Research paper

Subtypes of suicidal ideation among university students – An ecological momentary assessment study

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ABSTRACT

Background: Suicide is a leading cause of death among youth ages 15 to 29. This study identifies suicidal ideation (SI) subtypes among university students based on daily reports of SI, assesses how stress sensitivity may affect SI variability within these subtypes, and how they differ in terms of past and future self-injurious thoughts and behaviors (SITB).
Methods: 756 students participated in a 14-day ecological momentary assessment and web-based survey at baseline and 12-month follow-up. Latent Profile Analysis identified SI subtypes using indicators of intensity, variability and frequency. Multinomial regressions evaluated the associations between SITB and SI subtypes, as well between SI subtypes and future SITB. Linear models assessed how stress sensitivity was associated to SI variability within the subtypes.
Results: Three SI subtypes were identified: sporadic and low intensity/variability (S1), frequent and medium intensity/variability (S2), and frequent and high intensity/variability (S3). Stress sensitivity was highest in S2 and S3, in S3 higher stress sensitivity was associated with lower day-to-day variability. Nearly all aORs for SITB significantly increased from S1 to S3 compared to controls, with each subtype showing higher aORs compared to the previous subtype (S3 vs, S2 vs S1). S3 students showed higher persistence of suicidal thoughts and behaviors at follow-up (aOR = 20.6; 95 % CI = 8.3–51.2), with 4 of the 7 attempts occurring among students in this subtype.
Conclusions: Daily SI severity predicts future active SI and attempts, with stress sensitivity contributing to more extreme, rigid suicidal thinking. Targeting stress sensitivity could be effective for suicide prevention among university students.

1. Introduction

Suicide is a leading cause of death among youth ages 15 to 29 in Spain and at a global level, with rates increasing in recent years (Instituto Nacional de Estadística, 2022; World Health Organization, 2023). Suicidal thoughts and behaviors (STB) are a particularly hard clinical phenomenon to study given the complexity of its etiology, associated stigma and the historical difficulties to observe STB as it occurs in real-world contexts. As a result, significant gaps remain in our understanding of the underlying processes of STB, and further efforts are needed to improve their prediction and prevention (Franklin et al., 2017; Saab et al., 2022).

Technology has advanced in a way that allows the monitorization of suicidal ideation (SI) as it happens in the context of daily life, through Ecological Momentary Assessment (EMA) study designs (Allen et al., 2019). These are intensive longitudinal studies that collect survey data several times a day over multiple days. EMA studies have allowed to establish that suicidal ideation and its risk factors can fluctuate day to day and even within a day (Kleiman et al., 2017). Further, they have provided experimental evidence suggesting that daily life subtypes of how SI is experienced can be identified based on observations of its intensity, frequency and variability. These ecological subtypes are associated with STB history; in particular, individuals who experience a high intensity and low variability of SI in daily life are most likely to have attempted suicide in the past (Kleiman et al., 2018; Spangenberg et al., 2023). This is consistent with theoretical work by Bernanke and colleagues, which proposes that there are at least two subtypes of SI: a stress-responsive type, characterized by greater variability in ideation, and a non-stress responsive type, with more persistent ideation (Bernanke et al., 2017). Stress sensitivity (also referred to as affect reactivity) has been conceptualized as the momentary relationship between stress and negative affect, meaning that individuals with high levels of stress sensitivity have a higher negative affective response to same levels of stress intensity (Howland et al., 2017; Lataster et al., 2010; Myin-Germeys and van Os, 2007). Higher stress sensitivity has been proposed as an important risk factor for mental health disorders, particularly mood, psychotic disorders, and STB (Bale, 2006; O'Connor et al., 2020; Oquendo et al., 2021; Vaessen et al., 2017; van Winkel et al., 2015), although its role in the onset and persistence of STB is still not fully understood (O'Connor et al., 2020).

A clear understanding of the precise relationship between stress sensitivity, on the one hand, and important SI characteristics such as SI variability, on the other hand, is currently lacking. SI variability has been associated with stress levels in some individuals but not others, reinforcing the theory that stress sensitivity does not affect SI in the same way in all people (Oquendo et al., 2021). Previous research also has largely been carried out in clinical samples, given the heightened risk of suicide in this population (Forte et al., 2019). However, it is known that vulnerable groups in the general population also have a high prevalence of STB, with just a fraction seeking treatment, a prime example being university students (Mortier et al., 2017a). There are few EMA studies that have been designed to better understand STB in this population (Gerner et al., 2023; Layrón Folgado et al., 2022; Mandel et al., 2024), but none have examined the role of stress sensitivity in subtypes of suicidal ideation.

Using data from a 14-day EMA study among a large sample of university students ($n = 756$), this study aims to: (1) identify SI subtypes based on individual-level indicators of SI intensity, frequency, and variability; (2) investigate the association between stress sensitivity and the identified SI subtypes, including assessing whether the relationship between stress sensitivity and SI variability differs across subtypes; (3) investigate the associations of SI subtypes with important correlates such as recent mental disorders and past history of self-injurious thoughts and behaviors (SITB), including severity characteristics of past SITB; and (4) assess the prospective associations between SI subtypes and STB at 12-month follow-up. We hypothesize that at we will find at least two SI subtypes, that stress sensitivity and SI variability will be more strongly associated only in those subtypes with greater SI variability, that subtypes will differ according to stress sensitivity and past and future of SITB.

2. Methods

2.1. Study design and population

A 14-day EMA study was carried out as part of the PROMES-U project, a prospective observational cohort study among university students in Spain, part of the WHO World Mental Health International College Student (WMH-ICS) Initiative (Cuijpers et al., 2019). Enrollment was continuous and participants received push notifications on their smartphones 4 times a day, which occurred at a random time within 2-hour time intervals in the morning (8–10 am), midday (12–2 pm), afternoon (4–6 pm) and evening (8–10 pm). A reminder notification was sent after 30 min. The momentary assessment was marked as missed if the participant did not complete the assessment in the 2-hour window.

The 14-day EMA study was conducted just after a baseline web-based survey (April–June 2022), whose target population were undergraduate students of 5 public universities in Spain. All Spanish-speaking undergraduate students aged 18 and older enrolled in any of the participating universities were eligible to participate. In addition, a follow-up assessment was conducted 12 months after the baseline survey. For further details regarding the PROMES-U design, the protocol of the study (Portillo-Van Diest et al., 2023).

2.2. Recruitment

Of those who participated in the web-based baseline survey, a total of $n = 2427$ provided basic sociodemographic information, completed >50 % of required survey items, as well as the entire mental health section of the survey. Of these, 1259 were invited to participate in the EMA study (see Supplementary Fig. 1) after being assigned to one of four subsamples, in order to obtain comparably sized subsamples of students according to mental health status, i.e., based on 30-day screens in the baseline web-based survey for SI, harmful alcohol use, depression and anxiety (Portillo-Van Diest et al., 2024). Of those invited, $n = 782$ (62.1 %) participated in the EMA study, with a mean compliance of 76.9 % (SD = 27.7). The present study sample includes $n = 756$ students who answered at least one evening assessment, in which participants were asked about daily suicidal ideation (mean compliance = 78.7 %, SD = 24.7). The Expiwell® smartphone-based application was used to collect the EMA data, and participants who completed at least 80 % of momentary assessments received a monetary incentive of 30€.

2.3. Measures

2.3.1. EMA variables

Daily passive suicidal ideation was evaluated each evening as "Today, my desire to die was…", which presented the participant with a 7-point Likert-type scale ranging from 0 (very low) to 6 (very high).

Momentary Negative Affect (NA) was assessed as the mean score of four items based on the two axis circumplex model of affect (Russell, 1980), thus including items accounting for NA with high and low arousal, taken from the PHQ-9 (Kroenke et al., 2001), the GAD-7 (Spitzer et al., 2006) and the ESM item repository (Kirtley et al., 2018). Each item was presented with a common sentence: "Right now, I feel… nervous/upset/depressed/worried", and were 7-point Likert-type scales with answers ranging from 0 (not at all) to 6 (a lot).

Momentary stress was assessed with a single item ("Right now, I feel stressed") with the same response options as NA items, which was taken from the ESM item repository (Kirtley et al., 2018).

We used momentary stress and NA to calculate stress sensitivity (SS), as previously conceptualized in the literature (Howland et al., 2017;

Rauschenberg et al., 2022; van Nierop et al., 2018; Wichers et al., 2009). A multilevel regression was carried out with NA at time point t_i as the outcome, using lagged stress (at t_{i-1}) as a predictor, and controlling for lagged NA (at t_{i-1}). This approach was used to obtain individual-specific coefficients as the indicator of each participant's SS, which were summed to the fixed SS effect (Lataster et al., 2010). This was done using the *lme* function from R's *nlme* package. Stress sensitivity was standardized to ease interpretation of results (see Supplementary Fig. 2).

2.3.2. Baseline web-based survey

Four groups of variables from the baseline web-based survey were used to assess 30-day common mental disorders and (severity markers of) lifetime and 12-month self-injurious thoughts and behaviors (SITB). First, common mental disorders in the past 30-days were assessed using validated screeners for depression, anxiety, alcohol use, and suicidal ideation. Depression and anxiety were evaluated using the Composite International Diagnostic Interview Screening Scales or CIDI-SC (Kessler et al., 2013a). We used a dichotomized version of both screeners using the validated cutoffs (Kessler et al., 2013b), as well as their severity scores, calculated as the sum of all items of each scale, which range from 0 (none of the time) to 4 (all or almost all the time). Harmful alcohol use was assessed using the Alcohol Use Disorders Identification Test (AUDIT) (Saunders et al., 1993). A score was obtained through the sum of 10 items related to frequency, quantity, control, and negative repercussions of alcohol intake, which ranged from 0 to 4 indicating lowest to higher intensity. Frequency of SI in the past 30-days ranged from 0 (none of the time) to 4 (almost all of the time), assessed through an ad hoc question developed for the WMH-ICS (Cuijpers et al., 2019). All 30-days mental health scores were standardized to allow for comparability of the effects of results.

Second, lifetime and 12-month non-suicidal self-injury (NSSI) were assessed using items from the Self-Injurious Thoughts and Behaviors Interview or SITBI (Nock et al., 2007), including number of lifetime NSSI episodes and dichotomous 12-month NSSI.

A third series of variables assessed severity of lifetime STB. SI age of onset, number of lifetime years with SI and number of lifetime attempts were evaluated using items from or based on the Self-Injurious Thoughts and Behaviors Interview or SITBI (Nock et al., 2007). The Columbia-Suicide Severity Rating Scale or C-SSRS (Posner et al., 2011) was used to assess how often in their life the person has done dangerous things on purpose in order to tempt fate (dichotomized: No lifetime SI/Never/ Rarely Vs Sometimes/Often/Very often). Additionally, participants were asked three questions from the C-SSRS about the worst week with SI in their life through: the number of days with SI, average daily duration of SI (dichotomized: No lifetime SI/<1 h Vs >1 h or more), and perceived controllability of SI (dichotomized: No lifetime SI/Easy/A little difficult Vs Somewhat/Very difficult/Impossible).

Fourth, risk of transitioning from ideation to behavior was assessed through three variables. Lifetime and 12-month STB were assessed using the C-SSRS including separate items for suicidal ideation, plan and attempts. Probability of acting on suicidal thoughts in the next 12 months was taken from the P4 screener (dichotomized: No SI/Not at all likely Vs Not very likely/Somewhat likely/Very likely) (Dube et al., 2010).

2.3.3. Follow-up web-based survey

12-month STB at follow-up were assessed using items from the C-SSRS in the same way as at baseline. Participants were also asked the number of months in the past 12 (i.e., the year between baseline and follow-up surveys) in which they had experienced SI, using a question based on the SITBI.

2.4. Data quality

In a previous study (Portillo-Van Diest et al., 2024), we found that the data used in the present paper can reliably be used to investigate between-person and within-person associations. Only 0.86 % of all answered assessments (291/33,626), were flagged careless responses and eliminated from the data set due to low time of response (below 1 s per item) and giving the same response option to all items in the assessment. A total of 137 (17.5 %) participants were identified as potential careless responders. These participants are included in the sample for the present paper and sensitivity analyses were performed to assess how their exclusion may affect the results.

2.5. Statistical analysis

Subtypes of SI were identified using Latent Profile Analysis (LPA) in Mplus version 8.1. Following analyses done by Kleiman and Spangenberg (Kleiman et al., 2018; Spangenberg et al., 2023), we summarized each participant's daily passive SI reports using five indicators. Variability of suicidal ideation was operationalized using standard deviation (SD), which accounted for overall variability and root mean square of successive differences (RMSSD), which quantified variability between adjacent measures. Intensity of ideation was operationalized using two indicators: maximum reported value and mean expressed intensity of the person's ideation. Finally, frequency was measured through the percentage of days in which the participant had reported some degree of suicidal ideation (≥ 1 in the 0 to 6 scale).

We fixed students who reported no suicidal ideation at any time during the EMA study to conform a control subsample, in order to have this group as the reference class in all analyses. Subsequently, we ran the LPA only with those who had reported at least some degree of passive ideation (≥ 1 in the 0 to 6 scale) on any of the 14 days during the EMA study ($n = 352$). The final LPA model was decided upon based on the Bayesian information criterion (BIC), entropy, and Vuong-Lo-Mendell-Rubin likelihood-ratio test (LRT), as well as interpretability of the classes (see Annex I for more detailed information on the LPA analysis).

After assigning each individual to their most likely subtype based on class membership probabilities, we assessed the relationship between SS and SI subtypes through a multinomial logistic regression with SS as a predictor, adjusting for sex, age, field of study and EMA compliance. We then evaluated the association between SS and each of the two SI variability indicators (i.e., SD and RMSSD) *within* each of the identified subtypes using linear regression models that included the interaction between SI subtype and SS as predictors of each SI variability indicator, namely SD and RMSSD (Supplementary Fig. 2).

Multinomial logistic regression was used to investigate the associations of mental disorders and history of self-injurious thoughts and behaviors with the identified SI subtypes, with students with no SI during the study as the reference category. A different model was constructed for each predictor, each time adjusting for sex, age, field of study and EMA compliance.

Associations between suicidal ideation (SI) subtypes and 12-month suicidal thoughts and behaviors (STB) at follow-up were analyzed using regression models, adjusting for sex, age, field of study, and EMA compliance. Given the low frequency of suicide attempts observed during follow-up, we dichotomized the STB outcome (no suicidal thoughts or behaviors vs. any suicidal thoughts or behaviors) and applied binary logistic regression to assess associations with SI subtypes. Descriptive statistics for the disaggregated categories (ideation, plan, attempt) are also presented.

For the count outcome measuring the number of months with suicidal ideation in the past year at follow-up, we initially fit a Poisson regression model. However, given the overdispersion in this variable (i. e., variance exceeded the mean; $s^2 = 6.5 > \bar{x} = 1.1$), we refited the model using negative binomial regression. The latter provided a superior fit to the data as indicated by a lower Akaike Information Criterion (AIC: 780 vs. 1137) and a significant likelihood ratio test ($p < 0.001$) comparing both models. These analyses were conducted with R version 4.1.1 (R Core Team, 2021).

2.6. Preregistration of the study

The present study's analysis plan and rationale was preregistered in the Open Science Framework platform. Small deviations from the original plan reported in the same page following Willroth and colleagues (Willroth and Atherton, 2024), and the codes used for all analyses are also available on this page. See osf.io/u4kpn.

3. Results

3.1. Suicidal ideation subtypes

The control subsample was predefined as those without any 24-h SI ($n = 404$). The best-fitting LPA model found 3 latent classes representing 3 SI subtypes (S1–3) among the $n = 352$ students with 24-h SI on at least one day during the EMA study (Supplementary Table 1). Probabilities of most likely latent class membership were very high (≥ 0.97; see Supplementary Table 2).

We found increasingly higher mean values of the SI indicators across LPA classes, except for SI frequency, which showed similar values in S2 and S3 (Fig. 1A and Supplementary Table 3). On average, students in S1 presented low mean frequency of SI (20 % of days with SI), low intensity (mean SI = 0.20, maximum SI = 1.20) and low variability of SI (SD = 0.42, RMSSD = 0.53). Students in S2 had mean values indicating highly frequent SI (55 % of days with SI), medium intensity (mean SI = 1.04, maximum SI = 3.16), and medium variability of SI (SD = 1.05, RMSSD = 1.34). Finally, students in S3 also presented highly frequent SI (58 % of days), but with higher intensity (mean SI = 1.96, maximum SI = 5.37) and variability of SI (SD = 1.80, RMSSD = 1.98). See Fig. 1A and B, and Supplementary Table 2.

Concerning sociodemographics, most of the sample was female (79.4 %), with highest concentration of females in S3 (86.0 %), with an average age of 20.7, which was similar across groups (Table 1).

3.2. Stress sensitivity and SI subtypes

Stress sensitivity was significantly associated with SI subtype. Concretely, while students in the control subsample and S1 presented low mean standardized values of stress sensitivity ($SS_{control} = -0.10$; $SS_{S1} = -0.13$; $aOR_{S1} = 1.0$, 95 % CI = 0.8–1.2), students in S2 and S3

had higher positive standardized values of stress sensitivity ($SS_{S2} = 0.32$, $aOR_{s2} = 1.5$, 95 % CI = 1.2–1.9; $SS_{S3} = 0.38$; $aOR_{s3} = 1.6$, 95 % CI = 1.2–2.2). See Table 1 and Table 2.

We found a positive linear relationship between stress sensitivity and both SI variability indicators (SD and RMSSD; see Fig. 2). However, when examining this relationship by SI subtype, we found that stress sensitivity was significantly associated with SI variability only in S4. In this subtype, those with greater stress sensitivity presented slightly higher overall variability ($\beta = 0.05$, 95 % CI = 0.02–0.10) but lower variability between consecutive daily reports of SI ($\beta = -0.24$, 95 % CI = -0.31–0.17). See Fig. 2 and Supplementary Table 4.

3.3. The associations of mental disorders and SITB with SI subtypes

Table 2 shows the associations of SI subtypes with 30-day mental disorders and lifetime and 12-month self-injurious thoughts and behaviors, assessed just before EMA participation. Notably, almost all aORs significantly increased across S1 to S3 subtypes, when comparing to the control subsample, with most aORs also being significantly higher when comparing to the previous subtype (S3 vs S2, and S2 vs S1). Exceptions are harmful alcohol use (AUDIT score), which was significantly associated with S1 students, but not with S2 and S3, and age of onset of lifetime SI, which showed significantly lower odds only for S3, indicating earlier age of onset of ideation in this group.

3.4. SI subtypes as predictors for STB at 12-month follow-up

Table 3 shows that 4 of the 7 suicide attempts that accorded between baseline and the 12-month follow-up were from students in S3, who also had significantly higher odds of reporting STB compared to the control subsample (aOR = 20.6, 95 % CI = 8.3–51.2). S3 students also had higher persistence of 12-month ideation during follow-up, reporting on average 4 months with SI (compared to 2 months in S2 and <1 month in S1 and control group).

3.5. Sensitivity analyses

Sensitivity analyses were conducted after excluding potential careless responders (see Data quality subsection in Methods). As shown in Annex II, all findings remained significative, confirming that the results
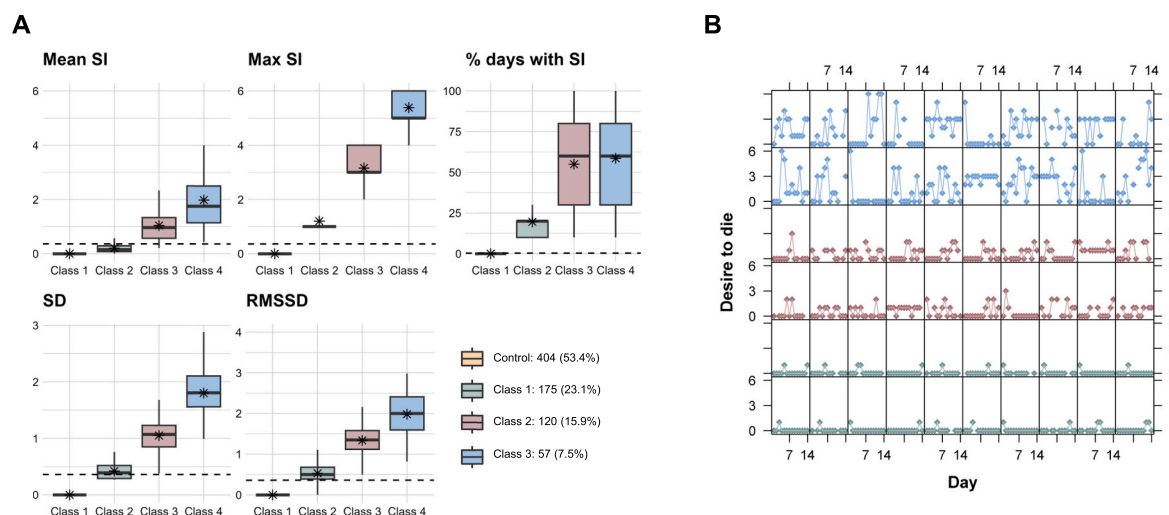

Fig. 1. Boxplots of SI indicators for the control group and SI subtypes (A) and random selection of individual graphs showing day-to-day fluctuations in suicidal ideation, stratified by control group and latent classes (B).

Footnote: Individuals shown in panel B were selected at random from those with EMA compliance ≥80 % and class probability assignation = 1. Dashed line in 1A is the mean of the overall sample.

Colors: yellow (control subsample), green (subtype 1), red (subtype 2), blue (subtype 3). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 1

Descriptive of SI subtypes according to sociodemographic characteristics, thirty-day mental disorders, history of self-injurious thoughts and behaviors, and stress sensitivity.

	OVERALL	CONTROL	SUBTYPE 1	SUBTYPE 2	SUBTYPE 3
	n (%) Mean (SD)	n (%) Mean (SD)	n (%) Mean (SD)	n (%) Mean (SD)	n (%) Mean (SD)
Sociodemographic					
Sex					
Male	156 (20.6 %)	85 (21.0 %)	40 (22.9 %)	23 (19.2 %)	8 (14.0 %)
Female	600 (79.4 %)	319 (79.0 %)	135 (77.1 %)	97 (80.8 %)	49 (86.0 %)
Age	20.7 (2.29)	20.8 (2.50)	20.3 (1.77)	20.9 (2.38)	20.5 (1.76)
Field of Study					
Arts and Humanities	85 (11.2 %)	39 (9.7 %)	26 (14.9 %)	16 (13.3 %)	4 (7.0 %)
Sciences	91 (12.0 %)	44 (10.9 %)	18 (10.3 %)	19 (15.8 %)	10 (17.5 %)
Health Sciences	215 (28.4 %)	115 (28.5 %)	57 (32.6 %)	29 (24.2 %)	14 (24.6 %)
Engineering and Architecture	99 (13.1 %)	51 (12.6 %)	28 (16.0 %)	15 (12.5 %)	5 (8.8 %)
Social and Legal Sciences	266 (35.2 %)	155 (38.4 %)	46 (26.3 %)	41 (34.2 %)	24 (42.1 %)
EMA Compliance	78.7 (24.7)	75.7 (28.0)	84.1 (17.0)	80.5 (22.6)	79.5 (21.3)
Thirty-day mental disorders					
Depression (yes/no)	195 (25.8 %)	70 (17.3 %)	45 (25.7 %)	48 (40.0 %)	32 (56.1 %)
Depression Severity[a]	0 (1.00)	−0.31 (0.93)	0.05 (0.92)	0.57 (0.84)	0.83 (0.98)
Anxiety (yes/no)	106 (14.0 %)	34 (8.4 %)	25 (14.3 %)	29 (24.2 %)	18 (31.6 %)
Anxiety Severity[a]	0 (1.00)	−0.25 (1.01)	0.04 (0.88)	0.50 (0.88)	0.58 (0.87)
AUDIT score[a]	0 (1.00)	−0.09 (0.93)	0.22 (1.13)	−0.06 (1.00)	0.11 (0.96)
Frequency of SI[a]	0 (1.00)	−0.37 (0.41)	−0.04 (0.83)	0.65 (1.28)	1.37 (1.69)
Lifetime and 12-month self-injurious thoughts and behaviors					
Number of NSSI (LT)	1.05 (2.00)	0.52 (1.40)	1.09 (1.92)	1.89 (2.45)	2.91 (2.96)
12-month NSSI (yes/no)	113 (14.9 %)	16 (4.0 %)	33 (18.9 %)	40 (33.3 %)	24 (42.1 %)
Lifetime STB					
No SI	380 (50.3 %)	275 (68.1 %)	70 (40.0 %)	25 (20.8 %)	10 (17.5 %)
Suicidal Ideation	136 (18.0 %)	65 (16.1 %)	37 (21.1 %)	26 (21.7 %)	8 (14.0 %)
Plan	178 (23.5 %)	53 (13.1 %)	54 (30.9 %)	51 (42.5 %)	20 (35.1 %)
Attempt	62 (8.2 %)	11 (2.7 %)	14 (8.0 %)	18 (15.0 %)	19 (33.3 %)
SI Age of Onset	15.2 (3.02)	15.8 (2.87)	15.3 (2.93)	15.1 (3.04)	13.8 (3.16)
Number of years with SI (LT)	1.64 (2.48)	0.72 (1.47)	1.74 (2.17)	3.34 (3.05)	4.26 (3.71)
Number of suicide attempts (LT)	0.229 (1.47)	0.06 (0.39)	0.13 (0.48)	0.28 (0.85)	1.67 (4.84)
Worst week with SI (LT)					
Number of days with SI	2.11 (2.65)	1.18 (2.13)	2.46 (2.69)	3.56 (2.66)	4.53 (2.73)
SI duration >1 h or more (yes/no)	178 (23.5 %)	40 (9.9 %)	49 (28.0 %)	56 (46.7 %)	33 (57.9 %)
Low perceived control over SI (yes/no)	187 (24.7 %)	47 (11.6 %)	51 (29.1 %)	54 (45.0 %)	35 (61.4 %)
Having tempted fate (LT) (yes/no)	65 (8.6 %)	14 (3.5 %)	11 (6.3 %)	19 (15.8 %)	21 (36.8 %)
12-Month STB					
No SI	523 (69.2 %)	352 (87.1 %)	111 (63.4 %)	43 (35.8 %)	17 (29.8 %)
Suicidal Ideation	123 (16.3 %)	36 (8.9 %)	41 (23.4 %)	34 (28.3 %)	12 (21.1 %)
Plan	103 (13.6 %)	16 (4.0 %)	21 (12.0 %)	42 (35.0 %)	24 (42.1 %)
Attempt	7 (0.9 %)	0 (0 %)	2 (1.1 %)	1 (0.8 %)	4 (7.0 %)
Non-zero probability of acting on SI (yes/no)	93 (12.3 %)	15 (3.7 %)	15 (8.6 %)	36 (30.0 %)	27 (47.4 %)
Stress Sensitivity[a]	0 (1.00)	−0.10 (0.89)	−0.13 (1.14)	0.32 (0.96)	0.38 (1.13)
TOTAL	756 (100 %)	404 (53.4 %)	175 (23.1 %)	120 (15.9 %)	57 (7.5 %)

Acronyms: LT (Lifetime), NSSI (Nonsuicidal Self-Injury), RMSSD (Root Mean Square of Successive Differences), SD (Standard Deviation), SI (Suicidal Ideation), SITB (Self-Injurious Thoughts and Behaviors), STB (Suicidal Thoughts and Behaviors), S1 (Subtype 1), S2 (Subtype 2), S3 (Subtype 3).

[a] Standardized values.

and conclusions remain robust.

4. Discussion

We present the first study that identified suicidal ideation (SI) subtypes in a large sample of university students using ecological momentary assessment (EMA). Three distinct SI subtypes were found, characterized by increasing levels of SI frequency, intensity, and variability. The more severe subtypes consistently exhibited higher levels of recent depression and anxiety, as well as a history of more serious self-injurious thoughts and behaviors. Importantly, these subtypes also presented higher rates of suicidal plans and attempts at 12-month follow-up. In students with more severe SI, higher stress sensitivity was associated to greater overall variability but lower day-to-day fluctuations.

Comparison with previous findings is limited by the scarcity of EMA studies on SI in non-clinical samples. One previous study among college students identified subtypes of SI trajectories, but included only 28 students who reported SI, resulting in very low statistical power (Layrón Folgado et al., 2022). The subtypes found generally align with those described in clinical populations, which used near identical indicators (Spangenberg et al., 2023; Kleiman et al., 2018). These studies identified an additional subtype with persistently elevated ideation (i.e., combining high-intensity with low-variability SI), which also presented the highest proportion of suicide attempts in the past month (Kleiman et al., 2018) and following year (Spangenberg et al., 2023). It is possible that a "persistently elevated" subtype also exists among university students, and that our study was unable to identify it. This could be because this group is likely very small in a non-clinical sample, and potentially less likely to participate in a burdensome study such as an EMA (Portillo-Van Diest et al., 2024). Another reason could be that our predominantly female sample may have affected our ability to detect this additional subtype, as we know that though females are more likely to report SI and have suicide attempts, males are more likely to die by suicide (Schrijvers et al., 2012). It is possible that certain SI subtypes, such as persistently elevated ideation, may present differently or be less detectable in a predominantly female sample. Further research is needed to clarify these sex-specific patterns, given that previous studies did not provide this information. This lack of male representation is a ripple effect form the participation bias that is typical in epidemiological studies (Galea

Table 2

Association between thirty-day mental disorders, history of self-injurious thoughts and behaviors, stress sensitivity and SI subtype.

	SUBTYPE 1	SUBTYPE 2		SUBTYPE 3	
	OR [95 % CI][b] *ref: control*	OR [95 % CI][b] *ref: control*	OR [95 % CI][b] *ref: S1*	OR [95 % CI][b] *ref: control*	OR [95 % CI][b] *ref: S2*
Thirty-day mental disorders					
Depression (yes/no)	1.9 [1.2–2.9]	3.4 [2.1–5.3]	1.8 [1.1–3.0]	6.4 [3.5–11.5]	1.9 [1.0–3.6]
Anxiety (yes/no)	2.1 [1.2–3.6]	3.7 [2.1–6.4]	1.8 [1.0–3.2]	5.2 [2.6–10.1]	1.4 [0.7–2.9]
Anxiety Severity[a]	1.5 [1.2–1.8]	2.4 [1.9–3.1]	1.6 [1.3–2.2]	2.7 [1.9–3.7]	1.1 [0.8–1.6]
AUDIT score[a]	1.4 [1.2–1.7]	1.1 [0.9–1.3]	0.7 [0.6–0.9]	1.3 [0.96–1.6]	1.2 [0.9–1.6]
Frequency of SI[a]	2.7 [1.9–3.8]	4.7 [3.4–6.5]	1.7 [1.4–2.2]	6.9 [4.8–9.9]	1.5 [1.2–1.8]
Lifetime and 12-month self-injurious thoughts and behaviors					
Number of NSSI (LT)	1.3 [1.1–1.4]	1.5 [1.3–1.6]	1.6 [1.0–2.6]	1.7 [1.5–1.9]	1.8 [1.0–3.5]
12-Month NSSI (yes/no)	5.3 [2.8–10]	11.7 [6.2–22]	1.3 [1.1–1.6]	17.8 [8.5–37]	1.2 [1.0–1.5]
Lifetime STB					
No SI	ref	ref	ref	ref	ref
Suicidal Ideation	1.4 [0.9–2.3]	1.5 [0.9–2.5]	1.0 [0.6–1.8]	0.8 [0.4–1.9]	0.6 [0.2–1.4]
Plan	3.1 [2.0–4.8]	4.9 [3.1–7.8]	1.6 [1.0–2.6]	3.7 [2.0–7.0]	0.8 [0.4–1.5]
Attempt	3.6 [1.6–8.3]	6.5 [2.9–14.5]	1.8 [0.9–3.9]	21.6 [9.2–50.3]	3.3 [1.5–7.2]
SI Age of Onset	1.0 [0.9–1.0]	0.9 [0.8–1.0]	1.0 [0.9–1.1]	0.8 [0.7–0.9]	0.9 [0.8–1.0]
Number of years with SI (LT)	1.5 [1.3–1.6]	1.8 [1.6–2.0]	1.7 [1.3–2.1]	2.0 [1.8–2.3]	1.4 [1.1–1.8]
Number of suicide attempts (LT)	1.6 [1.0–2.5]	2.1 [1.4–3.2]	1.5 [0.9–2.6]	3.3 [2.2–5]	1.9 [1.3–3.0]
Worst week with SI (LT)					
Number of days with SI	1.3 [1.2–1.4]	1.5 [1.3–1.6]	1.1 [1.0–1.2]	1.7 [1.5–1.9]	1.2 [1.0–1.3]
SI duration >1 h or more (yes/no)	4.1 [2.5–6.7]	8.6 [5.2–14.2]	2.1 [1.3–3.4]	15 [7.9–28.5]	1.7 [0.9–3.4]
Low perceived control over SI (yes/no)	3.6 [2.2–5.7]	6.6 [4.1–10.7]	1.8 [1.1–3.0]	13.6 [7.3–25.5]	2.1 [1.1–4.0]
Having tempted fate (LT) (yes/no)	2.3 [1.0–5.2]	5.7 [2.7–11.9]	2.5 [1.1–5.6]	19.8 [9–43.4]	3.5 [1.6–7.4]
12-Month STB					
No SI	ref	ref	ref	ref	ref
Suicidal Ideation	3.3 [2.0–5.5]	4.2 [2.4–7.1]	1.2 [0.7–2.1]	2.8 [1.4–5.9]	0.7 [0.3–1.5]
Plan	3.6 [1.8–7.2]	13.5 [7.2–25.5]	3.7 [2.1–6.8]	20.1 [9.6–42.3]	1.5 [0.8–2.9]
Attempt	*/	*/	0.8 [0.1–8.9]	*/	9.6 [1.0–89.9]
Stress Sensitivity[a]	1.6 [1.3–2.0]	2.9 [2.3–3.7]	1.8 [1.4–2.3]	3.9 [2.8–5.5]	1.4 [0.9–1.9]

Acronyms: LT (Lifetime), NSSI (Nonsuicidal Self-Injury), RMSSD (Root Mean Square of Successive Differences), SD (Standard Deviation), SI (Suicidal Ideation), SITB (Self-Injurious Thoughts and Behaviors), STB (Suicidal Thoughts and Behaviors), S1 (Subtype 1), S2 (Subtype 2), S3 (Subtype 3).

[a] Standardized values.

[*] / Not presented due to data sparsity.

[b] Adjusted by sex, age, field of study and EMA compliance.

and Tracy, 2007), which occurred in the baseline survey from which students were invited to participate in the EMA study (Portillo-Van Diest et al., 2024). To better clarify these aspects, future studies could replicate our analyses in a larger representative sample with more balanced sex representation, to see if additional subtypes are found and allowing for estimation of the prevalence of subtypes.

Kleiman and colleagues argue that their subtypes are broadly in line with those presented by Bernanke, Stanley and Oquendo's theoretical work (2017), which describes two major SI subtypes: a stress-responsive subtype, characterized by greater variability in ideation and a non-stress-responsive type, with more persistent ideation. However, these studies did not include measures of stress or stress sensitivity in order to further explore this theory. A study on patients with depression found that patients with higher SI variability experienced increases in SI after stressful events (Oquendo et al., 2021), although they did not identify specific SI subtypes. Our study advances this growing body of evidence by identifying distinct SI subtypes and examining their relationship with stress sensitivity in a vulnerable segment of the general population. Notably, we did not find a non-stress-responsive subtype, as both subtypes with more frequent SI reports (S2 and S3) presented higher levels of stress sensitivity. Instead, we found that students with more severe SI (S3) and higher stress sensitivity displayed slightly greater overall variability but also more persistent, extreme suicidal thinking on a day-to-day basis. It is possible that there is important heterogeneity within this higher-risk group, which our general population sample may not have fully captured. One undisclosed subtype could involve high-intensity, low-variability SI, as seen in clinical studies. Further research with larger samples is needed to determine if a non-stress-responsive subtype can be found in the general population and to explore how SI variability may be related to stress sensitivity.

An important contribution of our study is that we demonstrated that a lifetime history of severe STB during childhood-adolescence, characterized by early onset of ideation, more persistent ideation, low controllability, non-suicidal self-injury, and transition to suicide attempts, is associated with more severe reports of daily SI during college. It is well established that lifetime and recent depression, anxiety, and severity of STB history are major risk factors for persistence of SI (Ribeiro et al., 2018; Moller et al., 2023; Nock et al., 2018; Mortier et al., 2017b; Mortier et al., 2017a; Wilcox et al., 2010). Our results now show that this is also true for day-to-day persistence in SI, especially in individuals with higher sensitivity to stress. Childhood trauma has also been found to be strongly associated to both the onset and persistence of SI as well as heightened sensitivity to stress (Biscond et al., 2023; O'Connor et al., 2020; Nock et al., 2014). While some evidence suggest that different forms of childhood trauma may be linked with greater daily SI variability, this has only been evaluated in one study, and it remains unclear whether this relationship persists after adjusting for stress sensitivity (Oquendo et al., 2021). Future studies are needed to further clarify this relationship.

4.1. Limitations

There are several limitations to this study. First, the frequency of SI measurements lacked granularity, as it was only measured once a day. This may have missed important fluctuations that could occur within minutes or hours. Further, daily measurements require retrospective reporting, which could introduce bias and miss instances of SI. Second, we measured SI exclusively in terms of *desire to die*, even though SI is a multidimensional phenomenon that includes other aspects such as intent (Jobes et al., 2024), which could increase measurement error.
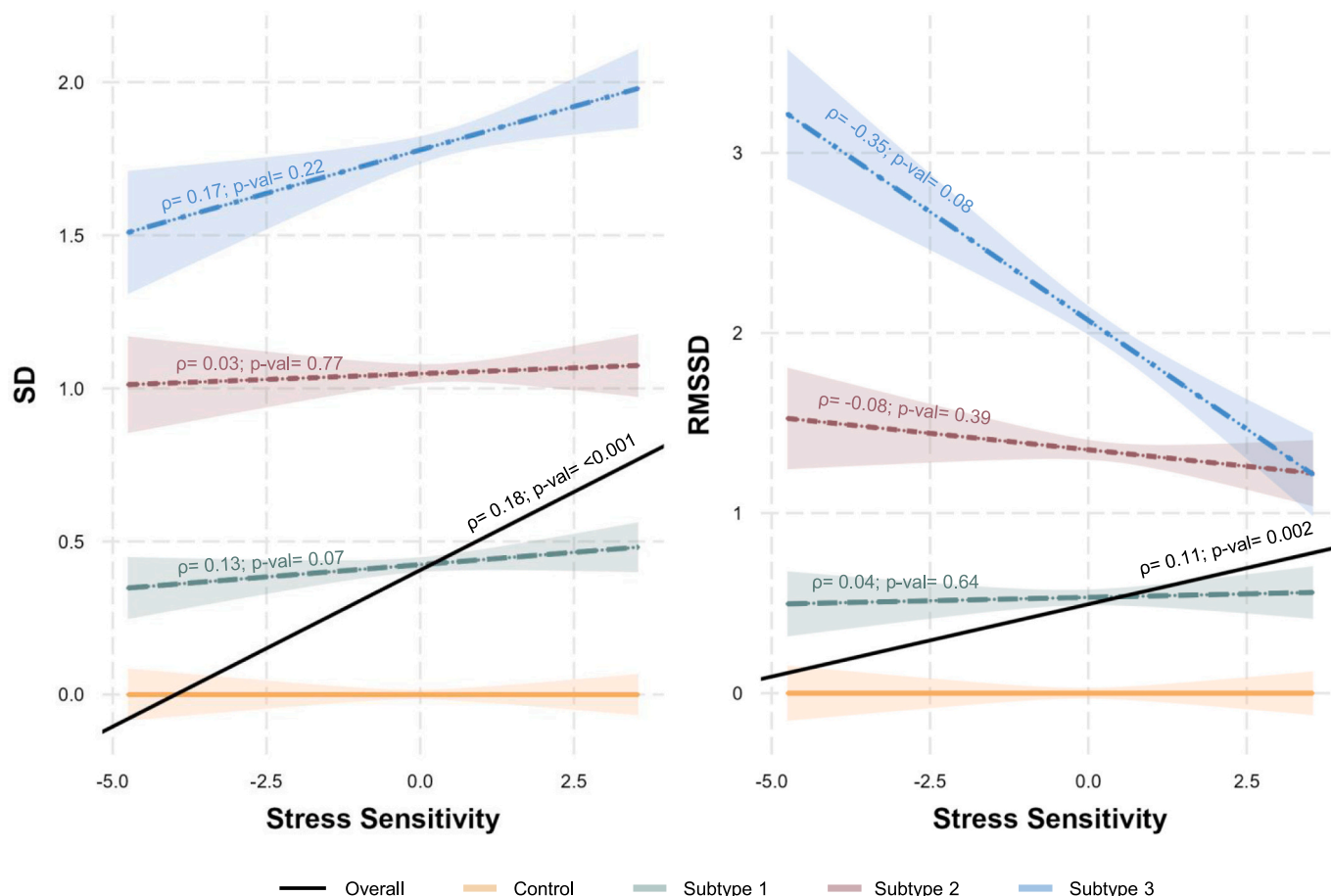
Fig. 2. The association of stress sensitivity and suicidal ideation variability, overall and stratified by control group and latent classes.
Colors: black (overall), yellow (control subsample), green (subtype 1), red (subtype 2), blue (subtype 3). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Table 3
Associations between SI subtype and suicidal thoughts and behaviors at follow-up.

	STB						Numb of months with SI	
	No SI	SI	Plan	Attempt	Any STB			
	n (%)	n (%)	n (%)	n (%)	n (%)	OR [95 % CI][a]	Mean (SD)	RR [95 % CI][a]
Control	157 (88.2)	12 (6.7)	8 (4.5)	1 (0.6)	21 (11.8)	Ref	0.34 (1.3)	Ref
Subtype 1	52 (70.3)	11 (14.9)	11 (14.9)	0 (0.0)	22 (29.7)	3.1 [1.6–6.2]	0.72 (1.7)	2.8 [1.4–5.5]
Subtype 2	31 (52.5)	10 (16.9)	16 (27.1)	2 (3.4)	28 (47.5)	6.4 [3.2–12.9]	2.17 (3.3)	7.1 [3.7–14.1]
Subtype 3	9 (28.1)	3 (9.4)	16 (50.0)	4 (12.5)	23 (71.9)	20.6 [8.3–51.2]	4.28 (4.3)	17.4 [7.8–38.7]

Acronyms: FU (Follow-Up), OR (Odds Ratio), RR (Rate Ratio), SI (Suicidal Ideation), STB (Suicidal Thoughts and Behaviors).
[a] Adjusted by sex, age, field of study and EMA compliance.

Nonetheless, passive ideation has significant clinical relevance, comparable to active ideation (Liu et al., 2020). Third, we treated stress sensitivity as a stable trait, using a single score for each participant calculated using all answers throughout the EMA study. Though this has previously been done in multiple studies (Howland et al., 2017; Lataster et al., 2010; Myin-Germeys and van Os, 2007), stress sensitivity may also fluctuate, which could introduce bias. Fourth, it remains unclear whether the identified groups represent distinct SI subtypes or simply reflect a severity gradient. However, entropy of the LPA model was extremely high, and it is evident that S3 isolates most severe students in the daily reports. Finally, the lack of representativity, particularly regarding gender, may have hampered our ability to identify the full range of potential subtypes. Given resource and time constraints, we oversampled individuals with SI and related mental health problems to ensure sufficient power for subtype identification, as our aim was not to estimate subtype prevalence but to explore which subtypes are present within a student population. Future studies with representative samples should be conducted to confirm the ideation subtypes identified in this study and to obtain population-level estimates of their prevalence.

5. Conclusions

More severe daily SI, in terms of intensity, variability and frequency, is associated with higher rates of future active SI and attempts one year

later. Stress sensitivity appears to contribute to more extreme and inflexible suicidal thinking across consecutive days. These findings suggest that targeting stress sensitivity could be an effective approach for suicide prevention in the general population to increase suicide resilience (Wang et al., 2022).

CRediT authorship contribution statement

Ana Portillo-Van Diest: Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Gemma Vilagut:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Laura Ballester:** Writing – review & editing, Methodology. **Paula Carrasco:** Writing – review & editing, Methodology. **Raquel Falcó:** Writing – review & editing, Methodology. **Margalida Gili:** Writing – review & editing, Methodology. **Glenn Kiekens:** Writing – review & editing, Methodology. **Francisco H. Machancoses:** Writing – review & editing, Conceptualization. **Jose A. Piqueras:** Writing – review & editing, Methodology. **Miquel Roca:** Writing – review & editing, Methodology. **Tíscar Rodríguez-Jiménez:** Writing – review & editing, Methodology. **Jordi Alonso:** Writing – review & editing, Methodology, Funding acquisition. **Philippe Mortier:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2025.119865.

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