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A 28-Day Ecological Momentary Assessment of Mental Health Among Psychiatric Outpatients With Suicidal Ideation

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ABSTRACT

Aims: Considering that suicide has remained a public health challenge in South Korea since 2009, the development of a real-time monitoring system for suicide risk is urgently needed, especially for those living in the community. The aims of this study were to explore the 28-day longitudinal pattern of suicidal ideation, compare momentary depression, anxiety and stress between different risk groups, and identify the association of suicidal ideation with momentary indicators in community-dwelling outpatients at risk of suicide.

Design: Observational and longitudinal investigation.

Methods: A total of 50 community-dwelling psychiatric outpatients were included herein. Those with a history of suicide attempts were classified into the high-risk group ($n = 40$, 80%), whereas the rest were classified into the low-risk group ($n = 10$, 20%). Real-time data on depression, anxiety, stress and suicidal ideation were collected from May 2021 to July 2023 based on ecological momentary assessment. Each participant provided reports at least three times a day for 4 weeks. A total of 3195 ecological momentary assessment responses were collected, among which 1345 with the highest mood intensity per day were selected for analysis. Panel mixed-effect linear regression models examined differences in ecological momentary assessment responses between high- and low-risk groups and elucidated the separate effects of depression, anxiety and stress on suicidal ideation in each risk group.

Results: Momentary depression, anxiety and stress were positively associated with momentary suicidal ideation in both risk groups, with these associations being higher among the high-risk group. In both risk groups, momentary suicidal ideation was more strongly associated with momentary depression than with momentary anxiety and stress.

Conclusions: Psychosocial stress indicators were associated with momentary suicidal ideation. Moreover, a strong association was observed between momentary depression and suicide attempts. Further research with larger samples should be conducted to evaluate whether depression interventions could reduce momentary suicidal ideation.

No Patient or Public Contribution.

Summary

- What is already known
  - Ecological momentary assessment (EMA) has been used to track fluctuations in suicidal ideation and its psychological risk factors, such as depression, anxiety and stress.

- What this paper adds
  - This study examined the 28-day longitudinal pattern of suicidal ideation among psychiatric outpatients at risk of suicide, differentiating between high- and low-risk groups.
  - Momentary depression, anxiety and stress were significantly associated with suicidal ideation, with stronger associations observed in individuals with a history of suicide attempts.

- Implications for practice/policy
  - Continuous real-time monitoring of suicidal ideation and psychological distress can enhance early detection and intervention strategies for at-risk individuals.
  - Depression-focused interventions may be particularly effective in reducing momentary suicidal ideation, especially in individuals with a history of suicide attempts.

1 | Introduction

Suicide remains among the most significant public health concerns globally. In fact, the World Health Organization (2023) had reported that over 700,000 deaths due to suicide occur annually worldwide. Specifically, South Korea has reported the highest suicide rates among the Organisation for Economic Cooperation and Development (OECD) countries, with rates reaching 23.6 suicides per 10,000 people, which translates to 36.6 suicides per day and 11,1206 suicides per year over the past decade (OECD 2024). As such, the Korean government has endeavoured to address this critical public problem since 2009, during which South Korea reached its highest suicide rate of 36.6 individuals per 100,000. In particular, the government enacted laws facilitating suicide prevention, improved social awareness with a culture of respecting life (Korea Suicide Prevention Center 2011), and announced a pan-governmental mental health policy that prioritises 'batter mental health in the nation' in 2023. These programmes have prompted mental health nursing researchers to generate scientific evidence to support policy making and national strategies for suicide prevention. The current study focused on individualised continuous monitoring of suicide risk and mental health indicators tailored for high-risk groups living in the community.

2 | Background

Suicidal ideation is crucial for understanding psychological processes in suicide research. On the suicidal continuum, suicidal ideation is often seen as a precursor to suicidal behaviour (Joiner 2005). Mental health researchers have attempted to identify common patterns, risky triggers and protective factors among at-risk individuals when developing effective prevention strategies and interventions. Since Joiner (2005) introduced his Interpersonal Theory of Suicide, suicidal ideation has been considered the first step of the 'Ideation-to-Action' framework. Even recent evidence supports the importance of suicidal ideation over suicidal plans or attempts in this field (Khajedaluee et al. 2021). Thus, identifying suicidal ideation is crucial in predicting and preventing suicide attempts through the identification of warning signs and early implementation of interventions.

Collecting real-time data on suicidal ideation is advantageous for researchers, given that it helps clinicians understand variations across time. The ecological momentary assessment (EMA) method involves individualised recording of real-time data, such as suicidal ideation, behaviours and emotions, through paper-based or electronic records (Shiffman et al. 2008). EMA can capture emotional fluctuations with greater precision and accuracy than traditional retrospective assessments, reducing the recall bias associated with retrospective evaluations (Kivelä et al. 2022). One study on adult psychiatric outpatients involved administering paper-based surveys and EMA concurrently to measure suicidal ideation using Question 9 of the Patient Health Questionnaire-9 (PHQ-9) (Torous et al. 2015). Their results indicated higher levels of suicidal ideation with the EMA method than with retrospective self-reporting.

In traditional research, depression and anxiety disorders mainly serve as risk factors for predicting suicidal ideation and attempts (Moitra et al. 2021) as well as perceived stress (Liu et al. 2020). Previous studies on EMA have reported the association between high real-time variability in suicidal ideation and mental health characteristics (Ben-Zeev et al. 2012; Kivelä et al. 2022; Oquendo et al. 2021; Zhu et al. 2024). The systemic review and other recent studies highlight the importance of simultaneous evaluation of negative mood and maladaptive behaviours, such as depression, anxiety and stress, when assessing suicidal ideation because these are critical predictors that often interact with and exacerbate risk. For instance, Ben-Zeev et al. (2012) found that negative emotions, such as sadness, tension and boredom, were indicative of impending suicidal ideation within a few hours among adult inpatients diagnosed with major depressive disorder. Another study reported that the presence of stressors significantly increased suicidal ideation among individuals with depressed moods (Oquendo et al. 2021). However, major limitations of these studies are that they were not able to: (1) compare the longitudinal pattern of momentary indicators by risk, (2) fully use both standardised evaluation and EMA measures and (3) interpret the findings based on theories, limited to conceptual understanding and clinical implications. Thus, this piecemeal approach may hinder a comprehensive understanding of the interactions between these variables and their collective influence on suicidal ideation. Thus, identifying the most important risk factors for effective intervention has remained challenging.

A theoretical framework is essential for identifying risk factors of suicidal ideation. In line with this, the current study utilised the stress–vulnerability model described in the protocol study by Kim et al. (2022) to design our study protocol, analyse data and interpret our findings. This model posits that mental illness results from the interaction between personal vulnerabilities and

environmental psychosocial stressors (Zubin and Spring 1977). Although suicide risk factors are often considered static, trait-like characteristics, the nature of suicide risk itself is more dynamic and fluctuating (Kleiman and Nock 2018). Thus, there is a growing need to determine time-varying risk factors that account for suicidal ideation variability. We propose that individual mental health characteristics, such as depression, anxiety and stress, are risk factors that increase intrinsic vulnerabilities (Kim et al. 2022) and may act as fluctuating triggers for suicidal ideation over time.

3 | The Study

3.1 | Aims

The current study aimed to (1) describe the demographic characteristics and baseline mental health status of adults with suicidal ideation; (2) explore the 28-day longitudinal pattern of suicidal ideation in two different at-risk groups and (3) identify concurrent correlations between suicidal ideation and momentary depression, anxiety and stress over time based on the EMA.

3.2 | Design

This is an observational and longitudinal study. This observational and longitudinal study was conducted over 28 days.

4 | Methods

4.1 | Participants

The study comprised 50 adults aged 19–58 years. The participants were outpatients registered at the National Suicide Prevention Center or recently discharged from the Department of Psychiatry of a tertiary referral hospital in South Korea. The inclusion criteria were that those were older than 18 and had recent suicidal ideation. The suicidality was measured based on the Korean version of the Beck Scale for Suicide Ideation (BSS). When they reported a score of one or higher they were included in the study. The exclusion criteria were communication difficulties due to psychotic features, such as positive symptoms from psychosis, hallucinations or severe delusions. More details are available in the previously reported protocol paper by Kim et al. (2022).

Among a total of 55 individuals who participated in the study, only 50 completed the study. Five individuals withdrew from the study due to psychiatric hospitalisation, skin irritation from the wearable device, employment and personal decision. The 50 participants who were eventually included in the study were classified into both high- and low-risk groups based on their history of suicide attempts. The high-risk group comprised those who had a suicide attempt history within the past weeks, whereas the low-risk group comprised those who had suicidal ideation but no attempts (World Health Organization, 2012). Suicide attempt records were based on participant responses. A history of suicide attempts was a significant risk factor for future suicide attempts (Bostwick et al. 2016).

4.2 | Data Collection With Measures

Data were collected from May 2021 to July 2023. The EMA online survey was conducted three times daily for 4 weeks. Data collection included structured self-report questionnaires administered at baseline (day 0), midpoint (day 14) and endpoint (day 28). Detailed information regarding the study variables and data collection is in the protocol paper by Kim et al. (2022) and Figure 1 in this report.

4.3 | Ecological Momentary Assessment

EMA was conducted via an online survey at least three times a day over a 28-day period. A short message containing a Google survey was sent upon awakening, going to bed and having very intense feelings about suicide. Along with our previous research (Kim et al. 2020; Kim et al. 2019), the hybrid measurements at fixed and personalised reporting times were determined based on the fact that (1) EMA should be reported at least once a day for a month (range, 1–6; Janssens et al. 2024) and (2) suicides occur slightly more frequently from morning to mid-day and peak during nighttime in other cases (Plöderl 2021). Four items of the EMA survey focused on current levels of suicidal ideation and psychosocial stress indicators, including depression, anxiety and stress levels by asking 'What is your current level of suicidal ideation/depression/anxiety/stress?' The self-report questions were extracted from standardised questionnaires, such as the BSS (Beck et al. 1988), the PHQ-9 (Kroenke et al. 2001), the General Anxiety Disorder-7 (GAD-7) (Spitzer et al. 2006) and the Perceived Stress Scale (PSS) (Cohen et al. 1983). Each question was rated on a five-point Likert scale (1 = lowest to 5 = highest).

Over the 28-day period, 50 participants reported a total of 3195 EMA responses (completion rate = 76.1%), with an average time of 25.1 days (range, 15–28 days). The 1,345 responses with the highest mood intensity during the day, regardless of response time, were used for analysis. Some participants provided only two EMA responses within a day when they had suicidal urges upon waking up or at bedtime. Furthermore, participants reported more EMA responses as needed when they had multiple suicidal urges in a day. Among the multiple responses in a day, the highest score was selected for analysis. For example, a participant could report the momentary ideation of suicide as 4 upon awakening, 2 at the time of suicidal urge and 3 upon bedtime. The highest score, 4, was used for analysis.

4.4 | Structured Questionnaires

To assess the participants' overall mental health status, structured self-reported questionnaires were administered at baseline, midpoint and endpoint. The BSS was used to measure suicidal ideation (Beck et al. 1988). Depression was assessed using the PHQ-9 (Kroenke et al. 2001). Anxiety levels were measured using the GAD-7 (Spitzer et al. 2006). Perceived stress was measured using the PSS (Cohen et al. 1983). The
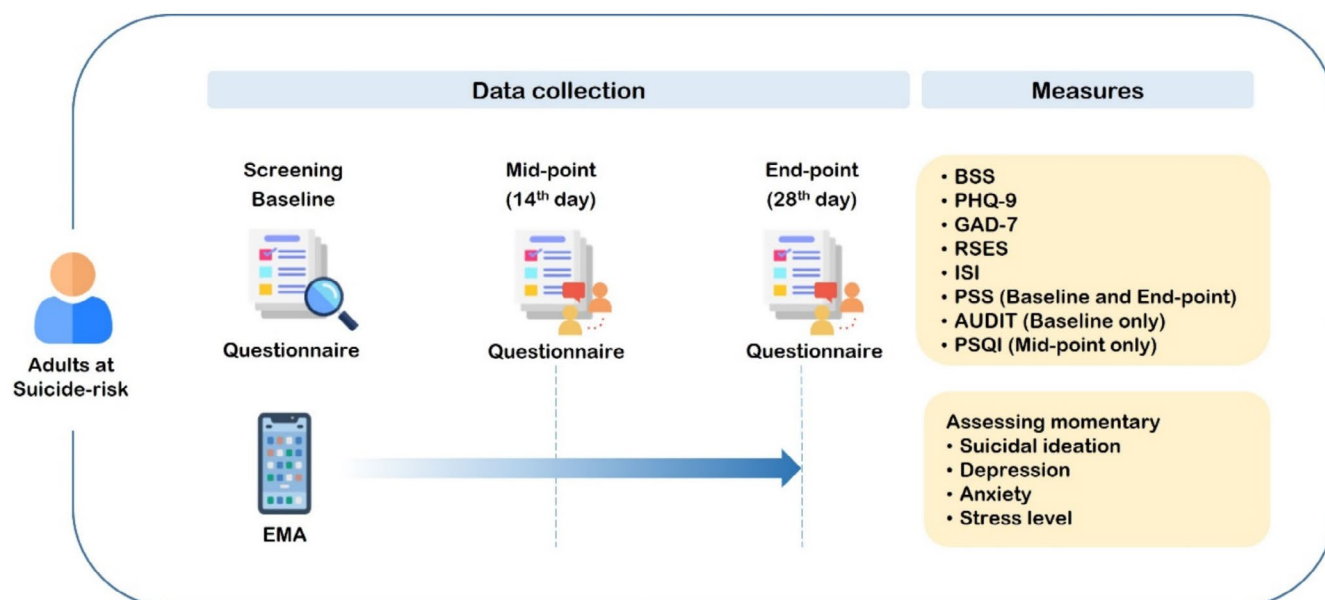
FIGURE 1 | Data collection process of the study. *Note:* This figure has been modified based on the protocol paper by Kim et al. (2022). Abbreviation: AUDIT-K, Alcohol Use Disorder Identification Test-Korean; BSS, Beck Scale for Suicidal Ideation; GAD-7, General Anxiety Disorder-7; ISI, Insomnia Severity Index; PHQ-9, Patient Health Questionnaire-9; PSQI, the Pittsburgh Sleep Quality Index; SS, Perceived Stress Scale; RSES, Rosenberg Self-Esteem Scale.

following additional characteristics were also measured: self-esteem using the Rosenberg Self-Esteem Scale (RSES) (Rosenberg 2015); sleep quantity and quality using the Pittsburgh Sleep Quality Index (PSQI) (Buysse et al. 1989); insomnia symptom severity using the Korean version of the Insomnia Severity Index (ISI) (Morin et al. 2011) and alcohol use disorder using the Alcohol Use Disorder Identification Test-Korean (AUDIT-K) (Saunders et al. 1993). The Korean version of the measurements and details has been reported in the protocol paper by Kim et al. (2022).

Sociodemographic information included age (Kim et al. 2016), gender (Oquendo et al. 2013) and self-reported socioeconomic status (SES) (Low et al. 2024). Health-related characteristics, including perceived health status and current smoking, were measured. Participants reported their psychiatric history, including diagnoses of mental health problems, duration since first psychiatric diagnosis and use of psychiatric medications, as well as their history of suicide attempts.

4.5 | Statistical Analysis

To address the research questions stated in the protocol paper by Kim et al. (2022), we used the following analytical methods. First, the nonparametric Wilcoxon rank-sum test (Wilcoxon 1945) and chi-square analysis were used to compare differences in sociodemographic, health-related, psychiatric and mental health characteristics between the high- and low-risk groups. Second, descriptive statistics of EMA responses for suicidal ideation, depression, anxiety and stress were reported using intraclass correlation coefficients (ICCs) and root mean square of successive differences (RMSSDs) to examine the interrelatedness and variability of each response. The ICC provides information on the proportion of variance in a measure attributable to

between- and within-person variabilities. The RMSSD reflects the average variability of EMA responses over time, with larger values indicating greater variability from one time point to the next (Rogers 2024). In addition, the t-test was used to identify differences in EMA responses by the high- and low-risk groups. Third, the effects of momentary depression, anxiety and stress on suicidal ideation were also examined using panel mixed-effects linear regression models according to risk group.

For the main analysis of the panel mixed-effects linear regression models, Model 1 tested the main effect of daily depression, anxiety and stress on suicidal ideation. Along with Model 1, Model 2 included age, gender and SES as covariates because they were related to various levels of suicidal ideation or attempts (Korea Foundation for Suicide Prevention 2022). Model 3 included depression, anxiety and stress, in addition to the variables already included in Model 2. The model fit of the mixed-effects linear regression was evaluated using ICCs and the likelihood ratio (LR) test. ICCs were reported for Model 3 to quantify the proportion of variability in suicidal ideation attributable to differences between subjects. LR tests were conducted to compare the mixed-effects models to those without subject-level effects. To describe the pattern of momentary depression, anxiety, stress and suicidal ideation, Figure 2 shows the average scores of the high- and low-risk groups over the 28-day period. All statistical analyses were performed using Stata 17.0 software (Stata Corp LP, College Station, TX, USA).

5 | Results

Table 1 describes the baseline characteristics of the 50 participants and presents some significant differences between the high- and low-risk groups based on the screening or baseline survey. The majority of the participants were women (82%),
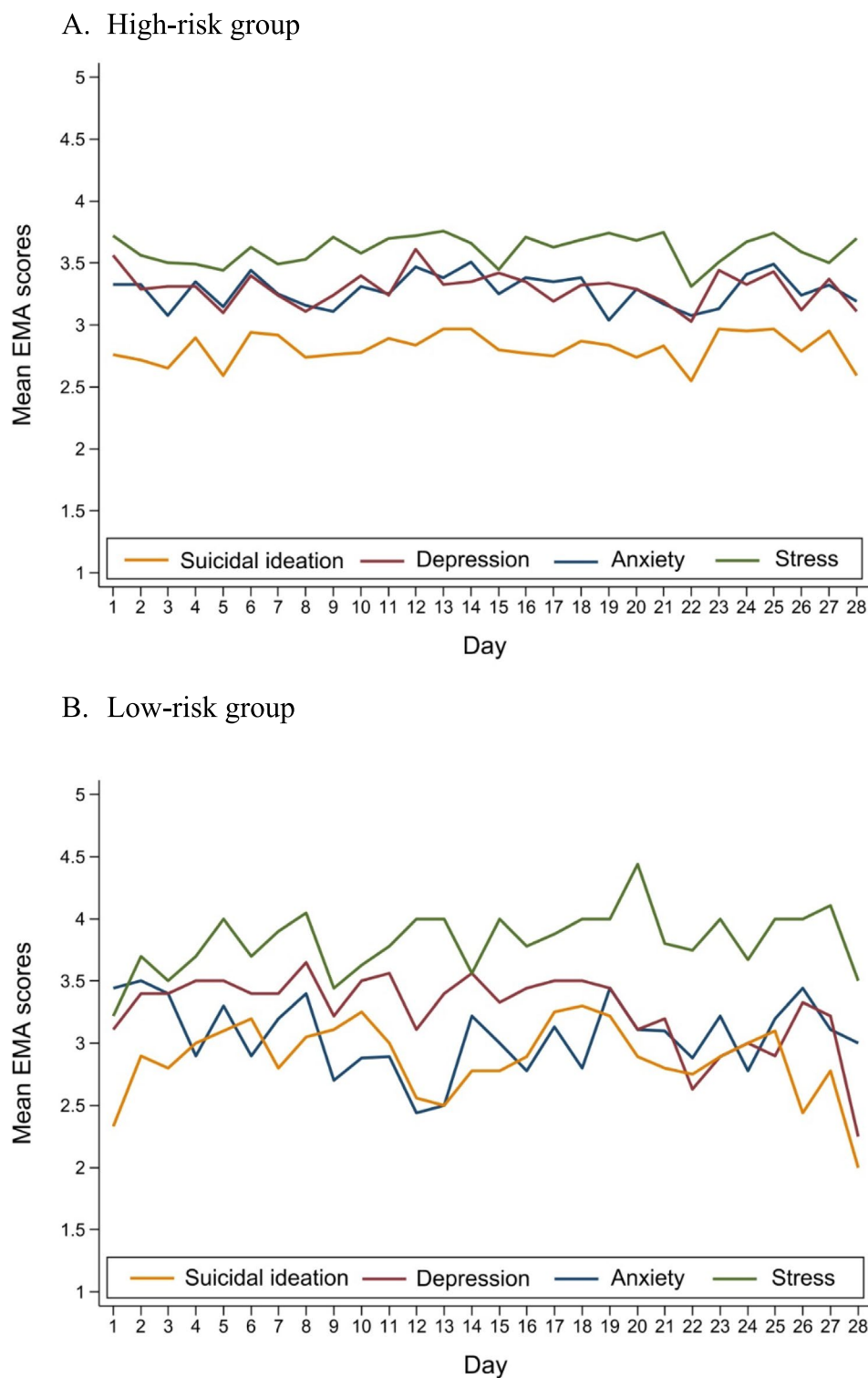
A. High-risk group

B. Low-risk group

FIGURE 2 | Two risk group patterns of depression, anxiety, stress and suicidal ideation over the 28-day period. High-risk group. Low-risk group. *Note:* The mean scores for EMA responses were calculated using the highest value reported each day.

were in the high-risk group with a history of suicide attempt (80%), were younger adults (average age, 29.10 ± 10.53 years) and were single (86%). Almost all participants had a history of diagnosed mental health problems (98%) and were taking psychiatric medications (96%). The average time since the first psychiatric diagnosis was 4.94 ± 4.69 years (range, 1–28 years). The average score for the PSQI was 11.6 ± 3.5, while that for the AUDIT-K was 11.8 ± 10.4. Some differences in psychiatric characteristics

were noted between the high- and low-risk groups. All participants in the high-risk group were diagnosed with mental health problems ($p < 0.043$) and were taking psychiatric medications ($p = 0.004$), outnumbering those in the low-risk group.

Table 2 shows descriptive statistics, ICCs and RMSSD of EMA responses over the 28-day period. The average scores of the highest daily values over the 28-day period were 2.83 ± 1.33,

TABLE 1 | Baseline characteristics derived from questionnaires (participants = 50).

Variable	Total M ± SD or *n* (%)	Low-risk group (participants = 10, 20%) M ± SD or *n* (%)	High-risk group (participants = 40, 80%) M ± SD or *n* (%)	*p*
Risk group (history of suicide attempts)				
Low-risk (no)	10 (40.0)			
High-risk (yes)	40 (60.0)			
Sociodemographic characteristics				
Age, years (range: 19–58)	29.10 ± 10.53	30.90 ± 12.88	28.65 ± 10.00	0.995
Gender				
Women	41 (82.0)	0 (0.0)	9 (22.5)	0.098
Men	9 (18.0)	10 (100.0)	31 (77.5)	
Education level				
<Undergraduate	27 (54.0)	4 (40.0)	23 (57.5)	0.733
≥Undergraduate	23 (46.0)	6 (60.0)	17 (42.5)	
Marital status				
Single	43 (86.0)	8 (80.0)	35 (87.5)	0.555
Married	2 (4.0)	1 (10.0)	1 (2.5)	
Widowed/ Divorced/Separated	5 (10.0)	1 (10.0)	4 (10.0)	
Self-reported economic status				
Middle/High	22 (44.0)	6 (60.0)	16 (40.0)	0.409
Low	28 (56.0)	4 (40.0)	24 (60.0)	
Health-related characteristics				
Perceived health status (range: 0–4)	1.23 ± 0.99	0.99 ± 0.76	1.28 ± 1.03	0.610
Currently smoking				
No	33 (66.0)	9 (90.0)	24 (60.0)	0.073
Yes	17 (34.0)	1 (10.0)	16 (40.0)	
Psychiatric characteristics				
Diagnosis of mental health problems				
No	1 (2.0)	1 (10.0)	0 (0.0)	0.043
Yes	49 (98.0)	9 (90.0)	40 (100.0)	
Duration from the first psychiatric diagnosis[a], years (range: 1–28)	4.94 ± 4.69	5.78 ± 5.14	4.74 ± 4.62	0.887
Use of psychiatric medications				
No	2 (4.0)	2 (20.0)	0 (0.0)	0.004
Yes	48 (96.0)	8 (80.0)	40 (100.0)	
Mental health characteristics				
AUDIT-K (range: 0–34)	11.78 ± 10.4	8.2 ± 6.49	12.68 ± 11.05	0.476
RSES (range:10–41)	23.48 ± 7.01	26.80 ± 7.57	22.65 ± 6.71	0.098

(Continues)

TABLE 1 | (Continued)

Variable	Total	Low-risk group (participants = 10, 20%)	High-risk group (participants = 40, 80%)	p
	M ± SD or *n* (%)	M ± SD or *n* (%)	M ± SD or *n* (%)	
PSQI(range: 3–20)	11.64 ± 3.50	12.40 ± 4.09	11.45 ± 3.37	0.269
ISI (range: 2–28)	13.76 ± 6.65	13.30 ± 8.14	13.88 ± 6.34	0.545
BSS (range: 7–35)	23.42 ± 6.37	21.60 ± 6.00	23.88 ± 6.45	0.271
PHQ-9 (range: 8–27)	17.90 ± 5.12	17.1 ± 4.12	18.10 ± 5.37	0.653
GAD-7 (range: 0–21)	12.82 ± 5.28	11.8 ± 3.58	13.08 ± 5.64	0.364
PSS (range: 3–39)	27.02 ± 6.17	26.10 ± 4.38	27.25 ± 6.57	0.628

Abbreviations: AUDIT-K, Alcohol Use Disorder Identification Test-Korean; BSS, Beck Scale for Suicidal Ideation; GAD-7, General Anxiety Disorder-7; ISI, Insomnia Severity Index; M, mean; PHQ-9, Patient Health Questionnaire-9; PSQI, Pittsburgh Sleep Quality Index; PSS, Perceived Stress Scale; RSES, Rosenberg Self-Esteem Scale; SD, standard deviation.
[a]Missing values included.

3.30 ± 1.25, 3.24 ± 1.31 and 3.65 ± 1.25 for suicidal ideation, depression, anxiety and stress respectively. Based on the grand mean of the average of the 28-day EMA responses, no difference in 28-day suicidal ideation and 28-day depression was observed between the two groups. However, the high-risk group had a significantly higher mean 28-day anxiety ($p = 0.019$) and lower mean momentary stress than the low-risk group ($p = 0.011$). Figure 2 illustrates the daily EMA data over the 28-day period according to risk groups. Accordingly, the high-risk group showed more flattened patterns for momentary depression, anxiety, stress and suicidal ideation over time (Figure 2A), whereas the low-risk group showed more fluctuating patterns over time (Figure 2B).

Table 3 presents the results for the association between momentary suicidal ideation and momentary psychosocial stress indicators over time according to high- and low-risk groups using the panel mixed-effect linear regression models. In Models 1 and 2, statistical analyses of the effects of momentary depression, anxiety and stress on suicidal ideation were performed separately (Table 3). Our results showed that all psychosocial stress indicators were positively associated with suicidal ideation in both the high- ($B = 0.666$, $p < 0.001$ in depression; $B = 0.545$, $p < 0.001$ in anxiety; $B = 0.566$, $p < 0.001$ in stress) and low-risk groups ($B = 0.620$, $p < 0.001$ in depression; $B = 0.423$, $p < 0.001$ in anxiety; $B = 0.445$, $p < 0.001$ in stress). In Model 3, depression, anxiety and stress were included as variables to compare the magnitude of their effects on suicidal ideation (Table 3). Among depression, anxiety and stress, depression had the largest effect on suicidal ideation in both the high- ($B = 0.438$, $p < 0.001$ for depression; $B = 0.176$, $p = 0.001$ for anxiety; $B = 0.239$, $p < 0.001$ for stress) and low-risk groups ($B = 0.492$, $p = 0.001$ for depression; $B = 0.166$, $p = 0.177$ for anxiety; $B = 0.111$, $p = 0.359$ for stress). All mixed-effects linear regression models of Model 3 (Table 3) demonstrated statistically significant model validity. In addition, Table S1 shows the statistical differences in these mental health characteristics according to high- and low-risk groups using panel mixed-effect linear regression models. Notably, no statistically significant differences in BSS, PHQ-9, GAD-7, PSS, RSES and ISI were observed between high- and low-risk groups after controlling for age, gender and SES.

6 | Discussion

The current study, which was designed based on a protocol paper by Kim et al. (2022), reported findings that show the possibility of using EMA to capture real-time suicidal ideation and relevant mental health indicators to understand the nature of momentary moods and suicide risk. First, our study was able to successfully demonstrate 28-day longitudinal patterns of momentary depression, anxiety, stress and suicidal ideation among 50 adult psychiatric outpatients. Second, our study compared sociodemographic, health-related and psychiatric characteristics between high- and low-risk groups at two or three observational time points. Third, we identified concurrently significant associations between suicidal ideation and momentary depression, anxiety and stress. Lastly, this study discusses what we have learned when applying EMA for suicide research.

Understanding the fluctuations of suicide ideation and other mental health indicators is critical. Our 28-day longitudinal data showed fluctuating patterns in momentary depression, anxiety, stress and suicidal ideation among 50 adult psychiatric outpatients who were exceedingly hard to reach. Based on the grand mean of the average of the 28-day EMA responses, no difference in momentary suicidal ideation was observed between the two groups or among three observations (weeks 0, 2, 4). It means that although an individual may report a low risk of suicide on the assessment day, they may feel an intense suicidal surge. It is a well-known limitation of cross-sectional studies, particularly when seeking to understand fluctuating patterns in momentary concepts, such as urges, moods or thoughts (Shiffman et al. 2008). Weekly or monthly evaluations may fail to detect the quickly changing risk of suicide. Therefore, one must be cautious about the limitations of one-time questionnaires or careless averaging in tracking emotional mood concerning capturing the short-term and nonlinear change process in suicidal ideation (Ammerman and Law 2022). Continuous long-term monitoring is very important for suicide prevention in natural settings, such as communities and homes.

Over the 28-day period, 50 participants reported 76.1% of EMA consistent with the previous studies (Glenn et al. 2022; Husky et al. 2014; Rogers 2021). Our study protocol and findings

TABLE 2 | Descriptive characteristics derived from EMA data (total observations = 1354; participants = 50).

EMA variables	Total			Low-risk group (total observations = 255; participants = 10)			High-risk group (total observations = 1099; participants = 40)			*p*
	M ± SD	ICC	RMSSD	M ± SD	ICC	RMSSD	M ± SD	ICC	RMSSD	
Suicidal ideation	2.83 ± 1.33	0.52	1.02	2.89 ± 1.28	0.44	1.12	2.82 ± 1.35	0.54	1.00	0.409
Depression	3.30 ± 1.25	0.53	1.01	3.29 ± 1.17	0.39	1.14	3.30 ± 1.27	0.56	0.98	0.928
Anxiety	3.24 ± 1.31	0.59	1.02	3.06 ± 1.38	0.56	1.14	3.28 ± 1.30	0.60	0.99	0.019
Stress	3.65 ± 1.25	0.52	1.01	3.83 ± 1.27	0.52	1.02	3.61 ± 1.24	0.52	1.01	0.011

Note: The EMA scores are presented by averaging the highest score within a day over a 28-day period.
Abbreviations: EMA, ecological momentary assessment; ICC, intraclass correlation coefficients; M, mean; RMSSD, root mean square of successive differences; SD, standard deviation.

provide fundamental details regarding the planning of studies on EMA methodologies and comprehensive mental health assessment (Kim et al. 2022), particularly in terms of developing study implementation strategies to prevent dropouts and non-adherence and providing basic information for the calculation of sample size and effect size. To complete our study protocol, we tried to overcome two methodological challenges of existing EMA research. First, individuals at high risk for suicide often experience emotional distress, which can hinder the completion of energy-intensive surveys (Svensson et al. 2015). This problem has caused high dropout rates in previous studies (Bergman et al. 2010; Svensson et al. 2015). To reduce this risk, two mid-study meetings were incorporated during the 28-day period, which resulted in 50 of the 55 participants completing the study. Second, previous suicide EMA studies have often included limited specific groups, such as psychiatric inpatients or those recently discharged from acute hospitals (Kivelä et al. 2022). However, our study included community-dwelling outpatient clinic attendees. Hence, our study is essential for discovering long-term follow-up and effective suicide prevention methods (Ben-Zeev et al. 2012; Ammerman and Law 2022).

As expected, our findings revealed that momentary depression, anxiety and stress followed the same pattern for suicidal ideation based on EMA responses. Moreover, the association among momentary depression, anxiety and stress and suicidal ideation was stronger in the high-risk group than in the low-risk group. Our findings are consistent with those of previous studies based on daily diary data (Ben-Zeev et al. 2012; Links et al. 2007; Oppenheimer et al. 2020). Concurrent correlation patterns were observed between suicidal ideation and negative mood states, including depression, anxiety and stress (Oquendo et al. 2021). For example, Oquendo et al. (2021), using EMA data of over 2 years, revealed that great emotional instability potentially predicts suicidal ideation among depressed people. These results suggest that subsequent or concurrent suicidal ideation and behaviour can be predicted using momentary psychosocial stress indicators. According to the South Korean suicide statistics, 53.8% of suicide completers in 2020 had a psychiatric disorder, including depression, insomnia, anxiety and bipolar disorder (Korea Foundation for Suicide Prevention 2022). Moreover, previous studies have repeatedly reported a correlation between psychosocial stress indicators and suicidal ideation

(Liu et al. 2020; Overholser et al. 2012), considering that poor mental health increases one's vulnerability to psychiatric disorders or psychological crises according to the stress–vulnerability theory (Zubin and Spring 1977). This finding suggests that depression, anxiety and stress need to be evaluated together during suicide monitoring as a full battery. Furthermore, managing mental health problems can help prevent suicide, given that improved control over emotional reactivity associated with momentary depression, anxiety and stress reduces suicidal ideation based on a comprehensive evaluation and multifactorial interventions (Zalsman et al. 2016).

In addition, the association between momentary depression, anxiety, stress and suicidal ideation was stronger in the high-risk group than in the low-risk group. To visualise the 28-day EMA data for suicidal ideation, some differences in patterns were noted between the high- and low-risk groups. Interestingly, the 28-day EMA reports for momentary suicidal ideation showed much more fluctuation in the low-risk group than in the high-risk group (Figure 2). Suicide attempt has been one of the clinical features used to classify EMA of risky suicidal behaviour (Bonilla-Escribano et al. 2023). Similar to our findings, a greater number of lifetime suicide attempts were reported in the low variability group than in the high variability group (Bonilla-Escribano et al. 2023; Links et al. 2007). Individuals with suicidal ideation likely lack emotional clarity and thus tend to have difficulty understanding their current feelings, clarifying how they feel and differentiating multiple emotions (Gratz and Roemer 2004). Thus, we understood the low variability of the high-risk group in our study based on emotional dysregulation.

In both the high- and low-risk groups, momentary depression scores had a much stronger association with suicidal ideation than did anxiety. Previous studies focusing on suicide attempters or completers reveal that depression and anxiety levels are correlated with suicidal ideation (Hallensleben et al. 2019; Peters et al. 2022). On the one hand, several studies have reported a strong association between depression and suicide (Kleiman et al. 2017; Liu et al. 2020; Moitra et al. 2021), suggesting that momentary depression may be an early indicator or a concurrent symptom of suicidal ideation. Previous EMA studies have shown that the severity of depression was positively correlated with suicidal ideation (Ben-Zeev et al. 2012). Hence,

TABLE 3 | Results of the panel mixed-effect linear regression models on the association between momentary depression, anxiety and stress and momentary suicidal ideation according to risk group (Total observation=1354; participants=50).

Variables	Total			Low-risk group (total observations=255; participants=10)			High-risk group (total observations=1099; participants=40)		
	Model 1[a]	Model 2[b]	Model 3[c]	Model 1[a]	Model 2[b]	Model 3[c]	Model 1[a]	Model 2[b]	Model 3[c]
	B(p)	B(p)	B(p)	B(p)	B(p)	B(p)	B(p)	B(p)	B(p)
Depression	0.660 (<0.001)	0.657 (<0.001)	0.452 (<0.001)	0.628 (<0.001)	0.620 (<0.001)	0.492 (0.001)	0.669 (<0.001)	0.666 (<0.001)	0.438 (<0.001)
Anxiety	0.520 (<0.001)	0.516 (<0.001)	0.170 (0.001)	0.431 (<0.001)	0.423 (<0.001)	0.166 (0.177)	0.547 (<0.001)	0.545 (<0.001)	0.176 (0.001)
Stress	0.548 (<0.001)	0.544 (<0.001)	0.216 (<0.001)	0.460 (<0.001)	0.445 (<0.001)	0.111 (0.359)	0.568 (<0.001)	0.566 (<0.001)	0.239 (<0.001)
Model fit of the Model 3	ICC [95% CI]=0.350 [0.14, 0.45] LR test (<0.001)			ICC [95% CI]=0.265 [0.14, 0.45] LR test (<0.001)			ICC [95% CI]=0.318 [0.23, 0.43] LR test (<0.001)		

Abbreviations: ICC, intraclass correlation coefficient; LR test, likelihood ratio test.

[a]Univariate model of suicidal ideation with each momentary variable.

[b]Univariate Model after controlling for covariates (age, gender and self-reported economic status).

[c]Multivariate model of suicidal ideation with all momentary variables and after controlling for Model 2's covariates.

simultaneous monitoring of momentary depression and suicide risk is essential for suicide prevention, especially for vulnerable populations. On the other hand, our findings showed a higher total average of momentary anxiety over the 28-day period in the high-risk group than in the low-risk group, whereas no difference in trait anxiety was observed between the high- and low-risk groups. Evidence suggests that momentary anxiety reported with the EMA method reflects the state of anxiety and the current situational emotional states (Endler and Kocovski 2001). Therefore, daily monitoring of static anxiety and increasing self-awareness for timely interventions is necessary for people with a history of suicide attempt.

Unexpectedly, those in the high-risk group reported lower total average momentary stress based on their EMA responses than did those without a history of suicide attempt. Previous research has identified negative stressful events, such as interpersonal conflict, financial strain and health concerns, as triggers for suicide attempts (Bagge et al. 2013), suggesting that stress levels play a central precipitating role in suicidal ideation (Choi et al. 2022; Gvion and Levi-Belz 2018). Dissimilar to our assumption, our results showed a low and flattened pattern of distress, which could be explained by the difficulties faced by more mentally vulnerable participants in sensitively perceiving and adequately reporting distress following stressful stimuli. The high-risk group might be exposed to long term and repeated stress that increases chronic inflammation and decreases critical neural connections in the brain (Han and Ham 2021). Further research that includes long-term information as predisposing factors should be conducted to support our interpretation and develop relevant interventions for reducing brain inflammation, which would improve self-reporting and active help-seeking for suicide prevention.

Our study has some limitations. First, given that this study had been conducted during the COVID-19 pandemic, uncontrolled threats to validity in terms of history were unavoidable. Inevitably, recruiting an adequate number of participants, preventing dropout and carefully protecting the mentally vulnerable ones had been extremely challenging. Thus, we were forced to make major changes to the published protocol (Kim et al. 2022), such as reducing the target sample size from 128 to 50. Despite the smaller sample size than initially planned, previous studies have indicated that the amount of data collected from the same subjects over a 28-day period could be considered adequate (Gutiérrez-Tobal et al. 2022). Second, this study was conducted in a cohort of psychiatric outpatients who had suicidal ideation or behaviour. Therefore, careful consideration should be taken before extrapolating our results to other groups in different settings. Third, this study relied on the self-reported history of suicide attempts rather than objective medical records or diagnosis codes. Although participants were recruited from the National Center for Suicide Prevention and outpatient clinics, the lack of medical record verification remains a limitation. Further studies should incorporate clinical assessments or medical records to increase the accuracy of suicide attempt history. Finally, this study was focused on intrinsic vulnerability and psychosocial stress indicators, thereby overlooking external factors, such as stressor-related experiences or other confounding variables (i.e., living arrangement, marital status and occupation) (Baek et al. 2023; Howarth et al. 2020).

Despite these limitations, the current study has spearheaded nursing research on the successful application of EMA methodology for suicide monitoring in the community setting. Nonetheless, future studies including larger sample sizes and analysing other confounding variables are imperative. Moreover, research can be further expanded to differentiate the subtypes of suicidal ideation utilising the trajectory analysis model with larger-scale studies. Thus, to develop interventions that reduce suicidal ideation, future studies should capture both external and internal stressors.

6.1 | Clinical Implications

Our research findings could be applied to current practice with clinical implications for mental health services, including health care providers and recipients. In South Korea, community-based mental health services have been provided through mental health and welfare centres and suicide-preventive centres during a high-risk period. However, the management of those at risk for suicide has been fraught with chronic issues given the very limited number of staff and sustainable programmes. Currently, each case manager visits those at high risk for suicide monthly and contacts them via phone for risk assessment (Jung et al. 2023). Our study findings and protocol may contribute to the development of remote telemonitoring with continuous data collection. This would allow the case manager to review the EMA and sensor data over time and determine dramatic mood changes, risk factors and behaviour patterns (Bryan et al. 2019). For mental health service providers, EMA methods allow for real-time monitoring to reduce time gaps from suicidal ideation to actual incidents among high-risk groups, which has been a long-term challenge in this field of practice (Franklin et al. 2017; Kivelä et al. 2022). Care providers can use EMA responses to personalise mental health services in terms of depression, anxiety and stress, including suicidal behaviours (Gvion and Levi-Belz 2018).

7 | Conclusion

This study successfully utilised the EMA methodology in nursing research to investigate suicide prevention, a socially important mental health concern. Our 28-day longitudinal data and findings are fundamental to understanding the fluctuating patterns of momentary depression, anxiety, stress and suicidal ideation in community settings. Our study findings contribute to the development of remote telemonitoring utilising real-time data and personalisation of mental health services based on psychological data for further research and practice.

Ethics Statement

This study had been approved by the Institutional Review Board of Yonsei University Health System, Severance Hospital (No. 4-2021-0219) and the Institutional Review Board of National Health Insurance Service Ilsan Hospital (No. 2021–10-014). This trial was registered with the Clinical Research Information Service (Registration Number: KCT0006165).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Peer Review

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/jan.16894.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.