Suicidal Ideation, Controlling for Previous-Day Suicidal Ideation

	B	*SE*	95% CI	*p*-value
EMA				
Subjective sleep quality (SSQ)	−0.090	0.012	[−0.114; −0.066]	< .001
Sleep efficiency (SE)	−0.008	0.002	[−0.012; −0.003]	< .001
Total sleep time (TST)	−0.001	0.001	[−0.002; −0.001]	< .001
Sleep onset latency (SOL)	0.002	0.001	[−0.001; 0.003]	.086
Wake after sleep onset (WASO)	0.003	0.001	[0.001; 0.004]	< .001
Nightmares	0.145	0.056	[−0.035; 0.256]	.010
Actigraphy				
Fragmentation index (FI)	0.007	0.003	[0.002; 0.012]	.004
Sleep efficiency (SE)	−0.003	0.004	[−0.011; 0.004]	.344
Total sleep time (TST)	−0.001	0.001	[−0.001; 0.001]	.829
Sleep onset latency (SOL)	0.002	0.001	[−0.001; 0.005]	.122
Wake after sleep onset (WASO)	0.003	0.001	[0.001; 0.005]	.009

Note: EMA = Ecological Momentary Assessment; significance was determined at $p < .005$

Suicidal Ideation and Subjective and Objective Sleep Parameters the Following Night

Examining the opposite direction of causality, SI during the day was not significantly associated with any of the subjective or objective sleep parameters the following night (Table S2).

Mediation Analyses: The Role of Hopelessness

Hopelessness significantly mediated the relationship with next-day SI for all subjective sleep parameters (SSQ, SE, TST, WASO), with partial mediation for SSQ and TST, and full mediation for SE and WASO. Hopelessness was not significantly associated with FI (actigraphy) and did not mediate its relation with SI (Table S3).

Discussion

In the present study, we examined the effects of subjective and objective sleep parameters on next-day SI. Overall, subjective sleep estimates appeared more consistently associated with SI than actigraphy measures, with subjective SSQ, SE, TST and WASO all significantly predicting next-day SI, while only actigraphy-measured FI emerged as a significant predictor.

The association between subjective SSQ and next-day SI is in line with prior research (Littlewood et al., 2019). However, while SE (which is often used as an indicator of sleep quality) did not emerge as a significant predictor in prior research (Littlewood et al., 2019), we found that subjective SE (but not objective SE) was associated with next-day SI. Indeed, only one of the objective sleep parameters, FI, remained a significant predictor after correction for multiple testing. FI is a measure of restlessness during the night, and higher values indicate greater sleep disruption (Shrivastava et al., 2014). The FI parameter has not previously been identified as a marker for increased SI. However, our findings are in line with a cross-sectional actigraphy study of 3,045 older adult women from the community, which found depressive symptoms to relate to poor subjective sleep quality and actigraphy-measured increased sleep fragmentation (as indicated by increased WASO) (Maglione et al., 2012). We also found objective WASO to be significantly associated with SI, but only prior to correction. The finding that indicators of sleep fragmentation (i.e., FI, WASO) specifically were highlighted both in our subjective and objective analyses, while SOL was significant in neither, seems to indicate that trouble maintaining sleep (i.e., middle insomnia) is more closely related to increased SI than trouble initiating sleep (i.e., early insomnia), at least in the very short-term. While both sleep deprivation (i.e., insufficient TST) and sleep fragmentation are associated with negative mental and physical health consequences, it has also been demonstrated that the effects of sleep fragmentation are unique and not simply explained by sleep loss (Benkirane et al., 2022; Bonnet and Arand, 2003). Explanations for the deleterious effects of sleep fragmentation include that it may be more detrimental to sleep architecture than short sleep duration in itself, therefore impairing the restorative function of sleep. For example, it has been shown that the increased sleep fragmentation associated with aging is specific to slow wave sleep (SWS) (Varga et al., 2016); this sleep stage is thought to be crucial for restoration and recovery (Roth, 2009).

Nightmares did not emerge as a significant predictor of next-day SI. This is contrary to a prior study that found nightmares to relate to increased next-day SI among adolescents (Glenn et al., 2021). Meanwhile, the general literature indicates that nightmares may be more closely tied to suicidal behavior (i.e., attempts) than ideation (Harris et al., 2020). Findings on the association between nightmares and suicidal ideation therefore appear inconclusive.

We did not find evidence for the opposite direction of causality (i.e., suicidal ideation disrupting sleep). Prior studies with daily measures have also indicated unidirectional effects of sleep on affect (Barber et al., 2023; de Wild-Hartmann et al., 2013; McCrae et al., 2008). One previous EMA study found significant bidirectional effects, but concluded that the effects of sleep on mood were substantially larger than vice versa (Triantafillou et al., 2019).

Hopelessness was a significant mediator when examining all subjective sleep parameters (SSQ, SE, TST, WASO) and their effects on next-day SI. We also previously found hopelessness reactivity to mediate the effect of insomnia on the persistence of suicidal ideation over time, based on an examination of 195 individuals observed over 9 years (Kivelä et al., 2019). Prior cross-sectional studies have also identified hopelessness as a mediator of both insomnia (Woosley et al., 2014) and nightmares (Littlewood et al., 2016). Here, we extend on these findings by indicating that disturbed sleep, through increased hopelessness, may have an immediate worsening effect on suicidal ideation the very next-day. Future research should further aim to examine the roots of hopelessness resulting from poor sleep, whether that be more direct worry about the consequences of a bad night's sleep (Jansson-Fröjmark et al., 2020; McCall and Black, 2013), or more complex mechanisms impacting affective (Groeger et al., 2022; Medic et al., 2017; Ritchie et al., 2018) or cognitive functioning (Alhola and Polo-Kantola, 2007; Holding et al., 2021; Medic et al., 2017). For example, executive dysfunction is observed both among people with insomnia (Bredemeier and Miller, 2015), as well as those at risk of suicide (Ballesio et al., 2019). Sleep fragmentation specifically has been identified as especially deleterious to cognition: in a study utilizing polysomnography, increased sleep fragmentation was associated with worse executive function performance, irrespective of sleep duration (Benkirane et al., 2022). Similar findings have emerged with regard to emotion regulation, whereby maladaptive emotion regulation (i.e., rumination) mediated the association between actigraphy-measured sleep fragmentation and negative affect (Boon et al., 2023). Future research may find it relevant to examine whether executive dysfunction and/or emotion dysregulation may underlie these associations between poor sleep, hopelessness and SI.

Finally, we examined concordance between EMA and actigraphy measures and found moderate-to-large correlations between subjective and objective SE, TST, SOL and WASO. Actigraphy provided estimates that were significantly lower for TST, SE and SOL, but higher for WASO, as compared to EMA. It is well-established that in comparison to PSG, actigraphy tends to overestimate sleep duration and underestimate wakefulness due to its movement-based algorithms that struggle to correctly classify moments of wakefulness in the absence of movement (e.g., when lying still in bed) (Lehrer et al., 2022; O'Hare et al., 2015; Sadeh, 2011). However, self-reports instead may *overestimate* sleep duration (Benz et al., 2023; Lehrer et al., 2022; Littlewood et al., 2019).

Limitations of the present study include more missing data on the objective measures. This may have reduced power in our actigraphy analyses, although our sample is still the largest to date to examine night-to-day associations between actigraphic sleep and SI. The general pattern observed in the present study is also in line with prior literature indicating larger effect sizes for suicide outcomes when self-report measures are used to estimate sleep (Harris et al., 2020). Further, a substantial portion of participants were using either antidepressant (40%), sedative (24%) or stimulant medication (12%). While antidepressants have been associated with side effects of both insomnia and hypersomnia (Wichniak et al., 2017), use of sedatives such as benzodiazepines may increase sleep duration while simultaneously decreasing sleep quality (Holbrook et al., 2001; Manconi et al., 2017). Likewise, stimulants may reduce both sleep quality and quantity through increased alertness (Stein et al., 2012). However, due to our small sample size and heterogeneity in medication usage we were unable to account for these potential confounders in our analyses. Finally, our sample was fairly young, and predominantly female: sleep characteristics may change as a function of age (Li et al., 2018), and gender-related differences in sleep architecture are also observed (Krishnan and Collop, 2006). Hence, our findings may have limited generalizability to older, and male, populations, and replication in corresponding samples is needed.

Our study underscores that sleep disturbances may represent an important warning sign for increased suicide risk. While estimates of sleep disturbances are well-known risk factors for suicidal ideation in longitudinal cohort studies (Harris et al., 2020), much less is known about the immediate effects of disturbed sleep on suicidal ideation in the short-term. Meanwhile, sleep disturbances also represent a risk factor that is readily modifiable through intervention. A number of recent studies have indicated reductions in SI following treatment for sleep disturbances in patients with bipolar disorder (Sylvia et al., 2021), college students with a lifetime history of SI (Crosby and Witte, 2021) and veterans with PTSD (Bishop et al., 2016). In a randomized controlled trial (RCT) of online-based cognitive behavioral therapy for insomnia (CBT-I), the treatment was associated with reduced SI both post-treatment, as well as 1-year follow up (Kalmbach et al., 2022). Similarly, RCTs examining pharmacotherapy for sleep disturbances have also indicated concomitant reductions in SI (see e.g., McCall et al., 2019). Sleep disturbances, if untreated, can persist even at times of remission, and may predispose individuals to both depressive as well as suicidal ideation relapse (Gallo et al., 2020). Further, as our findings indicate that poor sleep may have immediate effects on psychological well-being, improving sleep may be relevant as a crisis management intervention prior to employing more long-term treatments for SI. In addition to sleep interventions (Kalmbach et al., 2022; McCall et al., 2019), chronotherapeutics (i.e., interventions that work to re-synchronize the biological clock) have also been shown to have rapid antidepressant effects, including relief in suicidal symptoms (Sahlem et al., 2014).

In conclusion, we found that subjective sleep estimates (SSQ, SE, TST, WASO) relate to next-day SI, while sleep fragmentation (FI) emerged as the only significant predictor of the objective indices. Interpreting these sleep parameters as a whole, we observe that shorter sleep duration and interrupted sleep during the night pose individuals at increased risk of higher SI the following day. Increased hopelessness following from perceived insufficient sleep is an important explanatory factor when considering the link between sleep disturbances and SI.

References

Alhola, P., & Polo-Kantola, P. (2007). Sleep deprivation: Impact on cognitive performance. *Neuropsychiatric Disease and Treatment*, *3*(5), 553–567.

Ancoli-Israel, S., Martin, J. L., Blackwell, T., Buenaver, L., Liu, L., Meltzer, L. J., Sadeh, A., Spira, A. P., & Taylor, D. J. (2015). The SBSM guide to actigraphy monitoring: Clinical and research applications. *Behavioral Sleep Medicine*, *13 Suppl 1*, S4–S38. https://doi.org/10.1080/15402002.2015.1046356

Baglioni, C., Battagliese, G., Feige, B., Spiegelhalder, K., Nissen, C., Voderholzer, U., Lombardo, C., & Riemann, D. (2011). Insomnia as a predictor of depression: A meta-analytic evaluation of longitudinal epidemiological studies. *Journal of Affective Disorders*, *135*(1–3), 10–19. https://doi.org/10.1016/j.jad.2011.01.011

Ballesio, A., Aquino, M. R. J. V, Kyle, S. D., Ferlazzo, F., & Lombardo, C. (2019). Executive functions in insomnia disorder: A systematic review and exploratory meta-analysis. *Frontiers in Psychology*, *10*, 101. https://doi.org/10.3389/fpsyg.2019.00101

Barber, K. E., Rackoff, G. N., & Newman, M. G. (2023). Day-to-day directional relationships between sleep duration and negative affect. *Journal of Psychosomatic Research*, *172*, 111437. https://doi.org/10.1016/j.jpsychores.2023.111437

Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*(6), 1173–1182. https://doi.org/10.1037/0022-3514.51.6.1173

Batterham, P. J., Werner-Seidler, A., Calear, A. L., McCallum, S., & Gulliver, A. (2021). Specific aspects of sleep disturbance associated with suicidal thoughts and attempts. *Journal of Affective Disorders*, *282*, 574–579. https://doi.org/10.1016/j.jad.2020.12.150

Beck, A. T. (1961). An inventory for measuring depression. *Archives of General Psychiatry*, *4*(6), 561–571. https://doi.org/10.1001/archpsyc.1961.01710120031004

Beck, A. T., Kovacs, M., & Weissman, A. (1979). Assessment of suicidal intention: The Scale for Suicide Ideation. *Journal of Consulting and Clinical Psychology*, *47*(2), 343–352.

Benkirane, O., Delwiche, B., Mairesse, O., & Peigneux, P. (2022). Impact of sleep fragmentation on cognition and fatigue. *International Journal of Environmental Research and Public Health*, *19*(23), 15485. https://doi.org/10.3390/ijerph192315485

Benz, F., Riemann, D., Domschke, K., Spiegelhalder, K., Johann, A. F., Marshall, N. S., & Feige, B. (2023). How many hours do you sleep? A comparison of subjective and objective sleep duration measures in a sample of insomnia patients and good sleepers. *Journal of Sleep Research*, *32*(2), e13802. https://doi.org/10.1111/jsr.13802

Bernert, R. A., Hom, M. A., Iwata, N. G., & Joiner, T. E. (2017). Objectively assessed sleep variability as an acute warning sign of suicidal ideation in a longitudinal evaluation of young adults at high suicide risk. *Journal of Clinical Psychiatry*, *78*(6), e678–e687. https://doi.org/10.4088/JCP.16m11193

Bishop, T. M., Britton, P. C., Knox, K. L., & Pigeon, W. R. (2016). Cognitive behavioral therapy for insomnia and imagery rehearsal in combat veterans with comorbid posttraumatic stress: A case series. *Military Behavioral Health*, *4*(1), 58–64. https://doi.org/10.1080/21635781.2015.1100564

Bonnet, M. H., & Arand, D. L. (2003). Clinical effects of sleep fragmentation versus sleep deprivation. *Sleep Medicine Reviews*, *7*(4), 297–310. https://doi.org/10.1053/smrv.2001.0245

Boon, M. E., van Hooff, M. L. M., Vink, J. M., & Geurts, S. A. E. (2023). The effect of fragmented sleep on emotion regulation ability and usage. *Cognition and Emotion*, *37*(6), 1132–1143. https://doi.org/10.1080/02699931.2023.2224957

Bredemeier, K., & Miller, I. W. (2015). Executive function and suicidality: A systematic qualitative review. *Clinical Psychology Review*, *40*, 170–183. https://doi.org/10.1016/j.cpr.2015.06.005

Carney, C. E., Buysse, D. J., Ancoli-Israel, S., Edinger, J. D., Krystal, A. D., Lichstein, K. L., & Morin, C. M. (2012). The Consensus Sleep Diary: Standardizing prospective sleep self-monitoring. *Sleep*, *35*(2), 287–302. https://doi.org/10.5665/sleep.1642

Crosby, Eric. S., & Witte, Tracy. K. (2021). A pilot study of sleep scholar: A single-session, internet-based insomnia intervention for college students with a history of suicide ideation. *Journal of American College Health*, *71*(7), 1984–1998. https://doi.org/10.1080/07448481.2021.1953028

de Wild-Hartmann, J. A., Wichers, M., van Bemmel, A. L., Derom, C., Thiery, E., Jacobs, N., van Os, J., & Simons, C. J. P. (2013). Day-to-day associations between subjective sleep and affect in regard to future depressionin a female population-based sample. *British Journal of Psychiatry*, *202*(6), 407–412. https://doi.org/10.1192/bjp.bp.112.123794

Falck, R. S., Barha, C. K., Chan, P. C. Y., & Liu-Ambrose, T. (2020). Refining sleep measurement using the MotionWatch8: How many days of monitoring do we need to get reliable estimates of sleep quality for older adults with mild cognitive impairment? *Sleep Science and Practice*, *4*, 11. https://doi.org/10.1186/s41606-020-00048-w

Gallo, J. J., Hwang, S., Truong, C., Reynolds, C. F., & Spira, A. P. (2020). Role of persistent and worsening sleep disturbance in depression remission and suicidal ideation among older primary care patients: The PROSPECT study. *Sleep*, *43*(10), zsaa063. https://doi.org/10.1093/sleep/zsaa063

Geoffroy, P. A., Oquendo, M. A., Courtet, P., Blanco, C., Olfson, M., Peyre, H., Lejoyeux, M., Limosin, F., & Hoertel, N. (2021). Sleep complaints are associated with increased suicide risk independently of psychiatric disorders: Results from a national 3-year prospective study. *Molecular Psychiatry*, *26*(6), 2126–2136. https://doi.org/10.1038/s41380-020-0735-3

Glenn, C. R., Kleiman, E. M., Kearns, J. C., Boatman, A. E., Conwell, Y., Alpert-Gillis, L. J., & Pigeon, W. (2021). Sleep problems predict next-day suicidal thinking among adolescents: A multimodal real-time monitoring study following discharge from acute psychiatric care. *Development and Psychopathology*, *33*(5), 1701–1721. https://doi.org/10.1017/S0954579421000699

Groeger, J. A., Lo, J. C.-Y., Santhi, N., Lazar, A. S., & Dijk, D.-J. (2022). Contrasting effects of sleep restriction, total sleep deprivation, and sleep timing on positive and negative effect. *Frontiers in Behavioral Neuroscience*, *16*, 911994. https://doi.org/10.3389/fnbeh.2022.911994

Harris, L. M., Huang, X., Linthicum, K. P., Bryen, C. P., & Ribeiro, J. D. (2020). Sleep disturbances as risk factors for suicidal thoughts and behaviours: A meta-analysis of longitudinal studies. *Scientific Reports*, *10*(1), 13888. https://doi.org/10.1038/s41598-020-70866-6

Holbrook, A. M., Crowther, R., Lotter, A., & Endeshaw, Y. (2001). The role of benzodiazepines in the treatment of insomnia meta-analysis of benzodiazepine use in the treatment of insomnia. *Journal of the American Geriatrics Society*, *49*(6), 824–826. https://doi.org/10.1046/j.1532-5415.2001.49161.x

Holding, B. C., Ingre, M., Petrovic, P., Sundelin, T., & Axelsson, J. (2021). Quantifying cognitive impairment after sleep deprivation at different times of day: A proof of concept using ultra-short smartphone-based tests. *Frontiers in Behavioral Neuroscience*, *15*, 666146. https://doi.org/10.3389/fnbeh.2021.666146

Jansson-Fröjmark, M., Harvey, A. G., & Flink, I. K. (2020). Psychometric properties of the Insomnia Catastrophizing Scale (ICS) in a large community sample. *Cognitive Behaviour Therapy*, *49*(2), 120–136. https://doi.org/10.1080/16506073.2019.1588362

Kalmbach, D. A., Cheng, P., Ahmedani, B. K., Peterson, E. L., Reffi, A. N., Sagong, C., Seymour, G. M., Ruprich, M. K., & Drake, C. L. (2022). Cognitive-behavioral therapy for insomnia prevents and alleviates suicidal ideation: insomnia remission is a suicidolytic mechanism. *Sleep*, *45*(12), zsac251. https://doi.org/10.1093/sleep/zsac251

Kivelä, L., Krause-Utz, A., Mouthaan, J., Schoorl, M., de Kleine, R., Elzinga, B., Eikelenboom, M., Penninx, B. W., van der Does, W., & Antypa, N. (2019). Longitudinal course of suicidal ideation and predictors of its persistence – A NESDA study. *Journal of Affective Disorders*, *257*, 365–375. https://doi.org/10.1016/j.jad.2019.07.042

Kivelä, L. M. M., Fiß, F., van der Does, W., & Antypa, N. (2023). Examination of acceptability, feasibility, and iatrogenic effects of ecological momentary assessment (EMA) of suicidal ideation. *Assessment*, 10731911231216052. https://doi.org/10.1177/10731911231216053

Krishnan, V., & Collop, N. A. (2006). Gender differences in sleep disorders. *Current Opinion in Pulmonary Medicine*, *12*(6), 383–389. https://doi.org/10.1097/01.mcp.0000245705.69440.6a

Kuo, W.-H., Gallo, JosephJ., & Eaton, WilliamW. (2004). Hopelessness, depression, substance disorder, and suicidality. *Social Psychiatry and Psychiatric Epidemiology*, *39*(6), 497–501. https://doi.org/10.1007/s00127-004-0775-z

Lehrer, H. M., Yao, Z., Krafty, R. T., Evans, M. A., Buysse, D. J., Kravitz, H. M., Matthews, K. A., Gold, E. B., Harlow, S. D., Samuelsson, L. B., & Hall, M. H. (2022). Comparing polysomnography, actigraphy, and sleep diary in the home environment: The Study of Women's Health Across the Nation (SWAN) sleep study. *Sleep Advances*, *3*(1), zpac001. https://doi.org/10.1093/sleepadvances/zpac001

Li, J., Vitiello, M. V, & Gooneratne, N. S. (2018). Sleep in Normal Aging. *Sleep Medicine Clinics*, *13*(1), 1–11. https://doi.org/10.1016/j.jsmc.2017.09.001

Littlewood, D. L., Gooding, P. A., Panagioti, M., & Kyle, S. D. (2016). Nightmares and suicide in posttraumatic stress disorder: The mediating role of defeat, entrapment, and hopelessness. *Journal of Clinical Sleep Medicine*, *12*(3), 393–399. https://doi.org/10.5664/jcsm.5592

Littlewood, D. L., Kyle, S. D., Carter, L. A., Peters, S., Pratt, D., & Gooding, P. (2019). Short sleep duration and poor sleep quality predict next-day suicidal ideation: An ecological momentary assessment study. *Psychological Medicine*, *49*(3), 403–411. https://doi.org/10.1017/S0033291718001009

Liu, R. T., Steele, S. J., Hamilton, J. L., Do, Q. B. P., Furbish, K., Burke, T. A., Martinez, A. P., & Gerlus, N. (2020). Sleep and suicide: A systematic review and meta-analysis of longitudinal studies. *Clinical Psychology Review*, *81*, 101895. https://doi.org/10.1016/j.cpr.2020.101895

Maglione, J. E., Ancoli-Israel, S., Peters, K. W., Paudel, M. L., Yaffe Md, K., Ensrud, K. E., & Stone, K. L. (2012). Depressive symptoms and subjective and objective sleep in community-dwelling older women. *Journal of the American Geriatrics Society*, *60*(4), 635–643. https://doi.org/10.1111/j.1532-5415.2012.03908.x

Manconi, M., Ferri, R., Miano, S., Maestri, M., Bottasini, V., Zucconi, M., & Ferini-Strambi, L. (2017). Sleep architecture in insomniacs with severe benzodiazepine abuse. *Clinical Neurophysiology*, *128*(6), 875–881. https://doi.org/10.1016/j.clinph.2017.03.009

McCall, W. V., Benca, R. M., Rosenquist, P. B., Youssef, N. A., McCloud, L., Newman, J. C., Case, D., Rumble, M. E., Szabo, S. T., Phillips, M., & Krystal, A. D. (2019). Reducing Suicidal Ideation Through Insomnia Treatment (REST-IT): A randomized clinical trial. *American Journal of Psychiatry*, *176*(11), 957–965. https://doi.org/10.1176/appi.ajp.2019.19030267

McCall, W. V., & Black, C. G. (2013). The link between suicide and insomnia: Theoretical mechanisms. *Current Psychiatry Reports*, *15*(9), 389. https://doi.org/10.1007/s11920-013-0389-9

McCrae, C. S., McNamara, J. P. H., Rowe, M. A., Dzierzewski, J. M., Dirk, J., Marsiske, M., & Craggs, J. G. (2008). Sleep and affect in older adults: Using multilevel modeling to examine daily associations. *Journal of Sleep Research*, *17*(1), 42–53. https://doi.org/10.1111/j.1365-2869.2008.00621.x

Medic, G., Wille, M., & Hemels, M. (2017). Short- and long-term health consequences of sleep disruption. *Nature and Science of Sleep*, *9*, 151–161. https://doi.org/10.2147/NSS.S134864

Morin, C. M., Belleville, G., Bélanger, L., & Ivers, H. (2011). The Insomnia Severity Index: Psychometric indicators to detect insomnia cases and evaluate treatment response. *Sleep*, *34*(5), 601–608.

O'Hare, E., Flanagan, D., Penzel, T., Garcia, C., Frohberg, D., & Heneghan, C. (2015). A comparison of radio-frequency biomotion sensors and actigraphy versus polysomnography for the assessment of sleep in normal subjects. *Sleep and Breathing*, *19*(1), 91–98. https://doi.org/10.1007/s11325-014-0967-z

Pigeon, W. R., Pinquart, M., & Conner, K. (2012). Meta-analysis of sleep disturbance and suicidal thoughts and behaviors. *The Journal of Clinical Psychiatry*, *73*(09), e1160–e1167. https://doi.org/10.4088/JCP.11r07586

Posner, K., Brown, G. K., Stanley, B., Brent, D. A., Yershova, K. V., Oquendo, M. A., Currier, G. W., Melvin, G. A., Greenhill, L., Shen, S., & Mann, J. J. (2011). The Columbia–Suicide Severity Rating Scale: Initial validity and internal consistency findings from three multisite studies with adolescents and adults. *American Journal of Psychiatry*, *168*(12), 1266–1277. https://doi.org/10.1176/appi.ajp.2011.10111704

Ritchie, H. K., Knauer, O. A., Guerin, M. K., Stothard, E. R., & Wright, K. P. (2018). Both positive and negative affect are impacted by sleep deprivation. *Sleep*, *41 Suppl 1*, A72. https://academic.oup.com/sleep/article/41/suppl_1/A72/4988219

Robotham, D. (2011). Sleep as a public health concern: Insomnia and mental health. *Journal of Public Mental Health*, *10*(4), 234–237. https://doi.org/10.1108/17465721111188250

Romier, A., Maruani, J., Lopez-Castroman, J., Palagini, L., Serafini, G., Lejoyeux, M., d'Ortho, M.-P., & Geoffroy, P. A. (2023). Objective sleep markers of suicidal behaviors in patients with psychiatric disorders: A systematic review and meta-analysis. *Sleep Medicine Reviews*, *68*, 101760. https://doi.org/10.1016/j.smrv.2023.101760

Roth, T. (2009). Slow wave sleep: does it matter? *Journal of Clinical Sleep Medicine, 5*(2 Suppl), S4-S5.

Sadeh, A. (2011). The role and validity of actigraphy in sleep medicine: An update. *Sleep Medicine Reviews*, *15*(4), 259–267. https://doi.org/10.1016/j.smrv.2010.10.001

Sahlem, G. L., Kalivas, B., Fox, J. B., Lamb, K., Roper, A., Williams, E. N., Williams, N. R., Korte, J. E., Zuschlag, Z. D., El Sabbagh, S., Guille, C., Barth, K. S., Uhde, T. W., George, M. S., & Short, E. B. (2014). Adjunctive triple chronotherapy (combined total sleep deprivation, sleep phase advance, and bright light therapy) rapidly improves mood and suicidality in suicidal depressed inpatients: An open label pilot study. *Journal of Psychiatric Research*, *59*, 101–107. https://doi.org/10.1016/j.jpsychires.2014.08.015

Sheehan, D. V, Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T., Baker, R., & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *The Journal of Clinical Psychiatry*, *59 Suppl 20*, 22–57.

Shrivastava, D., Jung, S., Saadat, M., Sirohi, R., & Crewson, K. (2014). How to interpret the results of a sleep study. *Journal of Community Hospital Internal Medicine Perspectives*, *4*(5), 24983. https://doi.org/10.3402/jchimp.v4.24983

Simmons, Z., Erickson, L. D., Hedges, D., & Kay, D. B. (2020). Insomnia is associated with frequency of suicidal ideation independent of depression: A replication and extension of findings from the National Health and Nutrition Examination Survey. *Frontiers in Psychiatry*, *11*, 561564. https://doi.org/10.3389/fpsyt.2020.561564

Staner, L. (2003). Sleep and anxiety disorders. *Dialogues in Clinical Neuroscience*, *5*(3), 249–258. https://doi.org/10.31887/DCNS.2003.5.3/lstaner

Stein, M. A., Weiss, M., & Hlavaty, L. (2012). ADHD treatments, sleep, and sleep problems: Complex associations. *Neurotherapeutics*, *9*(3), 509–517. https://doi.org/10.1007/s13311-012-0130-0

Sylvia, L. G., Janos, J. A., Pegg, S. L., Montana, R. E., Gold, A. K., Bianchi, M., & Nierenberg, A. A. (2021). Pilot study of a brief sleep intervention for suicidal ideation in bipolar disorder. *Journal of Psychiatric Practice*, *27*(2), 109–114. https://doi.org/10.1097/PRA.0000000000000528

Triantafillou, S., Saeb, S., Lattie, E. G., Mohr, D. C., & Kording, K. P. (2019). Relationship between sleep quality and mood: Ecological momentary assessment study. *JMIR Mental Health*, *6*(3), e12613. https://doi.org/10.2196/12613

Varga, A. W., Ducca, E. L., Kishi, A., Fischer, E., Parekh, A., Koushyk, V., Yau, P. L., Gumb, T., Leibert, D. P., Wohlleber, M. E., Burschtin, O. E., Convit, A., Rapoport, D. M., Osorio, R. S., & Ayappa, I. (2016). Effects of aging on slow-wave sleep dynamics and human spatial navigational memory consolidation. *Neurobiology of Aging*, *42*, 142–149. https://doi.org/10.1016/j.neurobiolaging.2016.03.008

Wichniak, A., Wierzbicka, A., Walęcka, M., & Jernajczyk, W. (2017). Effects of antidepressants on sleep. *Current Psychiatry Reports*, *19*(9), 63. https://doi.org/10.1007/s11920-017-0816-4

Winsper, C., & Tang, N. K. Y. (2014). Linkages between insomnia and suicidality: Prospective associations, high-risk subgroups and possible psychological mechanisms. *International Review of Psychiatry*, *26*(2), 189–204. https://doi.org/10.3109/09540261.2014.881330

Woosley, J. A., Lichstein, K. L., Taylor, D. J., Riedel, B. W., & Bush, A. J. (2014). Hopelessness mediates the relation between insomnia and suicidal ideation. *Journal of Clinical Sleep Medicine*, *10*(11), 1223–1230. https://doi.org/10.5664/jcsm.4208

Zhang, Y., Law, C. K., & Yip, P. S. F. (2011). Psychological factors associated with the incidence and persistence of suicidal ideation. *Journal of Affective Disorders*, *133*(3), 584–590. https://doi.org/10.1016/j.jad.2011.05.003

Appendix

Table S1. Sociodemographic and Clinical Characteristics of the Sample

	EMA *N* = 82	Actigraphy *n* = 61	N/A *n* = 21	*t*-test / Chi-Square (df)	*p*-value
Age (M, SD)	27 (8.6)	28 (8.6)	25 (7.8)	−1.59 (80)	.116
Gender - Female (*N*, %)	63 (77%)	45 (74%)	18 (86%)	1.87 (2)	.393
Depressive symptom severity (BDI) (*M, SD*)	25.5 (9.6)	25.3 (10.2)	26.4 (7.6)	0.40 (69)	.917
Suicidal ideation severity (BSSI) (*M, SD*)	15.3 (8.6)	15.4 (8.7)	15.1 (8.7)	−0.10 (69)	.689
Suicidal ideation (EMA) (*M, SD*)	3.1 (2.0)	2.9 (2.0)	3.4 (1.8)	0.86 (80)	.395
Current diagnoses (*N*, %)					
Depressive disorder	63 (77%)	48 (79%)	11 (52%)	1.05 (1)	.313
Anxiety disorder	47 (57%)	33 (54%)	14 (67%)	0.87 (1)	.444
PTSD	18 (22%)	10 (16%)	8 (38%)	4.13 (1)	.065
OCD	7 (9%)	6 (10%)	1 (5%)	0.54 (1)	.670
ADHD	10 (12%)	6 (10%)	4 (19%)	1.18 (1)	.275
Medication (*N*, %)					
Sedatives	20 (24%)	16 (26%)	4 (19%)	0.44 (1)	.509
Stimulants	10 (12%)	6 (10%)	4 (19%)	1.23 (1)	.266
Antidepressants	33 (40%)	27 (44%)	6 (29%)	1.60 (1)	.206
Concurrent medical diagnosis (*N*, %)	35 (43%)	28 (46%)	7 (33%)	1.00 (1)	.315
Non-psychoactive medication	26 (32%)	19 (31%)	7 (33%)	0.03 (1)	.853
Insomnia severity (ISI)	11.8 (5.0)	11.8 (5.4)	11.8 (3.5)	−0.04 (69)	.972

Note: EMA = Ecological Momentary Assessment, N/A = actigraphy data not available, BDI = Beck Depression Inventory, BSSI = Beck Scale for Suicide Ideation, PTSD = Post-traumatic stress disorder, OCD = Obsessive compulsive disorder, ADHD = Attention deficit hyperactivity disorder, ISI = Insomnia Severity Index; statistics are reported for group comparisons between those with and without actigraphy data

Table S2. Multilevel Regression of Suicidal Ideation on Subjective and Objective Sleep Parameters the Following-Night

	B	*SE*	95% CI	*p*-value
EMA				
Subjective sleep quality (SSQ)	−0.005	0.047	[−0.098; 0.088]	.923
Sleep efficiency (SE)	−0.298	0.268	[−0.824; 0.228]	.266
Total sleep time (TST)	1.050	2.121	[−3.112; 5.212]	.621
Sleep onset latency (SOL)	1.188	0.673	[−0.132; 2.508]	.078
Wake after sleep onset (WASO)	0.218	0.823	[−1.397; 1.833]	.792
Nightmares*	0.028	0.059	[−0.088; 0.144]	.634
Actigraphy				
Fragmentation index (FI)	0.382	0.284	[−.175; 0.939]	.178
Sleep efficiency (SE)	−0.025	0.210	[−0.437; 0.387]	.905
Total sleep time (TST)	3.362	2.066	[−0.691; 7.415]	.104
Sleep onset latency (SOL)	0.248	0.585	[−0.899; 1.395]	.671
Wake after sleep onset (WASO)	0.126	0.691	[−1.231; 1.482]	.856

Note: Sleep characteristics are the outcome; EMA = Ecological Momentary Assessment; significance was determined at $p < .005$; *based on a multilevel binary logistic regression analysis

Table S3. Multilevel Mediation Analyses of Hopelessness in the Relation Between Subjective and Objective Sleep Parameters and Next-Day Suicidal Ideation, Controlling for Previous-Day Suicidal Ideation

	B	*SE*	95% CI	*p*-value
EMA				
Subjective sleep quality (SSQ)				
Path a	−0.257	0.026	[−0.308; −0.206]	< .001
Path b	0.167	0.012	[0.143; 0.192]	< .001
Path c	−0.090	0.012	[−0.114; −0.066]	< .001
Path c’	−0.047	0.012	[−0.070; −0.023]	< .001
Sleep efficiency (SE)				
Path a	−0.025	0.005	[−0.035; −0.016]	< .001
Path b	0.179	0.013	[0.154; 0.204]	< .001
Path c	−0.008	0.002	[−0.012; −0.003]	< .001
Path c’	−0.003	0.002	[−0.008; −0.001]	.114
Total sleep time (TST)				
Path a	−0.003	0.001	[−0.004; −0.001]	< .001
Path b	0.178	0.012	[0.153; 0.202]	< .001
Path c	−0.001	0.001	[−0.002; −0.001]	< .001
Path c’	−0.001	0.001	[−0.001; −0.001]	.004
Wake after sleep onset (WASO)				
Path a	0.008	0.002	[0.005; 0.011]	< .001
Path b	0.176	0.012	[0.152; 0.200]	< .001
Path c	0.003	0.001	[0.001; 0.004]	< .001
Path c’	0.001	0.001	[−0.001; 0.003]	.037
Fragmentation index (FI)				
Path a	0.009	0.006	[−0.004; 0.021]	.163
Path b	0.176	0.014	[0.001; 0.011]	< .001
Path c	0.007	0.003	[0.002; 0.012]	.004
Path c’	0.006	0.003	[0.001; 0.11]	.013

Note: EMA = Ecological Momentary Assessment; significance was determined at $p < .005$

CHAPTER 06:

Suicide Attempt

Digital Phenotypes of Real-Time Suicidal Ideation: Correlates and Consequences

Published as:

Kivelä, L., van der Does, W., Gilissen, R., & Antypa, N. (2024). Digital Phenotypes of Real-Time Suicidal Ideation: Correlates and Consequences. *Acta Psychiatrica Scandinavica.* https://doi.org/10.1111/acps.13750

Abstract

Background: Suicidal ideation variability refers to within-day fluctuations in suicidal ideation, and has recently been proposed as an indicator of suicide risk. However, not much is known yet about its correlates and clinical relevance. **Methods:** We examined characteristics of real-time suicidal ideation using Ecological Momentary Assessment (EMA) in 82 individuals with current active suicidal ideation. Data were collected four times daily over 21 days. Latent profile analysis was used to identify subtypes of suicidal ideation. We further examined sociodemographic and clinical correlates of the profiles, and their association with the occurrence of suicide attempts during a one-year follow-up. **Results:** We identified three 'digital' phenotypes of suicidal ideation that differed on the frequency, intensity and variability of ideation. The profiles were: high frequency, high intensity, moderate variability (Phenotype 1), moderate/high frequency, moderate intensity, high variability (Phenotype 2) and moderate frequency, low intensity, low variability (Phenotype 3). Phenotypes 1 and 2 were associated with a worse clinical profile at baseline (higher suicidal ideation and depressive symptom severity), and increased odds of suicide attempt during follow-up, compared to Phenotype 3. Phenotype 1 was further characterized by repeated suicidal behavior. **Conclusions:** Two phenotypes of real-time suicidal ideation were identified that appear to confer a higher risk of suicidal behavior in the near future (12 months). These phenotypes were characterized by higher variability of suicidal ideation – and also higher intensity and frequency of ideation. Considering the small sample size, the clinical usefulness of the profiles remains to be demonstrated.

Introduction

Suicidal ideation can fluctuate greatly in daily life, both between individuals, but also within individuals over time. Recent studies employing real-time measures (such as Ecological Momentary Assessment, EMA; Shiffman et al., 2008) have illustrated how these moment-to-moment changes can be observed in suicidal ideation (see Kivelä et al., 2022 for a review). These studies have illustrated sizeable fluctuations in suicidal ideation over time. For example, among 54 individuals with a recent suicide attempt who completed EMA four times per day over 28 days, approximately one third of suicidal ideation ratings differed from the previous time point by at least one standard deviation, without clear linear changes over time (Kleiman et al, 2017). Others have presented similar results on the temporal dynamics of suicidal ideation (Hallensleben et al., 2018). These findings illustrate how the transition from low- to high-intensity states may happen within just a few hours.

Identifying those with greater suicidal ideation variability is especially relevant, as indices of variability may provide important information about an individual's risk status. It has been proposed that higher suicidal ideation variability may represent a phenotypic marker for increased suicide risk (Oquendo et al., 2020; Wang et al., 2021). Witte and colleagues (2005, 2006) previously reported evidence of suicidal ideation variability being related to a prior history of suicide attempts. This finding has since been replicated using real-time data, whereby those with multiple past suicide attempts (vs. single attempt) exhibited higher suicidal ideation variability (Peters et al., 2020). More recently, temporal variability in suicidal ideation (as measured through EMA during hospitalization) was found to be a better predictor of post-discharge suicide attempt than baseline sociodemographic or clinical characteristics, or EMA-measured suicidal ideation intensity (Wang et al., 2021). Explanations for the association between variability and heightened risk status include that individuals may find variability more distressing than stable symptomatology, even when more severe (Witte et al., 2006). Consequently, understanding which individuals are more likely to experience greater variability may be relevant to prevent suicide attempts and mortality.

Individuals with higher (EMA-measured) mean suicidal ideation scores also have higher variability (Kleiman et al., 2017; Oquendo et al., 2020). However, suicidal ideation variability was found to relate neither to baseline depression nor suicidal ideation severity (Hallensleben et al., 2018). While suicidal ideation variability (as measured with EMA) was found to relate to EMA-measured depressed mood variability, it did not associate with baseline characteristics, such as general affective lability, or depression or suicidal ideation severity (Peters et al., 2020). Consequently, our understanding of suicidal ideation variability is still limited.

The increased application of EMA in suicide research has resulted in a potential new indicator of increased risk: suicidal ideation variability. However, prior research has also identified other predictors of future suicidal behavior, such as the intensity (Nock et al., 2008), frequency (Chang & Chang, 2016) and peak-level of ideation (Beck et al., 1999; Law et al., 2018). For example, while it is understood that the risk of future suicidal behavior increases as the intensity of ideation increases (Nock et al., 2008), it has also been found that suicidal ideation at its worst point (i.e., peak level) may be a stronger predictor of suicide attempt than its average intensity (Beck et al., 1999; Law et al., 2018). Likewise, those with more frequent thoughts about suicide experience heightened risk for future suicidal behavior (Chang & Chang, 2016). These dynamics are interconnected, and should not be considered in isolation. For example, individuals with high or low mean intensity of ideation may show less variability due to floor and ceiling effects (Bos, 2021).

Profiling based on electronically-collected data on these suicidal ideation dynamics has been called *digital phenotyping* of suicidal ideation (Ballard et al., 2021; Kivelä et al., 2022; Kleiman et al., 2017). Examining these dynamics, no less than five phenotypes of suicidal ideation were observed in a sample of 51 individuals with a recent suicide attempt: these phenotypes were characterized by low intensity, low variability (Type 1), low intensity, moderate variability (Type 2), moderate intensity, high variability (Type 3), high intensity, low variability (Type 4), and high intensity, high variability (Type 5) (Kleiman et al., 2018). While others have also observed heterogeneity in the short-term dynamics of suicidal ideation (Hallensleben et al., 2018; Rizk et al., 2019), the suicidal ideation phenotypes have not yet been replicated.

In the present study, we examined suicidal ideation through EMA, four times per day, over 21 days. Our aim was to examine whether distinct subtypes (i.e., digital phenotypes) would emerge when considering dynamics of real-time suicidal ideation. Our methodology was based on the prior study by Kleiman et al. (2018), who created digital phenotypes based on EMA-measured suicidal ideation intensity (i.e., mean), frequency (i.e., % of non-zero ratings), peak (i.e., highest score recorded) and variability (as depicted by the within-person standard deviation, as well as the root mean square of successive differences (RMMSD)). Our aim was to replicate and further extend on this phenotyping approach by considering aspects of both passive and active suicidal ideation (as the previous study was focused on active ideation and intent only), in line with recommendations that comprehensive suicide risk assessments should include both constructs (Wastler et al., 2023). Further, we examined which sociodemographic and clinical characteristics were related to these phenotypes, and whether there were differences between the phenotypes in their associated odds of making a suicide attempt during a one-year follow-up.

Methods

Participants

Participants (*N* = 82) were adults with a recent (past year) history of a suicide attempt and/or active suicidal ideation (Columbia Suicide Severity Rating Scale (CSSRS) (Posner et al., 2011) >= 3, or >= 2 if symptoms present in the past two months). Participants were recruited through referral from collaborating mental health treatment centers, as well as community advertisements. Participants were excluded in case of current bipolar disorder, a psychotic disorder or severe substance dependence; as the present study was designed to examine short-term (hourly, daily) fluctuations in suicidal ideation, we excluded patients with disorders that are episodic in nature (such as bipolar and psychotic disorders), where such fluctuations may be markedly different depending on episode status. Likewise, extended time periods characterized by substance intoxication may introduce similar confounding effects (for more details, see Kivelä et al., 2023). Participants received 20€ compensation after completing the 21-day EMA period, and a further 30€ after completing the one-year follow-up period, as well as compensation for travel costs (if applicable).

Measures

Baseline Characteristics A custom semi-structured interview was used to assess participants' age and gender, lifetime history of psychiatric disorders, and current use of psychoactive prescription medication. An adapted version of the CSSRS (Posner et al., 2011), comprised of the first five questions and with additional items included on participants' lifetime history of suicide attempt(s), was used to assess history of suicidal thoughts and behaviors. The M.I.N.I. PLUS International Neuropsychiatric Interview (v. 5) (Sheehan et al., 1998) and the Structured Clinical Interview for DSM-5 Personality Disorders – Borderline Personality Disorder subscale (SCID-PD-BPD) (First, 2015) were used to establish current diagnoses. Self-report questionnaires assessed symptom severity of psychopathology: the Beck Depression Inventory (BDI-I) (Beck, 1961), the Beck Scale for Suicide Ideation (BSSI) (Beck et al., 1979), and the Hospital Anxiety and Depression Scale – Anxiety Subscale (HADS-A) (Zigmond & Snaith, 1983). Participants further completed the Quality of Life Enjoyment and Satisfaction Questionnaire – Short Form (Q-LES-Q-SF) (Endicott et al., 1993), the Leiden Index of Depression Sensitivity –

Revised (LEIDS-R) (Solis et al., 2017) and the State-Trait Anger Expression Inventory – Trait Anger Scale (STAXI-T) (Zigmond & Snaith, 1983).

Ecological Momentary Assessment (EMA) Data on momentary suicidal ideation were gathered through 4x/day EMA over 21-days. Two items were used to measure passive suicidal ideation *("At the moment... How strong is your desire to live? How strong is your desire to die, or go to sleep and not wake up?"*), and two to measure active ideation (*"At the moment... Do you actually have thoughts of killing yourself? How strong is your intention to act on these thoughts?"*). All items were rated from 0 (None/Not at all) to 10 (Very strong/Very much) (positively worded items were reverse coded). Mean scores were created for each outcome (passive/active suicidal ideation).

Suicide Attempts Data on suicide attempts were gathered through a weekly questionnaire during 12 months. Participants indicated whether they had made a suicide attempt during the previous week (*"Did you make a suicide attempt? Yes/No"*). An aggregate variable was created to indicate whether a participant had a suicide attempt during the 12-month follow-up (0 = no, 1 = yes).

Procedure

Intake Interview Participants attended an intake interview during which they received information about the study, and provided written informed consent and data on their sociodemographic and clinical characteristics. After establishing eligibility, personalized safety plans were created for each participant.

Baseline Assessment Following the intake interview (which could be done online or in-person, depending on the participant's preference), participants received a link to an online questionnaire they were instructed to fill in within 72 hours (see *Measures: Baseline characteristics*).

21-Day Ecological Momentary Assessment (EMA) The EMA period commenced the day after the intake interview. Participants received alerts 4x/day through a mobile phone app (*Avicenna (Ethica)*, avicennaresearch.com) on a pseudorandom schedule between 7am and 10pm. Participants had 180 minutes to fill in the first (i.e., morning) assessment, and 120 minutes to fill in the remaining assessments during the day; a reminder alert was sent out after 30 minutes in case the participant had not yet filled in the EMA. Participants could also initiate additional entries at any time (e.g., after missing an entry, or when experiencing high/low suicidal ideation). Eighty-one participants (99%) completed the 21-day EMA period (*nb.* prior to withdrawing, the participant who dropped out of the study during the EMA period provided EMA comparable in number to the range observed among the completers (k = 16, range among completers k = 16-88), and was hence retained in the present analyses).

Weekly Questionnaire After the 21-day EMA, participants who agreed to continue into the second phase of the study (n = 72, 88%) commenced a 12-month monitoring period during which they filled in a digital questionnaire 1x/week. Each questionnaire was released on a Sunday (using the *Avicenna (Ethica)* app), and participants had 48 hours to fill it in; reminder alerts were sent out after 12, 24 and 36 hours.

Statistical Analysis

We calculated intraclass correlation coefficients (ICC) to quantify within- versus between-person variability, and RMMSD to examine moment-to-moment variability in suicidal ideation. The ICC estimates correlation within repeated measures (Liljequist et al., 2019). Higher ICC scores indicate that a greater amount of the total variation is attributable to between-personal variation (with 1-ICC indicating the proportion of within-person variability). The RMMSD estimates variability over time based on the difference between successive observations within an individual (von Neumann et al., 1941) and has previously been applied to quantify short-term variability in affect (Bos et al., 2019) and suicidal ideation (Rizk et al., 2019), as in the previous study by Kleiman et al. (2018). For calculating the RMMSD, we did not remove rows with missing data, ensuring that successive differences were only calculated between two adjacent time points (as also previously done by e.g., Bos et al., 2019).

In IBM SPSS Statistics (v.29), we fitted intercept-only linear-mixed models with suicidal ideation as outcome to estimate ICCs. The *psych* package (Revelle, 2023) for R (R Core Team, 2016) was used to calculate RMMSD values, and *ggplot2* (Wickham, 2016) to create time-series plots to visualize variability. The *mclust* package (Scrucca et al., 2016) was used to perform latent profile analysis (LPA) in order to identify phenotypes of suicidal ideation. We used ten within-person characteristics of real-time suicidal ideation to distinguish the phenotypes: mean of passive (1) and active ideation (2); standard deviation of passive (3) and active ideation (4); peak (i.e., highest score recorded) of passive (5) and active ideation (6); frequency (i.e., percentage of non-zero ratings) of passive (7) and active suicidal (8); and RMSSD of passive (9) and active ideation (10). These characteristics were based on Kleiman et al., 2018, but further extended to include estimates of both passive and active suicidal ideation, in line with findings indicating different temporal patterns for different components of ideation (Oakey-Frost et al., 2023). The within-person standard deviation and the RMSSD were both used as measures of variability (and collectively referred to as such within the present paper). To further specify, the within-person standard deviation depicts average within-person variability over time (i.e., dispersion), while the RMMSD captures the temporal dynamics of short-term change (i.e., instability) (Bos et al., 2019; Dejonckheere et al., 2019). The optimal number of latent profiles was determined based on model fit (the Bayesian Information Criterion (BIC) and the Bootstrapped Likelihood Ratio Test (BLRT) with 1,000 resamples) and entropy (i.e., a measure of separation between profiles which estimates the accuracy of classification) (Sinha et al., 2021). Analyses of variance (ANOVAs) and Chi-square tests were used to examine differences between phenotypes in suicidal ideation and baseline characteristics. Fisher's exact test was used to examine differences in the occurrence of suicide attempts during follow-up. Significance was determined at $p < .05$.

Table 1. Fit Statistics from Latent Profile Analysis (LPA)

	BIC	Entropy	k – 1 BLRT
1 Profile	−2880.00	0.00	-
2 Profile	−2526.03	0.95	751.00, $p < .001$
3 Profile	−2481.03	1.55	359.10, $p < .001$
4 Profile	−2693.27	1.85	602.47, $p < .001$
5 Profile	−2707.86	2.13	377.42, $p < .001$
6 Profile	−2793.31	2.42	1001.26, $p < .001$

Note: BLRT = Bootstrapped likelihood ratio test between two successive models (# profiles – 1)

Table 2. Profile Membership from Latent Profile Analysis (LPA)

	1	2	3	4	5	6
1 Profile	82 (100%)					
2 Profile	52 (63%)	30 (37%)				
3 Profile	20 (24%)	27 (33%)	35 (43%)			
4 Profile	26 (32%)	24 (29%)	26 (32%)	6 (7%)		
5 Profile	25 (30%)	24 (29%)	19 (23%)	5 (6%)	9 (11%)	
6 Profile	17 (21%)	24 (29%)	18 (22%)	6 (7%)	8 (10%)	9 (11%)

Note: Individual class probabilities for the 3 profile solution are included in the Appendix

Results

Descriptives

The sample (N = 82) was predominantly female (77%), with a mean age of 27 (SD = 8.6). Participants on average filled in M = 63 (78%) of the scheduled EMA entries[1] and M = 3 additional entries, resulting in M = 66 entries completed on average per person. During the one-year follow-up, participants (n = 72) on average filled in M = 34 (65%) of the weekly questionnaires. Thirty-six participants had sufficient data to be included in the prospective analyses on suicide attempts i.e., either reported a suicide attempt (n = 7), and/or completed the study assessments up until the end of the one-year follow-up (n = 29); participants lost to follow-up (and who did not report a suicide attempt prior) were excluded in order to ascertain that we would not incorrectly classify any non-responders as non-suicide attempters. Those excluded did not significantly differ from those included on age, gender, baseline depressive symptoms, past suicide attempt history, or phenotype classification (all p's > .05), but had lower baseline suicidal ideation (M_{inlcuded} = 18.0 vs. M_{excluded} = 13.0, p = .014).

Table 3. Characteristics and Subtypes of Real-Time Suicidal Ideation

	OVERALL (N = 82)	TYPE 1 (n = 20)	TYPE 2 (n = 27)	TYPE 3 (n = 35)	ANOVA	p-value
M, Passive	2.93	5.25_a	3.37_b	1.26_c	69.29	< .001
M, Active	1.20	3.49_a	0.89_b	0.11_c	66.52	< .001
SD, Passive	1.21	1.21_a	1.77_b	0.77_c	75.79	< .001
SD, Active	0.97	1.33_a	1.46_a	0.37_b	43.43	< .001
Peak, Passive	6.46	8.02_a	8.01_a	4.38_b	51.61	< .001
Peak, Active	4.51	6.58_a	6.00_a	2.17_b	39.33	< .001
% non-zero, Passive	90.8	99.9_a	96.2_a	81.3_b	7.85	< .001
% non-zero, Active	37.4	95.2_a	33.6_b	7.2_c	308.49	< .001
RMSSD, Passive	1.36	1.23_a	1.87_b	1.04_a	23.97	< .001
RMSSD, Active	1.00	1.33_a	1.49_a	0.42_b	26.75	< .001

Note: M = Mean, *SD* = Standard deviation, RMMSD = Root mean square of successive differences; subscript letters denote groups that significantly differ from each other based on p < .05

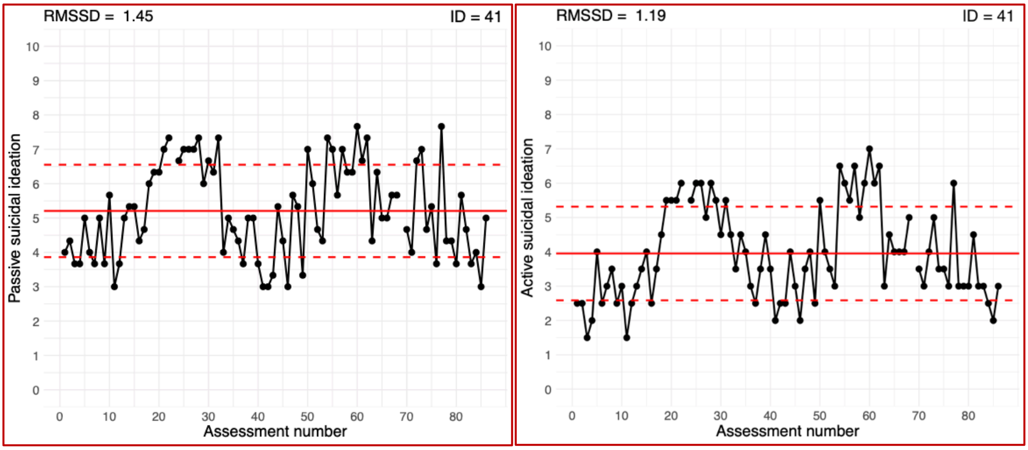
[1] Participants filled in four daily assessments per day for the first 20 days, as well as a final morning assessment on day 21, resulting in a total of 81 scheduled prompts.

Figure 1. A Graphical Overview of the Defining Features of the Phenotypes

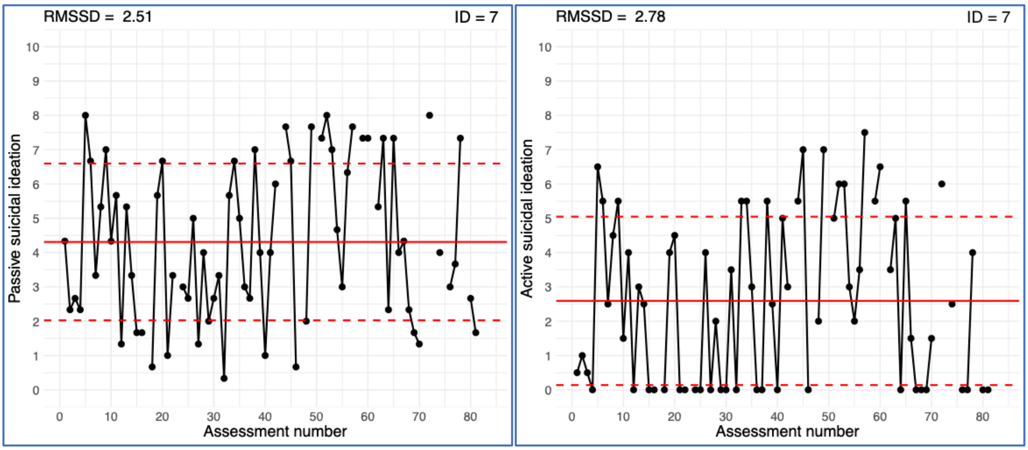
(a) Table classification

	Phenotype 1	Phenotype 2	Phenotype 3
Frequency	High	Moderate/High	Moderate
Intensity	High	Moderate	Low
Variability	Moderate	High	Low

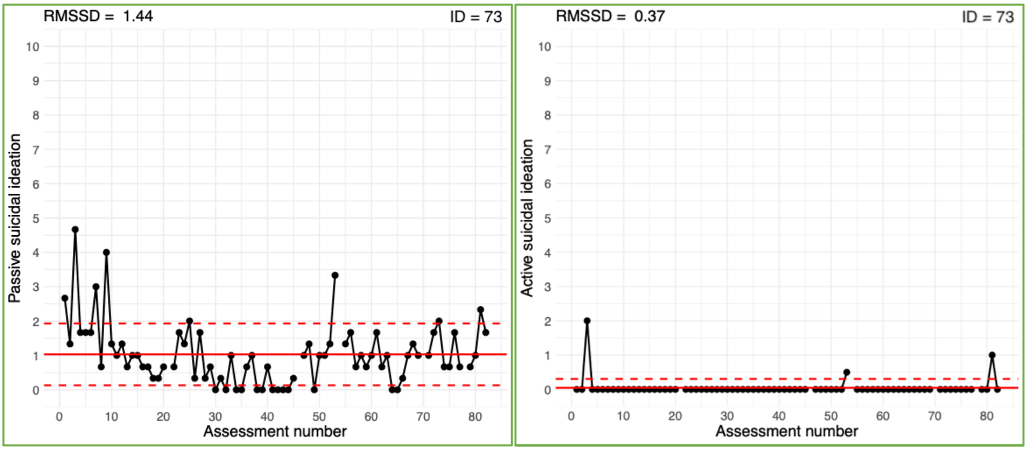
(b) Example of Phenotype 1



(c) Example of Phenotype 2



(d) Example of Phenotype 3



Note: Time-series plots indicate the person-mean (solid red line) and standard deviation around the mean (dashed red lines); the RMSSD (root mean square of successive differences) indicates within-person variability; frequency is inferred by scores > zero; Phenotype 1 is represented in red, Phenotype 2 in blue, and Phenotype 3 in green; ID numbers do *not* correspond to participant numbers assigned during data collection

Descriptive statistics for suicidal ideation are presented in Table 3 (correlations and reliability statistics can be found in the Appendix). Passive suicidal ideation had a higher mean and greater within-person variability (RMSSD) than active ideation. ICCs indicated that 70% of the variation in passive, and 67% of the variation in active suicidal ideation, was attributable to between-person variability.

Latent Profile Analysis of Suicidal Ideation

We estimated model fit for solutions with 1, 2, 3, 4, 5 and 6 profiles, respectively (Table 1). The BLRT and entropy values indicated improved fit with each successive model. However, the BIC indicated best fit for the model with three profiles. As entropy values may be inflated in overfitted models, we decided to rely on the BIC and chose the three profile solution. This solution also provided group sizes that were approximately equal, whereas the additional profiles only accounted for <=10% of the sample each (Table 2).

Differences in suicidal ideation characteristics between the phenotypes are presented in Table 3. Figure 1 presents a graphical overview of the defining features of the phenotypes (a), as well as time-series plots for example participants from Phenotype 1 (b), Phenotype 2 (c) and Phenotype 3 (d) (see Appendix for all time-series plots).

Table 4. Sociodemographic and Clinical Correlates of Suicidal Ideation Subtypes

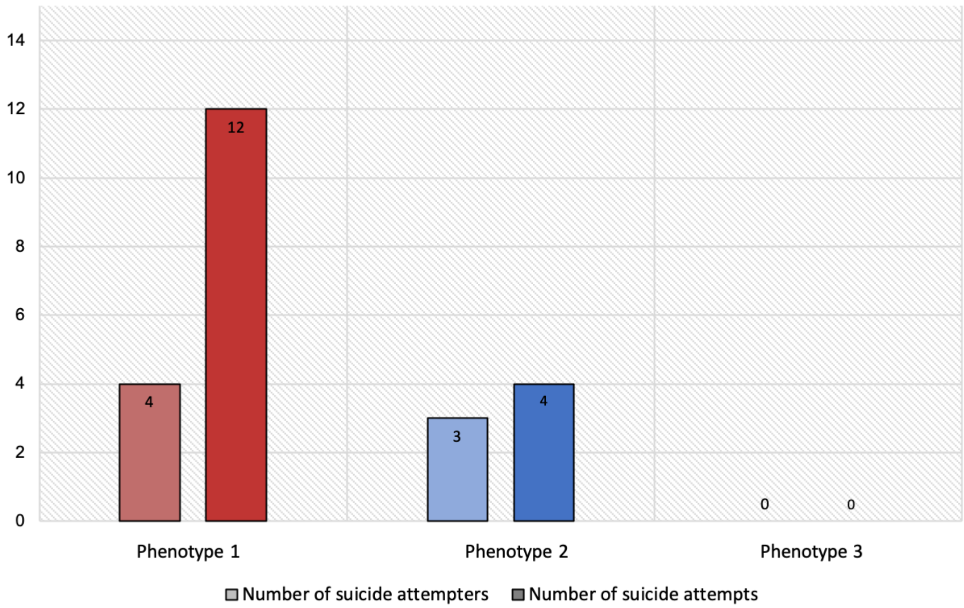
	OVERALL (N = 82)	**TYPE 1** (n = 20)	**TYPE 2** (n = 27)	**TYPE 3** (n = 35)	ANOVA / Chi-square	p-value
Age	27.2	27.5_a	25.5_a	28.3_a	0.88	.420
Gender, Female	63 (77%)	16 (80%)$_a$	18 (67%)$_a$	29 (83%)$_a$	2.39	.302
Diagnosis						
MDD	41 (50%)	14 (70%)$_a$	19 (70%)$_a$	8 (23%)$_b$	17.20	< .001
Anxiety disorders	47 (57%)	13 (65%)$_a$	18 (67%)$_a$	16 (46%)$_a$	2.91	.234
PTSD	18 (22%)	8 (40%)$_a$	7 (26%)$_{ab}$	3 (9%)$_b$	7.40	.025
BPD	12 (15%)	2 (10%)$_a$	6 (22%)$_a$	4 (11%)$_a$	1.79	.408
OCD	7 (9%)	0 (0%)$_a$	3 (11%)$_a$	4 (11%)$_a$	2.52	.284
ADHD	10 (12%)	2 (10%)$_a$	5 (19%)$_a$	3 (9%)$_a$	1.44	.486
ASD	14 (17%)	6 (30%)$_a$	4 (15%)$_a$	4 (11%)$_a$	3.26	.197
Comorbidity	57 (70%)	17 (85%)$_a$	23 (85%)$_a$	17 (49%)$_b$	11.66	.003
Symptom severity						
BSSI	15.3	22.5_a	15.8_b	10.5_c	15.32	< .001
BDI	25.5	32.3_a	27.3_a	19.9_b	13.38	< .001
HADS-A	11.5	13.3_a	11.5_{ab}	10.6_b	3.49	.036
Q-LES-Q-SR	43.0	37.6_a	42.3_{ab}	47.0_b	6.75	.002
LEIDS-R	65.5	66.9_a	65.8_a	63.2_a	0.32	.730
STAXI-T	19.4	18.6_a	19.5_a	19.7_a	0.23	.798
Medication						
Antidepressants	33 (40%)	9 (45%)$_a$	10 (37%)$_a$	14 (40%)$_a$	0.30	.859
Anxiolytics/ Sedatives	20 (24%)	6 (30%)$_a$	5 (19%)$_a$	9 (25%)$_a$	0.88	.644
Stimulants	10 (12%)	1 (5%)	5 (19%)$_a$	4 (11%)$_a$	1.99	.369
Suicide attempt history						
Yes	35 (42%)	10 (50%)$_a$	11 (41%)$_a$	14 (40%)$_a$	0.58	.747
Yes, multiple	24 (29%)	8 (40%)$_a$	9 (33%)$_a$	7 (20%)$_a$	4.98	.083
Recent (past 12 month)	17 (21%)	5 (25%)$_a$	6 (22%)$_a$	6 (17%)$_a$	0.35	.840

Note: MDD = Major depressive disorder, PTSD = Post-traumatic stress disorder, BPD = Borderline personality disorder, OCD = Obsessive compulsive disorder, ADHD = Attention deficit hyperactivity disorder, ASD = Autism spectrum disorder; Comorbidity i.e., more than one current diagnosis; BSSI = Beck Scale for Suicide Ideation, BDI = Beck Depression Inventory, HADS-A = Hamilton Anxiety and Depression Scale – Anxiety Subscale, Q-LES-Q-SR = Quality of Life Enjoyment and Satisfaction Questionnaire – Short Form, LEIDS-R = Leiden Index of Depression Sensitivity – Revised, STAXI-T = State-Trait Anger Expression Inventory – Trait Anger Scale

Sociodemographic and Clinical Correlates of Suicidal Ideation Phenotypes

Differences between the phenotypes on baseline characteristics are presented in Table 4. Phenotype 1 had higher suicidal ideation (BSSI) at baseline compared to Phenotype 2, which in turn had a higher BSSI score than Phenotype 3. Phenotypes 1 and 2 also had higher depressive symptoms, more cases with current MDD, and more comorbidity, than Phenotype 3. Further, Phenotype 1 had higher anxiety symptoms and lower quality of life, and more cases with current PTSD, than Phenotype 3. Phenotype 1 had the highest percentage of both people with a past suicide attempt and those with multiple past attempts; however, none of the comparisons on prior suicide attempt history reached statistical significance.

Figure 2. Number of Suicide Attempters and Attempts as a Function of Phenotype



Risk of Future Suicide Attempt

Follow-up data (n = 36) was available for 55% of individuals for Phenotype 1, 41% for Phenotype 2, and 40% for Phenotype 3; phenotype categorization was not a significant determinant of exclusion from the follow-up analyses (p = .515). During the subsequent one-year, seven participants reported a total of sixteen suicide attempts (*Med* = 2, Range 1–5 attempts/person). Participants with Phenotypes 1 and 2 were significantly more likely to make a suicide attempt during follow-up than those with Phenotype 3 (with no difference between Phenotypes 1 and 2), based on Fisher's exact test (p = .040, Cramer's V = .40). Further, Phenotype 1 was specifically characterized by repeat suicidal behavior, with four participants in Phenotype 1 (n = 11) accounting for twelve suicide attempts, and three participants in Phenotype 2 (n = 11) accounting for four attempts (with no suicide attempts in Phenotype 3, n = 14) (Figure 2). In comparison, those with a past suicide attempt history (which is generally considered to be the best predictor of future suicidal behavior) were also significantly more likely to make a suicide attempt during follow-up (p = .002, Cramer's V = .52).

An exploratory analysis of the 17 participants with a past suicide attempt history revealed that the distribution across phenotypes was 7 (Phenotype 1), 7 (Phenotype 2) and 3 (Phenotype 3). The number of participants with a suicide attempt during follow-up was 4 (Phenotype 1), 3 (Phenotype 2) and 0 (Phenotype 3). Hence, 50% of those with a past suicide attempt history within Phenotypes 1 and 2 had a repeat attempt, compared to 0% of those within Phenotype 3.

Discussion

In the present study, we used EMA data to identify digital phenotypes of suicidal ideation. A three-profile solution provided the best fit. We also found that these phenotypes were associated with distinct clinical profiles at baseline and different odds of making a suicide attempt during a one-year follow-up, although the latter finding warrants replication in larger samples.

The first attempt to apply digital phenotyping to electronically-collected data on suicidal ideation was based on a sample of 51 individuals with a recent suicide attempt (Kleiman et al., 2018). Five phenotypes were identified, predominantly distinguished by differences in the intensity and variability of ideation. Our analyses indicated the presence of three phenotypes that partly overlap with the previously identified profiles. Our Phenotype 2 roughly corresponds to the previously identified Type 3 (moderate mean, high variability), and our Phenotype 3 to the previously identified Type 1 (low mean, low variability). The remaining two phenotypes with low numbers of participants (n < 10) in the Kleiman et al. (2018) study instead appear to merge with the three identified phenotypes in our sample (see Appendix for a graphical overview). It should also be noted that in contrast to Kleiman et al. (2018), we considered aspects of passive and active suicidal ideation separately, whereas they predominantly focused on active ideation (incl. active ideation, intent, and acquired capability). Differences between the categorizations may therefore be explained by the inclusion of items specifically estimating passive ideation.

However, it is also possible that simply with the higher number of predictors included, our model converged better with fewer clusters. Indeed, the entropy values of the LPA solutions were fairly large, which can indicate overfitting. However, individual class probabilities of the final three profile solution were high (0.88 – 1.00), indicating that the estimated probability that a given individual belongs to the group they were assigned to was between 88-100% (see Appendix).

The idea of establishing suicidal ideation phenotypes has existed long before the advent of real-time monitoring studies. For example, two subtypes of suicidal ideation have been proposed, characterized by variable vs. stable ideation (Bernanke, Stanley and Oquendo, 2017). Integrating more comprehensive data on the temporal dynamics of suicidal ideation, our findings as well as those of Kleiman et al. (2018), illustrate that even more distinct subtypes of suicidal ideation may emerge. Further, these subtypes are differentiated not only by variability, but also other dynamic characteristics of suicidal ideation, such as frequency and intensity.

Examination of baseline characteristics indicated worse clinical profiles for Phenotypes 1 and 2, most prominently higher suicidal ideation and depressive symptom severity, and more comorbidity, compared to Phenotype 3. Furthermore, Phenotype 1 had the highest number of both suicide attempters and those with multiple past attempts, increased anxiety levels and more patients with a PTSD diagnosis; however, these comparisons were not significantly different from estimates in Phenotype 2. Hence, it appears that both Phenotype 1 and 2 may capture those patients with more chronic, and comorbid symptomatology (as indicated by higher symptom severity on longitudinal symptom measures, as well as a higher incidence of psychiatric disorders and comorbidity); this observation needs further verification in future research.

When examining the prospective occurrence of suicide attempts over one year, we found Phenotypes 1 and 2 to be at a significantly higher risk of future suicidal behavior compared to Phenotype 3 (effect size V= 40). In comparison, past suicide attempt history had an effect size of V= 52, indicating that both are strong predictors (Kim, 2017) of future suicidal behavior. Further, Phenotype 1 was specifically associated with repeat suicidal behavior (i.e., multiple attempts). It should be noted that a history of suicide attempt more strongly predicted future suicidal behavior than the digital phenotypes. Future studies may investigate whether the combination of past history and phenotype indicators further improves prediction. In our sample, all participants who made a suicide attempt during follow-up had a past suicide attempt history. Suicide attempt history alone may have limited specificity in identifying those individuals with a past suicide attempt history that are at *lower* risk, especially in the near term (identified as Phenotype

3 in our sample). Predicting re-attempt among those with a past suicide attempt history is difficult, as other established predictors (such as sociodemographic characteristics and psychiatric comorbidity (Irigoyen et al., 2019; Parra-Uribe et al., 2017)) are rather general predictors of not only re-attempt, but also index attempt, and initial suicidal ideation (Nock et al., 2008). Hence, risk management among past suicide attempters remains a distinctive challenge. Further, identifying those individuals at risk of repeat suicidal behavior is crucial, as the number of past suicide attempts significantly increases the risk of completed suicide (Azcárate-Jiménez et al., 2019). Our findings indicate that real-time suicidal ideation characteristics may aid in identifying not only those at risk of future suicidal behavior (Phenotypes 1 & 2), but specifically those at risk of repeat attempts (Phenotypes 1). This is especially relevant, as Phenotypes 1 and 2 (which were both characterized by a worse clinical profile at baseline) may not readily be differentiated by patient characteristics alone.

Our findings suggest that indices of real-time suicidal ideation may provide important information about an individual's risk status. Specifically, suicidal ideation variability may represent a marker for increased suicide risk (Witte et al., 2005, 2006). Our Phenotypes 1 and 2 were associated with higher variability and increased risk of suicide attempt. However, we observed no further differences between Phenotypes 1 and 2, although we expected that Phenotype 2 (with the highest variability) would confer the highest risk. Further, Phenotypes 1 and 2 were also associated with higher intensity and frequency of ideation, indicating that variability should not be considered in isolation. Hence it seems that both high intensity ideation together with moderate variability, as well as moderate intensity ideation with high variability, may confer increased risk. Our results also partly align with the finding that suicidal ideation variability was a risk factor for making a suicide attempt in the month following discharge from inpatient care (Wang et al., 2021). Here, we demonstrate that digital phenotypes (including variability) may predict risk during the next 12 months. An exploratory analysis suggests that the prediction may be improved by considering both past behavior and current phenotype.

Future research should further examine outcomes related to suicidal ideation phenotypes. For example, it has been suggested that those with more variable suicidal ideation are more impacted by stressful life events, and may represent more 'impulsive' suicide attempters (Bostwick et al., 2016). Therefore, future research should consider how these phenotypes interact with other risk factors (such as patient characteristics and environmental stressors) in their associations with suicidal behavior. It has been proposed that phenotyping of suicidal ideators may pave the way for more personalized treatment (Barrigon et al., 2019), but such interventions require further knowledge on these interactions. Methodological considerations for future research include establishing more standardized, and reliable, protocols to quantify variability in suicidal ideation. While the RMSSD (or the mean square of successive differences, MSSD) is the most frequently used measure to indicate variability in EMA-measured suicidal ideation (see e.g., Hallensleben et al., 2018; Kleiman et al., 2017, 2018; Oquendo et al., 2020; Peters et al., 2020; Rizk et al., 2019; Wang et al., 2021; Witte et al., 2005, 2006), and is also frequently used in similar EMA designs to quantify variability in affect (see e.g., Bos et al., 2019), there are some limitations to how it is currently used in the EMA-suicide literature. For example, the RMSSD assumes equally spaced observations – an assumption that is violated both by the present study (due to the inclusion of night-to-morning time jumps) as well as each of the prior studies mentioned, none of which (reported that they) accounted for transitions between days. We therefore opted to follow the same methodology in order to establish comparability with our results and that of prior studies focusing on suicidal ideation assessments using EMA. However, future research should account for different time lags in their RMSSD calculations, as previously done in other EMA research (see e.g., Ebner-Priemer et al., 2009; Jahng et al., 2008; Sperry & Kwapil, 2020).

A number of limitations should be considered. Our approach was exploratory, and we did not correct for multiple testing. The number and characteristics of the digital phenotypes may be dependent on population and sample size. Replication of these findings in larger and more representative samples is needed, in order to account for the diversity of individuals experiencing suicidal ideation. This way, the phenotypes that exhibit the most consistency across samples may be identified, prior to drawing further conclusions about their clinical relevance. Further, within our one-year monitoring, we included an item only on suicide attempts, and did not inquire about related, preparatory behaviors (such as planning, or obtaining means). However, such behaviors may represent important indicators of risk. Future studies employing similar longer-term repeated assessments may consider incorporating such dimensions. This would also allow to test for the hypothesis that those with more variable suicidal ideation transition more impulsively to attempt (as proposed by Bostwick et al., 2016).

In conclusion, digital phenotypes of real-time suicidal ideation appear to be associated with different clinical profiles and risk of future suicidal behavior. Profiles associated with an increased occurrence of suicide attempts were characterized by higher variability in suicidal ideation – but also by higher intensity and frequency. Comprehensive suicide risk assessments may benefit from considering multiple characteristics of ideation; our findings show that intensity levels remain a crucial factor to assess, and that variability and frequency can further add important information to clinical assessments. It remains to be examined whether phenotypes significantly add predictive value when considered in tandem with other established risk factors, in order to further elucidate on the utility of such phenotyping.

References

Azcárate-Jiménez, L., López-Goñi, J. J., Goñi-Sarriés, A., Montes-Reula, L., Portilla-Fernández, A., & Elorza-Pardo, R. (2019). Repeated suicide attempts: a follow-up study. *Actas Espanolas de Psiquiatria*, *47*(4), 127–136.

Ballard, E. D., Gilbert, J. R., Wusinich, C., & Zarate, C. A. (2021). New methods for assessing rapid changes in suicide risk. *Frontiers in Psychiatry*, *12,* 598434. https://doi.org/10.3389/fpsyt.2021.598434

Barrigon, M. L., Courtet, P., Oquendo, M., & Baca-García, E. (2019). Precision medicine and suicide: An opportunity for digital health. *Current Psychiatry Reports, 21*(12), 131. https://doi.org/10.1007/s11920-019-1119-8

Beck, A. T. (1961). An inventory for measuring depression. *Archives of General Psychiatry*, *4*(6), 561–571. https://doi.org/10.1001/archpsyc.1961.01710120031004

Beck, A. T., Brown, G. K., Steer, R. A., Dahlsgaard, K. K., & Grisham, J. R. (1999). Suicide ideation at its worst point: a predictor of eventual suicide in psychiatric outpatients. *Suicide & Life-Threatening Behavior*, *29*(1), 1–9.

Beck, A. T., Kovacs, M., & Weissman, A. (1979). Assessment of suicidal intention: The Scale for Suicide Ideation. *Journal of Consulting and Clinical Psychology*, *47*(2), 343–352.

Bos, E. H., de Jonge, P., & Cox, R. F. A. (2019). Affective variability in depression: Revisiting the inertia–instability paradox. *British Journal of Psychology*, *110*(4), 814–827. https://doi.org/10.1111/bjop.12372

Bos, F. M. (2021). *Ecological momentary assessment as a clinical tool in psychiatry: Promises, pitfalls, and possibilities [Doctoral Dissertation].* University of Groningen.

Bostwick, J. M., Pabbati, C., Geske, J. R., & McKean, A. J. (2016). Suicide attempt as a risk factor for completed suicide: Even more lethal than we knew. *American Journal of Psychiatry*, *173*(11), 1094–1100. https://doi.org/10.1176/appi.ajp.2016.15070854

Chang, E. C., & Chang, O. D. (2016). Development of the Frequency of Suicidal Ideation Inventory: Evidence for the Validity and Reliability of a Brief Measure of Suicidal Ideation Frequency in a College Student Population. *Cognitive Therapy and Research*, *40*(4), 549–556. https://doi.org/10.1007/s10608-016-9758-0

Dejonckheere, E., Mestdagh, M., Houben, M., Rutten, I., Sels, L., Kuppens, P., & Tuerlinckx, F. (2019). Complex affect dynamics add limited information to the prediction of psychological well-being. *Nature Human Behaviour*, *3*(5), 478–491. https://doi.org/10.1038/s41562-019-0555-0

Ebner-Priemer, U. W., Eid, M., Kleindienst, N., Stabenow, S., & Trull, T. J. (2009). Analytic strategies for understanding affective (in)stability and other dynamic processes in psychopathology. *Journal of Abnormal Psychology, 118*(1), 195.

Endicott, J., Nee, J., Harrison, W., & Blumenthal, R. (1993). Quality of Life Enjoyment and Satisfaction Questionnaire: A new measure. *Psychopharmacology Bulletin*, *29*(2), 321–326.

First, M. B. (2015). Structured Clinical Interview for the *DSM* (SCID). In *The Encyclopedia of Clinical Psychology* (pp. 1–6). John Wiley & Sons, Inc. https://doi.org/10.1002/9781118625392.wbecp351

Hallensleben, N., Spangenberg, L., Forkmann, T., Rath, D., Hegerl, U., Kersting, A., Kallert, T. W., & Glaesmer, H. (2018). Investigating the dynamics of suicidal ideation: Preliminary findings from a study using ecological momentary assessments in psychiatric inpatients. *Crisis*, *39*(1), 65–69. https://doi.org/10.1027/0227-5910/a000464

Irigoyen, M., Porras-Segovia, A., Galván, L., Puigdevall, M., Giner, L., De Leon, S., & Baca-García, E. (2019). Predictors of re-attempt in a cohort of suicide attempters: A survival analysis. *Journal of Affective Disorders*, *247*, 20–28. https://doi.org/10.1016/j.jad.2018.12.050

Jahng, S., Wood, P. K., & Trull, T. J. (2008). Analysis of affective instability in ecological momentary assessment: Indices using successive difference and group comparison via multilevel modeling. *Psychological Methods, 13*(4), 354.

Kim, H.-Y. (2017). Statistical notes for clinical researchers: Chi-squared test and Fisher's exact test. *Restorative Dentistry & Endodontics*, *42*(2), 152. https://doi.org/10.5395/rde.2017.42.2.152

Kivelä, L. M. M., Fiß, F., van der Does, W., & Antypa, N. (2023). Examination of acceptability, feasibility, and iatrogenic effects of Ecological Momentary Assessment (EMA) of suicidal ideation. *Assessment*, 10731911231216052. https://doi.org/10.1177/10731911231216053

Kivelä, L., van der Does, W. A. J., Riese, H., & Antypa, N. (2022). Don't miss the moment: A systematic review of ecological momentary assessment in suicide research. *Frontiers in Digital Health*, *4,* 876595. https://doi.org/10.3389/fdgth.2022.876595

Kleiman, E. M., Turner, B. J., Fedor, S., Baele, E. E., Huffman, J. C., & Nock, M. K. (2017). Examination of real-time fluctuations in suicidal ideation and its risk factors: Results from two ecological momentary assessment studies. *Journal of Abnormal Psychology*, *126*(6), 726–738. https://doi.org/10.1037/abn0000273.supp

Kleiman, E. M., Turner, B. J., Fedor, S., Beale, E. E., Picard, R. W., Huffman, J. C., & Nock, M. K. (2018). Digital phenotyping of suicidal thoughts. *Depression and Anxiety*, *35*(7), 601–608. https://doi.org/10.1002/da.22730

Law, K. C., Jin, H. M., & Anestis, M. D. (2018). The intensity of suicidal ideation at the worst point and its association with suicide attempts. *Psychiatry Research*, *269*, 524–528. https://doi.org/10.1016/j.psychres.2018.08.094

Liljequist, D., Elfving, B., & Skavberg Roaldsen, K. (2019). Intraclass correlation – A discussion and demonstration of basic features. *PLoS ONE*, *14*(7), e0219854. https://doi.org/10.1371/journal.pone.0219854

Nock, M. K., Borges, G., Bromet, E. J., Alonso, J., Angermeyer, M., Beautrais, A., Bruffaerts, R., Wai, T. C., De Girolamo, G., Gluzman, S., De Graaf, R., Gureje, O., Haro, J. M., Huang, Y., Karam, E., Kessler, R. C., Lepine, J. P., Levinson, D., Medina-Mora, M. E., Ono, Y., Posada-Villa, J., & Williams, D. (2008). Cross-national prevalence and risk factors for suicidal ideation, plans and attempts. *British Journal of Psychiatry*, *192*(2), 98–105. https://doi.org/10.1192/bjp.bp.107.040113

Oakey-Frost, N., Moscardini, E. H., Cowan, T., Cohen, A., & Tucker, R. P. (2023). The temporal dynamics of wish to live, wish to die, and their short-term prospective relationships with suicidal desire. *Behavior Therapy*, *54*(3), 584–594. https://doi.org/10.1016/j.beth.2022.12.011

Oquendo, M. A., Galfalvy, H. C., Choo, T. H., Kandlur, R., Burke, A. K., Sublette, M. E., Miller, J. M., Mann, J. J., & Stanley, B. H. (2020). Highly variable suicidal ideation: A phenotypic marker for stress induced suicide risk. *Molecular Psychiatry, 26,* 5079–5086. https://doi.org/10.1038/s41380-020-0819-0

Parra-Uribe, I., Blasco-Fontecilla, H., Garcia-Parés, G., Martínez-Naval, L., Valero-Coppin, O., Cebrià-Meca, A., Oquendo, M. A., & Palao-Vidal, D. (2017). Risk of re-attempts and suicide death after a suicide attempt: A survival analysis. *BMC Psychiatry*, *17*(1). https://doi.org/10.1186/s12888-017-1317-z

Peters, E. M., Dong, L. Y., Thomas, T., Khalaj, S., Balbuena, L., Baetz, M., Osgood, N., & Bowen, R. (2020). Instability of suicidal ideation in patients hospitalized for depression: An exploratory study using smartphone ecological momentary assessment. *Archives of Suicide Research*, *26*(1), 56–69. https://doi.org/10.1080/13811118.2020.1783410

Posner, K., Brown, G. K., Stanley, B., Brent, D. A., Yershova, K. V., Oquendo, M. A., Currier, G. W., Melvin, G. A., Greenhill, L., Shen, S., & Mann, J. J. (2011). The Columbia–Suicide Severity Rating Scale: Initial validity and internal consistency findings from three multisite studies with adolescents and adults. *American Journal of Psychiatry*, *168*(12), 1266–1277. https://doi.org/10.1176/appi.ajp.2011.10111704

R Core Team. (2016). *R: A language and environment for statistical computing.* R Foundation for Statistical Computing. Retrieved from: https://www.R-project.org/

Revelle, W. (2023). *psych: Procedures for Psychological, Psychometric, and Personality Research* [R package version 2.3.9]. Northwestern University. Retrieved from: https://cran.r-project.org/web/packages/psych/index.html

Rizk, M. M., Choo, T. H., Galfalvy, H., Biggs, E., Brodsky, B. S., Oquendo, M. A., Mann, J. J., & Stanley, B. (2019). Variability in suicidal ideation is associated with affective instability in suicide attempters with borderline personality disorder. *Psychiatry*, *82*, 173–178.

Scrucca, L., Fop, M., Murphy, T., B., & Raftery, A. E. (2016). mclust 5: Clustering, classification and density estimation using gaussian finite mixture models. *The R Journal*, *8*(1), 289. https://doi.org/10.32614/RJ-2016-021

Sperry, S. H., & Kwapil, T. R. (2020). Comparing static and dynamic measures of affect intensity and affect lability: Do they measure the same thing? *Motivation and Emotion, 44*, 870-879.

Sheehan, D. V, Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., Hergueta, T., Baker, R., & Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (M.I.N.I.): The development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *The Journal of Clinical Psychiatry*, *59 Suppl 20*, 22–57.

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annual Review of Clinical Psychology, 4*(1), 1–32. https://doi.org/10.1146/annurev.clinpsy.3.022806.091415

Sinha, P., Calfee, C. S., & Delucchi, K. L. (2021). Practitioner's guide to latent class analysis: Methodological considerations and common pitfalls. *Critical Care Medicine*, *49*(1), e63–e79. https://doi.org/10.1097/CCM.0000000000004710

Solis, E., Antypa, N., Conijn, J. M., Kelderman, H., & Van der Does, W. (2017). Psychometric properties of the Leiden Index of Depression Sensitivity (LEIDS). *Psychological Assessment*, *29*(2), 158–171. https://doi.org/10.1037/pas0000326

von Neumann, J., Kent, R. H., Bellinson, H. R., & Hart, B. I. (1941). The mean square successive difference. *The Annals of Mathematical Statistics*, *12*(2), 153–162. https://doi.org/10.1214/aoms/1177731746

Wang, S. B., Coppersmith, D. D. L., Kleiman, E. M., Bentley, K. H., Millner, A. J., Fortgang, R., Mair, P., Dempsey, W., Huffman, J. C., & Nock, M. K. (2021). A pilot study using frequent inpatient assessments of suicidal thinking to predict short-term postdischarge suicidal behavior. *JAMA Network Open*, *4*(3), e210591. https://doi.org/10.1001/jamanetworkopen.2021.0591

Wastler, H. M., Khazem, L. R., Ammendola, E., Baker, J. C., Bauder, C. R., Tabares, J., Bryan, A. O., Szeto, E., & Bryan, C. J. (2023). An empirical investigation of the distinction between passive and active ideation: Understanding the latent structure of suicidal thought content. *Suicide and Life-Threatening Behavior*, *53*(2), 219–226. https://doi.org/10.1111/sltb.12935

Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag: New York. Retrieved from: https://ggplot2.tidyverse.org/

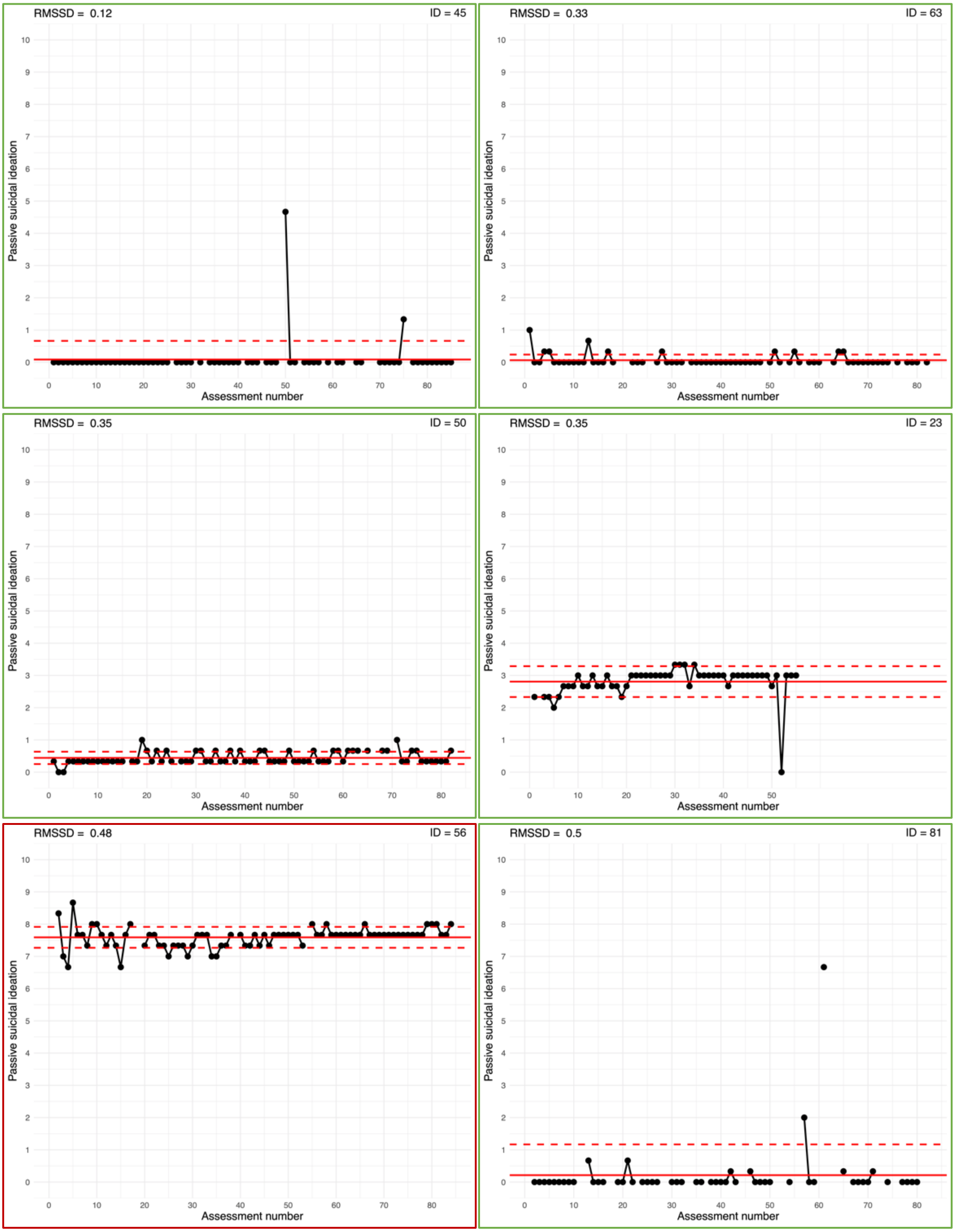
Witte, T. K., Fitzpatrick, K. K., Joiner, T. E., & Schmidt, N. B. (2005). Variability in suicidal ideation: A better predictor of suicide attempts than intensity or duration of ideation? *Journal of Affective Disorders*, *88*(2), 131–136. https://doi.org/10.1016/j.jad.2005.05.019

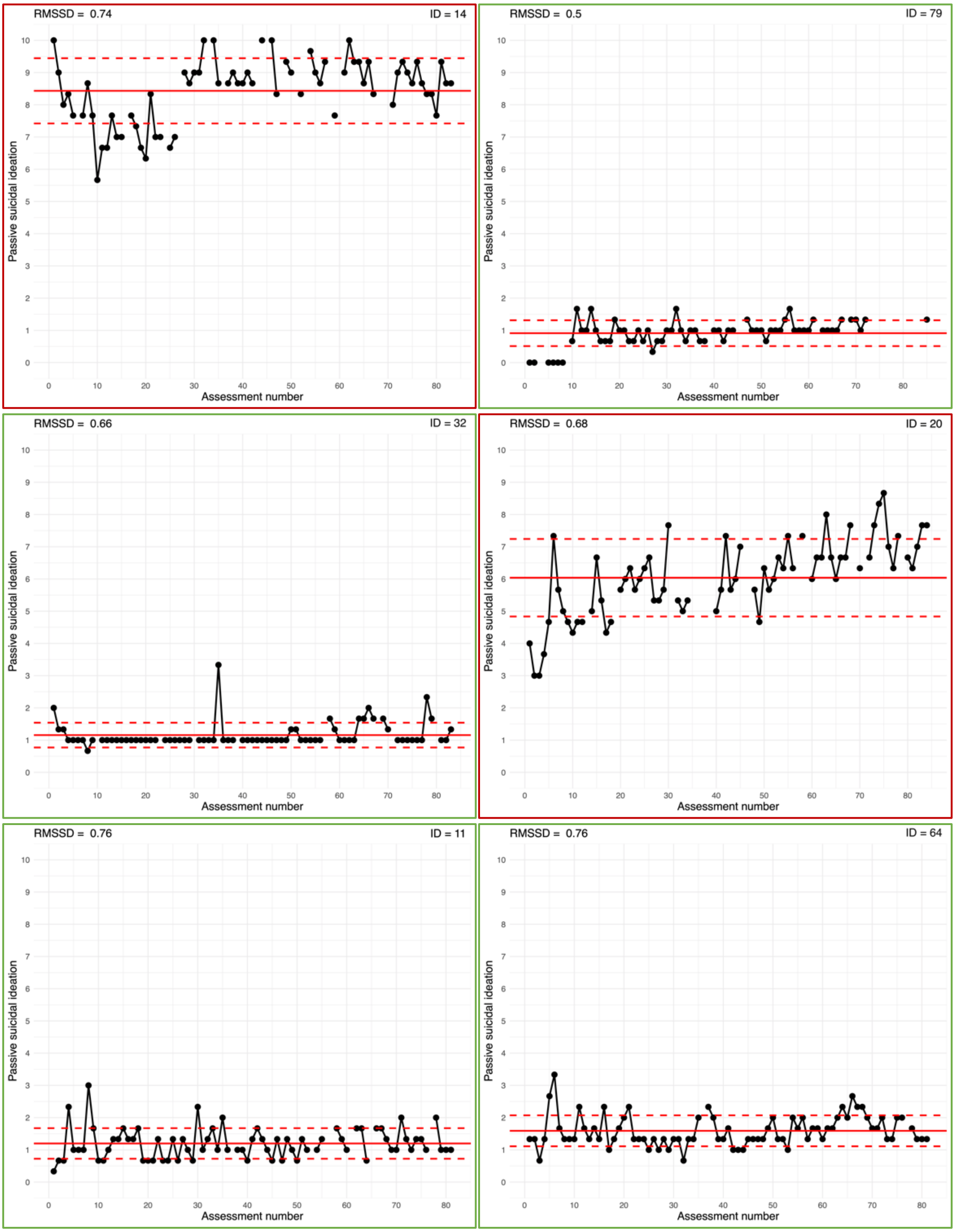
Witte, T. K., Fitzpatrick, K. K., Warren, K. L., Schatschneider, C., & Schmidt, N. B. (2006). Naturalistic evaluation of suicidal ideation: Variability and relation to attempt status. *Behaviour Research and Therapy*, *44*(7), 1029–1040. https://doi.org/10.1016/j.brat.2005.08.004

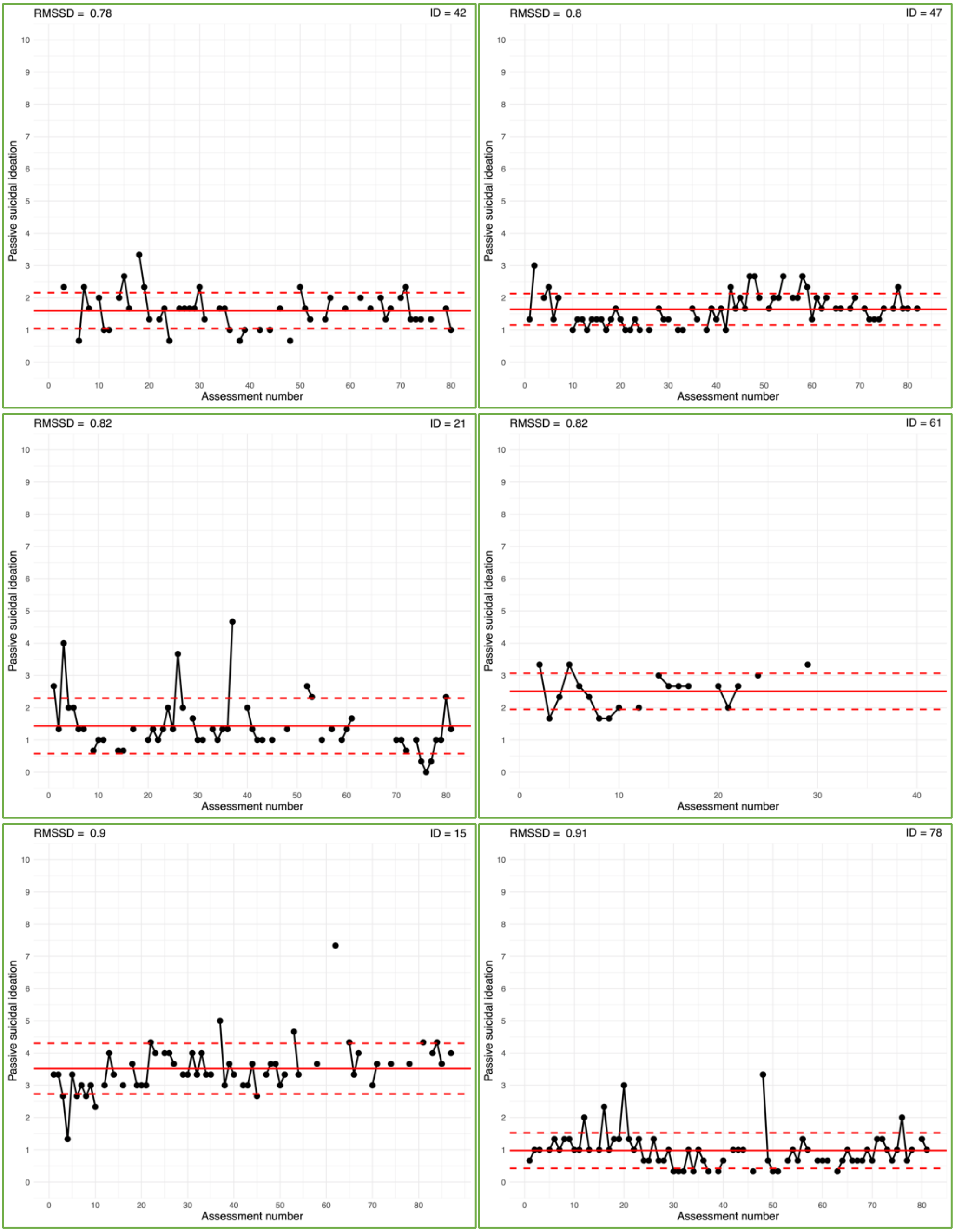
Zigmond, A. S., & Snaith, R. P. (1983). The Hospital Anxiety and Depression Scale. *Acta Psychiatrica Scandinavica*, *67*(6), 361–370. https://doi.org/10.1111/j.1600-0447.1983.tb09716.x

Appendix

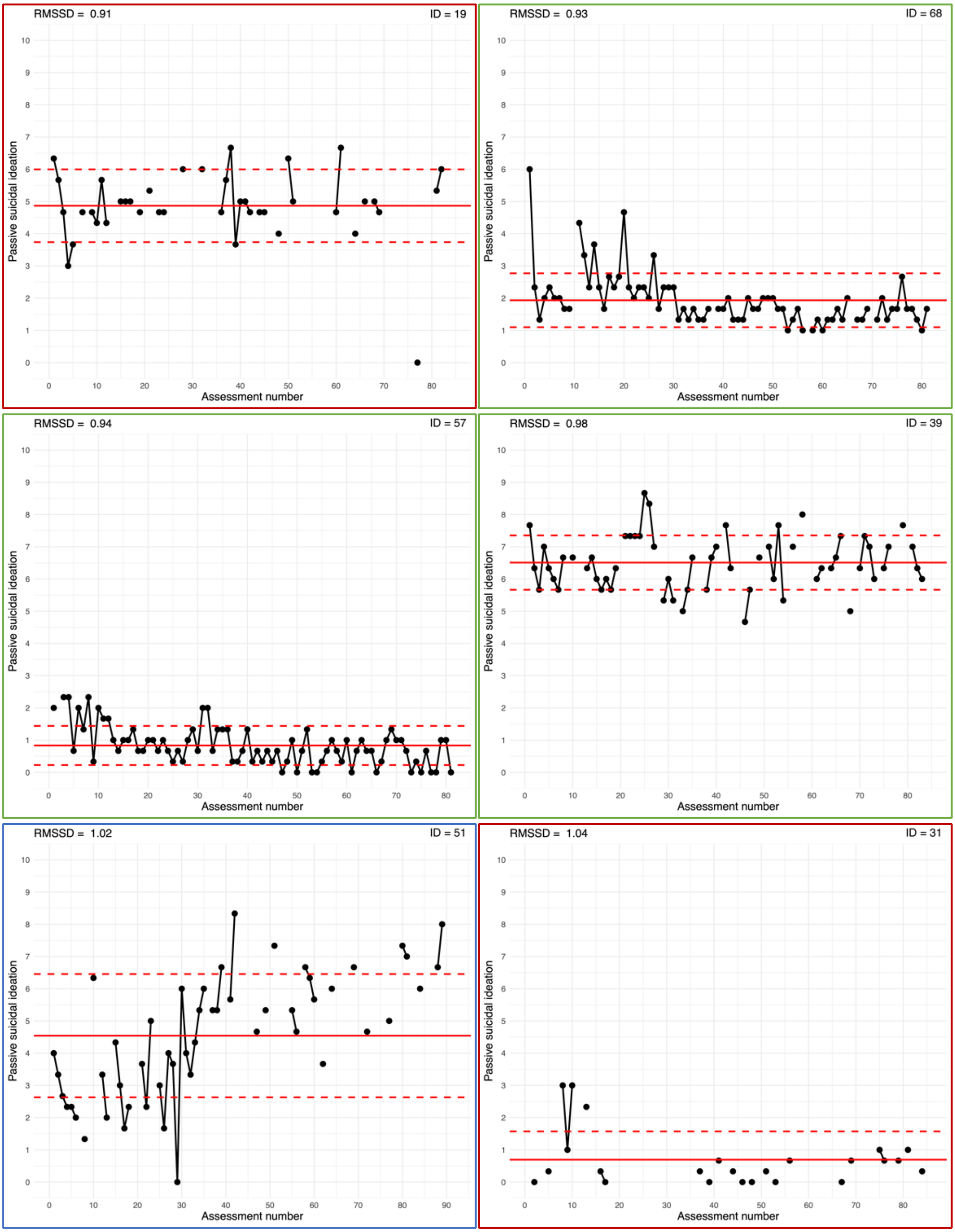
Figure S1. Variability in Passive Suicidal Ideation

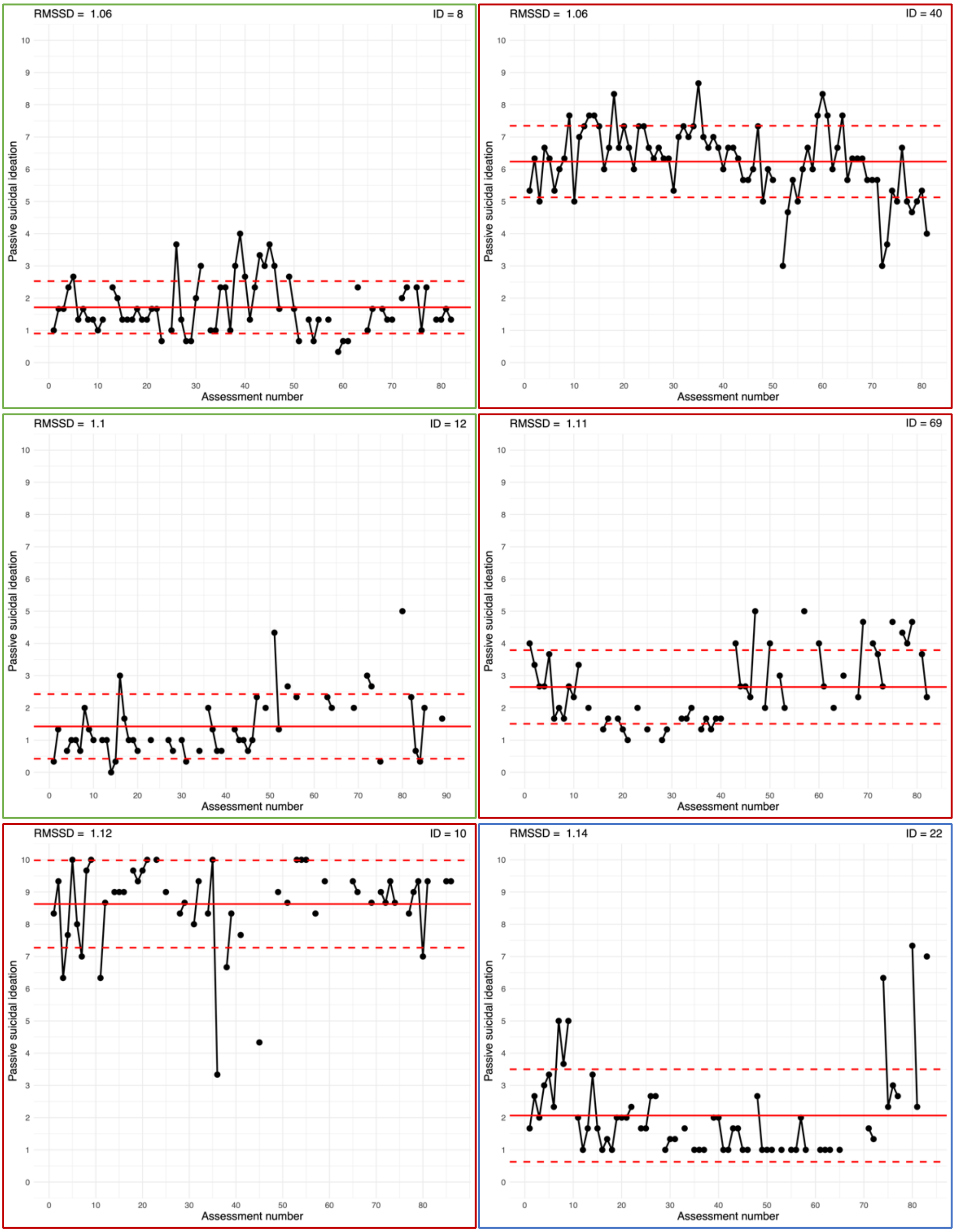



RMSSD = 0.74
ID = 14
RMSSD = 0.5
ID = 79
RMSSD = 0.66
ID = 32
RMSSD = 0.68
ID = 20
RMSSD = 0.76
ID = 11
RMSSD = 0.76
ID = 64
Passive suicidal ideation
Assessment number

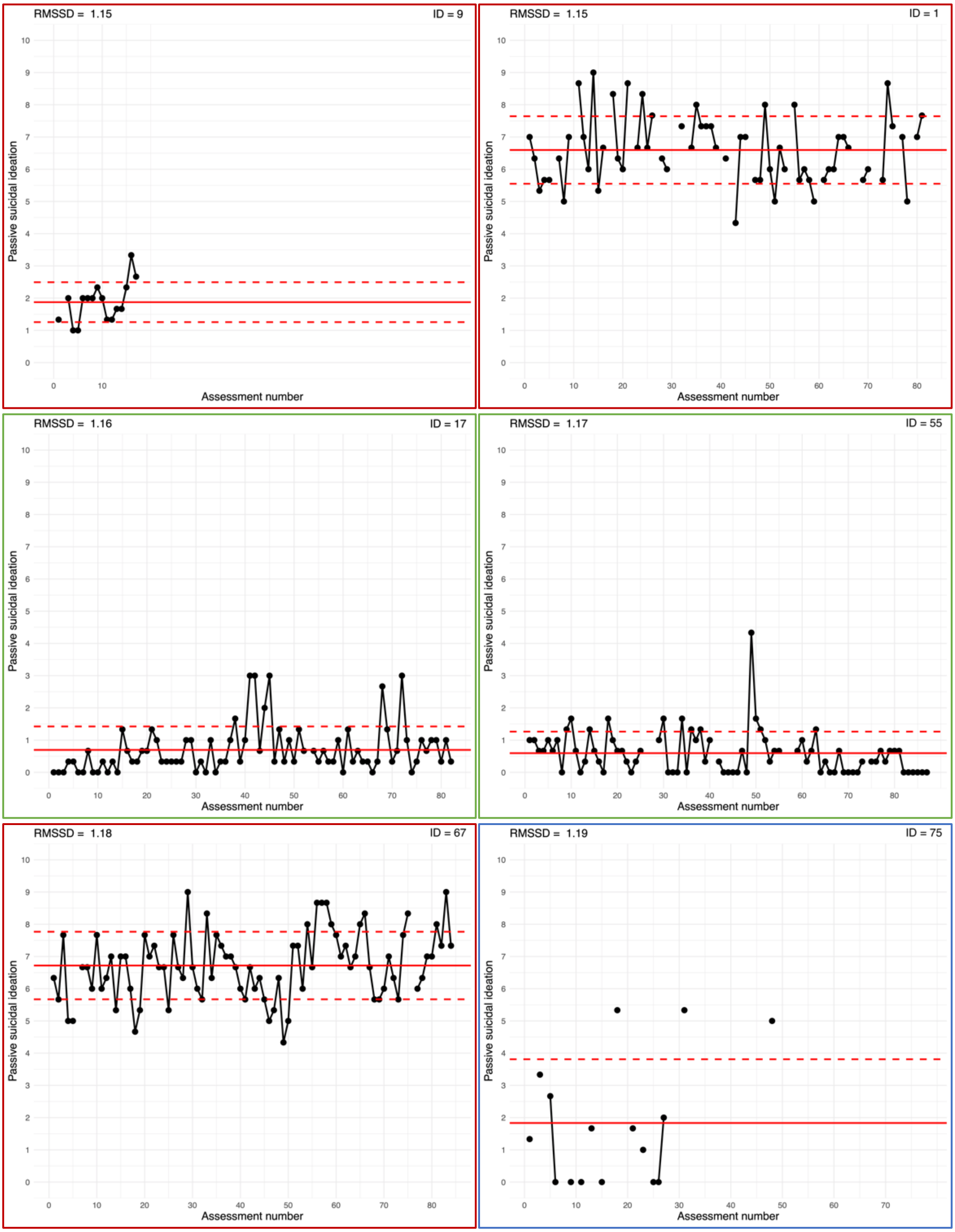


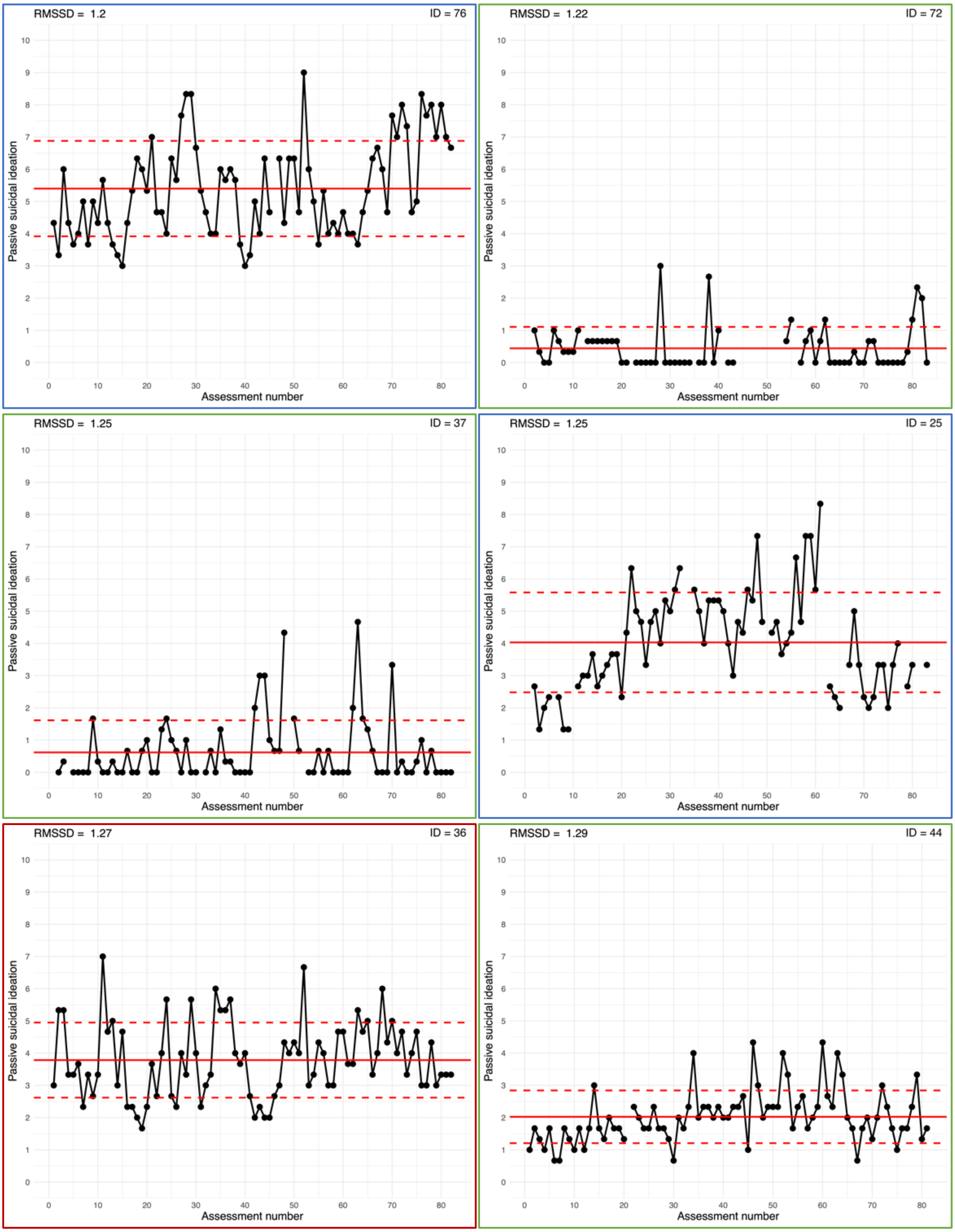
RMSSD = 0.78
ID = 42
RMSSD = 0.8
ID = 47
RMSSD = 0.82
ID = 21
RMSSD = 0.82
ID = 61
RMSSD = 0.9
ID = 15
RMSSD = 0.91
ID = 78
Passive suicidal ideation
Assessment number


RMSSD = 0.91
ID = 19
RMSSD = 0.93
ID = 68
RMSSD = 0.94
ID = 57
RMSSD = 0.98
ID = 39
RMSSD = 1.02
ID = 51
RMSSD = 1.04
ID = 31
Passive suicidal ideation
Assessment number

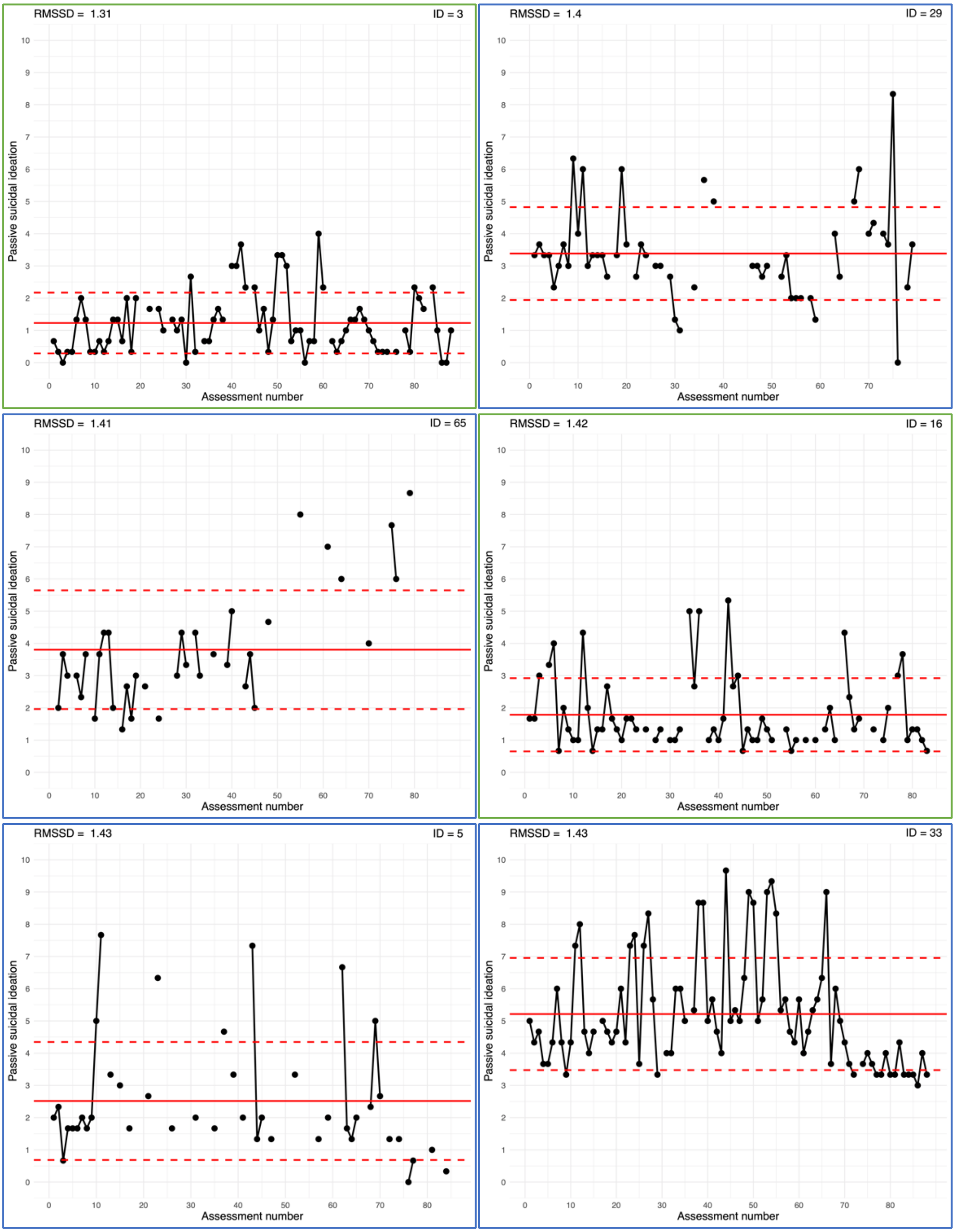


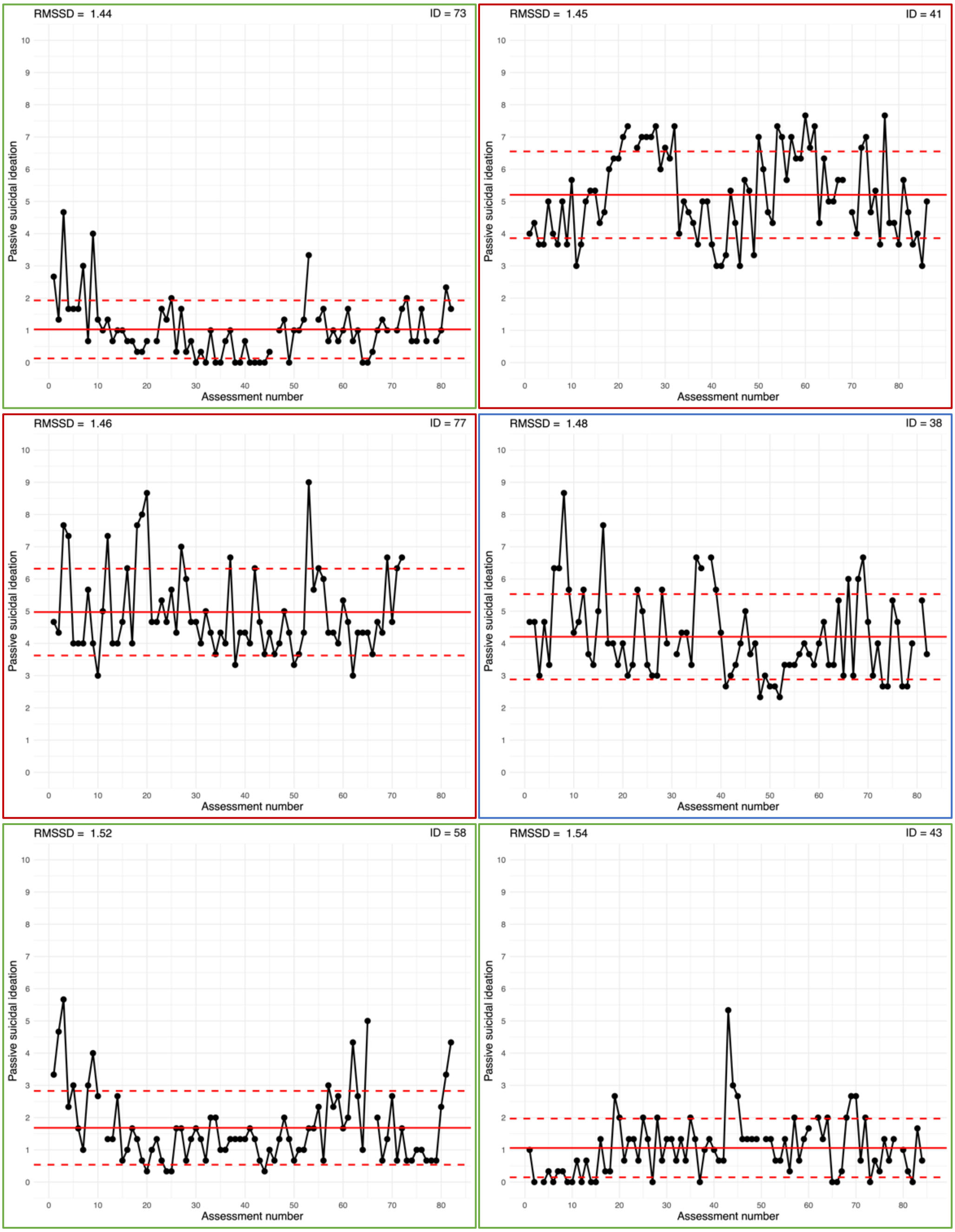
RMSSD = 1.06
ID = 8
RMSSD = 1.06
ID = 40
RMSSD = 1.1
ID = 12
RMSSD = 1.11
ID = 69
RMSSD = 1.12
ID = 10
RMSSD = 1.14
ID = 22
Passive suicidal ideation
Assessment number

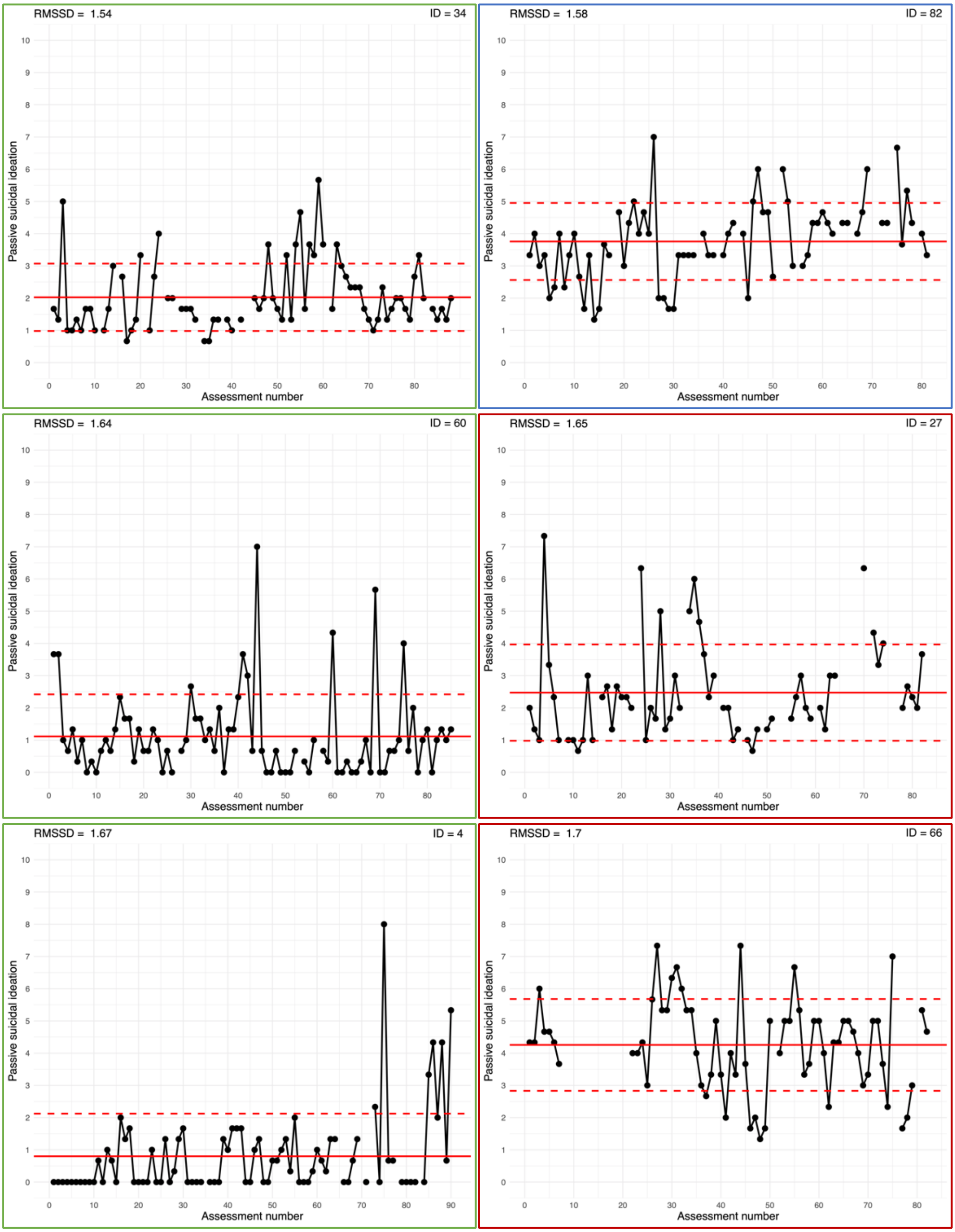

RMSSD = 1.15
ID = 9
RMSSD = 1.15
ID = 1
RMSSD = 1.16
ID = 17
RMSSD = 1.17
ID = 55
RMSSD = 1.18
ID = 67
RMSSD = 1.19
ID = 75
Passive suicidal ideation
Assessment number

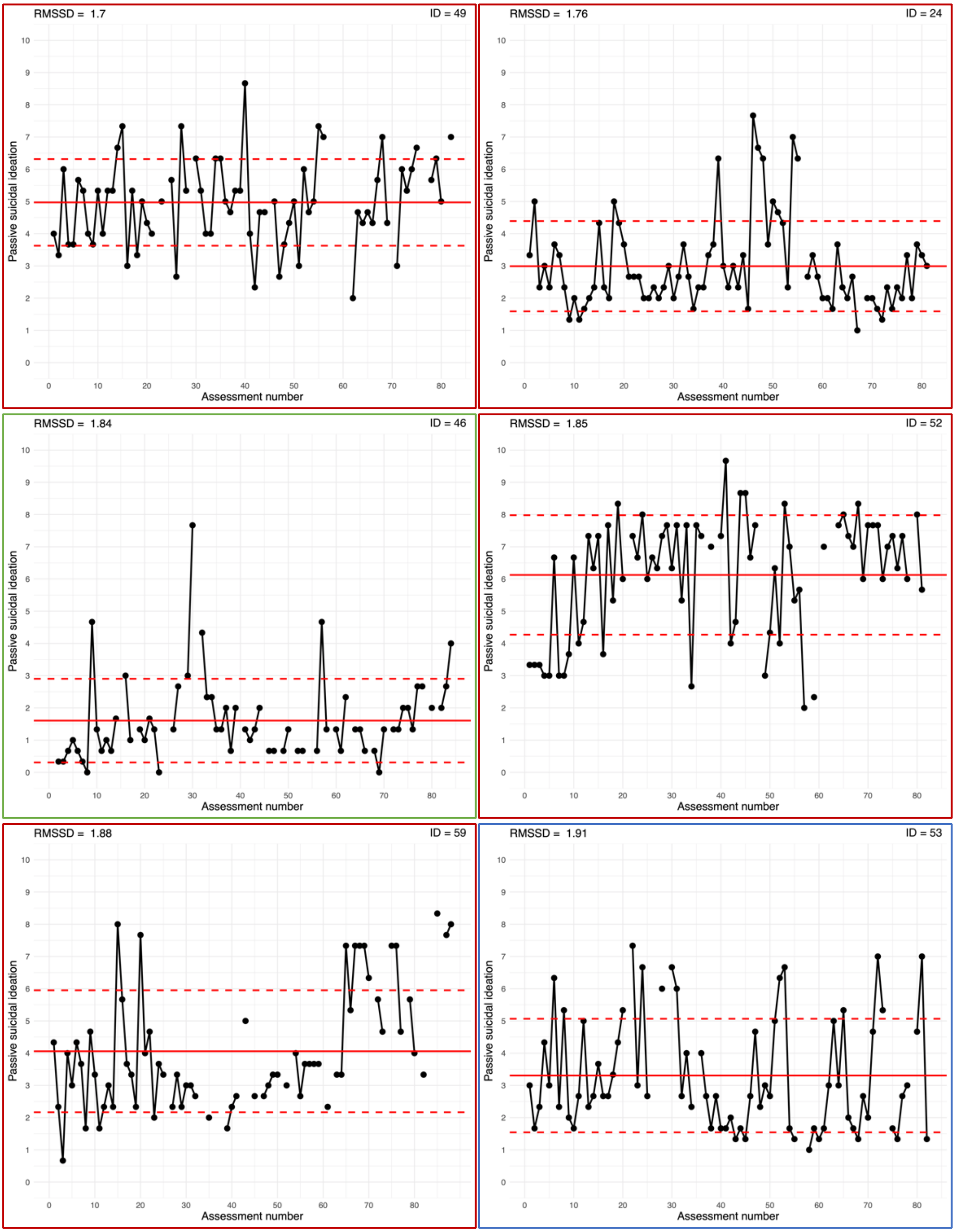


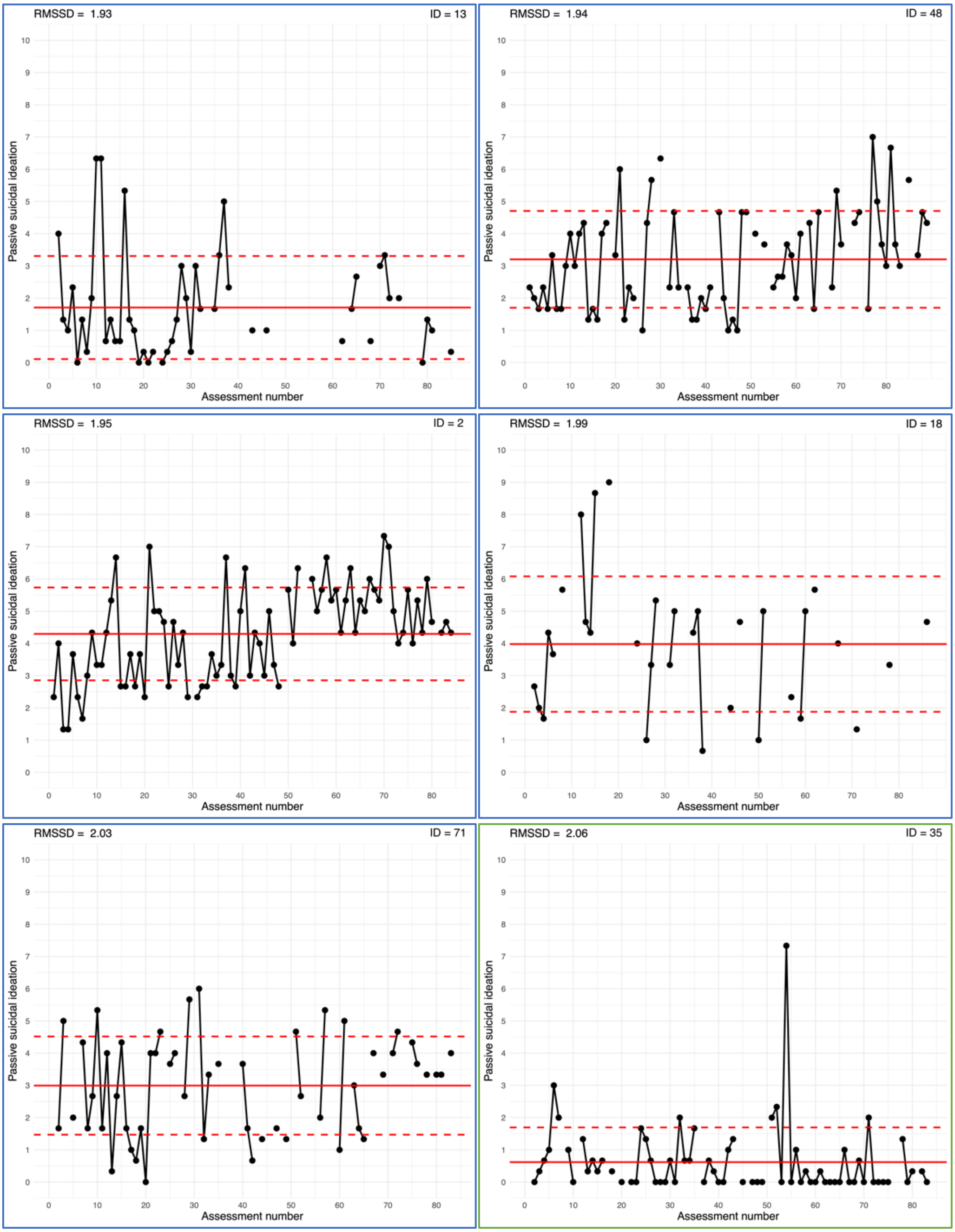
RMSSD = 1.2
ID = 76
RMSSD = 1.22
ID = 72
RMSSD = 1.25
ID = 37
RMSSD = 1.25
ID = 25
RMSSD = 1.27
ID = 36
RMSSD = 1.29
ID = 44
Passive suicidal ideation
Assessment number

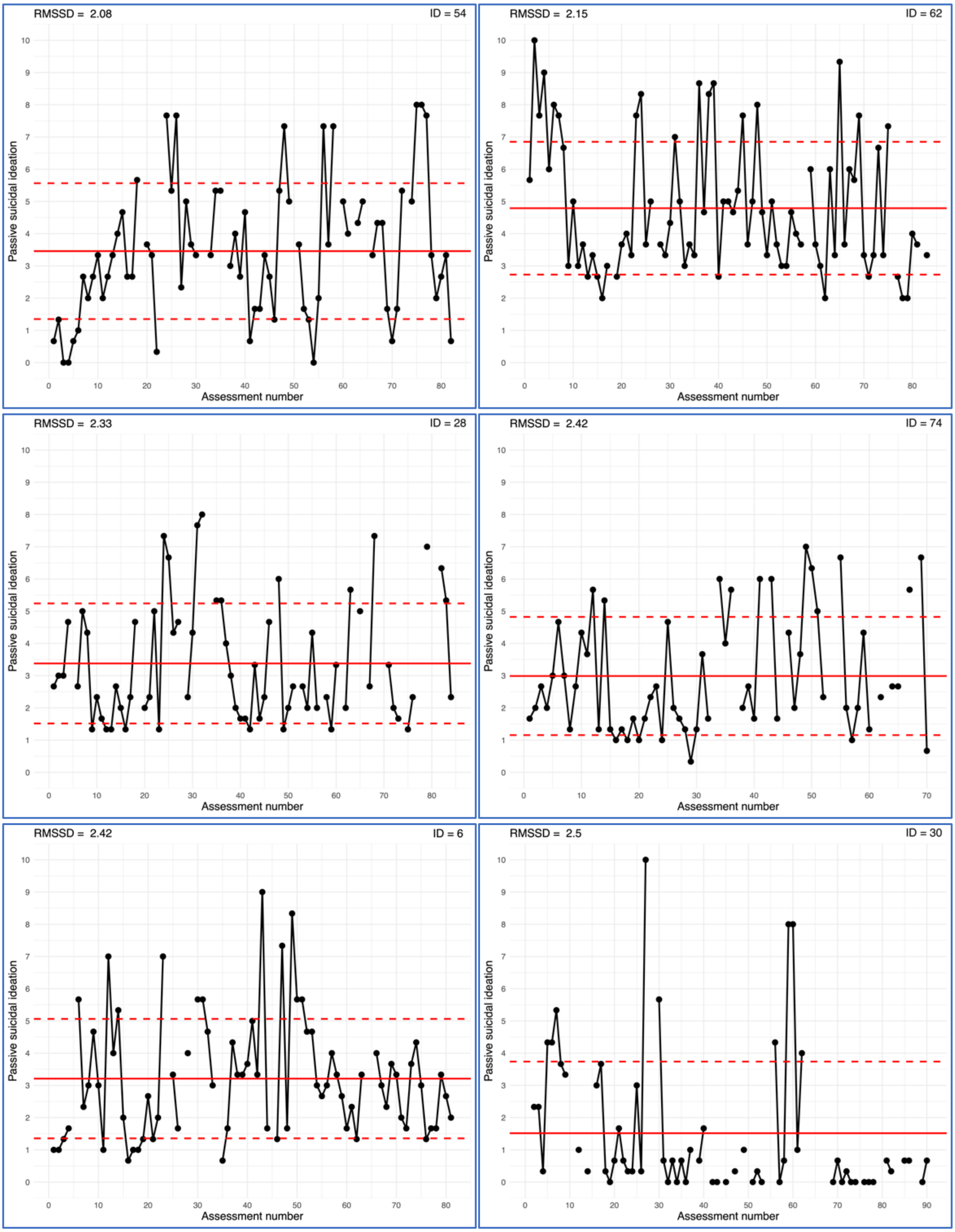

RMSSD = 1.31
ID = 3
RMSSD = 1.4
ID = 29
RMSSD = 1.41
ID = 65
RMSSD = 1.42
ID = 16
RMSSD = 1.43
ID = 5
RMSSD = 1.43
ID = 33
Passive suicidal ideation
Assessment number

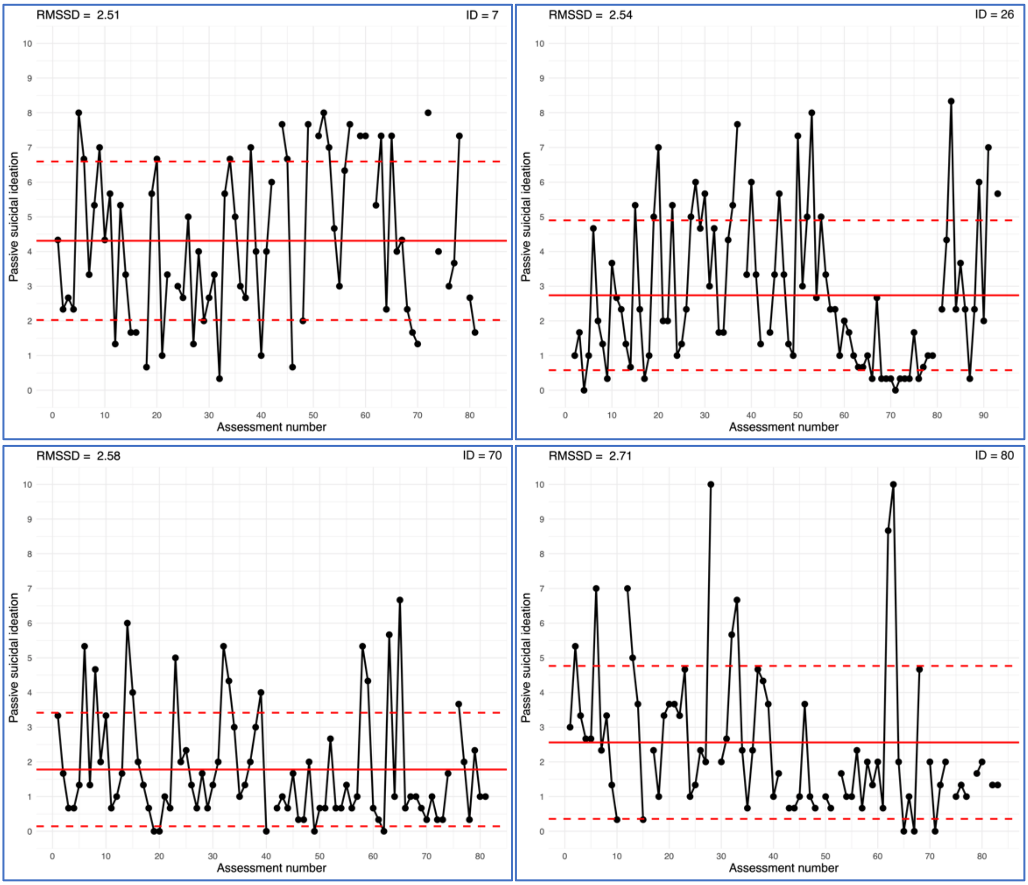

RMSSD = 1.44
ID = 73
RMSSD = 1.45
ID = 41
RMSSD = 1.46
ID = 77
RMSSD = 1.48
ID = 38
RMSSD = 1.52
ID = 58
RMSSD = 1.54
ID = 43
Passive suicidal ideation
Assessment number


RMSSD = 1.54
ID = 34
RMSSD = 1.58
ID = 82
RMSSD = 1.64
ID = 60
RMSSD = 1.65
ID = 27
RMSSD = 1.67
ID = 4
RMSSD = 1.7
ID = 66
Passive suicidal ideation
Assessment number


RMSSD = 1.7
ID = 49
RMSSD = 1.76
ID = 24
RMSSD = 1.84
ID = 46
RMSSD = 1.85
ID = 52
RMSSD = 1.88
ID = 59
RMSSD = 1.91
ID = 53
Passive suicidal ideation
Assessment number


RMSSD = 1.93
ID = 13
RMSSD = 1.94
ID = 48
RMSSD = 1.95
ID = 2
RMSSD = 1.99
ID = 18
RMSSD = 2.03
ID = 71
RMSSD = 2.06
ID = 35
Passive suicidal ideation
Assessment number

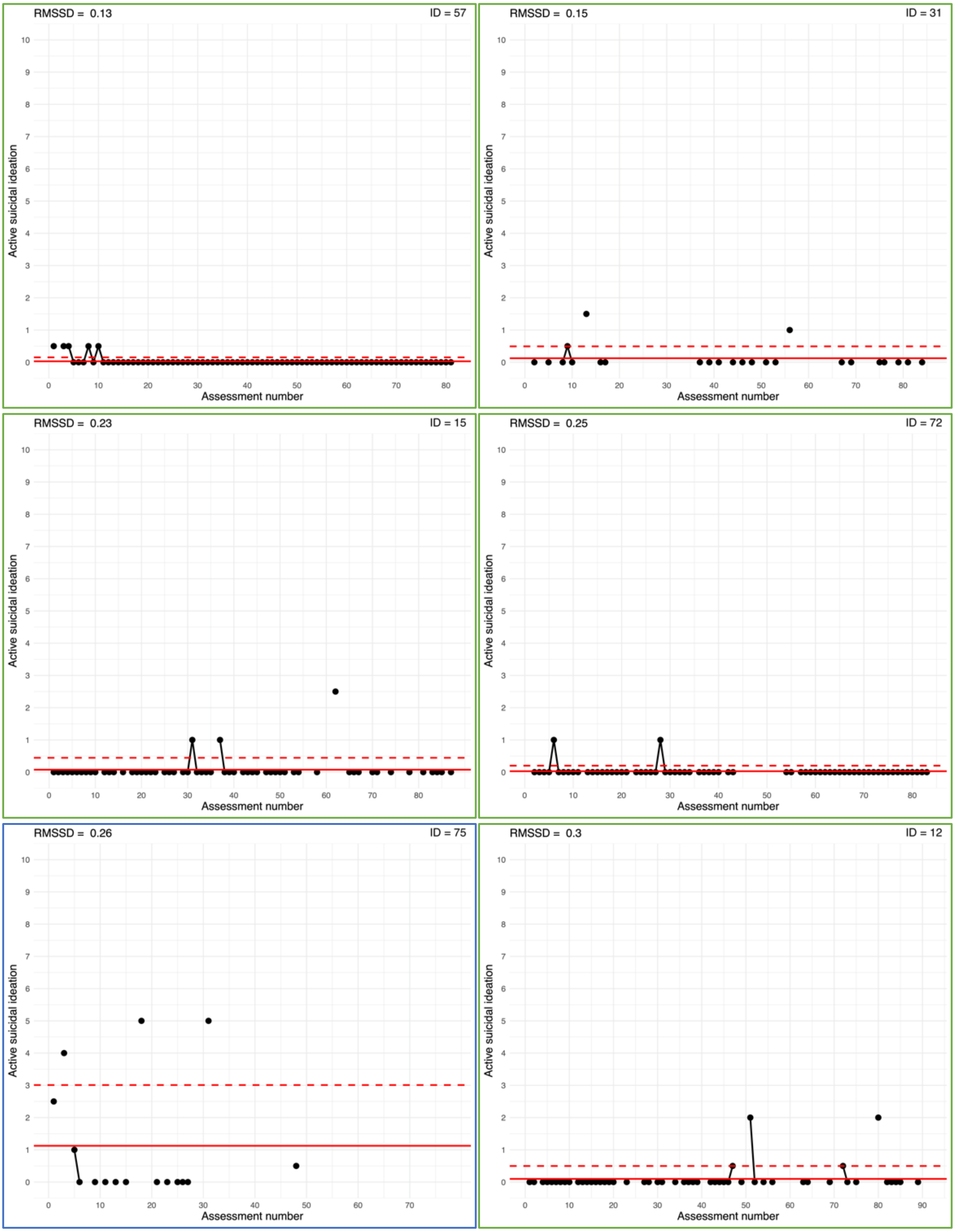

RMSSD = 2.08
ID = 54
RMSSD = 2.15
ID = 62
RMSSD = 2.33
ID = 28
RMSSD = 2.42
ID = 74
RMSSD = 2.42
ID = 6
RMSSD = 2.5
ID = 30
Passive suicidal ideation
Assessment number

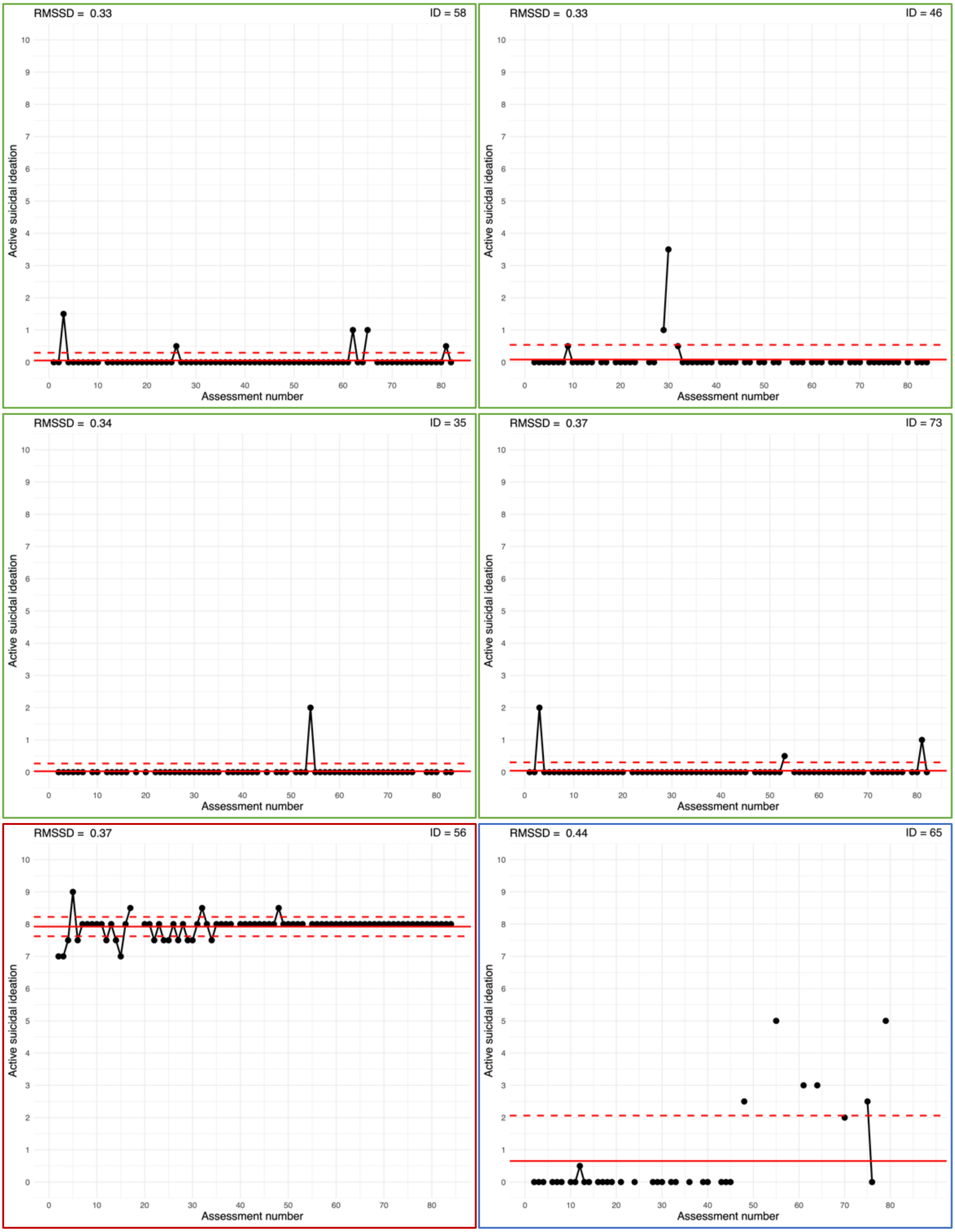


Note: Time-series plots are presented in order of low to high RMSSD (root mean square of successive differences); Phenotype 1 is represented in red, Phenotype 2 in blue, and Phenotype 3 in green; ID numbers do *not* correspond to participant numbers assigned during data collection

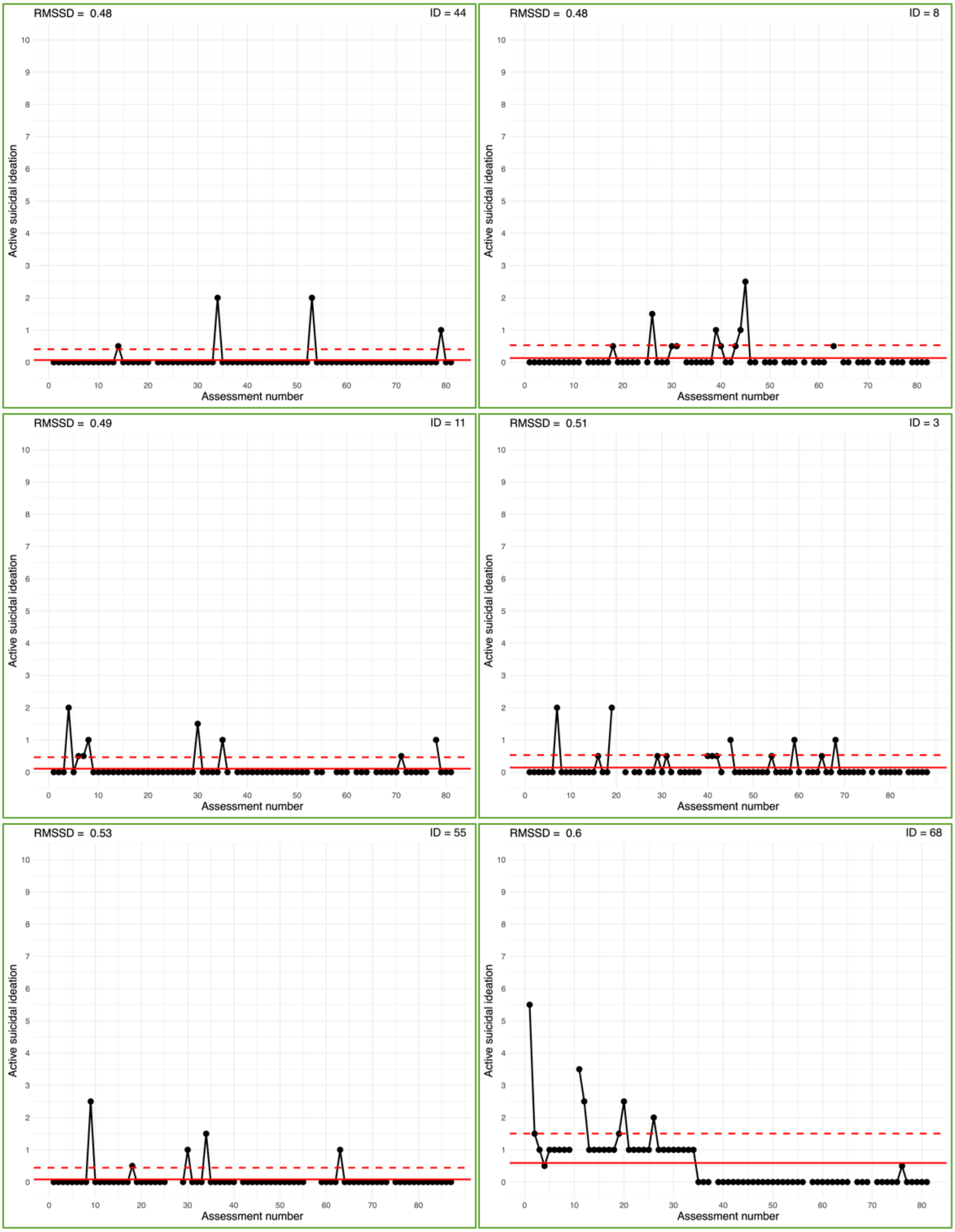
Figure S2. Variability in Active Suicidal Ideation


RMSSD = 0
ID = 63
RMSSD = 0.08
ID = 32
RMSSD = 0.08
ID = 78
RMSSD = 0.1
ID = 42
RMSSD = 0.11
ID = 43
RMSSD = 0.12
ID = 61
Active suicidal ideation
Assessment number

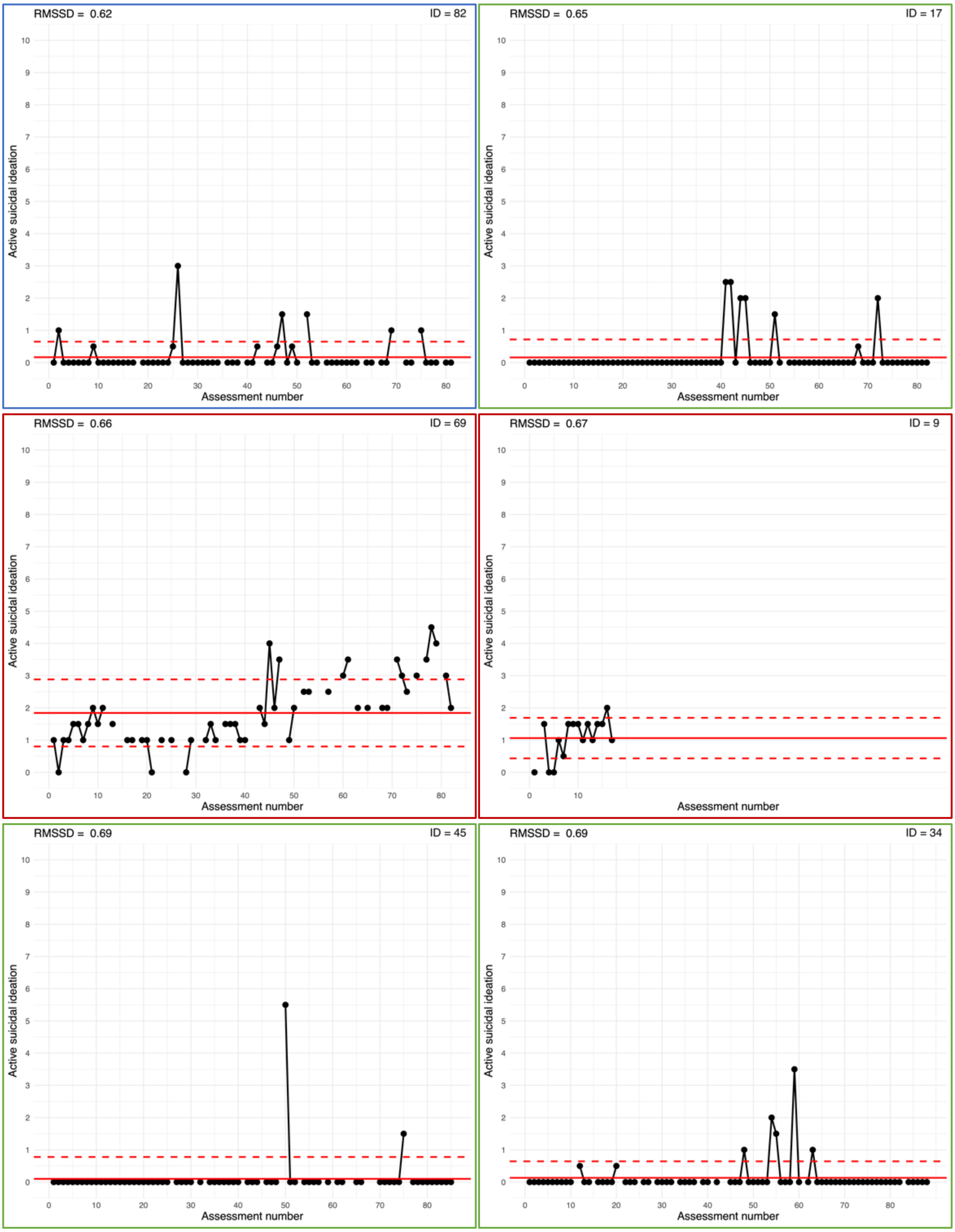

RMSSD = 0.13
ID = 57
RMSSD = 0.15
ID = 31
RMSSD = 0.23
ID = 15
RMSSD = 0.25
ID = 72
RMSSD = 0.26
ID = 75
RMSSD = 0.3
ID = 12
Active suicidal ideation
Assessment number

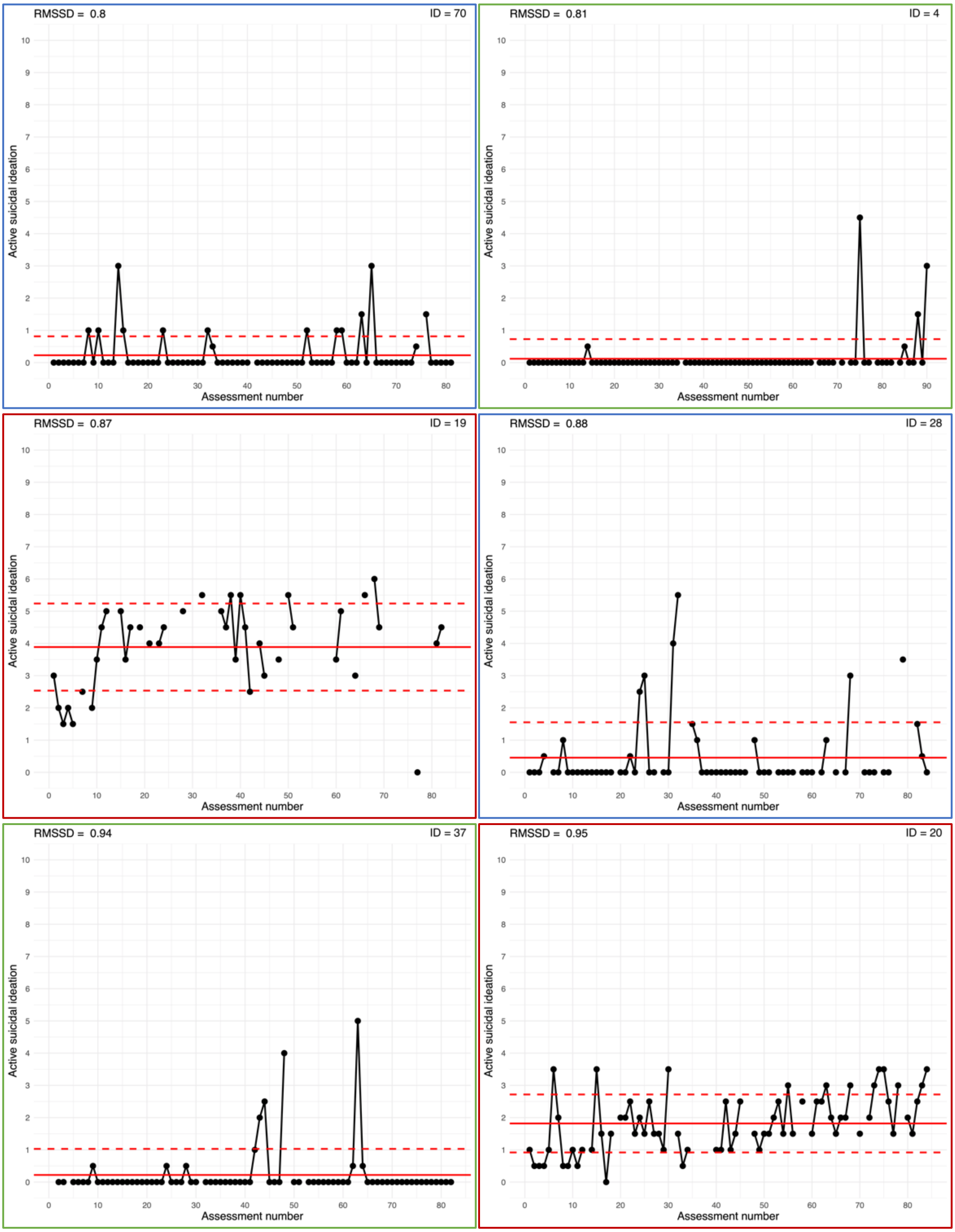


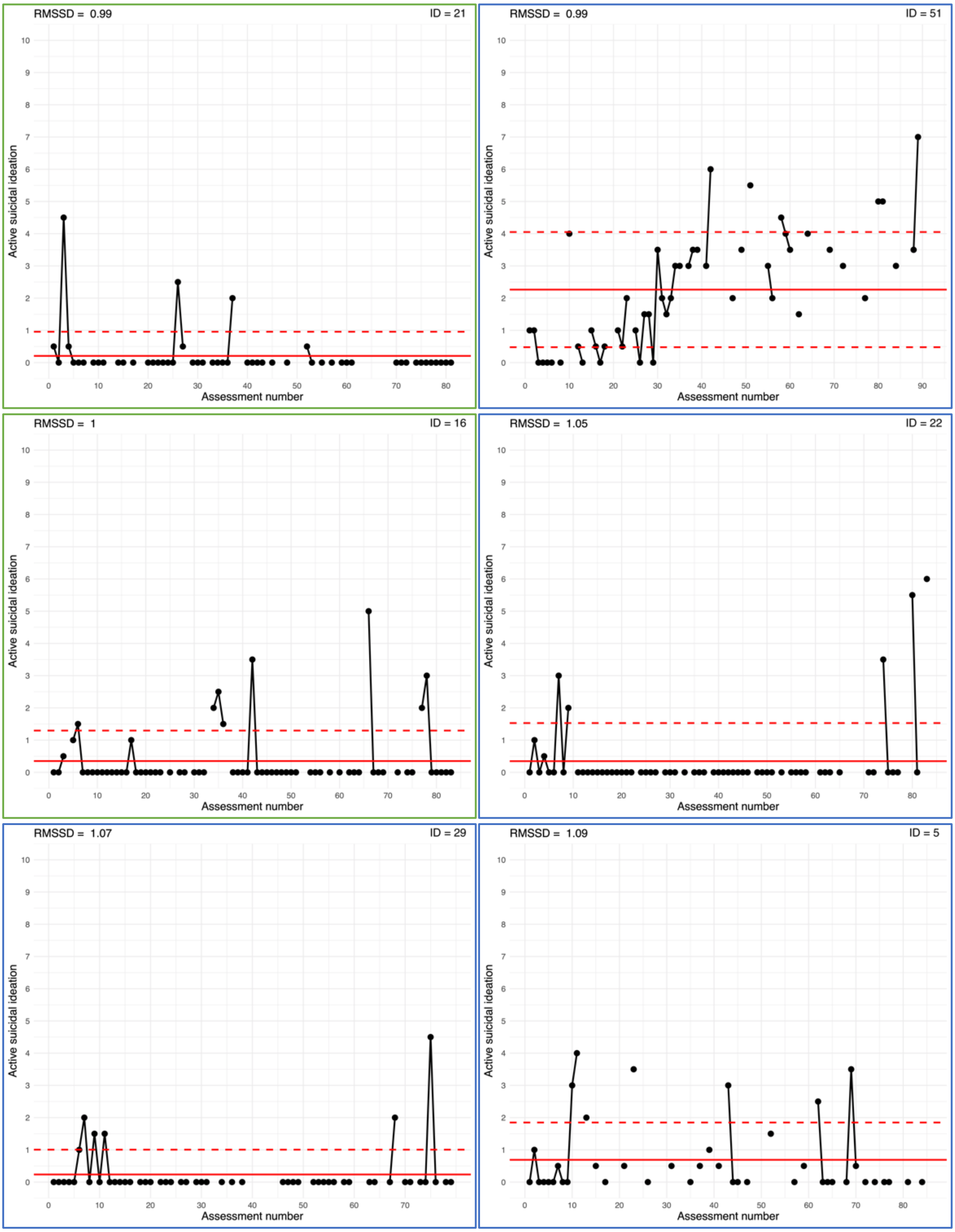
RMSSD = 0.33
ID = 58
RMSSD = 0.33
ID = 46
RMSSD = 0.34
ID = 35
RMSSD = 0.37
ID = 73
RMSSD = 0.37
ID = 56
RMSSD = 0.44
ID = 65
Active suicidal ideation
Assessment number

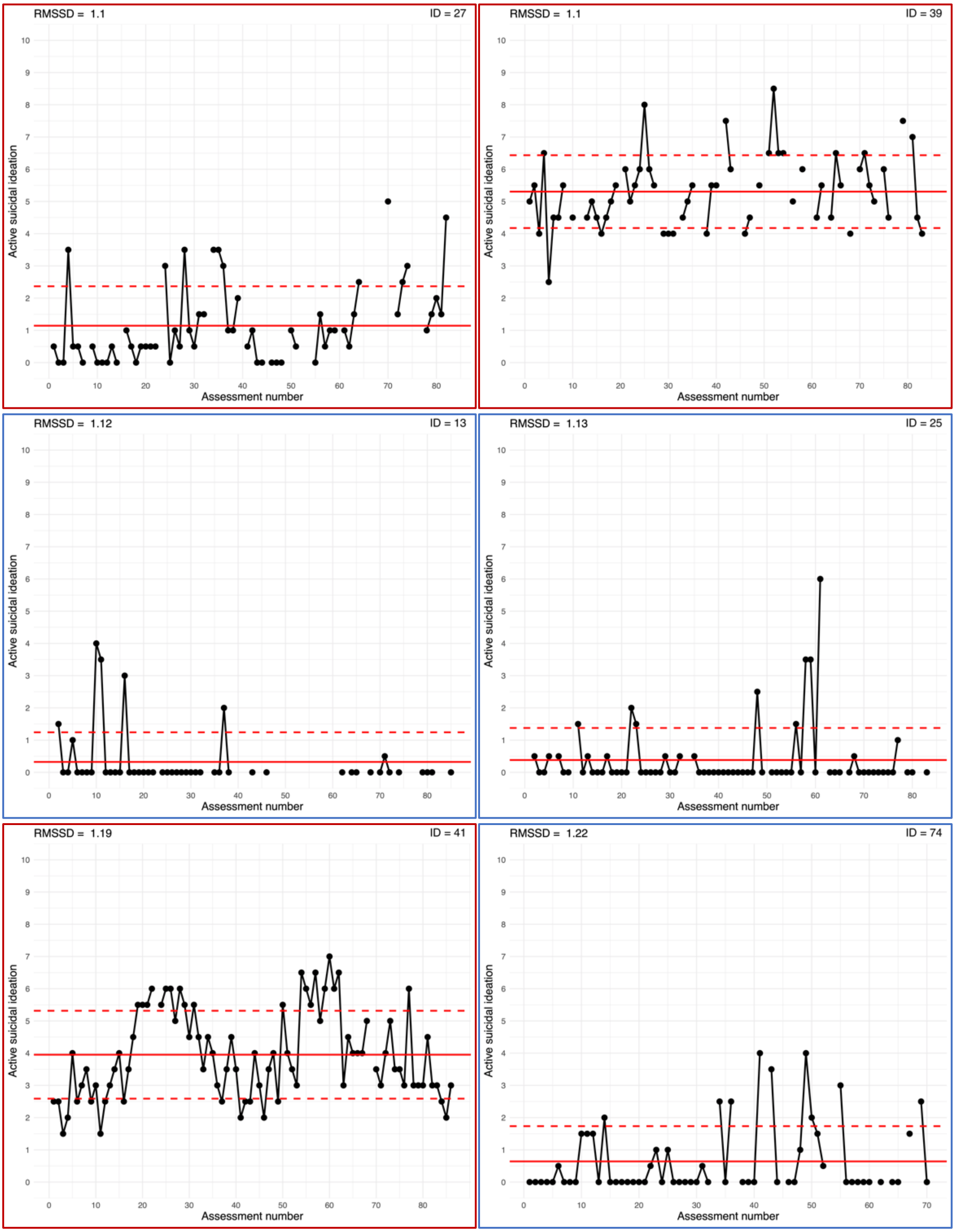


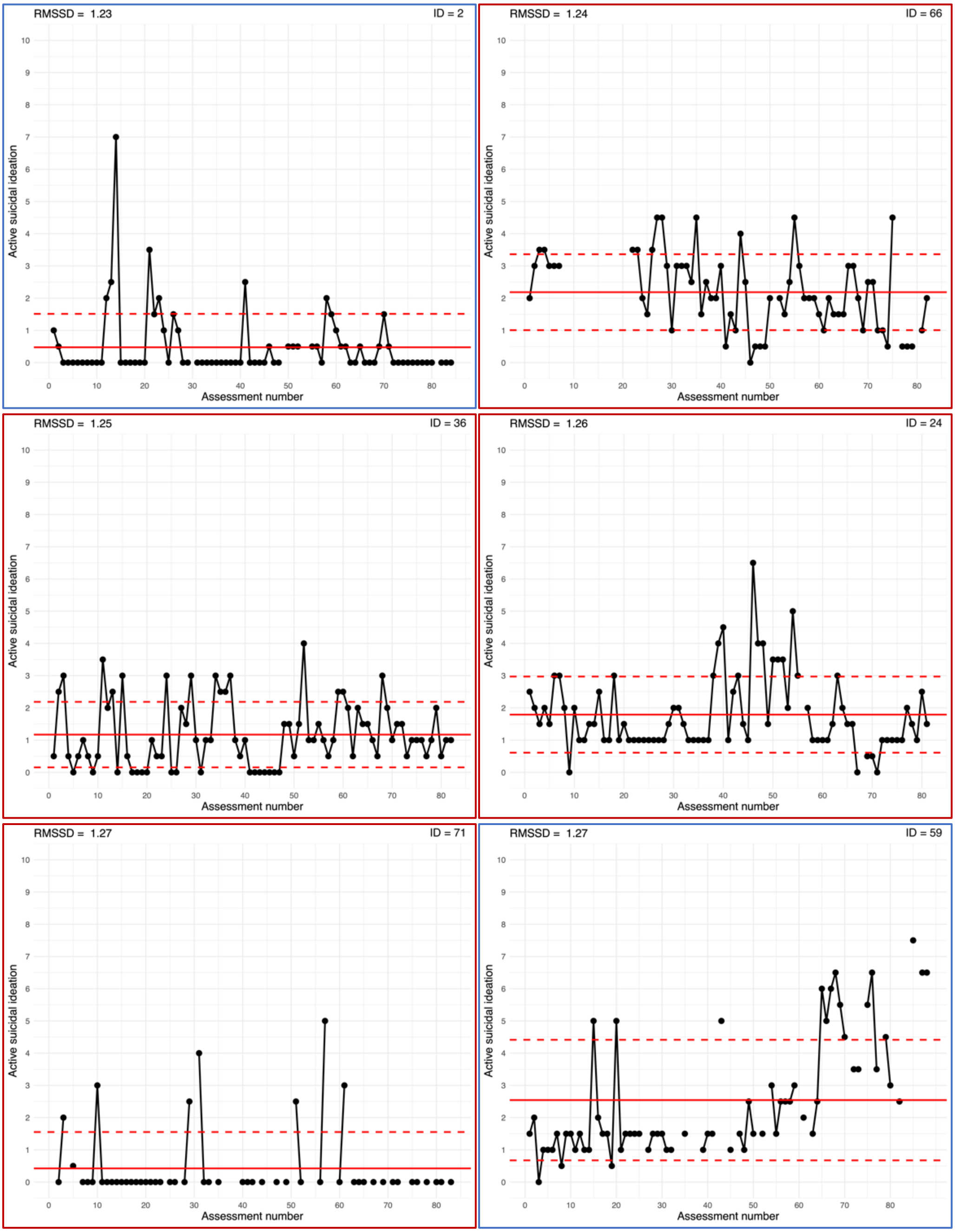
RMSSD = 0.48
ID = 44
RMSSD = 0.48
ID = 8
RMSSD = 0.49
ID = 11
RMSSD = 0.51
ID = 3
RMSSD = 0.53
ID = 55
RMSSD = 0.6
ID = 68
Active suicidal ideation
Assessment number

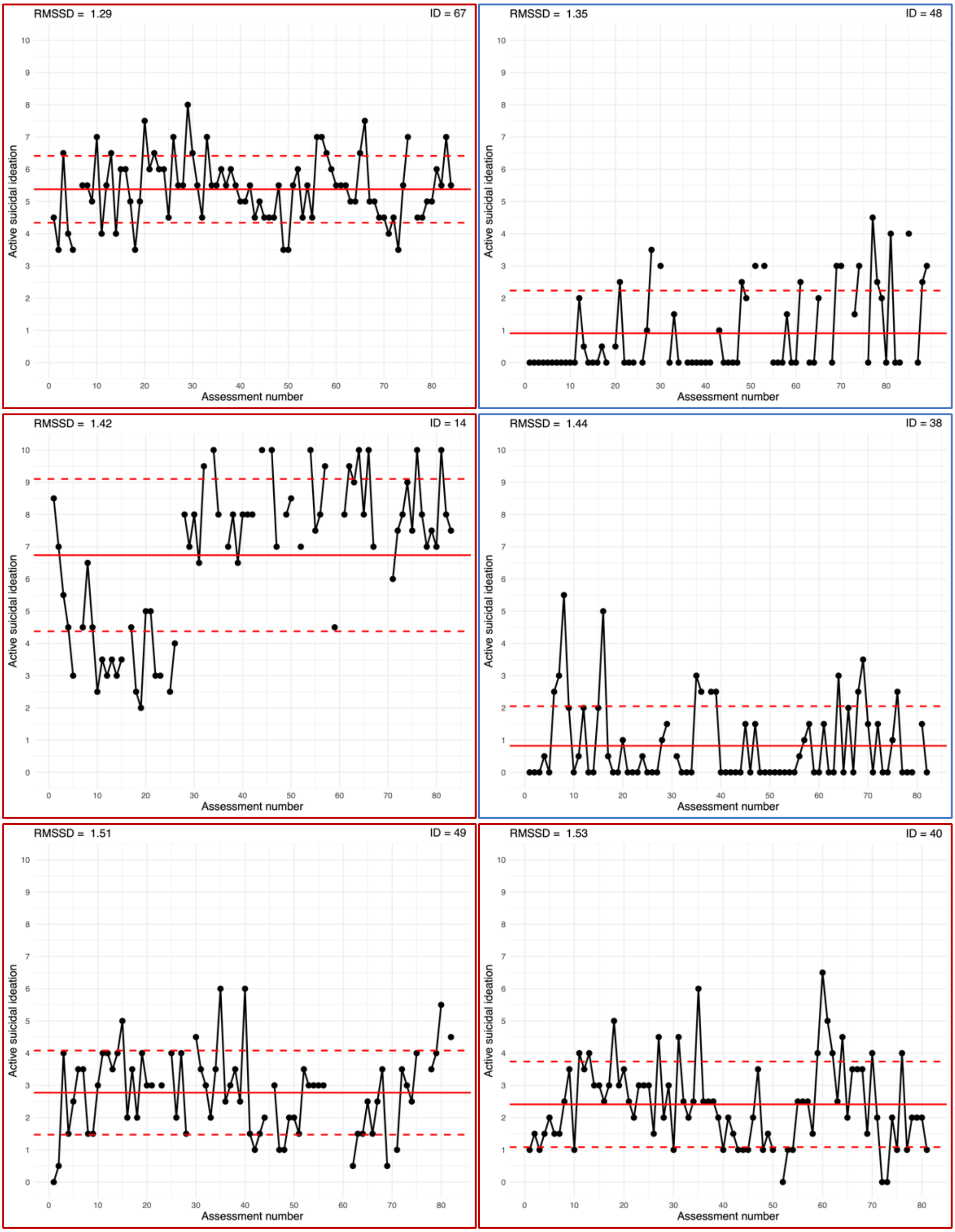

RMSSD = 0.62
ID = 82
RMSSD = 0.65
ID = 17
RMSSD = 0.66
ID = 69
RMSSD = 0.67
ID = 9
RMSSD = 0.69
ID = 45
RMSSD = 0.69
ID = 34
Active suicidal ideation
Assessment number

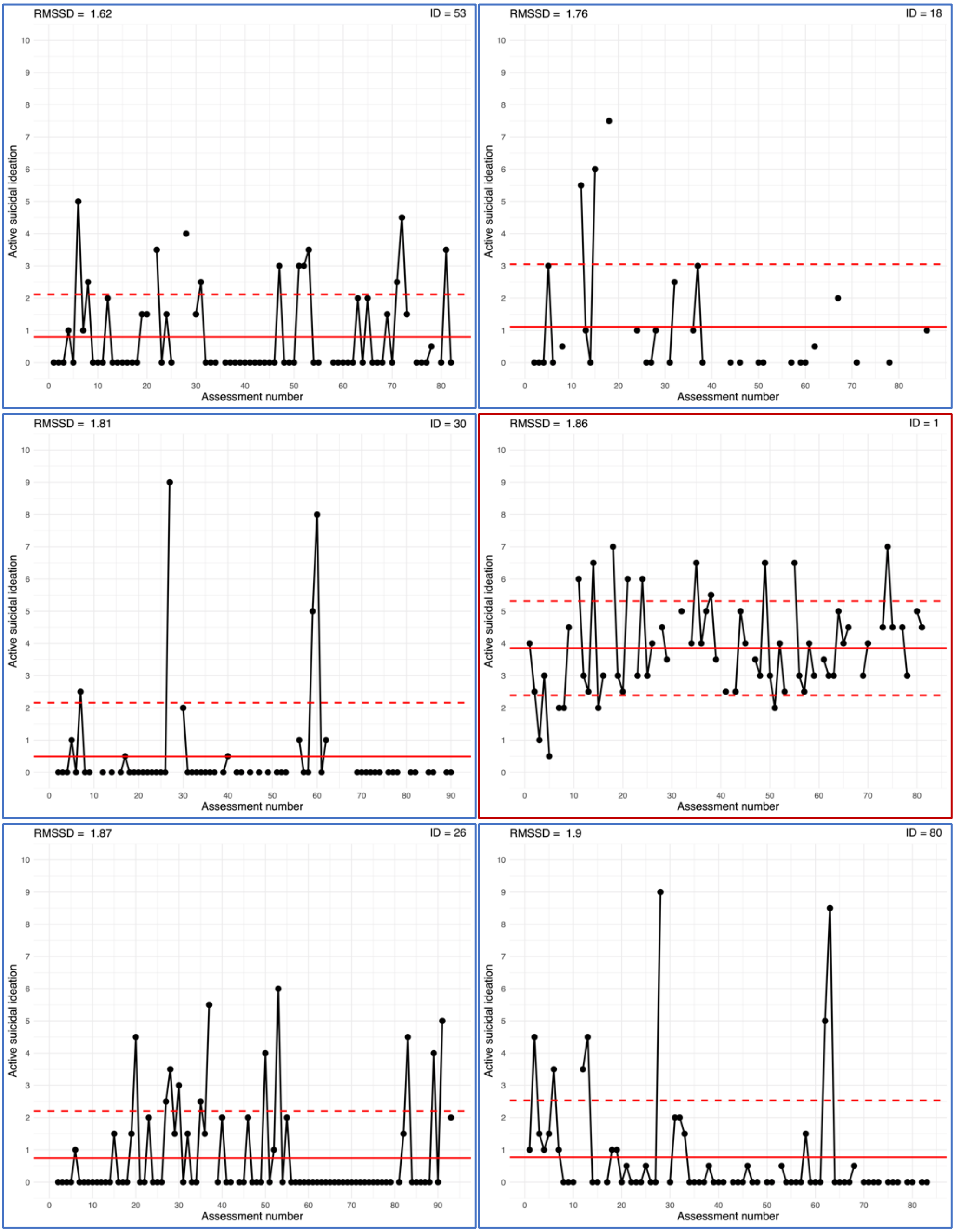

RMSSD = 0.8
ID = 70
Active suicidal ideation
Assessment number
RMSSD = 0.81
ID = 4
Active suicidal ideation
Assessment number
RMSSD = 0.87
ID = 19
Active suicidal ideation
Assessment number
RMSSD = 0.88
ID = 28
Active suicidal ideation
Assessment number
RMSSD = 0.94
ID = 37
Active suicidal ideation
Assessment number
RMSSD = 0.95
ID = 20
Active suicidal ideation
Assessment number

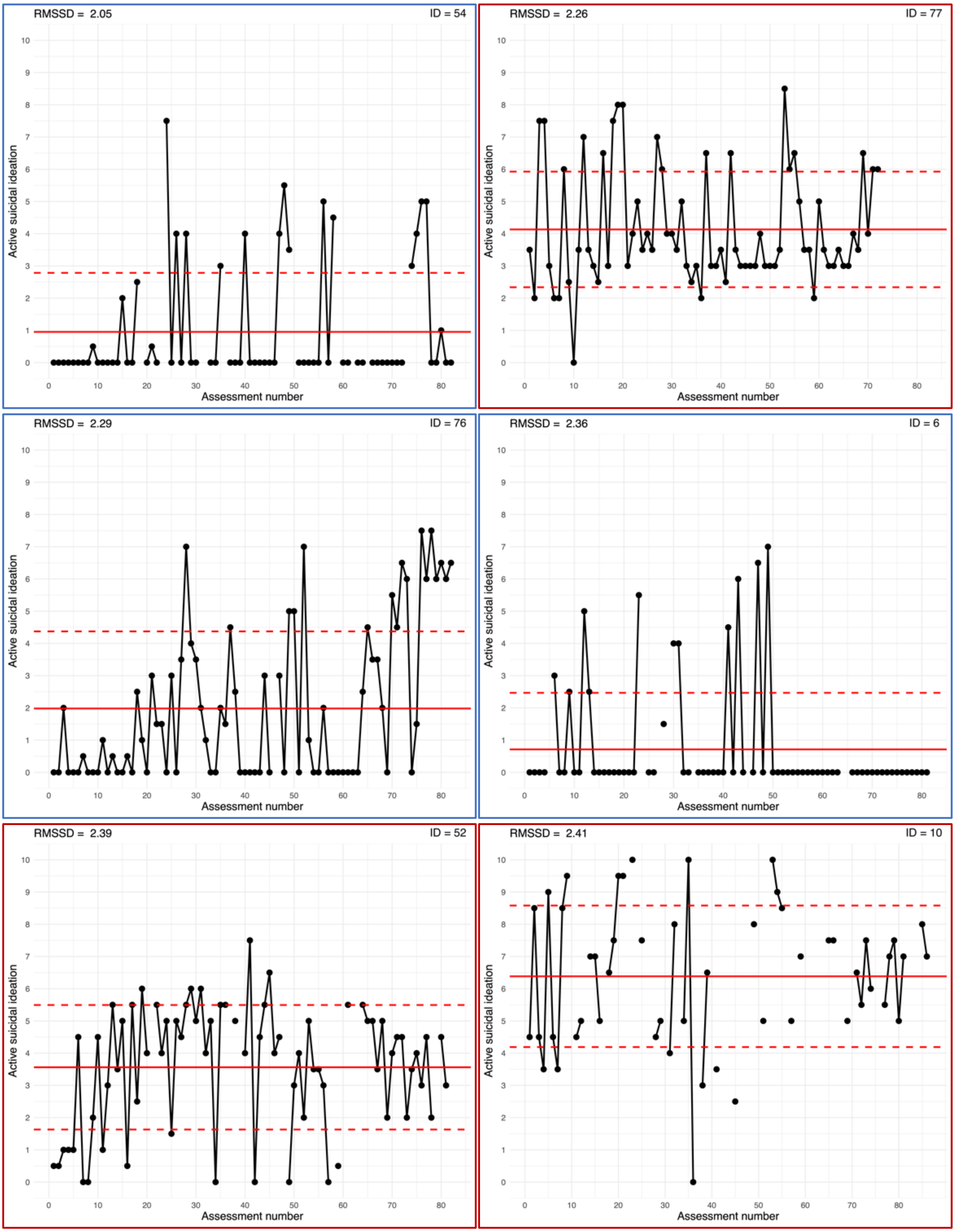

RMSSD = 0.99
ID = 21
RMSSD = 0.99
ID = 51
RMSSD = 1
ID = 16
RMSSD = 1.05
ID = 22
RMSSD = 1.07
ID = 29
RMSSD = 1.09
ID = 5
Active suicidal ideation
Assessment number

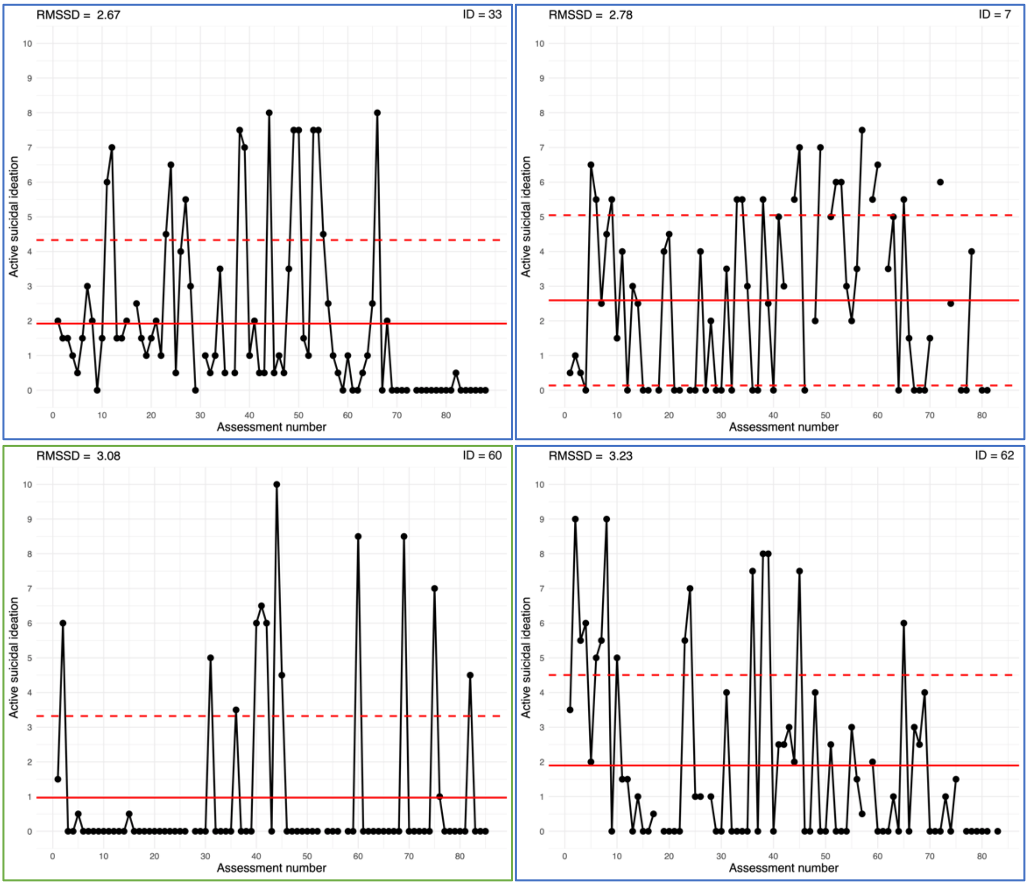

RMSSD = 1.1
ID = 27
RMSSD = 1.1
ID = 39
RMSSD = 1.12
ID = 13
RMSSD = 1.13
ID = 25
RMSSD = 1.19
ID = 41
RMSSD = 1.22
ID = 74
Active suicidal ideation
Assessment number


RMSSD = 1.23
ID = 2
RMSSD = 1.24
ID = 66
RMSSD = 1.25
ID = 36
RMSSD = 1.26
ID = 24
RMSSD = 1.27
ID = 71
RMSSD = 1.27
ID = 59
Active suicidal ideation
Assessment number


RMSSD = 1.29
ID = 67
RMSSD = 1.35
ID = 48
RMSSD = 1.42
ID = 14
RMSSD = 1.44
ID = 38
RMSSD = 1.51
ID = 49
RMSSD = 1.53
ID = 40
Active suicidal ideation
Assessment number


RMSSD = 1.62
ID = 53
RMSSD = 1.76
ID = 18
RMSSD = 1.81
ID = 30
RMSSD = 1.86
ID = 1
RMSSD = 1.87
ID = 26
RMSSD = 1.9
ID = 80
Active suicidal ideation
Assessment number


RMSSD = 2.05
ID = 54
RMSSD = 2.26
ID = 77
RMSSD = 2.29
ID = 76
RMSSD = 2.36
ID = 6
RMSSD = 2.39
ID = 52
RMSSD = 2.41
ID = 10
Active suicidal ideation
Assessment number



Note: Time-series plots are presented in order of low to high RMSSD (root mean square of successive differences); Phenotype 1 is represented in red, Phenotype 2 in blue, and Phenotype 3 in green; ID numbers do *not* correspond to participant numbers assigned during data collection

Table S1. Pearson Correlations and Reliability Statistics for the Subscales of Passive and Active Suicidal Ideation

	1.	2.	3.	4.	ICC	Cronbach's alpha
Passive suicidal ideation					.70	0.85
1. Desire to live	-	**.75**	**.64**	**.54**		
2. Desire to die	-	-	**.83**	**.73**		
Active suicidal ideation					.67	0.97
3. Suicidal thoughts	**.64**	**.83**	-	-		
4. Suicidal intent	**.54**	**.73**	**.94**	-		

Note: ICC = Intra-class correlation coefficient; correlation coefficients significant with $p < .05$ are indicated in **bold**

Table S2. Pearson Correlations between Passive and Active Suicidal Ideation Characteristics

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. *M*, Passive	-	-	-	-	-	-	-	-	-
2. *M*, Active	**.86**	-	-	-	-	-	-	-	-
3. *SD*, Passive	**.33**	.13	-	-	-	-	-	-	-
4. *SD*, Active	**.62**	**.51**	**.78**	-	-	-	-	-	-
5. Peak, Passive	**.73**	**.56**	**.75**	**.77**	-	-	-	-	-
6. Peak, Active	**.70**	**.68**	**.65**	**.88**	**.84**	-	-	-	-
7. % non-zero, Passive	**.51**	**.27**	**.23**	**.26**	**.28**	**.23**	-	-	-
8. % non-zero, Active	**.82**	**.84**	**.29**	**.60**	**.60**	**.65**	**.36**	-	-
9. RMSSD, Passive	.10	−.05	**.82**	**.49**	**.55**	**.43**	**.22**	.06	-
10. RMSSD, Active	**.55**	**.43**	**.70**	**.90**	**.74**	**.83**	**.26**	**.50**	**.57**

Note: M = Mean, *SD* = Standard deviation, RMMSD = Root mean square of successive differences; correlation coefficients significant with $p < .05$ are indicated in **bold**.

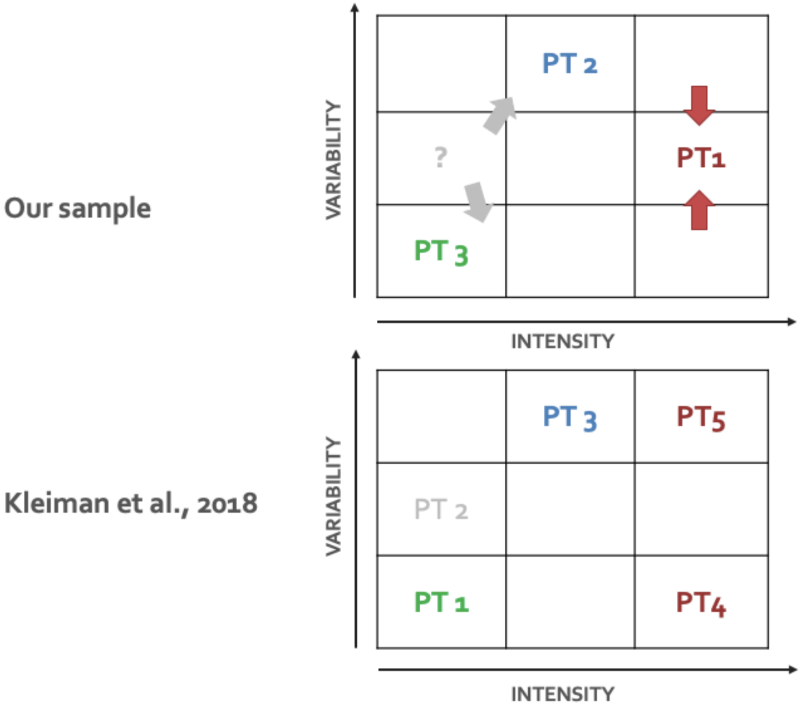
Table S3. Individual Class Probabilities for the Final Three Profile Solution

	Type 1	Type 2	Type 3		Type 1	Type 2	Type 3
ID 1	**1.00e+00**	2.27e-26	3.36e-157	ID 42	1.03e-38	6.76e-06	**1.00e+00**
ID 2	3.39e-20	**1.00e+00**	4.08e-06	ID 43	1.94e-279	4.22e-06	**1.00e+00**
ID 3	2.17e-61	1.55e-03	**9.98e-01**	ID 44	1.87e-35	6.67e-04	**9.99e-01**
ID 4	0.00e+00	6.64e-11	**1.00e+00**	ID 45	0.00e+00	3.38e-35	**1.00e+00**
ID 5	1.10e-17	**1.00e+00**	1.22e-11	ID 46	1.44e-52	3.07e-02	**9.69e-01**
ID 6	2.17e-28	**9.99e-01**	8.02e-04	ID 47	5.46e-40	2.72e-06	**1.00e+00**
ID 7	1.24e-06	**1.00e+00**	4.61e-28	ID 48	5.35e-14	**9.98e-01**	1.54e-03
ID 8	6.01e-29	1.61e-04	**1.00e+00**	ID 49	**1.00e+00**	1.56e-12	1.01e-54
ID 9	**1.00e+00**	8.64e-13	4.22e-25	ID 50	4.64e-50	8.09e-13	**1.00e+00**
ID 10	**1.00e+00**	4.25e-105	0.00e+00	ID 51	3.71e-02	**9.63e-01**	9.16e-35
ID 11	3.50e-33	1.55e-08	**1.00e+00**	ID 52	**1.00e+00**	1.69e-13	5.74e-91
ID 12	1.69e-37	1.46e-02	**9.85e-01**	ID 53	7.19e-19	**1.00e+00**	6.82e-07
ID 13	9.38e-117	**9.97e-01**	2.93e-03	ID 54	4.66e-40	**1.00e+00**	1.04e-10
ID 14	**1.00e+00**	1.36e-137	0.00e+00	ID 55	0.0e+00	8.6e-09	**1.0e+00**
ID 15	1.70e-34	5.60e-04	**9.99e-01**	ID 56	**1.00e+00**	1.02e-277	0.00e+00
ID 16	4.73e-28	1.02e-03	**9.99e-01**	ID 57	1.77e-186	8.81e-08	**1.00e+00**
ID 17	2.09e-305	7.33e-09	**1.00e+00**	ID 58	3.66e-34	1.88e-02	**9.81e-01**
ID 18	3.91e-15	**1.00e+00**	4.62e-13	ID 59	**1.00e+00**	7.54e-08	5.09e-39
ID 19	**1.00e+00**	1.13e-28	1.30e-202	ID 60	0.00e+00	4.34e-12	**1.00e+00**
ID 20	**1.00e+00**	9.11e-12	1.10e-28	ID 61	8.79e-35	1.24e-04	**1.00e+00**
ID 21	2.38e-35	1.26e-05	**1.00e+00**	ID 62	2.77e-11	**1.00e+00**	7.91e-08
ID 22	3.98e-32	**1.00e+00**	2.42e-04	ID 63	0.00e+00	1.16e-32	**1.00e+00**
ID 23	1.00e-41	4.95e-04	**1.00e+00**	ID 64	2.97e-40	3.03e-06	**1.00e+00**
ID 24	**1.00e+00**	2.44e-10	7.65e-27	ID 65	2.66e-25	**1.00e+00**	6.47e-25
ID 25	6.59e-23	**1.00e+00**	2.68e-06	ID 66	**1.00e+00**	2.26e-09	4.80e-26
ID 26	2.52e-28	**1.00e+00**	9.68e-08	ID 67	**1.00e+00**	2.07e-85	0.00e+00
ID 27	**1.00e+00**	1.11e-05	9.42e-15	ID 68	8.34e-10	6.10e-03	**9.94e-01**
ID 28	2.30e-26	**1.00e+00**	8.51e-08	ID 69	**1.00e+00**	1.01e-11	6.91e-21
ID 29	4.81e-34	**88e-01**	16e-02	ID 70	3.35e-59	**9.29e-01**	7.10e-02
ID 30	0.00000	**0.99859**	0.00141	ID 71	2.23e-33	**9.99e-01**	1.18e-03
ID 31	0.00e+00	2.11e-06	**1.00e+00**	ID 72	0.00e+00	1.36e-14	**1.00e+00**
ID 32	2.44e-40	1.56e-07	**1.00e+00**	ID 73	2.28e-262	9.48e-05	**1.00e+00**
ID 33	1.05e-02	**9.89e-01**	9.89e-11	ID 74	1.33e-17	**1.00e+00**	2.07e-07
ID 34	3.98e-32	1.40e-02	**9.86e-01**	ID 75	0.0e+00	**1.0e+00**	9.6e-60
ID 35	0.00e+00	1.86e-14	**1.00e+00**	ID 76	1.90e-06	**1.00e+00**	2.33e-08
ID 36	**1.00e+00**	4.74e-07	1.19e-27	ID 77	**1.00e+00**	5.83e-29	1.80e-193
ID 37	0.0e+00	1.3e-12	**1.0e+00**	ID 78	1.06e-39	6.90e-07	**1.00e+00**

ID 38	1.62e-10	**1.00e+00**	1.07e-05	ID 79	2.75e-111	7.16e-09	**1.00e+00**
ID 39	**1.00e+00**	6.25e-87	0.00e+00	ID 80	4.48e-34	**1.00e+00**	2.45e-05
ID 40	**1.00e+00**	4.74e-09	3.10e-37	ID 81	0.00e+00	2.47e-32	**1.00e+00**
ID 41	**1.00e+00**	6.89e-33	4.16e-215	ID 82	6.16e-26	**9.75e-01**	2.49e-02

Note: The class that the participant was ultimately assigned to is indicated in **bold**

Figure S3. Graphical Depiction of Similarities with the Phenotypes by Kleiman et al. (2018)



CHAPTER 07:

Discussion

Discussion

In the previous chapters, we have explored the short-term temporal dynamics of suicidal ideation and the value of real-time assessment methods in the study of both suicidal ideation and its related risk and protective factors in daily life. Finally, in the previous chapter, we explored how this real-time data may be used to make predictions of individuals' suicide risk in the future. Here, we discuss how these findings fit within our greater understanding of suicidal ideation, consider the strengths and weaknesses of the methodologies used, and discuss directions for future research. Finally, we explore the promise of real-time monitoring approaches for clinical practice.

Ecological Momentary Assessment (EMA) in Suicide Research

The use of ecological momentary assessment (EMA) in mental health research in general, and suicide research specifically, has grown exponentially in recent years. A 2016 review of 669 e-mental health research articles (including EMA) concluded that 57% of the identified literature had been published in the previous five years (Firth et al., 2016). A more recent review of 35 articles on EMA in suicide research concluded that 74% of the studies had been published within the prior three years (Sedano-Capdevila et al., 2021). It therefore appears that pleas to increasingly focus on short-term timeframes when examining suicidal thoughts and behaviors (Bryan and Rudd, 2016; Franklin et al., 2017) have been heard and put into action – aided by the omnipresence of mobile phones and other commercial wearables in our modern society.

Considering the marked expansion of EMA in psychological research, concerns may arise that the feasibility and safety of such measures in at-risk populations has not been comprehensively assessed prior to such broad application. It should be noted, though, that a number of reviews have previously concluded that EMA is feasible and safe; EMA has been tested in a number of clinical populations, including those with anxiety (Walz et al., 2014) and depressive disorders (Colombo et al., 2019). Since then, these findings have been extended to patients with suicidal thoughts and behaviors (see **Chapter 2**, as well as Gee et al., 2020; Sedano-Capdevila et al., 2021 for reviews). Our examination of the acceptability, feasibility and safety of EMA in **Chapter 3** also largely supports these early conclusions, although two major points are discussed here that should be taken into consideration when designing EMA studies in suicide research.

Feasible – with Certain Limitations In **Chapter 2**, we reviewed EMA studies in suicide research and concluded that EMA appears feasible, even in this potentially challenging patient group. This is reassuring, considering that patients with more severe mental health symptomatology may generally be less inclined to participate in scientific research (Sheridan et al., 2020), and be more likely drop out of longitudinal cohort studies (Lamers et al., 2012). Instead, we found evidence of high compliance to study assessments (i.e., EMA response rates), both in the prior literature (*Med* = 70%; **Chapter 2**) as well as in the present cohort (*Med* = 84%; Chapter 3). Likewise, attrition was low (*Med* = 6% in prior studies; **Chapter 2**, and 1% in our cohort during the EMA period; **Chapter 3**), giving further support for the feasibility of EMA among patients with suicidal symptoms.

It is evident, however, that recruitment remains a challenge for mental health research in general (Tranberg et al., 2023), and EMA studies in particular (Nuij et al., 2022). While patients with more severe symptomatology may feel less able to further exert themselves by taking part in scientific research (Sheridan et al., 2020), it is also known that the increased burden of EMA designs specifically may discourage potential participants (Bos, 2021). While our sample size (*N* = 82) was larger than the average of previous studies (*Med* = 50; **Chapter 2**), larger cohorts have also been assessed (e.g., *n* = 237 in Rogers, 2021). Once part of the study, however, it appears that the burden of repeated assessments does not impact data quality and quantity, at least within typical EMA designs (with an average duration of *Med* = 14 days; **Chapter 2**). However, missingness may become more apparent when researchers aim to extend electronic symptom monitoring to span many months, or even a year, as in the present study (**Chapter 6**). The reduction in response rates from our daily EMA (*Med* = 84%) to our weekly questionnaires (*Med* = 74%) was substantial, but response was still sufficient for analysis. Indeed, prior feasibility studies on digital assessments of suicidal ideation have only focused on short-term EMA, rather than symptom monitoring over longer timeframes. We are the first to employ such repeated (weekly) electronic assessments of suicidal ideation over an extended (12-month) period. Consequently, current conclusions from the field rightfully, and carefully, state that "it is feasible to apply *short-duration* [electronic symptom monitoring]" (van Genugten et al., 2020, p. 1). The feasibility of extended symptom assessments, therefore, warrants further examination. Preliminary findings from our study are encouraging and indicate that such symptom monitoring does not, at the very least, appear *un*feasible. Such extended monitoring may be needed when events of interest concern suicidal behavior (due to the low base rate of suicide attempts and mortality) (Glenn & Nock, 2014). For such studies, it seems clear that researchers should aim for larger initial sample sizes in order to account for the more substantial attrition that follows from intensive longitudinal assessments over longer timeframes.

Considering Participant Safety When Examining Risk Studies have consistently shown that EMA of suicidal ideation does not lead to systematic negative symptom reactivity (see **Chapter 2** for a review of the literature, and **Chapter 3** for our examination of EMA iatrogenic effects in our sample). However, our findings indicate that a minority of participants may experience such effects. Namely, 18% of our participants reported retrospectively that the EMA had sometimes triggered their suicidal ideation (when not experiencing ideation prior to the EMA prompt), and 10% that the EMA had sometimes worsened their ideation (when already experiencing ideation).[1] It should be noted that these reports were not accompanied by observable increases in the participants' EMA-ratings. These inconsistencies indicate that this topic requires continued attention. It also remains to be examined to what *extent* these negative consequences are experienced by participants, and certain limitations should be considered when interpreting these findings. Most importantly, we did not specify in our questionnaire whether any triggering or worsening effects were experienced only *occasionally,* or *systematically* in response to every prompt, and how *distressing* these perceived increases were for the participants. Many testing procedures within medical and psychological research (such as blood tests, Lavery & Ingram, 2005) or paradigms including distressing imagery (Jorm et al., 2007)) may cause a certain level of discomfort to participants, but these effects are typically short-lived. Indeed, the literature indicates that participating in mental health research (Jorm et al., 2007), including research on suicide-related phenomena (Schatten et al., 2022; Smith et al., 2010), is more likely to result in positive rather than negative outcomes. This was also apparent in our sample, with 22% of participants reporting *improved* mood in response to the EMA measures, and the group as a whole exhibiting a reduction in overall suicidal ideation severity from pre- to post-EMA (although the latter finding may simply reflect regression to the mean).

Another question regarding participant safety that readers may have while considering the data reported in **Chapter 6**, as well as the description of ***Case Study 3***, is: *could something have been done to intervene and prevent an attempt?* The implementation of safety procedures and how such procedures may look like is a focal point in the discourse regarding suicide research, and especially that of the ever-growing field of EMA. Even though we can relatively confidently conclude that, based on the existing evidence, repeat suicidal ideation assessments do not lead to systematic, substantial or sustained increases in symptoms (**Chapter 2** & **Chapter 3**), the fact remains

[1] 5 participants reported both a triggering and a worsening effect, 5 reported a triggering effect only, and 1 participant reported a worsening effect only.

that such assessments do provide unique opportunities for intervention. However, such safeguards are rarely implemented in EMA designs, unless studying underage populations (**Chapter 2**). In the present study, we employed a number of safety measures. First, we performed a comprehensive assessment of the participants' risk status at baseline in order to determine whether the participant was stable enough to participate, or in need of immediate referral for emergency services or specialized mental health care. Second, we required all participants with severe symptomatology to be currently under the care of a specialist (psychologist and/or psychiatrist), and we notified the general practitioner, and/or treating specialist of each participant of their involvement in the study. Third, we created personalized suicide safety plans for each participant, detailing their preferred coping strategies and resources to be consulted in case of suicidal crises. These safety plans also included a reminder to the participants that if they felt like their participation in the study was affecting their mental health in a negative way, they could discontinue at any time. Finally, we explicitly informed the participants that their responses within the app would not be viewed by study personnel prior to the completion of the data collection period(s) (first after the end of the 21-day EMA, and then after the 1-year monitoring period) and in case they experienced issues with the study proceedings (incl. iatrogenic effects) they should directly contact the study personnel, or if they experienced a suicidal crisis, they should consult their suicide safety plan (which also included resources such as the 113 suicide prevention line, and the emergency line (112)). Yet, we did not employ built-in algorithms within the app that would have triggered an alert to the study personnel in response to the participants' reports of high levels of suicidal ideation. However, a question also remains about how effective such safeguards might be. For example, an EMA study of 434 adolescent and adult psychiatric patients with a recent history of suicidal ideation and/or behavior employed real-time interventions in response to participant's EMA suicidal ideation ratings (based on scores >= 8 out of 10) (Bentley et al., 2024). This included presenting participants with their safety plan, as well as a message being sent out to the study's risk monitoring team that subsequently contacted the participant within 24 hours. For patients whose responses triggered this intervention, there was evidence of discontinuity in ratings such as that participants were more likely to rate their ideation below the threshold in future entries. Further, 22% of suicidal ideation ratings that triggered the response were changed to a lower rating (most commonly, a 7 i.e., just below the threshold) before submitting the survey after participants received a pop-up notification about the intervention steps. Hence, it appears that the possibility of intervention may not necessarily lead to a better identification of crises, but rather the omission of the reporting of such crises when they occur, and can cause strategic responding that may impact data quality due to artificial ceiling effects. Developing real-time intervention protocols that do not lead to such effects remains a goal, but also a challenge, for future research. Despite these limitations, when used in primary mental health care, monitoring of scores in real-time can be beneficial.

Correlates and Predictors of Real-Time Suicidal Ideation

In **Chapter 2**, we discuss how EMA has utility not only for the real-time assessment of suicidal ideation, but also for the examination of the correlates and predictors of suicidal thoughts. Based on our review of the literature, we found that a range of such potential risk and protective factors have already been examined in EMA designs, with the most commonly assessed predictors including contextual factors, affective states, as well as constructs from *the Interpersonal Psychological Theory of Suicide (IPTS)* (Van Orden et al., 2010) (i.e., hopelessness, thwarted belongingness (or loneliness), and burdensomeness). However, studies so far have predominantly considered only a small number of variables within a certain model, and been unsuccessful in establishing robust short-term temporal predictors of suicidal ideation that may function as warning signs (i.e., factors that signal imminent changes in ideation levels). Such lack of significant temporal findings may reflect a true lack of relations between the observed variables, but may also result from insufficient modeling techniques.

Symptom Networks of Suicidal Ideation In **Chapter 4**, we examined associations between a range of cognitive-affective predictors in relation to real-time suicidal ideation using *network modeling*. The network perspective is increasingly applied to better understand co-occurring symptoms (Borsboom, 2017; Fried et al., 2017), such as those that may lead to the emergence and maintenance of suicidal ideation (de Beurs, 2017). Within this perspective, network modeling allows us to consider these factors not only as correlates or predictors, but also *consequences,* of suicidal ideation (Borsboom et al., 2021; de Beurs, 2017). Complex and bi-directional associations may then be examined, to see how symptoms influence each other over time.

We found that suicidal ideation was concurrently associated with hopelessness, loneliness and burdensomeness, as well as increased sadness and shame, and reduced happiness, calmness and optimism. These experiences also feature in the case studies presented in **Chapter 1**, such as when Vivian (***Case Study 1***) and Mary (***Case Study 2***) struggle to stay calm and optimistic as their daily struggles accumulate, and they feel increasingly hopelessness about future outcomes. Rodrigo (***Case Study 3***) also feels hopeless and alone following the end of an abusive relationship. Likewise, Mary describes how she is "*well aware of* [her] *loneliness"* as she struggles to reach out to friends and is consumed by sadness and grief about the prospect of losing her husband.

We further found that shame, specifically, was concurrent associations with active ideation, and prospectively predicted increases in acquired capability at the subsequent time point. Shame is acknowledged to play a significant role in suicidal outcomes, especially among patients with post-traumatic stress disorder (PTSD) (Goffnett et al., 2020). Shame may elicit more negative arousal than other negative cognitive-affective states, such as sadness or hopelessness (Piretti et al., 2023). Therefore, shame may represent a more undesirable state that individuals feel greater need to escape from, explaining its role in active ideation and capability for suicide specifically. However, shame is rarely treated as an important trans-diagnostic risk factor in clinical practice. Our findings indicate that not only is shame a significant correlate of suicidal ideation, but that it may specifically signal increases in preparedness for suicide, and therefore, increase the risk of future suicidal behavior. Although a number of interventions exist that target shame (Goffnett et al., 2020; Norder et al., 2023), they are not frequently employed in suicide prevention. However, shame-reduction components may easily be incorporated into many interventions that are already commonly used in mental health care, such as cognitive behavioral therapy (CBT) or mindfulness-based interventions (Goffnett et al., 2020).

Further, we found that although the experience of passive suicidal ideation was predictive of increased hopelessness over time, experiences of active ideation were instead followed by *improvements* in mood. Such findings indicate that suicidal ideation may sometimes have a relief function and that it may be used by individuals as a form of maladaptive coping (Coppersmith, et al., 2018). Suicidal plans may also increase an individual's sense of control over their lives, especially in the face of uncontrollable stressors and lack of other avenues for escape. Such motives were also apparent in the case studies presented in **Chapter 1**, where Vivian (***Case Study 1***) describes her suicidal ideation as a form of coping and escapism, and when Mary (***Case Study 2***) grows *more* hopeless after letting go of her suicide plan. These observations are also in line with the *Integrated Motivational-Volitional Model (IMV)* of suicidal behavior (O'Connor & Kirtley, 2018), which highlights the perception of entrapment as a driving force in the emergence of suicidal ideation.

Sleeplessness and Hopelessness Another factor that we found to prospectively predict suicidal ideation is sleep. Sleep disturbances as risk factors for suicidal thoughts and behaviors have long received limited attention in comparison to many other longitudinal risk factors (such as depressive symptoms or sociodemographic characteristics (Borges et al., 2008)). However, this is starting to change, with two recent meta-analyses examining sleep as a longitudinal predictor of suicidal outcomes (Harris et al., 2020; Liu et al., 2020). In **Chapter 5**, we subsequently examined sleep characteristics as short-term (next-day) predictors of suicidal ideation, and found evidence indicating that interrupted sleep during the night (i.e., *middle insomnia*), as assessed with both subjective and objective measures, specifically appeared to lead to worse mental-health outcomes (i.e., hopelessness and suicidal ideation) the subsequent day. Namely, subjective reports of poor sleep quality, short sleep duration and increased nighttime awakenings were all associated with increased symptoms the next day. Therefore, our findings indicate that rather than accumulating over time, the detrimental consequences of poor sleep may be immediately observable in participants' psychological functioning the following day. Sleep disturbances are also explicitly mentioned by Vivian in ***Case Study 1***, where her ideation intensifies in late evening hours when she is unable to sleep and her mind becomes "stuck" on negative thoughts.

On the other hand, our findings also indicate that sleep may represent a fruitful target for suicide interventions. However, like shame-reduction techniques, such interventions are not commonly used in the treatment of patients with suicidal ideation. Sleep interventions are more frequently offered to other patient groups, such as those with PTSD (Miller et al., 2020) or depressive disorders (Gee et al., 2019), due to their high co-occurrence with clinically significant sleep complaints. Existing evidence also indicates that such interventions may not only improve sleep, but also general mental health functioning (Scott et al., 2021). We also recently performed a systematic review and meta-analysis of the effectiveness of sleep interventions in reducing suicidal thoughts and behaviors (McLellan et al., in preparation). Our findings indicated that sleep interventions, overall, had a small but significant effect size in reducing suicidal outcomes. Circadian rhythm treatments, specifically, had a moderate effect size, and CBT for insomnia a small effect size, while pharmacotherapy (i.e., hypnotic-sedative medication) was not associated with reductions in suicidal symptoms. The effectiveness of sleep interventions for reducing suicidal thoughts and behaviors has not previously been systematically evaluated, and our findings support the application of sleep therapies for individuals at-risk for suicide. While sleep complaints may often get overlooked in clinical practice (both general medicine as well as mental health care) (Ogeil et al., 2020), such disregard may contribute to their chronicity and associated negative consequences, including depression, hopelessness and suicidal ideation (Roth, 2007). However, many effective sleep therapies exist, and these interventions may also be provided in a group setting (or more recently, online), widening their potential reach for at-risk groups (van der Zweerde et al., 2016). Further, circadian rhythm therapies, which had a larger effect size in our meta-analysis than CBT and pharmacotherapy, are even less often employed in health care than sleep therapies (Kramer et al., 2022). However, it is well established that circadian disruptions are implicated in many psychiatric disorders including depression, although longitudinal studies on suicide outcomes are lacking (Kivelä et al., 2018).

Variability of Suicidal Ideation

The focal point of many early EMA studies on suicidal ideation has been the variability of ideation within days (see e.g., Hallensleben et al., 2018; Kleiman et al., 2017). As presented in **Chapter 6**, we also examined different dimensions of real-time suicidal ideation dynamics, including its frequency, intensity and variability over time. Our subsequent findings were in line with prior studies, including the early observation that *"variability in suicidal ideation appears the norm, rather than the exception"* (Witte et al., 2006, p. 1038). However, while much of the discourse on real-time suicidal ideation dynamics has focused on its variability, we also observed substantial between-person differences in the average intensity, as well as frequency, of ideation. Therefore, early findings on the instability of suicidal ideation in the short-term may have led to an excessive emphasis on variability statistics. Our findings indicate that important determinants of suicidal ideation also include other characteristics (such as its intensity and frequency). Indeed, it should now be apparent that variability should not (and probably *can*not) be considered in isolation of these factors.

The variability of suicidal ideation, however, has important implications for clinical practice. Crucially, even though patients may appear stabilized after intervention (e.g., when preparing patients for discharge), such stability may not be maintained once the patient exits a highly controlled clinical setting. Further, the highly variable nature of suicidal ideation indicates that even though patients may indicate the absence of suicidal desire at discharge, they may return to high-intensity ideation moments only a few hours or days later. Indeed, it is often reported that those planning suicidal acts frequently deny such plans only shortly before taking their lives (Berman, 2018). These findings are sometimes interpreted to reflect dishonesty on the part of the individual. Our findings indicate that these patients may be honest – at least *in the moment* – but that reports of low-risk status may have limited temporal continuity. Mental health professionals who assess suicide risk are well aware that repeat assessments of suicidal ideation over a number of hours and/or days are warranted. This is especially relevant when evaluating those leaving in-patient treatment, as the week immediately following hospitalization represents an especially high-risk timeframe for a repeat suicide attempt (Chung et al., 2019). Risk of suicide attempt is also elevated following discharge for those psychiatric patients whose reason for hospitalization was *not* a suicidal crisis (Chung et al., 2017; Haglund et al., 2019). Indeed, this timeframe may be associated with a number of triggers, such as return to stressful environments, or feelings of helplessness when lacking follow-up care. Such worries, and their impact on suicidal ideation, is also apparent in ***Case Study 1***: towards the end of the assessment period, we can see Vivian growing increasingly worried about her return home after attending an extended residential treatment program. These concerns subsequently appear to reduce her resilience, with Vivian's suicidal ideation levels exhibiting substantially higher peaks in response to the same stressors that in the previous weeks had led to only minor increases.

Prediction of Suicide Attempts

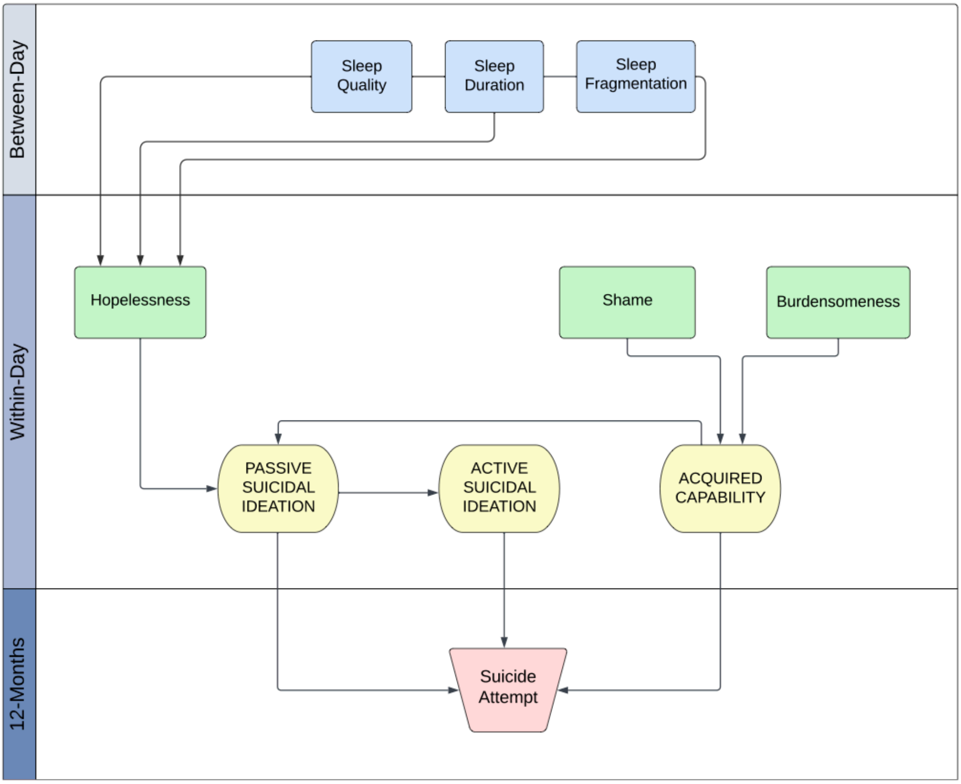
In **Chapter 6**, we examined the prospect of *digital phenotyping* of suicidal ideation, that is, identifying subtypes of suicidal ideation based on electronically collected data on suicidal ideation dynamics (Ballard et al., 2021). Curiously, while this approach was also implemented in one of the first EMA studies in the field (Kleiman et al., 2018) it has not been employed since – until the present study. Our findings also showed partial support for the phenotype classification presented by Kleiman et al. (2018), indicating that meaningful subtypes may be identified among patients with suicidal ideation based on the temporal dynamics of their ideation (incl. frequency, intensity, variability). More specifically, our findings indicate that profiles characterized by higher variability – but also higher frequency and intensity of ideation – may be associated with worse clinical profiles at baseline, and pose a higher risk for suicidal behavior in the future. However, the exact number and clinical relevance of such subtypes warrants further research and replication in larger and more representative samples, before these findings can be generalized to the highly heterogeneous population of individuals with suicidal ideation.

It has frequently been proposed that EMA data on acute suicide risk factors (i.e., warning signs) have increased utility in predicting suicide risk, especially in the short-term. However, only two studies (Wang et al., 2021 and **Chapter 6**) so far have actually put this hypothesis to test, and used EMA-data to prospectively predict suicidal behavior. Both studies found that EMA-derived data on suicidal ideation dynamics significantly predicted the risk of suicide attempt in the future (1-month later: Wang et al., 2021, to 12-months later: **Chapter 6**). However, neither study considered other EMA-derived predictors than suicidal ideation itself. Hence it remains to be determined whether other short-term predictors (such as hopelessness, loneliness, coping, or substance use) may be used to predict acute risk.

Further, the utility of phenotyping approaches in predicting suicidal behavior warrants further research. Importantly, our phenotype categorization was not a stronger predictor of future suicide attempt than prior attempt history. However, no predictors exist that are considered to be as robust in predicting future suicidal behavior than past suicide attempt history (Bostwick et al., 2016; Cornaggia et al., 2013), while we found both past suicide attempt history as well as our phenotype categorization to exhibit comparable (large) effect sizes. Our findings also indicate that, in tandem with past suicide attempt history, phenotyping may be especially useful in identifying those individuals with a past attempt history that may no longer be at high risk. As all individuals who made a repeat attempt during our follow-up period had a past suicide attempt history, attempt history alone had poor specificity in differentiating those participants at *low* risk. Based on our results, those past suicide attempters with current moderate frequency, but low intensity and low variability ideation, may not presently represent a risk group. Therefore, phenotyping might be combined with information about past suicide attempt history to produce even stronger prediction models, although this remains to be tested in future studies. Figure 1 presents a graphical depiction of the significant study findings relating to prospective predictors of suicidal ideation and behavior.

Future examinations of prospective suicidal behavior will necessitate assessments over lengthy follow-up periods (e.g., 12-months as in the present study), and subsequently considerations of how to maintain compliance over extended study periods. Our experience (**Chapter 3**) indicates that both direct contact with participants (either in-person or online), as well as the promise of personalized feedback on the data provided, may be effective in maintaining compliance both short- and long-term. Indeed, in the final feedback survey that the participants filled in following the 1-year monitoring period (data not reported here) many indicated that they would have wished for a feedback report also following this period. Participants often choose to specifically participate in research that they perceive to be personally relevant to them (Sheridan et al., 2020); as such, incentives offered to participants should ideally also have personal meaning.

Figure 1. A Graphical Overview of Significant Study Findings Relating to Prospective Predictors of Suicidal Ideation and Behavior



Note: The direct association between acquired capability and suicide attempt in the figure reflects the observed association between past suicide attempt history and prospective re-attempt

Limitations

Many of the limitations relevant for the present findings and study design have already been discussed within this chapter, but four overarching points are summarized here. First, although our sample size was within the (upper) range of similar past (EMA) studies (*Med* = 50; **Chapter 2**), it is still meager in comparison to the broader literature on longitudinal cohort studies on suicidal ideation (Large et al., 2016). Our sample size further diminished in size considerably with the extension of our measurements over a full year. Hence, it bears repeating that our findings need replication, especially in larger samples. Future studies should also aim to better understand participants lost to follow-up, such as how many may have become non-responders due to suicide. Examining differences in suicidal ideation dynamics between those with a prospective suicide attempt, and those with suicide mortality, may provide further insights into the clinical relevance of such indices. Risk factors for suicide and suicide attempts are known to overlap, but also differ, and predictors of suicide remain less well-established (Cornaggia et al., 2013).

A limitation not yet addressed in detail is the representativeness of our sample. Overall, our sample was predominantly female, young, and highly educated (**Chapter 3**). It is known that women are more likely to experience suicidal ideation and to attempt suicide than men (Canetto & Sakinofsky, 1998) – but also to participate in scientific research (Glass et al., 2015; Saphner et al., 2021). Meanwhile, men are more likely to die by suicide (Canetto & Sakinofsky, 1998), but remain more underrepresented in mental health research (Watkins, 2012), perhaps because they are also less likely to seek professional help (Chatmon, 2020). In intervention studies specifically, women outnumber men 3:1 (Knox et al., 2023). Further, those with a lower education level are also more likely to die by suicide (Nock et al., 2008), but less likely to participate in empirical research (Saphner et al., 2021). These factors together may limit the generalizability of our findings, especially with regard to better understanding and predicting suicidal behavior within these populations.

When considering the clinical applicability of our findings, it should be acknowledged that group-level findings may not always be relevant to the individual case. For example, there has recently been discourse about the extent to which associations identified in group-level network models are applicable to the individual (Bos & Wanders, 2016; Bos, 2021). While such limitations are partially addressed by examining within-person rather than between-person effects within the networks (i.e., examining intraindividual change rather than between-person differences, as also done in the present study, **Chapter 4**), the fact remains that such models are based on data pooled across individuals. As such, only some connections identified in group-level models, but not others, may be observable in a specific individual. However, due to the repeated nature of EMA measures, in clinical practice where the focus is on an individual patient, data collected from such a patient may also be used to create and examine individual (i.e., *idiographic*) networks. Such networks may provide unique insights into the patient's case, although caution should be used when applying and interpreting these models, as standardized methodologies are lacking, and interpretation of the *meaning* of such models is limited by subjective interpretation (von Klipstein et al., 2020). For example, in one recent study, 12 research teams analyzed a dataset from the same individual using network modeling, and produced vastly different models and clinical recommendations thereafter (Bastiaansen et al., 2020). Overall, it should be recognized that statistical models reflect limited simplifications of real-world experience, whether that be on the group- or individual-level.

Finally, as discussed in **Chapter 1**, suicidal ideation and behavior are highly heterogeneous phenomena that are influenced by socio-cultural, developmental, and psycho-behavioral factors. More research is needed on how more distal risk factors, such as the experience of childhood trauma, may affect current suicidal ideation dynamics. For example, experiences of childhood abuse and neglect are known to associate with later difficulties in emotion regulation (Dvir et al., 2014), and that those with early trauma have more labile mood, as recently also demonstrated in an EMA study (Kuzminskaite et al., 2024). It is therefore conceivable that such risk factors may also affect current suicidal ideation dynamics, such as its variability. For example, in **Chapter 6** we found cases with PTSD to more frequently present with a phenotype characterized by increased variability. Regrettably, however, we did not assess history of childhood trauma within the present study, or inquire about the type and/or timing of other traumatic events. Future research should work to further examine the synergistic associations between distal and proximal risk factors, in order to observe how such acute risk factors may differently impact those with distinct vulnerability factors.

Future Directions

Research Perspectives Our suggestions for future research follow directly from our limitations. Larger sample sizes are needed for prediction models that are able to grasp the full range of the correlates and predictors involved in the emergence of suicidal ideation (Nock et al., 2008). We urge future research to also consider newer statistical techniques, such as machine learning and neural networks (Durstewitz et al., 2019), that may be used to both build and test suicide prediction models. Such models are also better able to account for the dependencies and temporal relations between a number of predictors simultaneously, while not being limited by assumptions of linearity. As frequently reported, short-term trajectories of suicidal ideation often lack clear linear patterns (Kleiman et al., 2017), and may not be suitable for linear statistics in the first place. Further, as discussed elsewhere (Bos & Wanders, 2016; Bos, 2021; von Klipstein et al., 2020), testing of idiographic prediction models are necessary in order to observe to what extend group-level findings can, or cannot, be applied to individual cases – especially as the prospect of employing EMA in clinical practice becomes more concrete.

Although the use of EMA in suicide research has grown exponentially in the past five years, the field of real-time data collection of suicidal outcomes is still in its infancy. Consequently, although there is a lot of discussion about the short-term dynamics of suicidal ideation and these patterns are becoming better understood, we largely lack knowledge about the dynamics of suicide risk and protective factors themselves. Therefore, as discussed previously, a lack of a significant association between a predictor and an outcome in EMA designs does not necessarily indicate that the association does not exist at all and should not be further studied; it may merely indicate that a certain association does not exist within the hyper-specific timeframe within which the data were sampled. For example, if momentary anger does not predict suicidal ideation four hours later (as was the timeframe in the present study), does that mean that it is not associated with ideation more imminently 5, 10 or 30 minutes later? As such, the field may necessitate a step back, where more information first needs to be gathered about the temporal dynamics of these predictors themselves, before they can optimally be studied in relation to real-time suicidal ideation. For this purpose, neural networks may also be used to model different temporal dependencies between suicidal ideation and its predictors, such as examining whether the predictors as examined 1, 2 or 3 etc. time points prior best predict current levels of suicidal ideation. Inconsistencies in study designs (incl. sampling windows) may also explain differences in findings or lack of replication between studies. More standardization within EMA protocols is needed, especially if researchers aim to extend EMA methods to clinical practice (see ***Clinical Application*** below). Qualitative data from participants, such as text entries provided within EMA, may also help clarify on these processes, and guide EMA study designs. For example, a recent interview study also used qualitative methods to elucidate on the timeframe of the stages of suicidal ideation, planning and final decision preceding a suicide attempt (Heesen et al., 2024).

Clinical Application Since its early emergence, it has been suggested that EMA represents not only a relevant research methodology, but also a potential clinical tool (Davidson et al., 2017). For example, it has been proposed that EMA's ability to provide more detailed data on symptom dynamics could be helpful for treatment, as it may provide direct targets for intervention (Bos, 2021). For example, clinicians may work with patients to eliminate exposure to person- and context-specific suicidal ideation triggers identified through EMA. One of the goals of CBT, for example, is to help clients identify and avoid high-risk conditions associated with problematic behaviors, and encourage them to spend more time in low-risk environments (Fenn & Byrne, 2013). Further, EMA may help identify cognitive and affective states most closely associated with the client's ideation (such as hopelessness or shame) that may benefit from being targeting more in-depth in treatment

Although EMA has not yet been utilized in clinical practice in a wide-spread manner, such application appears to receive fairly broad support. A 2022 survey of 89 mental health practitioners and 62 researchers indicated that both groups considered EMA to be applicable and useful in clinical practice (Piot et al., 2022). More specifically, most responders considered EMA-based symptom monitoring to be useful for gaining insights about the context in which symptoms are more likely to emerge (55%). However, fewer responders considered EMA to be useful as a direct intervention tool (e.g., to alert patients about symptom increases, which was endorsed by only 11% of the responders). Practitioners, specifically, also indicated that EMA was easier to use, and its results easier to interpret, than assessment methods per treatment-as-usual (incl. semi-structured interviews, screening questionnaires, and paper-and-pen diaries). They further reported that EMA could conceivably be applied in all stages of treatment, from diagnostics to relapse prevention (Piot et al., 2022).

While the development of ecological momentary interventions (EMI) is also ongoing and has produced some positive early findings (see McDevitt-Murphy et al., 2018 for a review), it should also not be discounted that EMA-based symptom-monitoring *in itself may produce therapeutic effects*. That is, EMA may benefit patients even without the incorporation of additional intervention steps (such as alerts signaling symptom increases or prompts to employ certain coping strategies). Much of the research into reactivity to suicide assessments has focused on negative (i.e., iatrogenic) effects, but has not considered the potential that suicide assessments may also lead to symptom relief. However, such effects may also occur: as discussed in **Chapter 3**, we found 22% of our participants to report *improved* mood in response to the EMA measures. Without explicit intervention, evidence of behavioral change was also apparent in our sample, as described by one participant: *"I – was more aware of how bad things were and therefore tried to get into a healthier pattern"* (**Chapter 3**). Symptom self-monitoring may also be useful for patients with suicidal ideation, as it can demonstrate the ebb and flow of ideation, and the factors influencing it. Therefore, if well-tolerated by the client, the addition of electronic symptom self-monitoring in adjunct to treatment-as-usual may benefit existing treatment approaches, and potentially be therapeutic on its own right. However, for certain patients such excessive focus on symptoms may not be desirable (Bos, 2021), and the choice to employ EMA should be made on an individual basis. Within CBT, it is thought that self-monitoring may increase a sense of collaboration between a therapist and a client, and increase the client's sense of agency regarding their treatment (Cohen et al., 2013). In a recent qualitative interview study of 27 adults who had recently attempted suicide, most reported that they felt like their suicidal symptoms *"were not taken seriously enough"* by health care workers, and wished they had had *“a safe space for discussing their feelings and thoughts related to their desire to die”* (Heesen et al., 2024,p. 8). The application of EMA-type digital recordings may signal to the patient that their complaints are properly acknowledged, and subsequently facilitate conversations between the patient and the clinician.

Final Conclusions

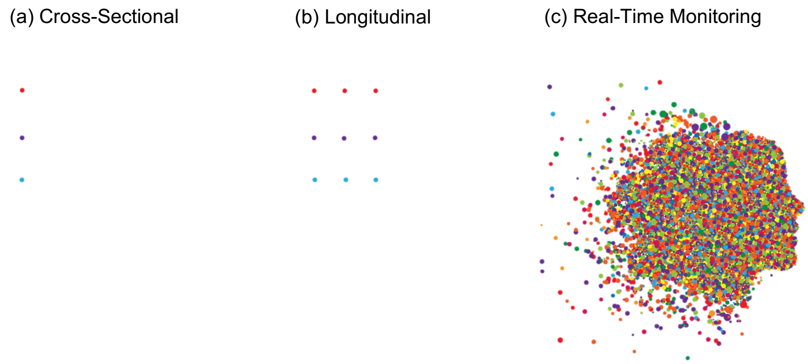
As discussed in **Chapter 1**, in ancient society, suicides were primarily seen as means-to-an-end to maintain societal status or to avoid humiliation and defeat (Hill, 2004). Therefore, suicides were considered to be a direct consequence of external events, and were not thought to necessitate further mental disturbance or distress on the part of the recently deceased. Indeed, suicide, as an act, was considered to be a rather unemotional event.

There exists, however, also a term in the Latin language that refers to the more psychological elements of suicidal ideation: *libido moriendi*, which describes the “lust for death” (Hill, 2004). Within this terminology is contained the idea that suicidal thoughts themselves can contain depth and despair beyond the Roman idea of suicide as an end result of a rational decision-making process. Indeed, in addition to shame and the desire to avoid humiliation, a wide array of thoughts and emotions can accompany suicidal thinking; these may include experiences of sadness, hopelessness and burdensomeness – but also feelings of calmness and relief. As described in **Chapter 4**, these emotions may further differ based on the stage of ideation one is at, be that the initial feelings of a dwindling desire to live, or later on, the emergence of more concrete thoughts about suicidal self-harm. However, rather fittingly within the Roman idea of suicide, we also found *shame*, specifically, to be a correlate for an active wish to die. As such, old and new theories of suicide may have commonalities.

The heterogeneity of suicidal ideation, both between and within individuals, is a theme that has transversed through each chapter of the dissertation, and is also apparent in the case studies presented in **Chapter 1** that illustrate how triggers and trajectories of suicidal ideation may differ based on the individual. In **Chapter 6**, we further aimed to quantify these differences in suicidal ideation by examining distinctive *between-person subgroups* of suicidal ideators, based on the *within-person dynamics* of their suicidal ideation. As such, heterogeneity need not be a challenge for research, but may also be used to establish order.

In the *Comprehensive Textbook of Suicidology,* Maris, Berman and Silverman (2000) address this heterogeneity by asking: *“Is suicide one thing or many things?”* and subsequently answer: *"Given this choice, it seems clear that the answer is 'many'"* (p. 50). They further conclude that *"The complexity, variability,* [and] *multidimensionality of suicide has* [...] *pragmatic consequences"* (Maris et al., 2000, p. 50). The defining strength of real-time monitoring in suicide research may hence be considered to be its ability to simultaneously capture the many dimensions of suicidal symptoms – their context, correlates, antecedents and consequences, as well as their frequency, intensity, duration, and variability. Through repeated data-collection methods, we may not only observe individual data points, but see how these dots form together, to produce a clearer picture of the target under observation (Figure 2). Such symptom monitoring may also function as a mirror to patients, allowing them to better understand their symptoms and their unique underlying causes. The evaluation of such therapeutic approaches represents the next steps in the clinical application of methodologies capturing real-time suicidal ideation.

Figure 2. A Graphical Illustration of the Differences in Data Granularity between Cross-Sectional, Longitudinal, and Real-Time Data Collection Methods



References

Ballard, E. D., Gilbert, J. R., Wusinich, C., & Zarate, C. A. (2021). New methods for assessing rapid changes in suicide risk. *Frontiers in Psychiatry, 12,* 598434. https://doi.org/10.3389/fpsyt.2021.598434

Bastiaansen, J. A., Kunkels, Y. K., Blaauw, F. J., Boker, S. M., Ceulemans, E., Chen, M., Chow, S.-M., de Jonge, P., Emerencia, A. C., Epskamp, S., Fisher, A. J., Hamaker, E. L., Kuppens, P., Lutz, W., Meyer, M. J., Moulder, R., Oravecz, Z., Riese, H., Rubel, J., Ryan, O., Servaas, M.N., Sjobeck, G., Snippe, E., Trull, T.J., Tschacher, W., van der Veen, D.C., Wichers, M., Wood, P.K., Woods, W.C., Wright, A.G.C., Albers, C.J., & Bringmann, L. F. (2020). Time to get personal? The impact of researchers choices on the selection of treatment targets using the experience sampling methodology. *Journal of Psychosomatic Research*, *137*, 110211. https://doi.org/10.1016/j.jpsychores.2020.110211

Bentley, K. H., Millner, A. J., Bear, A., Follet, L., Fortgang, R. G., Zuromski, K. L., Kleiman, E. M., Coppersmith, D. D. L., Castro-Ramirez, F., Millgram, Y., Haim, A., Bird, S. A., & Nock, M. K. (2024). Intervening on high-risk responses during ecological momentary assessment of suicidal thoughts: Is there an effect on study data? *Psychological Assessment*, *36*(1), 66–80. https://doi.org/10.1037/pas0001288

Berman, A. L. (2018). Risk factors proximate to suicide and suicide risk assessment in the context of denied suicide ideation. *Suicide and Life-Threatening Behavior*, *48*(3), 340–352. https://doi.org/10.1111/sltb.12351

Borges, G., Angst, J., Nock, M. K., Ruscio, A. M., & Kessler, R. C. (2008). Risk factors for the incidence and persistence of suicide-related outcomes: A 10-year follow-up study using the National Comorbidity Surveys. *Journal of Affective Disorders*, *105*(1–3), 25–33. https://doi.org/10.1016/j.jad.2007.01.036

Borsboom, D. (2017). A network theory of mental disorders. *World Psychiatry*, *16*, 5–13.

Borsboom, D., Deserno, M. K., Rhemtulla, M., Epskamp, S., Fried, E. I., McNally, R. J., Robinaugh, D. J., Perugini, M., Dalege, J., Costantini, G., Isvoranu, A.-M., Wysocki, A. C., van Borkulo, C. D., van Bork, R., & Waldorp, L. J. (2021). Network analysis of multivariate data in psychological science. *Nature Reviews Methods Primers*, *1*(1), 58. https://doi.org/10.1038/s43586-021-00055-w

Bos, E. H., & Wanders, R. B. K. (2016). Group-level symptom networks in depression. *JAMA Psychiatry*, *73*(4), 411. https://doi.org/10.1001/jamapsychiatry.2015.3103

Bos, F. M. (2021). *Ecological momentary assessment as a clinical tool in psychiatry: Promises, pitfalls, and possibilities.* University of Groningen.

Bostwick, J. M., Pabbati, C., Geske, J. R., & McKean, A. J. (2016). Suicide attempt as a risk factor for completed suicide: Even more lethal than we knew. *American Journal of Psychiatry*, *173*(11), 1094–1100. https://doi.org/10.1176/appi.ajp.2016.15070854

Bryan, C. J., & Rudd, M. D. (2016). The importance of temporal dynamics in the transition from suicidal thought to behavior. *Clinical Psychology: Science and Practice*, *23*(1), 21–25. https://doi.org/10.1111/cpsp.12135

Canetto, S. S., & Sakinofsky, I. (1998). The gender paradox in suicide. *Suicide & Life-Threatening Behavior*, *28*(1), 1–23.

Chatmon, B. N. (2020). Males and mental health stigma. *American Journal of Men's Health*, *14*(4), 155798832094932. https://doi.org/10.1177/1557988320949322

Chung, D., Hadzi-Pavlovic, D., Wang, M., Swaraj, S., Olfson, M., & Large, M. (2019). Meta-analysis of suicide rates in the first week and the first month after psychiatric hospitalisation. *BMJ Open*, *9*(3), e023883. https://doi.org/10.1136/bmjopen-2018-023883

Chung, D. T., Ryan, C. J., Hadzi-Pavlovic, D., Singh, S. P., Stanton, C., & Large, M. M. (2017). Suicide rates after discharge from psychiatric facilities. *JAMA Psychiatry*, *74*(7), 694. https://doi.org/10.1001/jamapsychiatry.2017.1044

Cohen, J. S., Edmunds, J. M., Brodman, D. M., Benjamin, C. L., & Kendall, P. C. (2013). Using self-monitoring: Implementation of collaborative empiricism in cognitive-behavioral therapy. *Cognitive and Behavioral Practice*, *20*(4), 419–428.

Colombo, D., Fernández-Álvarez, J., Patané, A., Semonella, M., Kwiatkowska, M., García-Palacios, A., Cipresso, P., Riva, G., & Botella, C. (2019). Current state and future directions of technology-based ecological momentary assessment and intervention for major depressive disorder: A systematic review. *Journal of Clinical Medicine*, *8*(4), 465. https://doi.org/10.3390/jcm8040465

Cornaggia, C., Beghi, Rosenbaum, & Cerri. (2013). Risk factors for fatal and nonfatal repetition of suicide attempts: A literature review. *Neuropsychiatric Disease and Treatment*, *9*, 1725–1736. https://doi.org/10.2147/NDT.S40213

Davidson, C. L., Anestis, M. D., & Gutierrez, P. M. (2017). Ecological momentary assessment is a neglected methodology in suicidology. *Archives of Suicide Research*, *21*(1), 1–11. https://doi.org/10.1080/13811118.2015.1004482

de Beurs, D. (2017). Network analysis: A novel approach to understand suicidal behaviour. *International Journal of Environmental Research and Public Health*, *14*(3), 219. https://doi.org/10.3390/ijerph14030219

Durstewitz, D., Koppe, G., & Meyer-Lindenberg, A. (2019). Deep neural networks in psychiatry. *Molecular Psychiatry*, *24*(11), 1583–1598. https://doi.org/10.1038/s41380-019-0365-9

Dvir, Y., Ford, J. D., Hill, M., & Frazier, J. A. (2014). Childhood maltreatment, emotional dysregulation, and psychiatric comorbidities. *Harvard Review of Psychiatry*, *22*(3), 149–161. https://doi.org/10.1097/HRP.0000000000000014

Emanuel, E. J. (2000). What makes clinical research ethical? *JAMA*, *283*(20), 2701. https://doi.org/10.1001/jama.283.20.2701

Fenn, K., & Byrne, M. (2013). The key principles of cognitive behavioural therapy. *InnovAiT: Education and Inspiration for General Practice*, *6*(9), 579–585. https://doi.org/10.1177/1755738012471029

Firth, J., Torous, J., & Yung, A. R. (2016). Ecological momentary assessment and beyond: The rising interest in e-mental health research. *Journal of Psychiatric Research*, *80*, 3–4. https://doi.org/10.1016/j.jpsychires.2016.05.002

Franklin, J. C., Ribeiro, J. D., Fox, K. R., Bentley, K. H., Kleiman, E. M., Huang, X., Musacchio, K. M., Jaroszewski, A. C., Chang, B. P., & Nock, M. K. (2017). Risk factors for suicidal thoughts and behaviors: A meta-analysis of 50 years of research. *Psychological Bulletin*, *143*(2), 187–232. https://doi.org/10.1037/bul0000084

Fried, E. I., van Borkulo, C. D., Cramer, A. O. J., Boschloo, L., Schoevers, R. A., & Borsboom, D. (2017). Mental disorders as networks of problems: A review of recent insights. *Social Psychiatry and Psychiatric Epidemiology, 52*(1), 1–10. https://doi.org/10.1007/s00127-016-1319-z

Gee, B. L., Han, J., Benassi, H., & Batterham, P. J. (2020). Suicidal thoughts, suicidal behaviours and self-harm in daily life: A systematic review of ecological momentary assessment studies. *Digital Health*, *6*, 205520762096395. https://doi.org/10.1177/2055207620963958

Gee, B., Orchard, F., Clarke, E., Joy, A., Clarke, T., & Reynolds, S. (2019). The effect of non-pharmacological sleep interventions on depression symptoms: A meta-analysis of randomised controlled trials. *Sleep Medicine Reviews*, *43*, 118–128. https://doi.org/10.1016/j.smrv.2018.09.004

Glass, D., Kelsall, H., Slegers, C., Forbes, A., Loff, B., Zion, D., & Fritschi, L. (2015). A telephone survey of factors affecting willingness to participate in health research surveys. *BMC Public Health*, *15*(1), 1017. https://doi.org/10.1186/s12889-015-2350-9

Glenn, C. R., & Nock, M. K. (2014). Improving the short-term prediction of suicidal behavior. *American Journal of Preventive Medicine*, *47*(3 Suppl. 2), S176–S180. https://doi.org/10.1016/j.amepre.2014.06.004

Goffnett, J., Liechty, J. M., & Kidder, E. (2020). Interventions to reduce shame: A systematic review. *Journal of Behavioral and Cognitive Therapy*, *30*(2), 141–160. https://doi.org/10.1016/j.jbct.2020.03.001

Haglund, A., Lysell, H., Larsson, H., Lichtenstein, P., & Runeson, B. (2019). Suicide immediately after discharge from psychiatric inpatient care. *The Journal of Clinical Psychiatry*, *80*(2), 18m12172. https://doi.org/10.4088/JCP.18m12172

Hallensleben, N., Spangenberg, L., Forkmann, T., Rath, D., Hegerl, U., Kersting, A., Kallert, T. W., & Glaesmer, H. (2018). Investigating the dynamics of suicidal ideation: Preliminary findings from a study using ecological momentary assessments in psychiatric inpatients. *Crisis*, *39*(1), 65–69. https://doi.org/10.1027/0227-5910/a000464

Harris, L. M., Huang, X., Linthicum, K. P., Bryen, C. P., & Ribeiro, J. D. (2020). Sleep disturbances as risk factors for suicidal thoughts and behaviours: A meta-analysis of longitudinal studies. *Scientific Reports*, *10*(1), 13888. https://doi.org/10.1038/s41598-020-70866-6

Heesen, K., Mérelle, S., van den Brand, I., van Bergen, D., Baden, D., Slotema, K., Gilissen, R., & van Veen, S. (2024). The forever decision: A qualitative study among survivors of a suicide attempt. *EClinicalMedicine*, *69*, 102449. https://doi.org/10.1016/j.eclinm.2024.102449

Hill, T. D. (2004). *Ambitiosa mors: Suicide and the self in roman thought and literature*. Routledge.

Jorm, A. F., Kelly, C. M., & Morgan, A. J. (2007). Participant distress in psychiatric research: A systematic review. *Psychological Medicine*, *37*(7), 917–926. https://doi.org/10.1017/S0033291706009779

Kivelä, L., Papadopoulos, M. R., & Antypa, N. (2018). Chronotype and psychiatric disorders. *Current Sleep Medicine Reports*, *4*(2), 94–103. https://doi.org/10.1007/s40675-018-0113-8

Kleiman, E. M., Coppersmith, D. D. L., Millner, A. J., Franz, P. J., Fox, K. R., & Nock, M. K. (2018). Are suicidal thoughts reinforcing? A preliminary real-time monitoring study on the potential affect regulation function of suicidal thinking. *Journal of Affective Disorders*, *232*, 122–126. https://doi.org/10.1016/j.jad.2018.02.033

Kleiman, E. M., Turner, B. J., Fedor, S., Baele, E. E., Huffman, J. C., & Nock, M. K. (2017). Examination of real-time fluctuations in suicidal ideation and its risk factors: Results from two ecological momentary assessment studies. *Journal of Abnormal Psychology*, *126*(6), 726–738. https://doi.org/10.1037/abn0000273.supp

Kleiman, E. M., Turner, B. J., Fedor, S., Beale, E. E., Picard, R. W., Huffman, J. C., & Nock, M. K. (2018). Digital phenotyping of suicidal thoughts. *Depression and Anxiety*, *35*(7), 601–608. https://doi.org/10.1002/da.22730

Knox, J., Morgan, P., Kay-Lambkin, F., Wilson, J., Wallis, K., Mallise, C., Barclay, B., & Young, M. (2023). Male involvement in randomised trials testing psychotherapy or behavioural interventions for depression: a scoping review. *Current Psychology*, *42*(34), 30322–30337. https://doi.org/10.1007/s12144-022-04017-7

Kramer, A., Lange, T., Spies, C., Finger, A.-M., Berg, D., & Oster, H. (2022). Foundations of circadian medicine. *PLoS Biology*, *20*(3), e3001567. https://doi.org/10.1371/journal.pbio.3001567

Kuzminskaite, E., Vinkers, C. H., Smit, A. C., van Ballegooijen, W., Elzinga, B. M., Riese, H., Milaneschi, Y., & Penninx, B. W. J. H. (2024). Day-to-day affect fluctuations in adults with childhood trauma history: a two-week ecological momentary assessment study. *Psychological Medicine*, *54*(6), 1160–1171. https://doi.org/10.1017/S0033291723002969

Lamers, F., Hoogendoorn, A. W., Smit, J. H., van Dyck, R., Zitman, F. G., Nolen, W. A., & Penninx, B. W. (2012). Sociodemographic and psychiatric determinants of attrition in the Netherlands Study of Depression and Anxiety (NESDA). *Comprehensive Psychiatry*, *53*(1), 63–70. https://doi.org/10.1016/j.comppsych.2011.01.011

Large, M., Kaneson, M., Myles, N., Myles, H., Gunaratne, P., & Ryan, C. (2016). Meta-analysis of longitudinal cohort studies of suicide risk assessment among psychiatric patients: Heterogeneity in results and lack of improvement over time. *PLOS One*, *11*(6), e0156322. https://doi.org/doi: 10.1371/journal.pone.0156322

Lavery, I., & Ingram, P. (2005). Venepuncture: Best practice. *Nursing Standard*, *19*(49), 55–65. https://doi.org/10.7748/ns2005.08.19.49.55.c3936

Liu, R. T., Steele, S. J., Hamilton, J. L., Do, Q. B. P., Furbish, K., Burke, T. A., Martinez, A. P., & Gerlus, N. (2020). Sleep and suicide: A systematic review and meta-analysis of longitudinal studies. *Clinical Psychology Review*, *81*, 101895. https://doi.org/10.1016/j.cpr.2020.101895

Maris, R. W., Berman, A. L., & Silverman, M. M. (2000). *Comprehensive textbook of suicidology*. Guilford Press.

McDevitt-Murphy, M. E., Luciano, M. T., & Zakarian, R. J. (2018). Use of Ecological Momentary Assessment and Intervention in Treatment With Adults. *FOCUS*, *16*(4). https://doi.org/10.1176/appi.focus.20180017

Miller, K. E., Brownlow, J. A., & Gehrman, P. R. (2020). Sleep in PTSD: treatment approaches and outcomes. *Current Opinion in Psychology*, *34*, 12–17. https://doi.org/10.1016/j.copsyc.2019.08.017

Nock, M. K., Borges, G., Bromet, E. J., Alonso, J., Angermeyer, M., Beautrais, A., Bruffaerts, R., Chiu, W.T., de Girolamo, G., Gluzman, S., de Graaf, R., Gureje, O., Haro, J.M., Huang, Y., Karam, E., Kessler, R.C., Lepine, J.P., Levinson, D., Medina-Mora, M.E., Ono, Y., Posada-Villa, J., & Williams, D. (2008). Cross-national prevalence and risk factors for suicidal ideation, plans and attempts. *British Journal of Psychiatry*, *192*(2), 98–105. https://doi.org/10.1192/bjp.bp.107.040113

Norder, S. J., Visvalingam, S., Norton, P. J., & Norberg, M. M. (2023). A scoping review of psychosocial interventions to reduce internalised shame. *Psychotherapy Research*, *33*(2), 131–145. https://doi.org/10.1080/10503307.2022.2082340

Nuij, C., van Ballegooijen, W., de Beurs, D., de Winter, R. F. P., Gilissen, R., O'Connor, R. C., Smit, J. H., Kerkhof, A., & Riper, H. (2022). The feasibility of using smartphone apps as treatment components for depressed suicidal outpatients. *Frontiers in Psychiatry*, *13*. https://doi.org/10.3389/fpsyt.2022.971046

O'Connor, R. C., & Kirtley, O. J. (2018). The integrated motivational–volitional model of suicidal behaviour. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *373*(1754), 20170268. https://doi.org/10.1098/rstb.2017.0268

Ogeil, R. P., Chakraborty, S. P., Young, A. C., & Lubman, D. I. (2020). Clinician and patient barriers to the recognition of insomnia in family practice: a narrative summary of reported literature analysed using the theoretical domains framework. *BMC Family Practice*, *21*(1), 1. https://doi.org/10.1186/s12875-019-1070-0

Piot, M., Mestdagh, M., Riese, H., Weermeijer, J., Brouwer, J. M. A., Kuppens, P., Dejonckheere, E., & Bos, F. M. (2022). Practitioner and researcher perspectives on the utility of ecological momentary assessment in mental health care: A survey study. *Internet Interventions*, *30*, 100575. https://doi.org/10.1016/j.invent.2022.100575

Piretti, L., Pappaianni, E., Garbin, C., Rumiati, R. I., Job, R., & Grecucci, A. (2023). The neural signatures of shame, embarrassment, and guilt: A voxel-based meta-analysis on functional neuroimaging studies. *Brain Sciences*, *13*(4), 559. https://doi.org/10.3390/brainsci13040559

Rogers, M. L. (2021). Feasibility and acceptability of ecological momentary assessment in a fully online study of community-based adults at high risk for suicide. *Psychological Assessment*. https://doi.org/10.1037/pas0001054

Roth, T. (2007). Insomnia: definition, prevalence, etiology, and consequences. *Journal of Clinical Sleep Medicine: JCSM: Official Publication of the American Academy of Sleep Medicine*, *3*(5 Suppl), S7-10.

Saphner, T., Marek, A., Homa, J. K., Robinson, L., & Glandt, N. (2021). Clinical trial participation assessed by age, sex, race, ethnicity, and socioeconomic status. *Contemporary Clinical Trials*, *103*, 106315. https://doi.org/10.1016/j.cct.2021.106315

Schatten, H. T., Allen, K. J. D., Carl, E. C., Miller, I. W., & Armey, M. F. (2022). Evaluating potential iatrogenic effects of a suicide-focused research protocol. *Crisis*, *43*(6), 508–515. https://doi.org/10.1027/0227-5910/a000823

Scott, A. J., Webb, T. L., Martyn-St James, M., Rowse, G., & Weich, S. (2021). Improving sleep quality leads to better mental health: A meta-analysis of randomised controlled trials. *Sleep Medicine Reviews*, *60*, 101556. https://doi.org/10.1016/j.smrv.2021.101556

Sedano-Capdevila, A., Porras-Segovia, A., Bello, H. J., Baca-García, E., & Barrigon, M. L. (2021). Use of ecological momentary assessment to study suicidal thoughts and behavior: A systematic review. *Current Psychiatry Reports*, *23*(7), 41. https://doi.org/10.1007/s11920-021-01255-7

Sheridan, R., Martin-Kerry, J., Hudson, J., Parker, A., Bower, P., & Knapp, P. (2020). Why do patients take part in research? An overview of systematic reviews of psychosocial barriers and facilitators. *Trials*, *21*(1), 259. https://doi.org/10.1186/s13063-020-4197-3

Smith, P., Poindexter, E., & Cukrowicz, K. (2010). The effect of participating in suicide research: Does participating in a research protocol on suicide and psychiatric symptoms increase suicide ideation and attempts? *Suicide and Life-Threatening Behavior*, *40*(6), 535–543. https://doi.org/10.1521/suli.2010.40.6.535

Tranberg, K., Due, T. D., Rozing, M., Jønsson, A. B. R., Kousgaard, M. B., & Møller, A. (2023). Challenges in reaching patients with severe mental illness for trials in general practice—a convergent mixed methods study based on the SOFIA pilot trial. *Pilot and Feasibility Studies*, *9*(1), 182. https://doi.org/10.1186/s40814-023-01395-y

van der Zweerde, T., Lancee, J., Slottje, P., Bosmans, J., Van Someren, E., Reynolds, C., Cuijpers, P., & van Straten, A. (2016). Cost-effectiveness of i-Sleep, a guided online CBT intervention, for patients with insomnia in general practice: Protocol of a pragmatic randomized controlled trial. *BMC Psychiatry*, *16*(1), 85. https://doi.org/10.1186/s12888-016-0783-z

van Genugten, C. R., Schuurmans, J., Lamers, F., Riese, H., Penninx, B. W., Schoevers, R. A., Riper, H. M., & Smit, J. H. (2020). Experienced burden of and adherence to smartphone-based ecological momentary assessment in persons with affective disorders. *Journal of Clinical Medicine*, *9*(2). https://doi.org/10.3390/jcm9020322

Van Orden, K. A., Witte, T. K., Cukrowicz, K. C., Braithwaite, S. R., Selby, E. A., & Joiner, T. E. (2010). The Interpersonal Theory of Suicide. *Psychological Review*, *117*(2), 575–600. https://doi.org/10.1037/a0018697

von Klipstein, L., Riese, H., van der Veen, D. C., Servaas, M. N., & Schoevers, R. A. (2020). Using person-specific networks in psychotherapy: Challenges, limitations, and how we could use them anyway. *BMC Medicine*, *18*(1). https://doi.org/10.1186/s12916-020-01818-0

Walz, L. C., Nauta, M. H., & aan het Rot, M. (2014). Experience sampling and ecological momentary assessment for studying the daily lives of patients with anxiety disorders: A systematic review. In *Journal of Anxiety Disorders* (Vol. 28, Issue 8, pp. 925–937). Elsevier Ltd. https://doi.org/10.1016/j.janxdis.2014.09.022

Wang, S. B., Coppersmith, D. D. L., Kleiman, E. M., Bentley, K. H., Millner, A. J., Fortgang, R., Mair, P., Dempsey, W., Huffman, J. C., & Nock, M. K. (2021). A pilot study using frequent inpatient assessments of suicidal thinking to predict short-term postdischarge suicidal behavior. *JAMA Network Open*, *4*(3), e210591. https://doi.org/10.1001/jamanetworkopen.2021.0591

Watkins, C. E. (2012). The study of men in short-term and long-term psychodynamic psychotherapy: A brief research note. *Psychoanalytic Psychology*, *29*(4), 429–439. https://doi.org/10.1037/a0025183

Summary

Title: Dynamics of Despair – Examining Suicidal Ideation Using Real-Time Methodologies

This dissertation examines the temporal dynamics of suicidal ideation in daily life using real-time assessment methods, including actigraphy and ecological momentary assessment (EMA). Suicidal ideation can be highly variable, and increased insight into these fluctuations can aid us in understanding how an individual may transition into moments of heightened suicidal ideation in real-time. Further, it has been proposed that variability in itself may serve as a phenotypic marker for increased suicide risk. Hence, obtaining a better understanding of the correlates and predictors of this variability is important for improved risk detection.

Suicidal ideation is both a prevalent and a potentially persistent disturbance: up to 20% of the general population will experience suicidal thoughts at some point over their lifespan, and for approximately 30% of these individuals, suicidal ideation becomes a persistent experience for years and even decades. However, the severity of ideation can exhibit substantial variability over time; individuals can experience lengthy periods characterized by the absence of symptoms, but may also exhibit substantial increases and decreases in ideation levels merely within the span of hours and days.

Prediction of suicide risk is hindered not only by the variable nature of suicidal ideation, but also the heterogeneity of risk factors. Multiple interacting risk and protective factors are involved in the emergence and maintenance of suicidal ideation over time, with each individual risk factors explaining only a very small portion of suicide risk. Further, most of our current understanding of these risk factors is centered around chronic, long-term determinants (such as sociodemographic characteristics). Instead, we largely lack understanding of *warning signs of suicide*, referring to factors that indicate increase suicide risk in the short-term.

Newly developed real-time assessment methods may help increase our understanding of the phenomenology of suicidal ideation. Such methods include *Ecological Momentary Assessment (EMA)*, referring to short, repeated self-report assessments completed within individuals daily lives, utilizing mobile technologies, such as smartphones. EMA therefore enables researches to study individuals' symptoms in the natural environment, examining their contributing factors in real- time. Additional ambulatory assessments, such as those examining sleep and activity patterns using *actigraphy*, can help supplement these self-reports with objective data.

This dissertation reports on the longitudinal SAFE study (Suicidal ideation Assessment: Fluctuation monitoring with Ecological momentary assessment), which employed EMA and actigraphy to examine suicidal ideation in daily life. The study included 82 individuals currently experiencing suicidal ideation. The study aimed to 1) describe how suicidal ideation fluctuates in real-time (within and between days), and which risk and protective factors are associated with these fluctuations, and 2) how these dynamics relate to suicide risk in the long-term (up to 1-year).

In **Chapter 1** of this dissertation, we give an introduction to the topic of suicidal ideation, review prominent theoretical models around it, and discuss our current understanding of the temporal dynamics of suicidal ideation; this includes both the long-term course of, as well as the short-term variability in, suicidal ideation. Further, we describe the relevant data collection methods (EMA and actigraphy) as well as introduce the SAFE study.

In **Chapter 2**, we present a systematic review of prior literature using the EMA method in suicide research to study the dynamics and predictors of real-time-suicidal ideation. The use of EMA for this purpose has seen an enormous increase in the past decade, and has already provided robust support for the notion that suicidal ideation may fluctuate greatly both between and within days, increasing and decreasing sharply merely within the span of hours. This finding highlights the need to better understand which risk factors may contribute to these fluctuations. However, while prior research has already identified a number of *correlates* of said fluctuations (that is, factors that increase and decrease in tandem with suicidal ideation, such as hopelessness and negative affect), research so far has been more limited in identifying corresponding *short-term predictors*. More research is therefore needed on this front. Further, research indicates that variability in suicidal ideation may be trait-like, and be associated with heightened suicide risk. However, prior research on this topic has been predominantly reliant on retrospective self-report, and prospective confirmatory studies are needed. Finally, while prior research supports the feasibility of using EMA among individuals with suicidal ideation, reporting on safety procedures and adverse events is inconsistent. Due to the focus on high-risk populations, these considerations also warrant further attention.

In **Chapter 3**, we report on the feasibility, acceptability and safety of EMA based on data from the SAFE study. Interpreting response and completion rates, we conclude that EMA appears highly feasible and well-tolerated among participants, including those experiencing high levels of suicidal ideation and/or other symptomatology (depression, anxiety). Our findings also generally supported the safety of EMA, as we did not observe systematic increases in real-time suicidal ideation over the study period. However, a minority of participants retrospectively reported (at the end of the study) that the EMA had sometimes triggered or worsened their ideation. As these reports are in opposition to the (lack of) pattern observed in the data, these effects do not appear to have impacted the participants to a substantial degree. Regardless, we urge researchers to transparently inform participants in similar studies about the potential to such effects.

In **Chapter 4**, we employ statistical network modeling to examine the interconnectedness of suicidal ideation (passive ideation and active ideation, and *acquired capability* i.e., preparedness for suicidal acts) and its cognitive-affective predictors (positive and negative affect, anxiety, hopelessness, loneliness, burdensomeness, optimism) in real-time. We identified differential associations with different facets of suicidal ideation, with constructs central to the Interpersonal Psychological Theory of Suicide (IPTS), including hopelessness, loneliness, and burdensomeness, being uniquely associated with passive suicidal ideation. Further, we found shame to be uniquely associated with active suicidal ideation and acquired capability. These findings indicate that shame may represent an especially important target for suicide prevention, as it appears to specifically associate with the active desire to die, and preparedness for such suicidal acts.

In **Chapter 5**, we use both EMA and actigraphy to examine sleep characteristics, hopelessness, and their associations with next-day suicidal ideation. We found support for the notion that sleep disturbances, and specifically interrupted sleep during the night (including increased night-time awakenings), can have immediate, night-to-day effects on suicidal ideation. That is, ideation was heightened following nights with disturbed sleep. Importantly, we replicated these findings using both subjective and objective measures of sleep. We further observed that such interrupted sleep increased feelings of hopelessness the following morning, and that these hopeless thoughts were a significant explanatory factor in the association between sleep and suicidal ideation. While hopelessness is a well-established risk factor for suicidal ideation, within this specific context, it remains to be established whether such hopelessness is specific to despair about the effects of lack of sleep, or due to broader cognitive-affective disturbances resulting from sleep loss.

In **Chapter 6**, we used latent profile modeling to identify subtypes of suicidal ideation based on EMA data, and their associations with the prospective risk of suicide attempts over 1-year. We identified four subtypes of suicidal ideation, namely 1) high frequency, high intensity, moderate variability ideation (Phenotype 1), moderate/high frequency, moderate intensity, high variability ideation (Phenotype 2), and moderate frequency, low intensity, low variability ideation (Phenotype 3). Further, we found Phenotypes 1 and 2 to have increased odds of making a suicide attempt over the 1-year follow-up, with Phenotype 1 specifically being characterized by repeat suicidal behavior (i.e., multiple suicide attempts). Therefore, our findings did not produce straightforward support for the notion that suicidal ideation variability *per se* is associated with heightened risk, but that such variability needs to be considered in the context of other suicidal ideation characteristics, such as frequency and (average) intensity. However, these preliminary findings need replication, due to a low sample size in our follow-up cohort.

In **Chapter 7**, we summarize and conclude on our findings from the previous chapters, and discuss the strengths and limitations of the SAFE study. We further integrate the study findings into the greater theoretical framework of suicidal ideation, and outline our suggestions for future research. Importantly, we support the value of EMA and other real-time data collection methods in suicide research, but urge researchers to consider newer statistical modeling techniques in analyzing their data, as the structure of EMA data sets additional demands on analysis methods. Further, we discuss the importance of improving our understanding of the temporal dynamics of not only suicidal ideation itself, but also its predictors, as such knowledge has important implications for study designs. Finally, we discuss the prospects of using real-time symptom measures in clinical practice; considering this implementation needs nuance, also in line with our findings that some individuals may perceive such increased attention to their symptoms as potentially triggering.

Dutch Summary (Nederlandse Samenvatting)

Titel: Dynamiek van Wanhoop – Onderzoek naar Suïcidale Gedachten met Real-Time Methodologieën

Dit proefschrift onderzoekt de tijdsgebonden veranderingen in suïcidale gedachten in het dagelijks leven, waarbij gebruik wordt gemaakt van real-time beoordelingsmethoden zoals actigrafie en Ecologische Momentane Beoordeling (EMA). Suïcidale gedachten kunnen sterk fluctueren, en beter inzicht in deze schommelingen kan ons helpen te begrijpen hoe iemand in realtime in een toestand van verhoogde suïcidale gedachten terechtkomt. Er wordt ook gesuggereerd dat deze variabiliteit op zichzelf een fenotypische marker kan zijn voor een verhoogd suïciderisico. Daarom is het essentieel om meer te weten te komen over de correlaten en voorspellers van deze variabiliteit, om het risico beter te kunnen inschatten.

Suïcidale gedachten zijn zowel veelvoorkomend als mogelijk aanhoudend: tot wel 20% van de bevolking zal op enig moment in hun leven met suïcidale gedachten te maken krijgen, en bij ongeveer 30% van hen blijven deze gedachten jarenlang, zelfs decennialang, aanwezig. De ernst van deze gedachten kan echter in de loop der tijd sterk variëren; individuen kunnen langere periodes doormaken zonder symptomen, maar kunnen ook een sterke toename of afname in de intensiteit van de gedachten ervaren binnen slechts enkele uren of dagen.

Het voorspellen van suïciderisico is lastig, niet alleen door de variabele aard van suïcidale gedachten, maar ook door de diversiteit aan risicofactoren. Het ontstaan en voortbestaan van suïcidale gedachten worden beïnvloed door meerdere, vaak onderling samenhangende risicofactoren en beschermende factoren, waarbij elke afzonderlijke factor slechts een klein deel van het totale risico verklaart. Bovendien richt het huidige onderzoek zich vooral op chronische, langetermijndeterminanten zoals sociaaldemografische kenmerken. Er is echter een gebrek aan inzicht in de *waarschuwingssignalen van suïcide*, oftewel factoren die op korte termijn een verhoogd suïciderisico kunnen aangeven.

Nieuw ontwikkelde real-time beoordelingsmethoden kunnen ons begrip van de aard van suïcidale gedachten vergroten. Een van deze methoden is *Ecologische Momentane Beoordeling (EMA)*, wat verwijst naar korte, herhaalde zelfbeoordelingen die individuen in hun dagelijkse leven uitvoeren met behulp van mobiele technologieën, zoals smartphones. EMA maakt het mogelijk om de symptomen van mensen in hun natuurlijke omgeving te bestuderen en de bijdragende factoren in realtime te onderzoeken. Aanvullende ambulante metingen, zoals het monitoren van slaap- en activiteitsniveaus via *actigrafie*, kunnen deze zelfrapportages aanvullen met objectieve gegevens.

Dit proefschrift beschrijft de longitudinale SAFE-studie (Suicidal ideation Assessment: Fluctuation monitoring with Ecological momentary assessment), waarbij EMA en actigrafie werden ingezet om suïcidale gedachten in het dagelijks leven te bestuderen. In deze studie werden 82 individuen betrokken die op dat moment suïcidale gedachten ervoeren. Het doel van de studie was 1) te beschrijven hoe suïcidale gedachten in realtime fluctueren (zowel binnen als tussen dagen), en welke risico- en beschermende factoren hiermee samenhangen, en 2) hoe deze dynamiek zich verhoudt tot het suïciderisico op de lange termijn (tot 1 jaar).

In **Hoofdstuk 1** geven we een introductie tot het onderwerp van suïcidale gedachten, bespreken we de belangrijkste theoretische modellen en behandelen we ons huidige begrip van de temporele dynamiek van suïcidale gedachten. Dit omvat zowel het langetermijnverloop als de kortetermijnvariabiliteit. Daarnaast beschrijven we de relevante dataverzamelingsmethoden (EMA en actigrafie) en introduceren we de SAFE-studie.

Hoofdstuk 2 bevat een systematisch overzicht van eerdere literatuur die de EMA-methode in suïcideonderzoek gebruikt om de dynamiek en voorspellers van suïcidale gedachten in realtime te bestuderen. Het gebruik van EMA voor dit doel is de afgelopen tien jaar aanzienlijk toegenomen en heeft al sterke ondersteuning geboden voor het idee dat suïcidale gedachten zowel tussen als binnen dagen sterk kunnen fluctueren, soms zelfs binnen enkele uren. Deze bevinding benadrukt de noodzaak om beter te begrijpen welke risicofactoren aan deze schommelingen bijdragen. Hoewel eerder onderzoek al enkele *correlaten* van deze fluctuaties heeft geïdentificeerd (dat wil zeggen, factoren die samen met suïcidale gedachten toenemen en afnemen, zoals hopeloosheid en negatief affect), is het tot nu toe beperkter geweest in het vinden van bijbehorende *kortetermijnvoorspellers*. Daarom is meer onderzoek op dit gebied nodig. Daarnaast suggereert onderzoek dat variabiliteit in suïcidale gedachten een blijvend kenmerk kan zijn dat verband houdt met een verhoogd suïciderisico. Eerdere studies waren echter grotendeels gebaseerd op retrospectieve zelfrapportages, waardoor prospectieve bevestigende studies noodzakelijk zijn. Ten slotte, hoewel eerder onderzoek de haalbaarheid van het gebruik van EMA bij individuen met suïcidale gedachten heeft aangetoond, is de rapportage over veiligheidsprocedures en bijwerkingen inconsistent. Gezien de focus op hoogrisicogroepen verdienen deze aspecten verdere aandacht.

In **Hoofdstuk 3** bespreken we de haalbaarheid, acceptatie en veiligheid van EMA, gebaseerd op gegevens uit de SAFE-studie. Door de respons- en voltooiingspercentages te analyseren, concluderen we dat EMA zeer haalbaar en goed verdraagbaar lijkt onder de deelnemers, inclusief degenen met hoge niveaus van suïcidale gedachten en/of andere symptomen (zoals depressie en angst). Onze bevindingen ondersteunen ook grotendeels de veiligheid van EMA, aangezien we gedurende de onderzoeksperiode geen systematische toename van suïcidale gedachten in realtime hebben waargenomen. Een klein aantal deelnemers gaf echter achteraf aan (aan het einde van de studie) dat de EMA-methode hun gedachten soms had getriggerd of verergerd. Aangezien deze rapporten in tegenspraak zijn met de waargenomen data, lijkt het er niet op dat deze effecten een substantiële impact hebben gehad op de deelnemers. Toch raden we onderzoekers aan om deelnemers in vergelijkbare studies openlijk te informeren over de mogelijkheid van dergelijke effecten.

In **Hoofdstuk 4** gebruiken we statistische netwerkanalyse om de onderlinge verbondenheid van suïcidale gedachten (zowel passieve als actieve gedachten, en *verworven capaciteit*, dat wil zeggen de bereidheid tot suïcidale handelingen) en hun cognitief-affectieve voorspellers (positieve en negatieve affectiviteit, angst, hopeloosheid, eenzaamheid, belastbaarheid, optimisme) in realtime te onderzoeken. We ontdekten verschillende associaties met verschillende facetten van suïcidale gedachten, waarbij constructen die centraal staan in de Interpersoonlijke Psychologische Theorie van Suïcide (IPTS) – waaronder hopeloosheid, eenzaamheid en belastbaarheid – specifiek geassocieerd waren met passieve suïcidale gedachten. Verder bleek schaamte uniek geassocieerd te zijn met actieve suïcidale gedachten en verworven capaciteit. Deze bevindingen suggereren dat schaamte een belangrijk doelwit voor suïcidepreventie kan zijn, aangezien het specifiek lijkt samen te hangen met zowel het actieve verlangen om te sterven als de bereidheid tot suïcidale handelingen.

Hoofdstuk 5 maakt gebruik van zowel EMA als actigrafie om slaapkenmerken, hopeloosheid en hun verband met suïcidale gedachten de volgende dag te onderzoeken. We vonden aanwijzingen dat slaapstoornissen, en met name onderbroken slaap gedurende de nacht (inclusief vaker wakker worden), onmiddellijke, nacht-tot-dag effecten kunnen hebben op suïcidale gedachten. Dit betekent dat gedachten werden verergerd na nachten met verstoorde slaap. Belangrijk is dat we deze bevindingen hebben gerepliceerd met zowel subjectieve als objectieve metingen van slaap. Daarnaast zagen we dat dergelijke onderbroken slaap de gevoelens van hopeloosheid de volgende ochtend deed toenemen, en dat deze hopeloze gedachten een belangrijke verklarende factor waren in de relatie tussen slaap en suïcidale gedachten. Hoewel hopeloosheid een bekende risicofactor is voor suïcidale gedachten, is het in deze specifieke context nog onduidelijk of deze hopeloosheid specifiek is voor wanhoop over de gevolgen van slaaptekort, of het resultaat is van bredere cognitief-affectieve stoornissen als gevolg van slaapverlies.

In **Hoofdstuk 6** pasten we latente profielmodellering toe om subtypen van suïcidale gedachten te identificeren op basis van EMA-gegevens en hun verband met het toekomstige risico op suïcidepogingen over een periode van een jaar. We identificeerden vier subtypen van suïcidale gedachten: 1) hoge frequentie, hoge intensiteit, gematigde variabiliteit (Fenotype 1), matige/hoge frequentie, matige intensiteit, hoge variabiliteit (Fenotype 2), en matige frequentie, lage intensiteit, lage variabiliteit (Fenotype 3). Verder vonden we dat Fenotypes 1 en 2 een verhoogde kans hadden op een suïcidepoging gedurende de 1-jarige follow-up, waarbij Fenotype 1 specifiek werd gekenmerkt door herhaald suïcidaal gedrag (meerdere suïcidepogingen). Onze bevindingen geven dus geen eenduidige ondersteuning voor de stelling dat variabiliteit in suïcidale gedachten op zichzelf geassocieerd is met verhoogd risico; deze variabiliteit moet in de context van andere kenmerken van suïcidale gedachten worden bekeken, zoals frequentie en gemiddelde intensiteit. Deze voorlopige bevindingen vereisen echter replicatie vanwege de kleine steekproefomvang in onze follow-up cohort.

In **Hoofdstuk 7** vatten we de bevindingen van de voorgaande hoofdstukken samen, bespreken we de sterke en zwakke punten van de SAFE-studie en integreren we de onderzoeksresultaten in het bredere theoretische kader van suïcidale gedachten. We doen ook aanbevelingen voor toekomstig onderzoek. We benadrukken de waarde van EMA en andere real-time dataverzamelingsmethoden in suïcideonderzoek, maar wijzen onderzoekers erop om nieuwere statistische analysetechnieken te overwegen, aangezien de structuur van EMA-data specifieke eisen stelt aan analysemethoden. Daarnaast bespreken we het belang van een beter begrip van de temporele dynamiek van zowel suïcidale gedachten zelf als hun voorspellers, omdat dit belangrijke implicaties heeft voor onderzoeksontwerpen. Tot slot bespreken we de mogelijkheden van het gebruik van real-time symptoommetingen in de klinische praktijk; hierbij moet de implementatie zorgvuldig gebeuren, ook in lijn met onze bevindingen dat sommige individuen deze verhoogde aandacht voor hun symptomen als mogelijk triggerend kunnen ervaren.

Publications

Publications in the Dissertation

Kivelä, L., van der Does, W., Riese, H., & Antypa, N. (2022) Don't Miss the Moment: A Systematic Review of Ecological Momentary Assessment in Suicide Research. *Frontiers in Digital Health, 4*, 876595. https://doi.org/10.3389/fdgth.2022.876595

Kivelä, L., Fiß, F., van der Does, W., & Antypa, N. (2023). Examination of Acceptability, Feasibility and Iatrogenic Effects of Ecological Momentary Assessment (EMA) of Suicidal Ideation. *Assessment, 31*(6), 1292-1308. https://doi.org/10.1177/10731911231216053

Kivelä, L., Fried, E., van der Does, W., & Antypa, N. (2023). Examining Contemporaneous and Temporal Associations of Real-Time Suicidal Ideation Using Network Analysis. *Psychological Medicine, 54*(12), 3357-3365 . https://doi.org/10.1017/S003329172400151X

Kivelä, L., van der Does, W., & Antypa, N. (2024). Sleep, Hopelessness and Suicidal Ideation: An Actigraphy and Sleep Diary Study. *Journal of Psychiatric Research, 177,* 46-52. https://doi.org/10.1016/j.jpsychires.2024.06.039

Kivelä, L., van der Does, W., Gilissen, R., & Antypa, N. (2024). Digital Phenotypes of Real-Time Suicidal Ideation: Correlates and Consequences*. Acta Psychiatrica Scandinavica.* https://doi.org/10.1111/acps.13750

Other Publications (Completed During the PhD)

Kivelä, L., Riese, H., Fakkel, T., Verkuil, B., Penninx, B., Lamers, F., van der Does, W., & Antypa, N. (2022). Chronotype, Daily Affect and Social Contact: An Ecological Momentary Assessment Study. *Psychiatry Research, 309,* 114386. https://doi.org/10.1016/j.psychres.2021.114386

Kivelä, L., Mouthaan, J., van der Does, W., & Antypa, N. (2022). Student Mental Health During the COVID-19 Pandemic: Are International Students More Affected? *Journal of American College Health*, *72*(2), 414-422. https://doi.org/10.1080/07448481.2022.2037616

Kivelä, L., Antypa, N., Fried, E., Schoevers, R., van Hemert, B., Penninx, B., & van der Does, W. (2023). Suicidal Ideation Across Depressive Episodes: A 9-Year Longitudinal Study. *British Journal of Psychiatry Open, 9*(6), e218. https://doi.org/10.1192/bjo.2023.608

Lamprou, E., **Kivelä, L.,** Rohling, J., Meijer, J., van der Does, W., & Antypa, N. (2024). Chronotype, Sleep Disturbance, Depression and Pre-Sleep Rumination: A

Seven-Day Diary and Actigraphy Study. *European Journal of Neuroscience.* https://doi.org/10.1111/ejn.16551

Pape, L., Jonker, S., **Kivelä, L.,** van Straten, A., & Antypa, N. (2024). Effectiveness of a Multi-Component Sleep-Mood Group Intervention on Improving Insomnia in University Students – A Pilot Randomized Controlled Trial. *BMC Psychology, 12,* 626. https://doi.org/10.1186/s40359-024-02057-1

McLellan, A., Pape, L., Antypa, N., & **Kivelä, L.** (2024). Effectiveness of Sleep Interventions for Treating Suicidality Over the Lifespan: A Systematic Review and Meta-Analysis. [in preparation]

Kivelä, L., Giltay, E., van der Does, W., & Antypa, N. (2024). Danger by Association: Dynamic Time Warp Analysis of Suicidal Ideation and Depressive Symptoms. [in preparation]

Curriculum Vitae

Liia M.M. Kivelä was born 6th of May 1992, in Espoo, Finland. She completed her secondary school education at Etelä-Tapiola Upper Secondary School in Espoo, Finland, and at Richmond High School in Sydney, Australia. During her gap year between 2012 and 2013, she took courses in creative writing and photography at the London School of Journalism and London School of Photography in London, United Kingdom. In 2013, she moved to the Netherlands to study at Leiden University, and completed her bachelor's degree in psychology (cum laude) in 2016. She went on to follow the research master program in clinical and health psychology, graduating with her master's degree (cum laude) in 2019. Between 2019 and 2024, she worked as a PhD researcher at the Department of Clinical Psychology, Leiden University, under the supervision of Dr. Niki Antypa and Prof. dr. Willem van der Does. Her research, funded by the Netherlands Organisation for Scientific Research (N.W.O) Research Talent Grant, was focused on using real-time assessment methodologies to study the temporal dynamics of suicidal ideation. During her PhD, she also attended the Dutch-Flemish Postgraduate School for Experimental Psychopathology (EPP), and completed trainings through the Leiden University Graduate School of Social and Behavioral Sciences, and the Dutch Institute for Schema Therapy. As part of her teaching responsibilities, she supervised 22 MSc theses, and lectured at the Leiden University Medical Center (LUMC) on the chronobiology of depression and suicidality. She also supervised student interns in both research and clinical tasks, including psychodiagnostics and suicide risk assessments in high-risk populations. Currently, she works as a clinician in The Hague.

Acknowledgements

A number of people were instrumental in guiding and supporting me through my work and the writing of this dissertation.

Niki, thank you for being the most wonderful supervisor, not just during my PhD, but also during my master's, and my bachelor's. I made an incredibly lucky pick with my bachelor's thesis topic, which has brought me here today. Thank you for guiding me, and supporting me, and helping me grow professionally. And thank you for doing all of that with an incredible amount of kindness and intelligence. **Willem**, thank you for your expertise, support and encouragement, and all your contributions in time and effort (and humour). I truly could not have asked for a better supervisory team, and I am sincerely grateful for all your support through the years. You both gave me guidance and advice, and supported my independence and autonomy – in perfect balance.

To my wonderful *colleagues* (friends) and office roommates, **Cosima** and **Marike**: while we really helped each other thrive during our PhDs, sadly we could not do the same for our office plants.

Thank you to my paranymphs, **Iida** and **Tahiti**, who have always been by my side, regardless of the physical distance between us.

Thank you, **Anthony,** for being my emotional (and tech) support.

Thank you to my parents, **Tero** and **Paula**, for their endless love and support, and sincere interest in my work and studies.

And finally, thank you to all my other friends and family – my grandparents, my godparents, and everyone else who has supported me along the way. Kiitos **Sari** ja **Hannu**, **Aino** ja **Veikko**, **Anne** ja **Manu, Risto** ja **Kristiina**, **Birgitta** ja **Lea,** siitä kuinka olette aina tukeneet minua.