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ABSTRACT

Objective: The study purpose was to examine the feasibility and acceptability of intensive ecological momentary assessment (EMA) among high-risk adolescents with suicidal thoughts and behaviors following discharge from acute psychiatric care.

Method: Fifty-three adolescents, 12–18 years old, and their parents, were recruited following discharge from acute psychiatric care for suicide risk. The study included a baseline assessment (adolescent and parent), 28 days of EMA surveys (5x per day) and wrist actigraphy (adolescent), and an interview at the end of the 28-day monitoring period (adolescent). Adolescents' outpatient clinicians were also surveyed about the study.

Results: Study feasibility was indicated by a reasonable enrollment rate, high adherence to wearing the actigraphy device, and good adherence to EMA surveys (highest in the first week with significant drop-off in subsequent weeks). Adolescents reported their overall experience in the study was positive, the questions were understandable, their responses to questions were generally accurate, and the surveys were minimally burdensome. The study procedures did not appear to be iatrogenic; suicide attempts and rehospitalizations were not study related and occurred at a rate comparable to other adolescents at the recruitment site. Adolescents' clinicians reported that the study was somewhat positive and minimally burdensome for them, and somewhat positive for their patients and families.

Conclusions: This study demonstrated that intensive EMA designs are feasible and acceptable among high-risk suicidal youth following acute psychiatric care. Specific procedures are provided for keeping adolescents safe during intensive EMA studies, including detailed information about the risk and safety monitoring plan.

Introduction

Suicidal thoughts and behaviors (STBs; i.e., thoughts and actions related to self-directed injury with at least some intent to die) are significant public health concerns in adolescents. STBs typically begin during the transition to adolescence and increase significantly during this developmental period (Nock et al., 2008, 2013). In 2017, approximately 17% of U.S. high school students seriously considered suicide and 7% attempted suicide at least once (Centers for Disease Control and Prevention [CDC], 2017b). Youth with STBs report significant impairment in academic and social domains (Copeland et al., 2017; Foley et al., 2006) and are substantial utilizers of healthcare services (CDC, 2017a). Together, adolescence is a critical period of increasing risk for STBs and a prime target for effective intervention and prevention (NAASP, 2014; Wyman, 2014).

Considerable research has focused on identifying risk factors for STBs (Franklin et al., 2017; Hawton et al., 2012). However, most studies have identified factors that are time-invariant (i.e., do not fluctuate over time, such as sociodemographic characteristics) and confer risk over longer time periods, such as months and years (Franklin et al., 2017). Far less is known about risk factors that are time-varying and confer risk over shorter time periods, such as hours and days (Glenn & Nock, 2014). Given that the first few months following discharge from acute psychiatric care is one of the highest risk periods for suicidal behavior in both adults and adolescents (Chung et al., 2017), this period provides a critical window to examine fluctuations in suicide risk and identify short-term risk and protective factors for suicidal behavior.

Ecological momentary assessment (EMA; also called experience sampling), which measures cognitions,

emotions, and behaviors repeatedly throughout the day as they occur in an individual's environment (Shiffman et al., 2008; Torous et al., 2017), is well suited for intensely examining fluctuations in STBs and their risk and protective factors as they occur in everyday life. Emerging research has used EMA and daily diary designs (i.e., one-time daily assessments) to examine fluctuations in suicide risk in adults (Ben-Zeev et al., 2017; Forkmann et al., 2018; Husky et al., 2017; Kleiman et al., 2017; Kleiman & Nock, 2018) and adolescents (Czyz et al., 2018; Nock et al., 2009). Prior research has found that EMA and daily diary designs are feasible and acceptable to use with suicidal populations (Czyz et al., 2018; Husky et al., 2014; Law et al., 2015), assess meaningful variability in STBs (Hallensleben et al., 2017; Kleiman et al., 2017), and provide unique information about STBs compared to aggregated reporting methods (Czyz et al., 2018). However, only a few studies to date have used these intensive designs among high-risk populations (i.e., during hospitalization or following acute psychiatric care), and most have been in adults (Ben-Zeev et al., 2017; Forkmann et al., 2018; Husky et al., 2017; Kleiman et al., 2017). In fact, only one prior study has used this type of design in high-risk suicidal youth. Using a daily diary design (i.e., one nightly assessment) to examine near-term risk factors for suicide ideation in adolescents over the 28 days post-hospitalization, Czyz et al. (2018) found that this design was feasible and acceptable among adolescents during this high-risk period. However, no published studies have used intensive EMA among high-risk adolescents during the period following discharge from acute psychiatric care. Although Czyz et al. (2018) offers promise that daily assessment is feasible in these populations, it is not known whether adherence would be similar for EMA studies that have far more frequent assessments and place a higher burden on participants.

One limitation of the EMA methodology is that it is most useful for assessing constructs that participants are able to self-report (e.g., STBs). There is growing interest in pairing EMA data with objective data collected passively from wearable devices (e.g., sleep, movement). Several studies lend promise to the idea of using EMA and wearable devices in high-risk adolescents, but do not directly assess this specific population. For example, studies have shown that it is feasible to use a wearable device (without EMA) among adolescents on an inpatient unit (Kleiman, Millner, et al., 2019) and to use EMA with a wearable device among adults with relatively low severity suicide ideation (Littlewood et al., 2019). Due to the added burden of using EMA and a wearable device, the findings from

these studies may not generalize to a high-risk population of adolescents outside of the hospital (where study staff cannot constantly monitor adherence). Therefore, it is important to examine the feasibility of conducting research using EMA and wearable devices with high-risk adolescents outside of acute psychiatric care.

The goal of the current EMA and wearable study was to examine short-term suicide risk among adolescents, 12–18 years old, during the 28 days following discharge from acute psychiatric care for suicide risk (i.e., suicide ideation with intent to act and/or a plan, suicide attempt). This manuscript describes the overall study design, feasibility, and acceptability of this intensive method for use with high-risk adolescents assessed following acute psychiatric care. The purpose of this paper is to disseminate key aspects of the study design that may be useful for other researchers using this methodology with high-risk youth.

Method

Participants

Study inclusion criteria were: adolescents (12–18 years old), presenting to acute psychiatric care (i.e., psychiatric emergency department [ED], inpatient hospitalization, or partial hospitalization) for a recent suicide attempt or suicidal crisis (i.e., suicide ideation with intent to act and/or a plan), transitioning to outpatient treatment at the index medical center, and with a parent/legal guardian willing to participate. Adolescents were excluded if they: did not meet the inclusion criteria, were unable to provide informed assent/consent (e.g., extreme cognitive impairment, acute psychosis), were unable to actively participate in the study (e.g., unwilling to wear an actigraphy watch), were a safety concern (e.g., risk of other-directed violence or imminent suicide risk warranting readmission to acute psychiatric care), or if their sibling was enrolled in the study (to ensure independence of data). See Figure 1 for participant flow from referral to enrollment.

The final sample included 53 adolescents (M_{age} = 14.85 years, SD = 1.61). Each adolescent enrolled in the study with one parent/legal guardian (hereafter referred to collectively as *parents*): 44 biological mothers, two adoptive mothers, six biological fathers, and one maternal grandmother. Sample sociodemographic and clinical severity information are presented in Table 1. The majority of adolescents (83.0%) reported at least one suicide attempt in their lifetime. Of the remaining 17.0% without
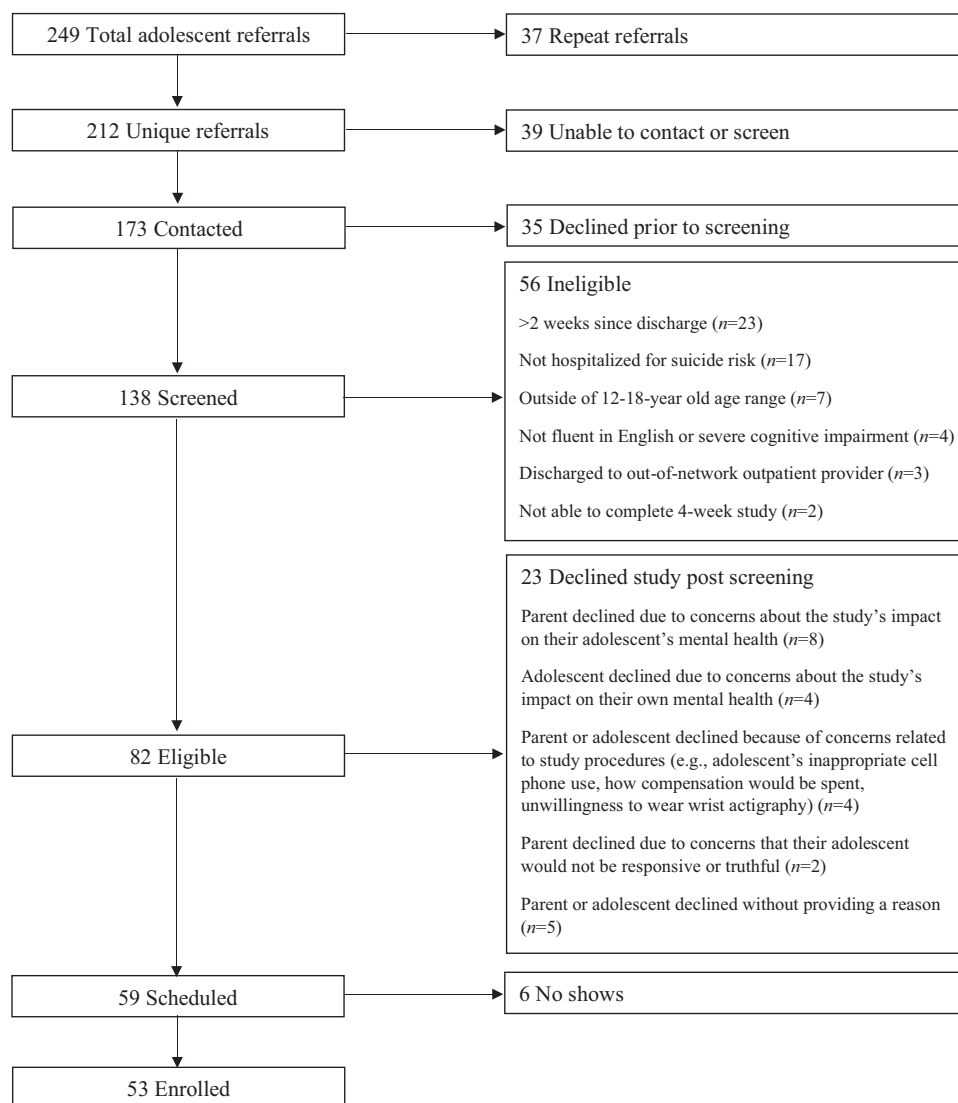
Figure 1. Study referrals and enrollment.

a prior attempt, almost all (88.9%) engaged in non-suicidal self-injury (NSSI) during their lifetime, and 100% reported active SI in the month prior to enrollment with 44.4% also having an active suicide plan with some intent to act.

Prior to outpatient treatment and enrollment in the study, 15.1% ($n = 8$) of adolescents were discharged directly from the psychiatric ED, 37.7% ($n = 20$) from inpatient hospitalization, and 47.2% ($n = 25$) from partial hospitalization (most adolescents, 68% [$n = 17$], were admitted to the psychiatric ED or inpatient prior to partial). Of the full sample, 18.9% ($n = 10$) received medical treatment for their suicide attempt before moving to a psychiatric unit. Adolescents presented to acute psychiatric care for the following reasons: 50.9% ($n = 27$) for a suicidal crisis (e.g., suicide ideation with intent and/or a plan) and 49.1% ($n = 26$) following a suicide attempt.

Measures and Procedure

Study procedures were approved by the University's Institutional Review Board (IRB). Participants were primarily referred by the outpatient treatment team but were also recruited via flyers posted in outpatient facility waiting areas. Adolescents' eligibility was assessed through screening with the parent and adolescent. Prior to study initiation, adolescent assent and parent permission (12–17 year-olds) or adolescent consent and parent consent for their own participation (18 year-olds) were obtained. Parents of 18 year-olds also provided information about their adolescent to keep study procedures consistent across participants. Following informed consent, contact information for the adolescent's outpatient provider was obtained for use during the study period (see *Risk and Safety Monitoring*). The study consisted of three phases: in-person baseline assessment, 28-day monitoring

Table 1. Adolescent and parent sociodemographic factors and adolescent clinical severity information.

	Adolescents (n = 53)	Parents (n = 53)
Age (years): M (SD)	14.9 (1.61)	44.2 (7.98)
Gender Identity: % (n)		
Female	64.2% (34)	88.7% (47)
Male	17.0% (9)	11.3% (6)
Nonbinary[1]	18.9% (10)	0.0% (0)
Race and Ethnicity: % (n)		
White/Caucasian	77.4% (41)	90.6% (48)
Black/African American	7.5% (4)	5.7% (3)
American Indian/Alaskan Native	1.9% (1)	0.0% (0)
Multi-racial	9.4% (5)	0.0% (0)
Other/Do not wish to answer	-	3.8% (2)
Hispanic/Latinx[2]	11.3% (6)	9.4% (5)
Sexual Orientation: % (n)		
Heterosexual	43.4% (23)	90.6% (48)
Gay or Lesbian	5.7% (3)	0.0% (0)
Bisexual	32.1% (17)	7.5% (4)
Pansexual	5.7% (3)	0.0% (0)
Asexual	3.8% (2)	1.9% (1)
Unsure	9.4% (5)	0.0% (0)
Annual Household Income: % (n)		
<$29,000	-	5.7% (3)
$30,000 – $69,000	-	30.2% (16)
$70,000 – $99,000	-	37.7% (20)
>$100,000	-	17.0% (9)
Prefer not to report	-	9.4% (5)
Employment Status: % (n)		
Full-time/self-employed	-	64.2% (34)
Stay-at-home parent/retired	-	13.2% (7)
Part-time employed	-	9.4% (5)
Full- or part-time student	-	9.4% (5)[3]
Unemployed/on disability	-	5.7% (3)
Major Psychiatric Disorders[4]: % (n)		
Anxiety Disorder	88.7% (47)	-
Attention-Deficit Hyperactivity Disorder	26.4% (14)	-
Bipolar Disorder	5.7% (3)	-
Disruptive Behavior Disorder	24.5% (13)	-
Eating Disorder	17.0% (9)	-
Major Depressive Disorder	79.2% (42)	-
Obsessive Compulsive Disorder	9.4% (5)	-
Posttraumatic Stress Disorder	17.0% (9)	-
Psychotic symptoms	5.7% (3)	-
Substance Use Disorder	7.5% (4)	-
Self-Injurious Thoughts and Behaviors:		
Lifetime suicide attempt: % (n)	83.0% (44)	-
Multiple lifetime attempts[5]:	61.4% (27)	-
Lifetime NSSI[6]: % (n)	81.1% (43)	-
Number of lifetime NSSI methods[6]: M (SD)	2.0 (.91)	-

[1]Nonbinary includes adolescents identifying as transgender, agender, and non-binary.
[2]Four adolescents preferred not to report their ethnicity.
[3]One parent reported that they were both employed full time and a full-time student.
[4]Current diagnoses were determined by integration of the adolescent and parent reports (obtained separately). Anxiety disorder includes any of the following current disorders: panic disorder, agoraphobia, social phobia, specific phobia, or generalized anxiety disorder; Attention-Deficit Hyperactivity Disorder includes any of the following current subtypes: combined, inattentive, or hyperactive/impulsive; Bipolar Disorder includes current bipolar I or II disorder; Disruptive Behavior Disorder includes current conduct disorder or oppositional defiant disorder; Eating Disorder includes current anorexia nervosa or bulimia nervosa; Substance Use Disorder includes current alcohol use disorder or substance (drug) use disorder. Percentages are out of the full sample (n = 53) but diagnostic data were missing for some adolescents (n = 2–6 adolescents depending on the disorder category).
[5]Out of the sample of lifetime suicide attempters, the percentage who reported more than one suicide attempt in their lifetime.
[6]NSSI = nonsuicidal self-injury. Average number of lifetime NSSI methods among adolescents reporting lifetime NSSI.

period including EMA and wrist actigraphy, and phone assessment at the end of the 28-day monitoring period. With permission, adolescents' electronic health records were accessed to obtain information about their most recent psychiatric care and for hospitalizations occurring within one year following the baseline assessment.

Baseline Assessment

The in-person baseline assessment occurred within two weeks of discharge from acute psychiatric care (M = 8.88 days, SD = 3.87, Range = 0–15[1]) and took approximately three hours to complete. Each adolescent and parent were compensated $25/hour. The

[1]When participant-reported discharge dates were confirmed with the adolescent's electronic medical record, one participant completed the baseline assessment 15 days post-discharge (as opposed to the reported 13 days post-discharge).

assessment included structured clinical interviews (adolescent and parent separately), self-report questionnaires (adolescent and parent separately), an orientation to the EMA software and actigraphy (adolescents and parents together), and a concluding suicide risk assessment (adolescent with parent follow-up as needed).

Clinical interviews were conducted by two study team members at a time (i.e., a combination of the principal investigator [PI] and two doctoral students, trained to reliability with the PI). Responses were coded separately by each interviewer with final consensus decisions made during group consultation with the PI and two doctoral students.

The adolescent and parent completed the clinical interviews separately. Adolescents were administered the Columbia Suicide Severity Rating Scale (C-SSRS; Posner et al., 2011) to assess lifetime, past year, and past month STBs, suicide intent, and perceived lethality of the most serious suicide attempt. A supplemental form, based on the Self-Injurious Thoughts and Behaviors Interview (SITBI; Nock et al., 2007), was used with the adolescent to measure the presence and frequency of NSSI. Parents provided additional information on STBs as needed (e.g., medical treatment received for suicide attempt). Current major psychiatric disorders were assessed via adolescent and parent report using the Mini International Neuropsychiatric Interview for Children and Adolescents, Child and Parent Versions (MINI-Kid; Sheehan et al., 2010), which is a brief structured diagnostic interview.

Following interviews, adolescents completed a battery of self-report measures, including the Beck Scale for Suicide Ideation (BSS; Beck & Steer, 1991) to measure severity of past-week suicide ideation and plans. Parents also completed a battery of self-report measures assessing their adolescent's clinical symptom severity. (Due to space limitations, a full list of self-report measures is not provided here but is available upon request.)

Next, the adolescent and parent received an orientation to the smartphone-based EMA application and the procedure for completing surveys during the 28-day monitoring period. Adolescents without a smartphone were loaned an Android (Tracfone) phone with a 30-day prepaid data plan. Study staff helped adolescents download the EMA application on their own or loaned phone, reviewed the content and procedures for completing EMA surveys, reviewed common questions, and completed a practice survey. Adolescents and parents were told that EMA responses would be monitored twice daily and that endorsement of items indicating high-risk for suicidal behavior would prompt a follow-up from the research team (see *Risk and Safety Monitoring*). Finally, they were provided a one-page information sheet with the lab's contact information and a summary of the information covered during the orientation.

Finally, the PI conducted a structured suicide risk assessment with the adolescent and reviewed the adolescent's safety plan developed by their treatment team during their most recent admission to acute psychiatric care. Lethal means restriction (e.g., firearm and medication safety) was discussed with the parent given the high-risk sample. Based on the adolescent's level of suicide risk, additional follow-up with the parent was completed as needed.

28-Day Monitoring Period

For 28 consecutive days beginning the day after the baseline assessment, adolescents completed daily EMA surveys using their smartphones and wore an actigraphy watch.

Ecological Momentary Assessment (EMA)

Surveys were completed using multi-platform (iOS and Android compatible), HIPAA-compliant software designed specifically for mobile EMA research. For the first four adolescents, surveys were administered using mEMA from ilumivu (mema.ilumivu.com). Due to technical issues, the remaining 49 adolescents completed surveys using Metricwire (www.metricwire.com). Both of these applications have been used in prior research with clinical samples (Kleiman et al., 2017; Schwartz et al., 2019). Adolescents were assigned a confidential code and e-mail to register so no identifying information would be shared with the software company. Survey data were collected on the phone and stored on the phone until an internet connection was available. Once a connection was available (usually immediately), the data were encrypted in transit and securely uploaded and stored on the software company server. These data were viewable by the study team via an online platform so that adolescents' adherence and risk status could be monitored twice daily (see *Risk and Safety Monitoring*).

Each participant provided information about their typical wake times, bedtimes, and availability during each day of the week. This information was used to customize each adolescent's EMA schedule to minimize unanswerable or inconvenient alerts (e.g., when asleep, in school, or involved in activities lasting two or more hours). Alerts were not scheduled during school hours to avoid conflict with school policies on phone use and to avoid penalizing adolescents for nonadherence if alerts arrived during instruction periods.

Survey types. Each day, adolescents were instructed to complete four types of EMA surveys: (a) one interval-contingent morning survey (ICAM), which was completed within two hours of waking up in the morning; (b) at least three signal-contingent surveys (SC), which were completed at random intervals (within a 30-minute window of receiving the prompt) during the periods adolescents indicated they would be available; (c) one interval-contingent bedtime survey (ICPM), which was completed before going to bed in the evening (within a 2-hour window before bed); and (d) optional event-contingent surveys (EC), which adolescents self-initiated when they experienced a STB or NSSI (collectively referred to as self-injurious thoughts and behaviors; SITBs). Together, each participant was prompted to complete at least 140 surveys (5 surveys/day; one ICAM, one ICPM, three SCs) during the 28-day monitoring period, excluding the optional EC surveys. (Due to space limitations, specific items are not provided here but are available upon request.)

The ICAM survey included 14 questions about the previous night's sleep. These surveys were scheduled to arrive 15 minutes after the adolescent's usual wake time each day of the week. They had two hours from the first alert to start this survey.

The SC surveys included 29 main items measuring affective and cognitive risk factors for STBs, as well as ratings of current suicide desire, intent, and ability to keep self safe (Nock et al., 2009). Adolescents also were asked if they recently experienced a SITB (see Table 2); if so, they completed additional questions about the timing, severity, and context of the SITB. These surveys were scheduled to arrive at random intervals at least three times per day (and up to six times per day depending on adolescents' availability), with a minimum interval of 60 minutes between prompts. Adolescents had 30 minutes from the first alert to start these surveys.

The ICPM survey included 13 main items assessing interpersonal negative life events, naps, and any substance use that day. They also were asked to report any SITBs that were not logged in an earlier survey. These surveys were scheduled to arrive one hour before the adolescent's usual bedtime each day of the week. They had two hours from the first alert to start the survey.

The EC surveys were self-initiated by adolescents to log SITBs in the moment, outside of the SCs and ICPMs. These surveys could be initiated at any time during the 28-day monitoring period and included questions about the timing, severity, and context of each SITB. The number of items varied depending on the number of SITBs endorsed in that survey (i.e., NSSI ranged from 8–27 items, STB ranged from 11–38 items).

Compensation. Adolescents demonstrated complete adherence to the EMA protocol if they completed five surveys per day: one ICAM, one ICPM, and three SCs. To increase adherence, reminder alerts were sent at 5, 10, and 15 minutes after the initial prompt for each of these surveys. Adolescents were compensated with a $25 Amazon gift card for each week if they completed at least 75% of these surveys. If a participant's weekly adherence rate dropped below 75%, or if they went 24 hours without submitting a response, study staff would send them a text message (via secure e-mail) with feedback about their compliance rate, a reminder about the gift card, and a prompt to contact the study team if they experienced any technical issues with the EMA application.

Actigraphy
To objectively assess sleep-wake activity, each participant wore an actigraphy watch – the Actiwatch Spectrum Plus (Philips Respironics, Bend, Oregon, United States), a lightweight (31 grams, or about the weight of 5 quarters), unobtrusive wristwatch-like device that consistently assesses movement and light exposure. The Actiwatch was worn on adolescents' non-dominant wrist. Although the device is waterproof, adolescents were asked to remove the watch while showering/bathing, swimming, or playing contact sports to minimize risk of damage. Otherwise, adolescents wore the Actiwatch continuously during the 28-day monitoring period. The Actiwatch Spectrum Plus allows for data collection at epochs as short as 15 seconds for up to 45 days, and therefore did not need to be charged during the study period. De-identified, raw actigraphy data is stored locally on the Actiwatch device. These data are not viewable in real-time and are only accessible using specialized software (Actiware; Philips Respironics, Bend, Oregon, United States) on a computer with Windows. The Actiwatch has been used successfully in prior clinical research with adolescents (e.g., Goldstein et al., 2018).

Participants returned the Actiwatch (and loaned smartphone, if applicable) to the research team by dropping it off at the lab, scheduling a time for pick-up in a public place (e.g., local library), or mailing it back in a prepaid padded envelope. Adolescents were told that their final payment for the study would be withheld until the devices were received, and that they would receive an additional $15 for returning the Actiwatch. All devices were successfully returned during the study. With adolescent and parent permission, a brief report summarizing each adolescent's sleep patterns during the 28-day monitoring period was generated and shared with their outpatient clinician after they returned their device.

Table 2. Ecological momentary assessment (EMA) risk monitoring items.

Category	EMA item	Response Scale	Follow-up Questions	Risk Threshold	EMA survey Type
Suicide desire	"How intense is your desire to kill yourself right now?"	0 = Absent/no desire, 1 = Present, but not at all intense to 5 = Extremely intense	-	≥ 4 (Very intense)[1]	Signal-contingent
Suicide intent	"How strong is your intent to kill yourself right now?"	0 = Absent/no intent, 1 = Present but not at all strong to 5 = Extremely strong	-	≥ 4 (Very strong)	Signal-contingent
Inability to keep self safe[2]	"How able are you to keep yourself safe right now?"	1 = I definitely CAN keep myself safe to 5 = I definitely CANNOT keep myself safe	-	≥ 3 (I'm not sure I can keep myself safe)	Signal-contingent
Suicidal thoughts and behavior	"Are you right now (or were you recently) thinking about attempting suicide (hurting yourself to die)?"	Yes or No	If Yes, questions assess intensity and duration of suicide ideation, planning, and behaviors.	Report of any suicide-related behavior (i.e., suicide plans, aborted, interrupted, or suicide attempts)	Signal-contingent (at end)
Suicidal thoughts and behavior	"Did you do anything to hurt yourself (with or without wanting to die) today?"	Yes or No	If Yes, questions assess whether thought or behavior was nonsuicidal or suicidal. Additional questions assess intensity and duration of suicide ideation, planning, and behaviors.	Report of any suicide-related behavior (i.e., suicide plans, aborted, interrupted, or full suicide attempts)	Interval-contingent (PM only)
Suicidal thoughts and behavior	"Are you right now (or were you just) thinking of doing any of the following?: Hurting myself, but not to die; Attempting suicide (hurting myself to die)"	Yes or No	If Yes, questions assess whether thought or behavior was nonsuicidal or suicidal. Additional questions assess intensity and duration of suicide ideation, planning, and behaviors.	Report of any suicide-related behavior (i.e., suicide plans, aborted, interrupted, or full suicide attempts)	Event-contingent

[1]The *suicide desire* threshold combined with either the *suicide intent* or *inability to keep self safe* threshold resulted in study follow-up.
[2]For the first four participants, the following EMA item was included based on prior EMA studies (Kleiman et al., 2017; Nock et al., 2009): *How strong is your ability to resist the urge to kill yourself?* Rated on a scale from 1 = *Not at all strong/inability to resist* to 5 = *Extremely strong ability to resist*]. However, this item was consistently misunderstood by adolescents (i.e., responding in the opposite direction). The *inability to keep self safe* item was added to replace this item starting with the fifth participant.

Follow-Up Assessment

Adolescents completed a 1-hour telephone follow-up assessment at the end of the 28-day monitoring period (*M* = 32.41 days from baseline, *SD* = 6.42, Range = 10–49[2]). Interviews were conducted by the PI and/or trained doctoral students closely supervised by the PI. Using abbreviated measures from the baseline assessment, adolescents reported on their SITBs, psychiatric symptoms, and treatment over the monitoring period. Adolescents also provided feedback on their study experience, including use of the EMA application, technical difficulties, and comfort wearing the Actiwatch. For the EMA surveys, adolescents were asked about their overall experience, understandability of questions, burdensomeness of surveys, perceived accuracy of survey responses, and perceived effort allocated to completing surveys (all questions rated: 0-*very negative/low* to 4-*very positive/*

high). Adolescents also were asked about the reasons for not completing surveys. Prior to the feedback interview, adolescents were informed that their responses would not impact their compensation or any other aspect of their involvement with the study. Finally, the interviewer conducted a structured suicide risk assessment with the adolescent and followed up with a parent and outpatient clinician as needed. The adolescent and parent were debriefed (typically separately) and the adolescent was compensated $25 for the follow-up assessment.

Risk and Safety Monitoring

In addition to structured suicide risk assessments at baseline and follow-up, we also developed a safety protocol to closely monitor all adolescents during their 28-day monitoring period.

[2]Four adolescents completed the follow-up interview prior to end of the 28-day monitoring period (*M* = 18.25 days, *SD* = 6.02, Range = 10–24 days) due to withdrawal from the EMA portion of the study.

Risk Flags in Daily EMA Surveys

Responses to all suicide-related EMA questions (see Table 2) were reviewed twice daily (i.e., once in the morning and once in the late afternoon/evening) during the 28-day monitoring period. After each monitoring session, trained research assistants emailed the PI with information about every adolescent's safety status, which included a review of the high-risk EMA items. Although adolescents and parents were aware that EMA responses were being monitored, they were not informed the specific times the adolescents' responses would be reviewed. In addition, both the adolescent and parent were informed that EMA responses would not be reviewed in real-time (i.e., responses were not monitored 24/7).

Risk cutoffs for EMA items were utilized to create a standardized method for monitoring and assessing risk during the study. Given the absence of any established cutoffs for this type of research, cutoffs were based on prior research (e.g., Kleiman et al., 2017) and collaboration between the researchers and clinical team. The following responses to suicide-related questions were flagged for risk on the SC surveys (see Table 2): suicide desire endorsed ≥4 (*Very intense*), suicide intent ≥4 (*Very strong*), and inability to keep self safe ≥3 (*I'm not sure I can keep myself safe*). For the SC, ICPM, and EC surveys, any endorsement of STBs (i.e., suicide plan, aborted attempt, interrupted attempt, or suicide attempt) were flagged as high-risk. If EMA responses were flagged for risk, the PI reviewed all responses since the last monitoring session to determine next steps (see Table 2). For instance, if suicide desire AND either suicide intent or inability to keep self safe were rated above threshold, the adolescent was contacted for a risk assessment. Based on their risk status following that assessment, their parent and outpatient clinician were contacted as needed. Endorsement of any suicide-related behavior since the previous monitoring session initiated follow-up contact with the adolescent, parent, and clinician (see *Follow-up contact*).

Follow-Up Contact

To further ensure adolescents' safety and to provide support to parents during the monitoring period, we partnered with the medical center's outpatient clinical team including the adolescent's individual outpatient clinician. This collaboration ensured that there was clear communication between study staff, outpatient clinicians, and parents in the event that the adolescent was at high risk for suicide during the 28-day monitoring period. In addition, this partnership with the adolescent's clinical team provided support for parents in managing expectations and risk related to suicide and

clinical severity. If adolescents transferred to another outpatient clinician after enrollment, we obtained permission to contact any additional mental health providers if adolescents were determined to be at high risk for suicide. Outpatient treatment adherence was not required to remain in the study. However, if there were safety concerns, we contacted the identified outpatient provider.

Per the safety protocol, some or all of the following individuals were contacted by the PI or trained doctoral students based on the adolescent's risk level: adolescent (always contacted first), parent (always contacted for suicide-related behavior), and outpatient clinician (always contacted for suicide-related behavior). The adolescent was always contacted first to ensure accuracy of survey information and to assess immediate safety. If the adolescent did not answer the PI's phone call, a voicemail was left informing the adolescent of the brief time window (i.e., 5 minutes) in which the adolescent was required to respond. Instances in which the adolescent did not respond, the PI would then contact their parent and outpatient clinician (by their preferred method of contact, such as secure e-mail or page). Appropriate steps to ensure the adolescent's safety were taken by the parent and/or clinician (with resources provided by the research team as needed).

Reportable Events

Anticipated adverse events were defined as any event that may involve life-threatening risk to the adolescent or others and can be reasonably expected given the study population. Based on the inclusion criteria, we anticipated that some adolescents may experience the following adverse events during the 28-day monitoring period: an acute suicidal crisis (e.g., severe suicide ideation with intent and/or plan requiring hospitalization) or suicide attempt. Following the report of an anticipated adverse event, the research team contacted, when possible, the adolescent, their parent, and their outpatient clinician to: (1) most importantly, assess the adolescent's current safety, and (2) when appropriate, the reason(s) for the adverse event to determine if the event was study related. Anticipated adverse events were reviewed by the research team and clinical partners (an elective Data and Safety Monitoring committee): the PI, a senior faculty Committee Chair, an outside suicide researcher and EMA consultant, head of the Child and Adolescent Outpatient Service (recruitment site for the study and clinical partner), and the project coordinator. The study team initially met after five adolescents had been enrolled in the study and every six months thereafter to review study progress, to review anticipated adverse events since the

prior meeting, and to discuss potential iatrogenic effects of the study procedures. In addition, the rehospitalization rate for adolescents in the current study was compared to the 30-day rehospitalization rate for all adolescents discharged from acute psychiatric care at the index medical center. Finally, as required, these events were reported to the appropriate IRB during the study's continuing review period.

Unanticipated adverse events were defined as any event that involved serious harm and would not be reasonably expected given the study population (i.e., suicide or natural death). No unanticipated adverse events occurred during the study.

Clinician Feedback Assessment

Upon conclusion of the study, adolescents' primary outpatient clinicians provided feedback on their experience and their patients' experience in the study. To maintain anonymity, clinicians completed the survey via a secure online survey platform (Qualtrics). Clinicians selected if they had one or more patients in the study (broad answer choices were used to maintain clinician anonymity). Clinicians provided feedback on the following: burdensomeness related to their own participation in the study (0-*not at all* to 4-*extremely burdensome*), impact on their patients and their patients' families (0-*very negative* to 4-*very positive*), frequency of patients' communication with their clinician about their SITBs during study enrollment, frequency of contact from the research team about their patients' safety, and if participating in the study influenced their clinical care. Clinicians also were given the opportunity to provide additional feedback and suggestions for improving future research. The survey took 15 minutes to complete and clinicians were compensated with a $20 Amazon gift card.

Data Analysis

Feasibility

To assess feasibility of the study design, we examined the total number of referrals over the recruitment period and the final study enrollment rate. In addition, we examined adherence to the EMA protocol and wearing the Actiwatch. Study adherence was examined as a function of a number of adolescent factors (e.g., sociodemographics, baseline STB severity, phone type)

using Pearson correlations (for continuous variables) and independent samples t tests (2 groups) or one-way ANOVA (3+ groups; posthoc Tukey's HSD). In addition, risk flags and reportable events during the 28-day monitoring period were used to examine potential iatrogenic effects.

Rehospitalizations and missing data were handled as follows: Patients who presented briefly to the psychiatric ED during the 28-day monitoring period remained in the study, and missing surveys due to ED visits were treated like other missing survey data. However, patients who were readmitted to longer term care (e.g., inpatient hospitalization) did not remain in the monitoring phase. Only data collected prior to rehospitalization were included in analyses.

Acceptability

Study acceptability was assessed from adolescents during the follow-up assessment and from adolescents' clinicians at the end of the study period. Analyses consisted of descriptive statistics and qualitative responses.

Results

Feasibility

Study Enrollment

Figure 1 displays the flow of participants from referral through enrollment in the study. Of the 212 unique referrals from September 2017 to July 2019, 53 adolescents and their parents were enrolled in the study (i.e., 25.0% of those initially referred). Most adolescents ($n = 42$; 79.2%) used their own phones (iPhones $n = 26$, 61.9%; Androids $n = 16$, 38.1%); three of these adolescents used their parents' phone (one iPhone and two Androids) at the parent's request to limit their adolescent's phone access.[3] The remaining 20.8% ($n = 11$) of adolescents were loaned Android (Tracfones) phones for the study. Reasons for needing a loaned phone included: not owning a phone or adolescent's phone was incompatible with the EMA application, broken, or taken away by their parent before/after acute psychiatric care.

Study Adherence

EMA surveys. Adherence to the EMA protocol was operationalized in a few different ways. First, we examined on how many days adolescents completed

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[3]The three adolescents who used their parents' phone for the study did not report that others seemed interested in what they were doing, asked to see their responses, or helped them answer the EMA questions. One adolescent reported that their answers felt less private and that they would sometimes avoid answering surveys. (This information was assessed during the follow-up assessment).

at least one survey. Out of the 28 days in the monitoring period, adolescents completed at least one EMA survey on average 21.09 days ($SD = 8.22$; 75.3% of total days). Nineteen adolescents (35.8%) completed at least one survey on all 28 days of the monitoring period. Of note, these adherence rates are a conservative estimate of EMA study adherence as they do not account for adolescents who may have withdrawn from the study, been rehospitalized, or experienced technical issues.

Seven adolescents (13.2%) withdrew during the 28-day monitoring period (but not from the rest of the study protocol); reasons for withdrawal included: having their phones taken away by their parent for inappropriate phone use ($n = 2$), significant technical issues that could not be resolved and could not wear the Actiwatch ($n = 1$), and significant stressors or mental health symptoms ($n = 4$).[4] In addition, seven adolescents (13.2%) were rehospitalized during the 28-day monitoring period. When examining only days when adolescents were actively enrolled in the study (i.e., not including days when adolescents were rehospitalized or had withdrawn from the monitoring period), EMA survey completion occurred on 89.0% of days ($SD = 17.7\%$).

Next, we examined adherence with each type of survey. For the once daily surveys, adolescents completed ICAM surveys on 3–28 days ($M = 15.98$, $SD = 8.03$) and ICPM surveys on 1–28 days ($M = 16.70$, $SD = 8.29$). SC surveys were completed on 4–28 days ($M = 19.32$, $SD = 8.54$); these surveys could be completed multiple times daily and were completed on average 54.77 times ($SD = 33.24$) over the study period. Twenty-nine adolescents (54.7%) completed between one and nine user-initiated EC surveys ($M = 2.62$, $SD = 2.13$) during the study. Eight of these adolescents reported more than one SITB in a single EC survey. Across the 76 total ECs completed across the sample, 105 instances of SITBs were reported: 56 NSSI thoughts, 15 NSSI, 20 suicide ideation, nine suicide plans, two aborted attempts, one interrupted attempt, and two suicide attempts.

Adolescents demonstrated full adherence to the EMA protocol if they completed five surveys per day: one ICAM, one ICPM, and three SCs (ECs were optional). Based on this threshold, the average adherence rate over the course of the study was 62.6% with wide variability ($SD = 34.0\%$, Range = 8.6–130.7%).[5] Adherence rates by week are displayed in Figure 2. There was a notable drop-off in adherence from Week 1 (86.6%) to Week 2
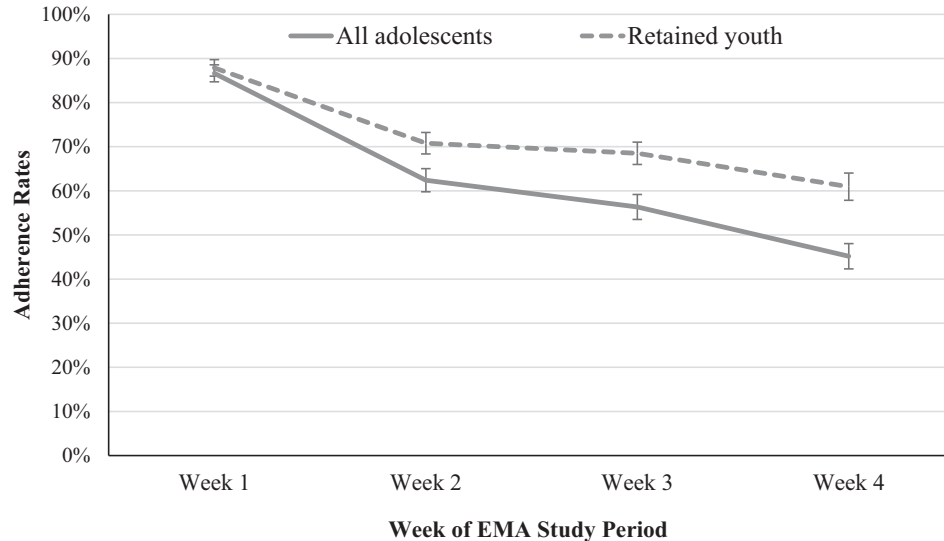
Figure 2. Adherence to the ecological momentary assessment (EMA) study protocol over the 4-week monitoring period. All adolescents displayed with the solid gray line. The dashed gray line displays adherence rates for retained youth at that point in the monitoring period (i.e., excluding youth who were rehospitalized or had withdrawn from the EMA portion of the study). Errors bars indicate standard error of the mean.

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[4]These four participants reported needing to stop due to a death in the family, severe depression, and high school-related stress that made it difficult to participate in the study. It is likely that other participants were experiencing similar levels of distress due to mental health symptoms but that they either: (a) found the study to be more beneficial than stressful, or (b) did not communicate this distress and instead exhibited low adherence.

[5]Adherence rates could exceed 100% if participants completed more than the required SC surveys per day (i.e., only three SCs were required but up to six were offered based on adolescents' schedules).

(62.4%) with a decrease continuing through Weeks 3 (56.3%) and 4 (45.2%). When adolescents were excluded at the point that they dropped out of the study (due to rehospitalization or withdrawal), the total adherence rate increased to 72.80% (see dashed line in Figure 2).

Technical issues were more difficult to account for in adherence rates because it was not always clear how many surveys were impacted by these issues (vs. other reasons for not completing surveys). Technical issues ranged from problems syncing for a couple of days to more extensive issues with the EMA application. Only one participant withdrew from the study due to ongoing technical issues (and also due to inability to wear the Actiwatch). However, 41.5% ($n = 22$) of the sample reported technical issues on at least one day during the study period. The more serious technical issues were due to the first EMA application utilized in the study (changed after the first four participants) and Tracfone use: 54.5% of loaned Tracfone users reported technical issues (as compared to 38.5% of iPhone and 37.5% of Android users). Notably, phone type was significantly related to EMA adherence, $F(2,52) = 6.12$, $p = .004$, $\eta^2 = 0.20$; loaned Tracfone users had the lowest adherence rates ($M = 34.27\%$, $SD = 21.69$) compared to Android users ($M = 78.04\%$, $SD = 33.59$, $p = .003$) or iPhone users ($M = 64.01\%$, $SD = 32.30$, $p = .033$). (Tracfone users were not more likely to withdraw or be rehospitalized than other phone users, $\chi^2 [2, N = 53] = 2.69$, $p = .261$.) The remaining 12 participants with technical issues reported more minor problems that were resolved by redownloading the application, updating their operating system, or resyncing the study surveys.

We examined how EMA adherence rates varied as a function of adolescent sociodemographic factors and STB severity at baseline. Adherence rates were not significantly related to adolescent's age ($r[53] = .19$, $p = .164$) or gender identity (male, female, non-binary, $F[2,52] = 1.31$, $p = .279$). Adherence did significantly differ by adolescent's race. Initial analyses indicated higher adherence among adolescents who identified as white ($M = 69.37\%$, $SD = 31.37$) compared to those who did not ($M = 39.62\%$, $SD = 33.83$, $t(51) = 2.84$, $p = .006$, $d = 0.91$). (This binary comparison was conducted given the small number of adolescents in any one minority group, which limited power for more specific subgroup analysis.) Adherence was also significantly related to annual household income (based on parent report; see Table 1), $F(3,47) = 2.84$, $p = .049$, $\eta^2 = 0.16$, with greatest adherence among adolescents whose annual household income was >$100,000 ($M = 88.18\%$, $SD = 16.49$) compared to adolescents whose household income was <$29,000 ($M = 49.79\%$, $SD = 32.40$, $p = .055$). Of note, all adolescents in the highest income bracket also identified as white. Moreover, adolescents in the lowest income bracket were more likely to use a loaned Tracfone, $\chi^2 (4, N = 48) = 13.12$, $p = .011$, $\phi = 0.52$. Finally, adherence was not significantly related to adolescents' history of suicidal behavior (i.e., no suicide attempt, single suicide attempt, multiple suicide attempts: $F[2,52] = 0.44$, $p = .649$) or to suicide ideation severity (BSS) at baseline, $r (53) = -.12$, $p = .400$.

During the follow-up assessment, adolescents were asked about their reasons for not completing EMA surveys. Thirty-eight adolescents (71.7%) completed the study feedback interview. The first four adolescents (7.5%) were not asked to complete this assessment, which was added during the third month of the study. Other reasons for not completing the feedback interview were: unable to schedule the final assessment (15.1%, $n = 8$) or unavailable due to long-term rehospitalization (5.6%, $n = 3$). Among those who completed this feedback interview, the most common reasons for not completing EMA surveys were: alert arrived at a bad time (57.9% reported that this was *Sometimes* or *Always* a reason for not responding), forgot to respond (55.3% reported *Sometimes* or *Always*), or did not want to complete the survey (28.9% reported *Sometimes* or *Always*). Other reasons included practical issues (e.g., phone not accessible, taken away, or battery dead) or technical issues with the EMA application.

Actigraphy

Over the 28-day monitoring period, adolescents wore the Actiwatch at least when sleeping (i.e., the main purpose of this device was to measure sleep) on the majority (76.1%) of days ($M = 21.31$ days, $SD = 8.52$). When examining only days when adolescents were actively enrolled in the study (i.e., not including days when adolescents were rehospitalized or withdrew), Actiwatch data increased to an average of 88.7% of days.

Risk and Safety Monitoring
Risk flags. Table 2 displays the EMA survey items that were flagged for risk and prompted follow-up assessment by the study team. Given the study design to follow up when certain high-risk items were endorsed, another way to operationalize study feasibility was to assess how often adolescents were flagged for risk and what level of follow up was needed. Seventeen adolescents (32.1%) were contacted at least once for a risk flag during the 28-day monitoring period (eight contacted once, seven contacted two times, two contacted 3+ times). Of the 17 adolescents with risk flags, 10 parents (18.9% of the total sample) were contacted at least once during the study about their adolescent's risk (six contacted once, two contacted two times, two

contacted 3+ times). Of the 17 adolescents with risk flags, seven clinicians (13.2% of the total sample) were contacted about their patients (four contacted once, one contacted two times, two contacted 3+ times).

Reportable events. Thirteen (24.5%) adolescents had 19 anticipated adverse events during the 28-day monitoring period: five adolescents (9.4%) attempted suicide at least once (two adolescents had multiple attempts) and 10 adolescents (18.9%) were rehospitalized one or more times (one adolescent was rehospitalized twice). Of the five adolescents who attempted suicide, two were rehospitalized and the other three were not (which was their clinician's decision based on the method, intent, and lethality of the attempt as well as the patient's history). Of note, these rehospitalizations were not the result of research team follow-up based on risk flags to EMA surveys. Most rehospitalizations were reported to the study team when an adolescent had stopped responding to EMA surveys. The study rehospitalization rate (18.9%) was not significantly different from the 30-day rehospitalization rate found in the index medical center (22%), χ^2 (2, $N = 3,715) = 0.31$, $p = .580$.

Acceptability

Adolescent

EMA surveys. Figure 3 displays the results from the feedback interview about the overall experience in the study. On average, adolescents reported that: their overall experience in the study was positive, the EMA questions were easy to understand, their responses to the surveys were accurate, they allocated effort to completing the surveys, and the surveys were not a burden to complete. Nine adolescents (23.7%) reported that other people (family, friends, others) seemed interested in surveys when they were completing them. When asked about the study, adolescents told others that it was "something for school" or a research study focused on sleep and/or mood (no adolescents mentioned the study's focus on suicide). Three adolescents reported that other people asked to see the surveys or their responses; one adolescent showed someone else the questions before answering (but not their responses) and the other two reported that they told the other it was important to the study that others did not see the surveys or their responses. However, five adolescents reported that another person helped them at some point with their responses; most of this assistance was with an anagram puzzle task designed to measure cognitive flexibility (included in the SC survey) and one instance where an adolescent reporting asking a parent for help with follow-up questions about a SITB. Seven (18.4%) adolescents reported that their responses felt less private because others were around when they received the survey prompt or were completing the survey. In these situations, most adolescents ($n = 5$) reported moving to a more private place, shielding responses from others, or completing the survey quickly; the other adolescents reported that the presence of others led to their skipping those surveys.
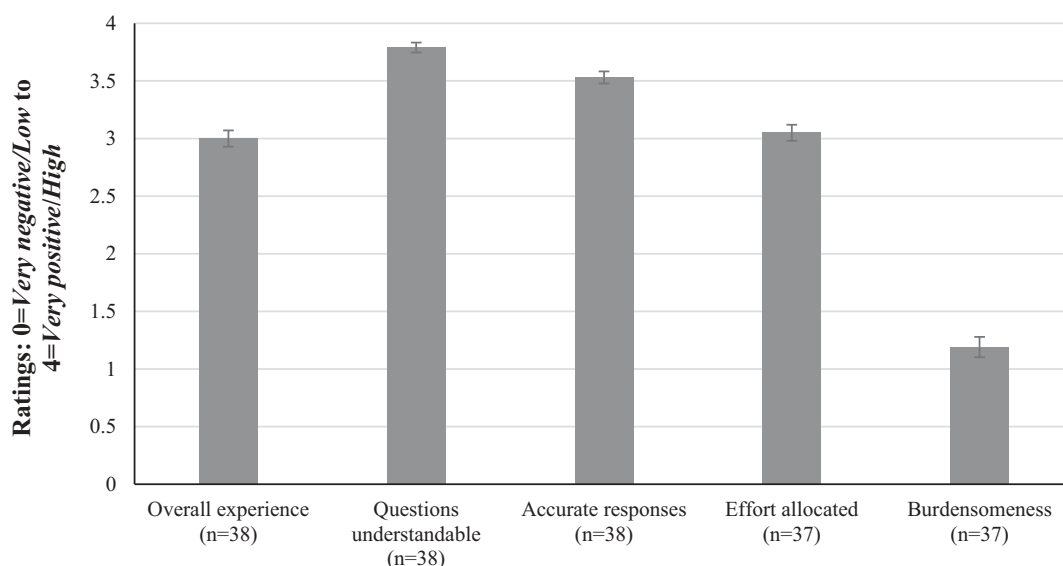
Figure 3. Adolescents' feedback about their experience in the ecological momentary assessment study. Error bars indicate standard error of the mean.

Actigraphy. Most adolescents (71.1%, $n = 27$) reported that wearing the Actiwatch was comfortable. Discomfort was due to: irritation under the watch, band tightness, new self-injury on wrist, or general dislike of wearing a watch (when they did not typically wear one). Only three adolescents (7.9%) reported that the Actiwatch interfered with daily activities.

Clinician

Adolescents' primary outpatient clinicians also provided feedback about the study. Out of the 27 clinicians who had at least one patient participate in the study, 20 clinicians ($n = 74.1\%$) completed the feedback survey. Because the clinician survey was anonymous, we were unable to examine differences between those who completed the survey and those who did not.

Twelve clinicians (60.0%) reported that they had only one patient participate in the study and the other eight clinicians (40.0%) had more than one patient participate. Clinicians rated their overall experience participating in the study as somewhat positive ($M = 3.00$, $SD = 0.84$). They reported that the most positive/helpful aspects were: additional monitoring of their patients during a high-risk time, feedback provided to clinicians about their patients' suicide risk and sleep patterns, and the positive impact on their patients. The most negative/least helpful aspects were: difficulty interpreting sleep data, receiving less information about their patients' participation in the study than they would have liked, and some patients' difficulty with appropriate smartphone use during the study. Clinicians reported that participating in the study was minimally burdensome for them ($M = 0.15$, $SD = 0.37$). The most burdensome study aspects were: responding to risk flags for patients who were chronically suicidal and interpreting sleep data to share information with families.

Clinicians were asked for feedback about the risk monitoring procedures used in the study. Seven clinicians (35.0%) reported having at least one patient flagged for suicide risk in which they were contacted by the research team (two chose not to answer). Clinicians reported liking the updates they received about their patients' risk, the level of detail provided about the specific items flagged for risk (typically via secure e-mail), and the timeliness of the information (often occurring before the next time they would see their patient). However, some clinicians reported disliking the lag between the patients' responses and when they were contacted (i.e., contact was not immediate) and the method used to communicate this information (of note, the preferred method of contact was obtained from each clinician once their patient was enrolled in

the study). When asked whether they were contacted enough over the course of the study about their patients' participation, 50% reported *Yes*, 25% *Somewhat*, and 25% *No*. For the 50% who reported *Somewhat* or *No*, clinicians wanted more regular updates about their patients' participation in the study and more access to their patients' EMA data even if they were not flagged for risk.

Clinicians were asked how they thought study participation impacted their patients and their families. On average, clinicians reported that the study had a neutral to somewhat positive impact on their patients ($M = 2.85$, $SD = 0.37$). Clinicians reported that the most positive aspects for their patients were: awareness due to regularly tracking symptoms, a sense of purpose from research participation, and the monetary incentive. They reported the most negative aspects for their patients were: increased burden during a high-stress time (i.e., post discharge) and misuse of phone during the study. Clinicians reported that the study had a neutral to somewhat positive impact on adolescents' families ($M = 2.60$, $SD = 0.50$). Clinicians noted that the most positive aspects for their patients' families were: increased understanding of connection between sleep and other mental health symptoms, communication when there were concerns for their adolescent's safety, and monetary compensation (especially for lower income families). They reported that the most negative aspects for their patients' families were: smartphone misuse and the time lag between risk flags and when parents were contacted. Clinicians were asked if the study impacted how their patients communicated with them (their provider) about their STBs. The majority (80.0%, $n = 16$) reported that it did not impact their patients' reporting of STBs and one clinician reported that their patient communicated about their STBs more often (three chose not to answer the question). Finally, when asked whether the study impacted how clinicians provided clinical care to their patients, 13 (65.0%) said *No* and six (30.0%) said *Yes* (one chose not to answer). For those who said *Yes*, clinicians reported that the study impacted their clinical care by: increasing awareness of risk among high-risk patients and enhancing understanding of sleep patterns with objective information.

Discussion

The current study is the first to examine an intensive EMA and wearable design among high-risk adolescents during the period following acute psychiatric care. In addition, this is the first study to obtain clinician feedback about this type of research design. Overall findings

support the feasibility and acceptability of EMA and wearable research with high-risk suicidal adolescents.

In terms of feasibility, the enrollment rate for the current study was comparable, although somewhat lower, than prior studies with adolescents recruited during the period following acute psychiatric care (Czyz et al., 2018). However, this enrollment rate is still high given that adolescents were referred to our study and recruited during a stressful time period. The adherence rate for EMA surveys was consistent with prior EMA research in clinical samples of youth (Heron et al., 2017; Van Roekel et al., 2019; Wen et al., 2017) and was comparable to a prior EMA study with adults in the period following acute psychiatric care (Husky et al., 2017). The current adherence rate was slightly lower than a prior daily diary study with suicidal adolescents during this period (Czyz et al., 2018), although the current EMA design was more intensive than a daily diary approach. Adherence rates dropped over the course of the 4-week assessment, consistent with the previous study with suicidal youth during the post-hospitalization period (Czyz et al., 2018) as well as prior EMA research with both clinical and nonclinical youth (Wen et al., 2017). Greater study adherence was found among adolescents identifying as white and with a higher family income (related sociodemographic factors in the current study). Adolescents in both of these groups were less likely to use loaned smartphones for the study, which were associated with technical issues and lower adherence rates. Although our study benefited from including adolescents who did not have access to a compatible smartphone, adolescents using loaned phones for the study reported technical issues much more often. This could be because they were less familiar with the phone than adolescents who used their own phone or because these inexpensive phones are of lower quality and therefore more prone to technical problems. Beyond technical issues, adolescents reported during the follow-up interview that lower study adherence was due to surveys arriving at an inconvenient time, forgetting to respond to prompts, and not wanting to complete surveys at that time.

The adherence rate for the Actiwatch was high, but not as high as similar research conducted using wrist-worn sensors with suicidal adolescents on an inpatient unit (Kleiman et al., 2019). It may be that adherence is higher on an inpatient unit because participants can be monitored in person by staff throughout the study. Most adolescents reported that the Actiwatch was comfortable and that it did not interfere with their daily activities. This is promising for future research using passive monitoring (including sensors) with this population.

Feasibility was also assessed by examining the percentage of risk flags from EMA surveys that warranted follow-up from the research team. Approximately 1/3 of the sample was flagged for risk at some point over the course of the study, with 1/5 requiring parental follow-up and 1/6 requiring outpatient clinician follow-up. Potential iatrogenic effects of the study were examined based on the anticipated adverse event rate (i.e., suicide attempts and suicide-related rehospitalizations) and the circumstances leading to these events. Given the high-risk population, higher rates of anticipated adverse events were expected in this population. Notably, the study's rehospitalization rate was comparable to that of the population of adolescents receiving acute psychiatric care at the index medical center from which adolescents were recruited. In addition, assessments following adverse events from a combination of the adolescent, parent, and clinician indicated that adverse events were not study related, but were most often precipitated by a negative interpersonal event. Taken together with prior research (Czyz et al., 2018; Husky et al., 2014; Law et al., 2015), EMA designs appear to be safe to use with high-risk populations including adolescents.

Adolescents also reported that the EMA methods were acceptable. At the end of the monitoring period, adolescents reported that their experience in the study was positive, that completing the EMA surveys was not burdensome, the questions were easy to understand, and they made an effort to respond accurately. In addition, they reported that overall their responses did not feel less private because others were around. If they were concerned that others could see their responses, they either moved to a more private place or did not respond to that particular survey. Moreover, adolescents reported few instances where others helped with their responses. Taken together, this feedback increases confidence in the validity of the data assessed using these methods.

Adolescents' outpatient clinicians also reported that participating in the study was overall somewhat positive and minimally burdensome for them. They reported that overall the additional monitoring of their patient was helpful and the method for following up about patients' risk flags was useful, but that they would have liked more information about their patients' risk in the study. Approximately 1/3 of clinicians said that participating in the study impacted their clinical care (e.g., by increasing awareness of high-risk periods for their patients). Clinicians reported overall that participating in the study was somewhat positive for their patients and families. However, clinicians reported that they, and some parents, had concerns

about the lag between when suicide risk was reported and when they were contacted by the study team. Future studies should clarify the risk and safety monitoring plan for parents, clinicians, and other supports multiple times over the course of the study (in addition to a clear explanation during initial consent). Taken together, these results are promising for future EMA studies and development of ecological momentary interventions with high-risk youth and the inclusion of clinicians in the risk and safety monitoring protocol.

Limitations of this study suggest important areas for future research. First, although parents were involved in the data collection and risk monitoring protocol, they did not provide detailed feedback on their experience in the study (like their adolescent and the adolescent's clinician). Parental feedback was not assessed because of concerns about additional burden during a high-stress time. However, many parents provided informal feedback at the end of the study indicating benefits of this research for their adolescent. Future research would benefit from parents' feedback. A second limitation is the generalizability of the current sample. Although there was some diversity in gender identity and sexual orientation, there was little racial and ethnic diversity in the current sample (primarily non-Hispanic white) – a significant issue in suicide research (Cha et al., 2018). We were unable to examine how the demographics for the referred sample compared to the enrolled sample, as this information was not provided with the initial referral. Future research with more diverse samples is crucial given the significant suicide risk among racial and ethnic minority youth (CDC, 2018; Lindsey et al., 2019). A third limitation is that this study examined only one risk and safety monitoring protocol for EMA research. Future research would benefit from testing different risk thresholds and methods of follow up for risk assessment and safety planning (e.g., pop-up message, text, phone call). A fourth limitation is the potential for reporting bias given that the feedback assessment was conducted as an interview (because other follow-up measures were administered over the phone). Future studies would benefit from anonymous surveys from adolescents about their experiences participating in these types of studies. Finally, this was an assessment study that, given the high-risk sample of minors, chose to monitor EMA responses for participant safety. This design could lead to underreporting of STBs, which has been documented in prior research with youth (Horesh et al., 2004; Negron et al., 1997). Future studies will be tasked with the same decisions and potential tradeoffs between obtaining the most accurate reporting of STBs and utilizing ethical monitoring procedures when working with high-risk youth. This is another reason that passive monitoring strategies that do not rely on individuals' accurate reporting of their own behaviors is important (Kleiman et al., 2019).

In conclusion, the current study is among the first to intensely monitor high-risk youth during the period following acute psychiatric care (see also Czyz et al., 2018), and the first to use an EMA design to examine within-day processes in this population. Findings from this study support the feasibility and acceptability of EMA research among high-risk suicidal adolescents during the months following acute psychiatric care. Importantly, EMA research with this population may help to identify mechanisms of risk as well as modifiable targets for intervention during this high-risk period (Kleiman et al., 2019).

Disclosure Statement

No potential conflict of interest was reported by the authors.

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