LONGITUDINAL ASSESSMENT OF THE SLEEP SUICIDE LINK IN VETERANS: METHODS AND STUDY PROTOCOL

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ABSTRACT

Although sleep disruption has emerged as a theoretically consistent and empirically supported suicide risk factor, the mechanistic pathways underlying the sleep-suicide link are less understood. This paper describes the methodology of a study intended to examine longitudinal mechanisms driving the link between sleep and suicide in Veterans at elevated suicide risk. Participants will be 140 Veterans hospitalized for suicide attempt or ideation with plan and intent or those identified through the Suicide Prevention Coordinator (SPC) office as being at acute risk. After study enrollment, actigraphy and ecological momentary assessment (EMA) data will be collected for eight weeks, with follow up assessments occurring at two, four, six, eight- and 26-weeks. Participants respond to EMA questionnaires, derived from psychometrically validated assessments targeting emotional reactivity, emotion regulation, impulsivity, suicide risk, and sleep timing constructs, five times a day. First and last daily EMA target sleep parameters including sleep quantity, quality, timing, nightmares, and nocturnal awakenings. During follow-up assessments, participants will complete self-report assessments and interviews consistent with EMA constructs and the Iowa Gambling Task. The primary outcome for aim 1 is suicide ideation severity and for the primary outcome for aim 2 is suicide behavior. Findings from this study will improve our understanding of the dynamic interactions among sleep disturbance, emotion reactivity/regulation, and impulsivity to inform conceptual Veteran sleep-suicide mechanistic models. Improved models will be critical to optimizing the precision of suicide prevention efforts that aim to intervene and mitigate risk in Veteran populations, especially during a period of acute risk.

Keywords: suicide, sleep, Veterans

STATEMENT OF SIGNIFICANCE

Suicide is a significant problem for Veterans and those who report sleep difficulties are at higher risk for suicidal thoughts and behaviors. Despite increasing recognition of this relationship, our understanding of how suicide and sleep are related remains limited. The study methods presented in this paper aim to address knowledge gaps using a longitudinal, multimodal assessment protocol. Sleep, suicidal thoughts and behaviors, and proposed mechanisms connecting the two such as emotional reactivity and impulsivity will be assessed regularly using ecological momentary assessment, actigraphy, and laboratory tasks. Findings will help clarify the nature of the sleep-suicide relationship and will help identify targets for suicide prevention.

INTRODUCTION

Suicide is a critical concern for both military personnel and Veterans, accounting for between 13.7-18% of all known suicides in the United States from 2001-2019 [1,2]. Since 2000, rates of military suicide have risen faster than rates in civilian populations with 16.8 Veterans dying by suicide each day in 2020 [3]. A lack of clear understanding regarding mechanisms that lead to acute suicide behavior may drive the lack of noticeable decreases in rates of suicide over the last 10 years [1].

Sleep disruption increases risk of suicide, and sleep disturbances ranging from short sleep duration, sleep discontinuity, nightmares, and insomnia have all been implicated in suicide [4,5]. Early studies largely focused on mental illness as driving the association between sleep and suicide [6]. A recent review supports the notion that sleep disruption is a causal factor for changes in suicidal ideation (SI) above the contribution of specific mental health disorders such Major Depressive Disorder [7] and Post Traumatic Stress Disorder [8,9]. In fact, sleep problems often precede mental health diagnoses [10,11]. In a multimodal longitudinal study [12] researchers found that insomnia symptoms drove subsequent changes in suicide ideation (SI) such that level of insomnia symptoms predicted lagged increases in suicidal ideation. In contrast, suicidal ideation was not found to predict changes in insomnia. Thus, recent longitudinal studies using dynamic analytic models lend support to the role of inadequate sleep in suicide risk.

Considerable gaps exist in our understanding of how suicide and sleep are related. Limitations of our understanding are driven by methodological differences including: 1) methods used for measuring sleep, 2) which sleep variable is considered, 3) which consequences of sleep disruption are assessed, 4) how suicide-related behaviors are assessed, and 5) limited, often cross-sectional approaches to assessment that fail to account for variability in distress over time. A systematic review from 2019 of the literature linking sleep

and suicide found that only 5 studies used either polysomnography or actigraphy to monitor sleep and none of these was conducted in Veterans [13]. The authors concluded that there is a strong need for the use of objective sleep measures in suicide studies. A recent review and meta-analysis concluded that the risk for suicide after hospital discharge has not improved since 1975 [14]. Indeed, the risks for suicide attempts (SA) after hospital discharge appear to be increasing [15]. Several factors may contribute to this trend, but the underlying message is clear: better understanding of the mechanistic risks for suicide is paramount. Fortunately, clear risk factors for suicide have been identified and there are unambiguous opportunities for further research to delineate the mechanisms underpinning these risks. The link between suicide and sleep is among the most compelling risk factors for study.

Moreover, few studies have investigated the neurocognitive mechanisms implicated in the relationship between sleep and suicide. Understanding such relationships is critical because sleep-induced changes to cognition may alter decision making via increased impulsivity and/or impaired emotion regulation, two constructs that have often been linked to suicide risk [16, 17]. It may also be the case that neurocognitive functioning and sleep variables have a bidirectional association with impairments in emotion regulation and decision-making, impacting sleep quality and subsequent suicide risk [18]. The studies that have evaluated neurocognition, sleep and suicide have demonstrated mediation of emotion regulation and impulsivity on the association between sleep disturbance and suicide [19, 20]. For instance, Weis et al. (2015) conducted a cross-sectional study of 460 young adults finding that the observed relationship between poor sleep quality and suicidal behaviors was indirectly mediated by depression, rumination, and emotion regulation [21]. However, prior research methodologies have not been able to assess the effect of temporal changes in neurocognition and have not utilized objective measures of sleep.

We propose to bridge the identified gaps by way of the following approaches: empirically supported assessments, innovative models for quantifying sleep disruption and targeted assessment of specific neurocognitive functions thought to underpin risk for suicide, comprehensive assessment of suicidal ideation and suicide-related behaviors, and the use of ecological momentary assessment (EMA). The use of EMA will facilitate the measurement of hypothesized mechanisms that are expected to vary on a daily basis including positive and negative affect, emotion regulation and impulsivity to better grasp their relationship to suicide related constructs and sleep variables. Findings may identify key neurocognitive factors (e.g., impaired decision making, emotional dysregulation) that mediate the impacts of sleep disturbance on suicide risk. This proposal would provide key additional information in this critically important area of research.

Current Aims

This paper describes the methods and research protocol for a study with the purpose to test how changes in sleep are prospectively associated with increased suicide risk and to identify the neurocognitive mechanisms involved in this relationship. The first aim of the study is to test a model of hypothesized mechanisms that might drive the relationship between sleep and suicide risk. We hypothesize that **H1**) momentary increases in emotional reactivity (ER) and decreased emotion regulation mediate the relationship between sleep disruption and suicidal ideation; and **H2**) momentary increases in impulsivity over the 8-week assessment period mediates the relationship between sleep disruption and suicidal thoughts.

The second aim of the study is to test whether sleep disruption prior to specific interpersonal stressors contributes to suicidal behavior following the stressor. We hypothesize that **H3**) sleep disruption 48 hours prior to an identified stressor will predict suicide

behaviors, beyond cross-sectional measures; and **H4**) sleep disruption 7 days prior to an identified stressor will predict suicide behaviors, beyond cross-sectional measures.

METHODS AND ANALYSES

Sample size calculation

One-hundred forty participants will be recruited for this study. A Monte Carlo simulation study [22] found adequate power (> .80) for dynamic structural modeling (DSEM) of a single variable in which the random mean, autocorrelation, and residual variance of that variable are regressed on the predictor (with moderate effects) in a sample of N = 100 and T = 50 repeated measures. When a dependent variable is added to the model, with T = 100 repeated measures, a sample of N = 50 is required to achieve adequate power (> .80) to detect weak effects of the random mean or the autoregression on the dependent variable, and N = 100 is required to detect the effect of the random variance or the effect of a covariate on the dependent variable.

Monte Carlo simulations were used to determine adequate power to test hypotheses in Aim 1. In the current study, N = 140 participants will be assessed three times per day for eight weeks resulting in T = 168 repeated measures per participant. Monte Carlo simulations using 2000 replications revealed 0.86 power to detect the regression of suicidal thoughts on the random mean of emotion regulation or impulsivity and > 0.99 power to detect the effect of a covariate on the random mean, autoregression, or random variance of emotion regulation or impulsivity, given this sample size.

Monte Carlo simulations were also used to determine adequate power to test hypotheses in Aim 2. These simulations included: 1000 replications and three seeds, modest effects of covariates, latent constructs modeled as single observed variables, separate models indicating either 5 EMA assessments (2 days before and after an episode) and 15 EMA assessments (7 days before and after an episode), and 10% missing data. Models that

included two parallel growth models indicated that there was adequate (> 0.80) power to detect moderate (0.38) effects between slopes for hypothesis 3 (H3) and to detect a slightly lower (0.22) effect between slopes for hypothesis 4 (H4). All models were achieved > 0.90 power to detect small (0.15) effects of seven covariates (e.g., demographics, medication use, substance use, etc.) on the slope of the suicidal behavior composite. Models that included a time-varying covariate (e.g., daily impulsivity) on the slope of suicidal behavior composite were estimated to achieve adequate (> 0.80) power to detect medium effects (0.30).

Participants

Veterans will be recruited from an inpatient ward and from Suicide Prevention Coordinator (SPC) office the Providence VA Medical Center. Veterans followed by the SPCS are those who are identified and assessed by a local suicide prevention coordinator to be at acute risk due to recent suicide behaviors or ideation with intent. Participants must be 18 or older, speak read and write English sufficiently, own a smart phone, and have had suicidal ideation with intent within the two weeks prior to hospitalization or screening or suicidal behavior (suicide attempt or preparatory behavior) within three months prior to hospitalization or screening . Exclusion criteria includes primary psychotic disorders, any cognitive impairment, and lack of a smartphone.

Procedures

Study participation will consist of screening, a baseline assessment, a training session, four follow up assessments, daily brief assessments delivered via smartphone, and daily wearing of an actigraph. Each of these procedures is described in greater detail below.

Screening & Enrollment

A HIPAA waiver will be obtained for pre-screening purposes. Participants will be identified through daily screening of medical records and potentially eligible participants will be approached on the unit by study staff to obtain informed consent.

Following informed consent, in-person screening will be conducted using the Columbia Suicide Severity Rating Scale (C-SSRS) [23] to confirm that the participant had a recent suicide attempt or endorsed suicide ideation with intent in the two weeks prior to their hospitalization or screening. Patients deemed eligible per study criterion will be invited to complete a baseline assessment.

Baseline Visit

The baseline visit will take place on the same day as the screening, or shortly after screening, per the participant's wishes. With patient consent, the baseline visit will be audio recorded for the purpose of quality control. During the baseline visit study staff will administer assessments as described in Table 1.

Discharge/Training Visit

Following the baseline assessment, study staff will schedule a follow-up appointment to train participants on how to use the actigraph watch, complete sleep diaries, and use the EMA program. Participants will sign an Actigraph Responsibility Form acknowledging that they understand how to handle the actigraph properly. EMA software will be downloaded onto personal smartphones on day of hospital discharge or at a research appointment shortly after discharge, since patients are not allowed access to their phones while hospitalized. Participants recruited through the SPC office will have EMA software downloaded during their scheduled training appointment. As part of EMA training, participants will practice completing phone surveys with research staff and complete a comprehension quiz with feedback provided. The process of downloading the app and training the participants will take approximately 30 minutes.

Follow Up Visits

Four follow up visits will be performed: 2-, 4-, 6-, and 8-weeks follow up. During these visits, participants will be asked to complete self-reports assessments and brief interview measures (see Table 1) and the actigraph battery will be replaced. Study staff will reconcile any perceived inconsistencies between actigraphy data and sleep diaries. To reduce in-person contact due to the COVID-19 pandemic, follow up self-report assessments may be completed remotely through a secure survey link.

At 26 weeks follow-up, participants will return for a final visit. The final assessment will be similar to the baseline visit with the option for self-report questionnaires to be completed remotely. Activities taking place at each study appointment are outlined in Table 1.

Daily Tasks

During the 8-week assessment period, participants will wear the actigraph wrist activity monitor (Micro Motionlogger Watch, AMI, Ardsley, NY, USA) day and night (with the exception of during swimming and high impact sports). Participants will also answer questionnaires on the EMA phone application up to five times per day, with each survey taking 2-15 minutes. Each day, participants will be prompted to complete a morning check in survey, three momentary assessments, as well as a bedtime check in survey.

The EMA daily questionnaire is made up of sections of the following assessments to capture current thoughts and mood: Positive and Negative Affect Schedule (PANAS) [35], Momentary Impulsivity Scale (MSI) [38] and Columbia Suicide Severity Rating Scale (C-SSRS) [23].

The EMA app will also function as the participant's sleep diary. The morning and bedtime check-in surveys will ask questions about sleep quantity, quality, timing, any nightmares, and any nocturnal wakening (See Supplementary Materials). Each day, study

staff will check data collected via the EMA app. In the event that a participant did not complete the previous night's survey or the morning survey for that day, staff will contact the participant by phone and ask them to do so through the app.

Compensation

Participants will be compensated up to $420 for their participation, which will be provided through gift-cards or electronic funds transfer. Participants who complete the screening visit but are deemed ineligible will not be compensated. Participants will receive $50 for the baseline visit, $25 at each follow-up appointment, $75 for returning the actigraph watch and $75 at the 26-week follow-up visit. Each week, participants who complete at least 75% of morning and bedtime surveys will earn $10, and those who complete at least 75% of daily EMA surveys will earn $5. Therefore, over the eight-week period, participants may earn up to $120 for their survey completion.

Primary Outcomes

The primary outcomes are suicide thoughts (Aim 1) and suicide behaviors (Aim 2). Ideation will be measured using the C-SSRS ideation items (presence, intensity, duration). Suicide behavior will be measured using a composite from the C-SSRS. This composite consists of the sum total number of actual attempts, interrupted attempts, and aborted attempts. This suicide composite score has been utilized successfully in prior trials to maximize variability and capture the range of suicide behaviors [39, 40]. Due to the low base rate occurrence of attempts in our sample, the composite of behaviors was selected over actual attempts to capture more instances of suicidal behaviors. Outcomes are measured at baseline and all follow-up assessments as well as multiple times per day in EMA.

Description of Data Collection Procedures

Actigraphy Data

At discharge, participants are provided with an Ambulatory Monitoring, Inc (AMI) Motionlogger Actigraph, receive a brief training on the actigraph, and complete an assessment to identify handedness to inform actigraph placement. Participants are asked to wear their actigraph at all times (except when swimming and playing high impact sports) on their non-dominant wrist for 8 weeks. Participants return to the VA every two weeks data during the 4 follow-up assessments to change the actigraph battery and for staff to reconcile perceived inconsistencies between actigraphy data and sleep diary using the methods reported in Meltzer et al. 2019 [41]. Activity data are collected in 1-minute epochs and downloaded with AMI's commercial software, ActionW version 2.6.9905 (AMI, Ardsley, NY) which estimates sleep/wake times.

This study operationalizes sleep disruption in three ways: sleep quantity, sleep quality, and sleep timing. For our analyses, we will examine the trajectory of total sleep time (TST) per night for the nights preceding the event of interest (defined below). We will examine sleep quality and sleep timing using the Sleep Regularity Index (SRI). The SRI is an index of sleep that calculates the percentage probability of an individual being in the same state (asleep vs. awake) at any two time-points 24 hours apart (e.g., [42]). Additionally, we plan to also apply non-parametric activity analyses to the actigraphy/sleep diary data [43].

Sleep Diary

During morning and evening surveys administered through the mEMA app, participants complete a sleep/wake diary for self-report of bedtimes, rise times, amount of sleep, nightmares, and other important sleep variables. These surveys are available for one-hour and are scheduled to repeat each day based on the participant's typical bedtime and rise time. Participants will have the ability to complete "on-demand" access morning or evening

surveys if they fail to complete the sleep diary during the one-hour availability window within the mEMA app. At the 2-, 4-. 6-, and 8- week follow up visits, comparisons are made between the participant's sleep diary and actigraph data to confirm bedtimes and rise times.

Ecological Momentary Assessments

Daily assessments of sleep, suicidal thoughts and behaviors, and hypothesized mechanisms (e.g., positive and negative affect, emotion regulation, impulsivity, social stressors, substance use) are collected over the 8-week assessment period via EMA delivered over smartphones. During the training visit, , the application used to collect EMA data for this study (mEMA) is installed on the participants' own devices. Participants are trained in how to use the app and provided with unique codes generated by the mEMA platform that they will enter to complete assessments. For the next 8 weeks, the mEMA application will signal five times each day (once in the morning, three times at random intervals, and once at night) instructing participants to complete a brief questionnaire assessing for their affect, cognitions, sleep, and behaviors. Momentary assessments will be randomized using a stratified random sampling plan in which the participant's wake window is divided into blocks (e.g. three 5-hour blocks) and a random time is selected within each block. Randomized surveys will be open for a 30-minute window in the mEMA app, with three notifications sent to alert the participant. During their initial visit, participants are also trained to complete an event-queued assessment whenever they either feel strong suicidal ideation or have the urge to engage in self-harm or suicidal behavior. Random and event-cued assessments are identical. EMA surveys are expected to take participants between 2-15 minutes to complete, depending on whether or not they endorse any suicide items. Participants enter responses on the on-screen keyboard or by tapping response options.

Data Analysis Plan

Data management and confidentiality

All study data will be collected and handled only by research staff trained in responsible research conduct, including how to deal appropriately with sensitive clinical issues. Upon consenting, each participant will be assigned a unique study ID that will be used to de-identify any corresponding study data.

Regarding EMA data, mEMA is a HIPAA-compliant web platform designed for the collection and secure transmission of EMA data to a cloud-based central server with dedicated data backup. Access to the mEMA data is only made accessible to the researchers by directly accessing the secure web portal hosted by Ilumivu Inc. using verified login credentials and downloading the dataset to the secure research server.

All data collected on actigraphs are stored on the watch until they are downloaded at the 2-, 4-, 6- and 8- week follow up and saved on the VA secure server. There is no personally identifiable information stored on the device. The saved data are subsequently imported into the Motionlogger Watchware software to be analyzed via the Motionlogger ActionW and Motionlogger Action4 systems (Ambulatory Monitoring Inc. Ardsley, NY). Data can only be accessed by research staff who have access to this proprietary software.

Overview

Data will be processed, cleaned, and analyzed using Excel, SPSS, R, and MPlus, allowing flexibly to test complex models of high frequency data while handling a wide variety of categorical, count, or continuous distributions. Variables will be examined for statistical assumptions and estimation procedures will be applied as appropriate (e.g., maximum likelihood estimation with robust standard errors (MLR) for non-normal distributions).

Missing data

We will assess missing data and apply missing data procedures where appropriate. MPlus permits both frequentist (full information maximum likelihood) and Bayesian (multiple imputation (MI) to provide averaged parameter estimates) estimation for models with missing data. In our previous work [44, 45], we have observed moderate to good compliance for responding to prompts. Even if participants respond to one prompt per day, we will have a large amount of data, totaling 56 observations per person and 7,840 total data points for the study. EMA literature indicates that compliance rates for EMA is frequently greater than 80% [46].

Aim 1: To evaluate a model of hypothesized mechanisms driving the sleep-suicide relationship.

Our first hypothesis is that sleep disruptions increase risk for suicide thoughts (ST) through momentary increases in emotional reactivity and decreases in emotional regulation over the 8 weeks following hospital discharge or enrollment through the SPC office. To evaluate this hypothesis, we will use dynamic structural modeling (DSEM) [47] in Mplus using Bayesian estimation [48] to model the cross-lagged effect of daily sleep (e.g., quality, quantity, timing, nightmares, nocturnal wakening, or interactions of these variables) and daily emotional reactivity on ST measured at 6-month follow-up. The estimated parameters are: 1) the means of sleep variables and ER over time, 2) the autoregressions of sleep disruption and emotional reactivity processes, 3) the within-person variances for sleep and emotional reactivity, and 4) the cross-lagged effects between emotional reactivity and sleep. Additionally, ST can be regressed on these parameters to examine whether these key parameters are predictive of risk for ST. Covariates will be included in the model to examine heterogeneity of model parameters due to variation in relevant factors (e.g., demographics, medications, comorbidities, psychiatric symptoms, etc.). If we are unable to fit a full DSEM

model, data can be aggregated into larger blocks of time (e.g., days/weeks) and a traditional cross-lagged panel model can be fit that incorporates random effects to account for variation across people. Analyses of emotional regulation will follow the same procedures.

Our second hypothesis is that sleep disruption increases risk for ST through momentary increases in impulsivity over the 8 weeks following hospital discharge or study enrollment through the SPC office. This will be evaluated as outlined above but will focus on daily impulsivity, rather than emotional reactivity.

Aim 2: To assess the influence of sleep disruption on suicidal behavior in the time surrounding an identified episode of risk.

Our third hypothesis is that sleep disruption in the 48 hours preceding an identified episode will be predictive of increased risk for suicide behaviors (SB; i.e., using the composite variable indicating risk across several types of behavior) above and beyond traditional cross-sectional measures. Our fourth hypothesis similarly proposes that sleep disruption in the 7 days preceding an identified episode will be uniquely predictive of increased risk for SB.

We will evaluate these hypotheses using latent growth modeling, leveraging the repeated measures data collected through assessments of SB measured via daily EMA, and will focus on the acute period of time surrounding an identified episode (e.g., totaling 5 repeated measures for H3 [which includes the two days before and after an event] and totaling 15 repeated measures for H4 [which includes the seven days before and after an event]). Models will examine constructs specified in the conceptual model (Figure 1), tapping into the domains of emotional reactivity, emotional regulation, social stressors (e.g., negative events), and impulsivity (e.g., measured as a time varying process in EMA and/or Iowa Gambling Task measured as a stable trait). Models will be specified as parallel or time lagged growth processes to account for shared variance but will be tested individually or entered as

time-varying covariates if parallel models cannot be fit. We will first fit unconditional models to estimate intercept (i.e., mean level of SB risk) and slope (i.e., linear rate of change in SB risk over time) for each process and we will investigate nonlinear (i.e. quadratic) slope or specify piecewise, discontinuous, linear growth processes should linear slope poorly describe the data. We use relevant time varying covariates (e.g., indices of sleep, substance use, medication use) or other cross-sectional/trait risk factors (e.g., psychiatric symptoms, demographic variables) when appropriate. Once the optimal change trajectory for daily SB is established, we will regress growth parameters (i.e., intercept and slope) on growth in other processes (e.g., sleep, emotional reactivity, emotion regulation, impulsivity), cross sectional (e.g. self-report and SB measured at baseline and/or follow-up), allowing us to examine the association of the latent variables above and beyond traditional cross-sectional measures of suicide risk. If we are unable to fit a model to the data, we will modify our model (i.e., exclusion of a risk variable, inclusion of covariance, change in time parameterization, etc.) or employ simplified, multiple linear regression.

ETHICS AND DISSEMINATION

Ethics

All study procedures were approved by the institutional review board (IRB) at the Providence VA. Serious adverse events will be reported to the IRB within 24 hours. If any patient endorses active suicidal ideation or behavior during an in-person visit, an on-call licensed clinician will be contacted to conduct a suicide risk assessment. If a participant manifests significant suicidal or homicidal ideation or risk, measures to ensure the safety of the patient and/or others will be taken. These steps may involve: a) escorting the patient to the hospital's admitting office for an emergency evaluation, b) alerting inpatient staff to the patient's level of risk, c) notifying the patient's clinician, primary care physician, and/or family member or d) calling the appropriate police departments.

Study staff will not be monitoring EMA survey responses in real time. Therefore, if a patient endorses suicidal ideation or behavior during a randomly cued EMA assessment, the program will trigger a safety message with telephone information for local emergency services.

In the event that a participant dies by suicide over the course of the study, the following steps will be taken: a) a serious adverse event will be reported immediately, b) the principal investigators will debrief study staff, c) if applicable, investigators will discuss the suicide with family members and referrals to grief counseling will be made, and d) the study staff will determine whether there were any errors in study procedure that need to be corrected.

Dissemination

The principal investigators will share de-identified datasets, statistics, and results by depositing these data at the National Library of Medicine (NLM) PubMed Central website repository, a VA supported data repository. Planned manuscripts include an outcome(s) paper submitted to a high impact journal such as JAMA Psychiatry or the American Journal of Psychiatry. Additional journals for secondary data analyses include Suicide and Life-Threatening Behavior, Military Psychology, and Psychiatry Research. Moreover, a fact sheet describing the study and the potential clinical implications of the findings will be produced and sent to the Army Suicide Prevention Program, VA Suicide Prevention Office, and Military Suicide Consortium. Results will also be submitted to the annual DoD/VA suicide prevention conference.

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Contributors

JEM and JP drafted the initial proposal with input from LB and MAC. MJQ, MRK, SN, EJF, CSH and SM drafted the manuscript, which all authors reviewed and revised.

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Competing interests None declared.

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Figure Captions

Figure 1. Visual depiction of participants characterized for SRI and sleep duration.

Table 1. Data Collection by Timepoint

Construct	Measure	Time point				
		Screening	Baseline	Daily	Biweekly	Final visit
CROSS SECTIONAL RISK FACTORS						
Demographics	Demographics form		x			
Diagnosis & Cognitive Impairment	Structured Clinical Interview for DSM-V (Quick SCID-V) [24]		x			
	Life Events Checklist for DSM-5 (LEC-5) [25]		x			
	Montreal Cognitive Assessment (MoCA) [26]		x			
Psychiatric symptoms	Brief Symptom Inventory (BSI) [27]		x			x
	Record review (hospital, state/national death registries)				x	x
Treatment/medication use	Treatment History Interview (THI) [28]		x	x		x
Alcohol & Substance Use	AUDIT & DUDIT [29,30]		x			x
SUICIDE OUTCOMES						
Suicide attempts	Columbia Suicide Severity Rating Scale (CSSRS) [23]	x		x	x	x
Suicide Ideation						
Psychiatric Hospitalization	THI & Medical record review				x	x
SLEEP						
Sleep Quantity	Total sleep time: Actigraph/Sleep Diary			x		
Sleep Quality	Sleep Regularity Index: Actigraph			x		
	Actigraphy/Sleep Diary			x		
	Pittsburg Sleep Quality Index [31]		x			x
	Insomnia Severity Index (ISI) [32]		x		x	x
Sleep Timing	Morningness-Eveningness Questionnaire: EMA [33]		x			
	Munic Chronotype Questionnaire: EMA [34]		x		x	x
Nightmares	Sleep Diary			x		
Traditional clinical sleep variables derived from Actigraphy/Sleep Diary	Sleep latency, Wake after sleep onset, Early morning awakening sleep efficiency			x		
Nocturnal Wakening	Indexed via Actigraphy/Sleep Diary and Sleep Regularity Index			x		
SOCIAL/INTERPERSONAL STRESSORS						
Social Stressors	EMA			x		
EMOTIONAL REACTIVITY						
Situation Emotion Reactivity	Positive and Negative Affect Schedule (PANAS-X): EMA [35]			x		
Emotional Regulation	Difficulties in Emotion Regulation Scale (DERS) [36]		x		x	x
IMPULSIVITY						
Impulsivity	Iowa Gambling Task [37]		x		x	x
	Momentary Impulsivity Scale (MIS): EMA [38]			x		

RELATED CONSTRUCTS						
Caffeine Use	EMA			x		
Substance Use	EMA			x		
Medication Use	Treatment History Interview (THI)		x	x	x	x
	EMA			x		
	Reconciliation of EMA prompts				x	

Figure 1. Visual Depiction of Participants Characterized for SRI and Sleep Duration