Long-Term Suicidal Ideation Profiles in Late-Life Depression and Their Association With Suicide Attempt or Death by Suicide

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ABSTRACT

Objective: In young and middle-aged adults, suicidal ideation is an important predictor of prospective suicide attempts, but its predictive power in late life remains unclear. In this study, we used Latent Profile Analysis (LPA) in a cohort of depressed older adults to identify distinct ideation profiles and their clinical correlates and test their association with risk of suicidal behavior longitudinally.

Methods: A total of 337 depressed older adults (aged 50–93 years) were assessed for suicidal ideation and behavior for up to 14 years (median = 3 years), at least once per year (study period: 2002–2020). LPA was used, which derived 4 profiles of ideation scores based on subject-level aggregates. Groups were compared using analysis of variance (ANOVA) and χ^2 tests at baseline and competing risk survival analysis during follow-up.

Results: Ideation showed significant decline over time, on average ($P < .001$). LPA identified 4 suicidal ideation profiles. Risk of suicide attempt/death was higher for chronic severe ideators (age-adjusted hazard ratio [HR] = 5.75; 95% CI, 2.25–14.7; $P < .001$) and highly variable ideators (HR = 3.21; 95% CI, 1.03–10.1; $P = .045$) compared to fast-remitting ideators, despite comparable current ideation severity at baseline. Fast-remitting ideators had higher risk than low/non-ideators with no attempts or suicides ($P < .001$). Chronic severe ideators displayed the most severe dysfunction across personality, social characteristics, and impulsivity measures, whereas highly variable and fast-remitting ideators displayed specific deficits.

Conclusions: Assessing suicidal ideation over months/ years has clinical relevance, as it enabled the identification of distinct ideation patterns associated with substantive differences in clinical presentation and risk of future suicidal behavior despite similar ideation levels at baseline.

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Suicide prevention is particularly difficult in older people,[1] who have the highest proportion of fatal attempts.[2] It is unclear whether suicidal ideation remains as important a predictor of suicidal behavior as in younger age groups.[3–6]

Prospectively, we found that older adults' worst lifetime ideation severity before being admitted to the study predicted near-fatal and fatal attempt.[7] However, recent cross-sectional studies suggest that older adults who become attempters late in life have a different, generally less pathological profile than suicide ideators in that age group. This has been shown for constructs as diverse as personality traits,[8] social/familial exposure to suicides,[9] and real-life decision-making competence.[10] Considering the aforementioned differences among suicidal older adults, suicidal ideation measured at one time point (whether current or lifetime) may not be enough to accurately predict suicide risk.

In older adults, high and persistent ideation has been associated with lower overall cognitive functioning,[11] which has in turn been found to characterize high-lethality attempts.[7,12] However, a direct relationship between ideation profiles and late-life suicidal behavior remains to be tested.

Using Latent Profile Analysis (LPA), an Ecological Momentary Assessment (EMA) study[13] identified 5 distinct ideator phenotypes in a younger population, based on subject-level aggregates containing measures of ideation frequency, severity, and variability. A recent re-analysis[14] of Sequenced Treatment Alternatives to Relieve Depression (STAR*D) study data used LPA on pointwise measures to identify ideation trajectories during the study. In both studies, the time frame of the measurements was short (days to weeks); thus, key questions remain of how these phenotypes relate to suicidal behaviors.

Applying these methods to a longer time frame, we use LPA in a cohort of depressed participants aged 50 years or older to (*a*) identify distinct ideation profiles and their clinical correlates and (*b*) test the profiles' association with risk of suicidal behavior before and during follow-up. We hypothesized that different profiles of suicidal ideation are associated with different risk levels and subtypes of suicidal behavior. Specifically, we hypothesized that a chronic high ideation profile, ie, participants with persistent high severity ideation, would have the strongest association with suicidal behavior, especially with high-lethality attempts, whereas profiles with more punctual or fluctuating ideation may be associated with lower-lethality suicidal behavior.

METHODS

Sample and Procedures

Sample. 337 depressed older adults (aged 50–93 years, mean [SD] = 65.12 [8.75] years) diagnosed with non-psychotic

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Clinical Points

- Clinicians should assess suicidal ideation repeatedly and ask not only about current ideation but also about worst suicidal ideation since last visit.
- Assessing suicidal ideation over longer periods of time (months/years) will help to identify individuals with differential risk of future suicidal behavior despite similar levels of ideation at baseline.
- Those with high persistent ideation and fluctuating high ideation levels (scores) are at especially high risk for future suicidal behavior and should be monitored and treated as such.

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unipolar depression by the Structured Clinical Interview for *DSM-IV* Axis I Disorders (SCID)[15] were recruited between 2002 and 2020 from geriatric inpatient units, outpatient clinics, and university research registries and through advertisements from the community to participate in a case-control longitudinal study of late-life suicidal behavior (see our previous article[7]). Study procedures were approved by the University of Pittsburgh Institutional Review Board (IRB0407166), and subjects provided informed consent. Participants were recruited in 3 groups: suicide attempters (n = 150), suicide ideators (n = 89), and nonsuicidal depressed controls (n = 98). Suicide attempters had a history of self-injurious act with intent to die and current suicidal ideation as assessed using the Beck Scale for Suicidal Ideation (SSI)[16] upon entry into the study. Suicide ideators endorsed current suicidal ideation with a plan, but had no lifetime history of self-injurious behavior at baseline. These participants seriously contemplated suicide and disclosed this to their family or health care professionals, typically triggering an inpatient admission or the intensification of outpatient care. Nonsuicidal depressed controls had no history of self-injurious behavior, suicidal ideation, or suicide attempt upon enrollment.

Follow-up. We prospectively assessed suicidal ideation and suicide attempts at least once per year. All subjects included in the current analysis had a minimum of two assessment points for suicidal ideation, including the baseline assessment.

Suicide attempt. At baseline, we assessed the presence or absence of suicidal behavior history, the number of attempts, and the severity of the maximum-lethality attempt as measured by the Beck Lethality Scale (BLS).[17] At follow-up, we recorded the exact dates and lethality for any attempts since the last visit.

Suicidal ideation. we used the SSI[16] to assess ideation severity at baseline and follow-ups. Scores on the SSI range from 0 (no ideation or passive death wish) to 36 (maximum level of ideation). At baseline, patients were asked about their current ideation (ideation within the past week) and their worst lifetime ideation (the time during life when ideation was at its worst). At follow-ups, patients were asked about their current ideation and their worst levels of ideation since their last visit.

Suicide death and natural death. "Dead or alive" status was assessed by search in the National Death Index and review of obituaries, the last search was performed in 2021. Cause of death was categorized as suicide versus natural/accidental death. The suicide category included those who were highly suspected as suicide death based on the coroners' report and additional information collected through the study (eg, suicide notes obtained from relatives).

Other clinical characterization. Depression severity was measured using the 17-item Hamilton Depression Rating Scale (HDRS)[18] with the suicide item removed. Impulsivity included attentional, non-planning, and motor impulsiveness scores derived from the Barratt Impulsiveness Scale (BIS-11)[19]; positive urgency, negative urgency, lack of premeditation, lack of perseverance, and sensation seeking derived from the UPPS-P Impulsive Behavior Scale,[20] a scale measuring impulsivity as a multidimensional construct; and self-harm/dyscontrol derived from the Personality Assessment Inventory–Borderline Scale (PAI-BOR).[21] Personality measures encompassed neuroticism, extraversion, openness, conscientiousness, and agreeableness measured by the NEO Five-Factor Inventory (NEO-FFI)[22] as well as borderline personality traits assessed by the PAI-BOR, namely affective instability, identity problems, and negative relationships. Social characteristics were also measured. Perception of social support was measured using the Interpersonal Support Evaluation List (ISEL)[23] (tangible, appraisal, self-esteem, and belonging), problem-solving abilities were assessed with the Social Problem Solving Inventory (SPSI),[24] interpersonal difficulties were assessed with the Inventory of Interpersonal Problems (IIP),[25] and perceived burdensomeness was measured by Perceived Burdensomeness, one of two subscales of the Interpersonal Needs Questionnaire.[26] Cognition was characterized using the Mattis Dementia Rating Scale (DRS)[27] for global cognitive ability, the Executive Interview (EXIT)[28] for cognitive control, and the Wechsler Test of Adult Reading (WTAR)[29] raw score for intellectual functioning. Severity of physical comorbidities was assessed using the Cumulative Illness Rating Scale, adapted for Geriatrics (CIRS-G).[30]

Statistical Methods

Statistical analyses were performed using R 4.0.3.[31]

Missing data. Missing data for suicidal ideation scores took 3 forms: missing both current and worst ideation at an attended assessment, missing one of the two when the other was reported for the same assessment point, and censoring of follow-up. The first two types of missingness occurred in 3% and 1% of the assessment points, respectively, with no differences among recruitment groups. For details about the censoring of follow-up, please see Supplementary Appendix 1.

Testing time trends in ideation. Subjects with no ideation ever were excluded from the time trend analyses. Two models were considered: first, the predictor was the log-transformed time in months since baseline, and second, the baseline time point was excluded. Due to the

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Figure 1. Flowchart Illustrating the Steps Taken to Derive the Ideation Profiles
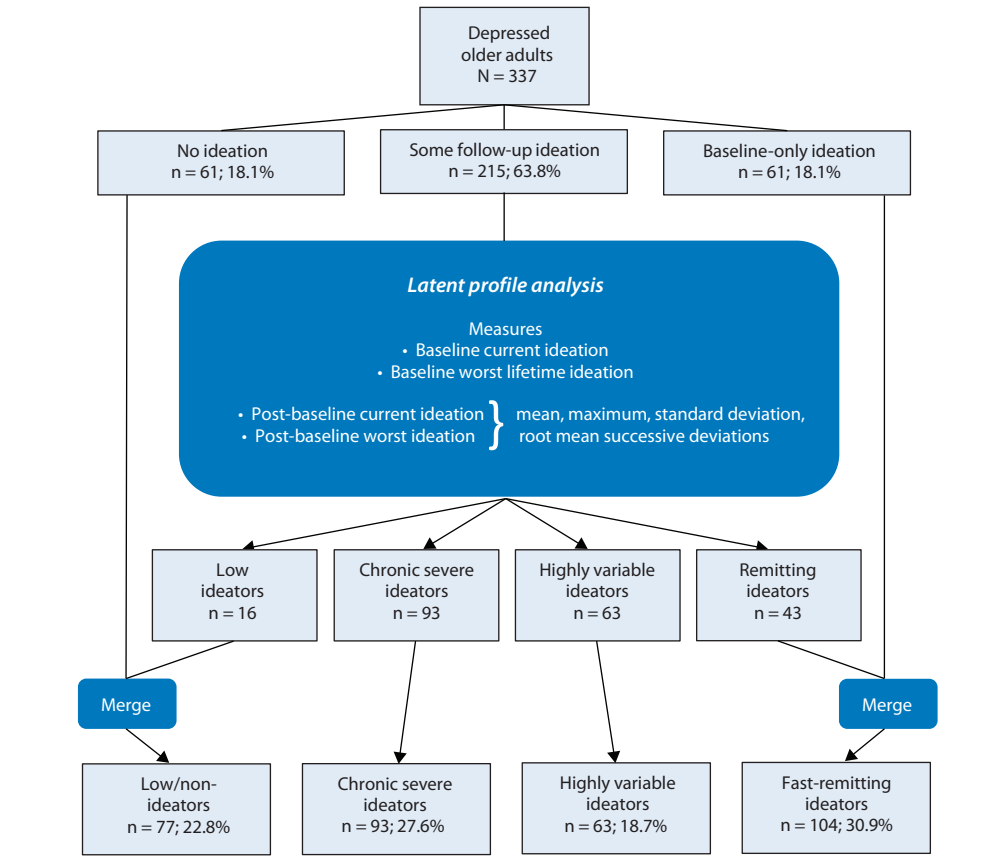
preponderance of zeros in the distribution of the ideation scores, zero-inflated Poisson mixed-effect regressions were run using the R library glmmTMB.[32]

Creating ideation profiles. Analysis steps are summarized in Figure 1. Due to the high zero-inflation in the distribution, the data were partitioned before the Gaussian distribution-based LPA was applied. Two rule-based subgroups were created: the first group had no ideation at any timepoint (no ideation), and the second had ideation at baseline and no ideation afterward (baseline-only ideation).

For the remaining subjects, post-baseline ideation values were aggregated by subject and timeframe (current vs worst ideation) into 5 summary indices, previously used by Kleiman and colleagues[13] to derive ideation profiles: mean, maximum, proportion of zero values, standard deviation, and the root mean successive squared deviation (RMSSD), a measure of variability combining the amplitude of the deviations from a subject's average and the autocorrelation of within-subject data. The 5 aggregates were calculated separately for current and worst ideation values. Baseline worst and baseline current ideation values were added to these, for a total of 12 values.

We applied LPA to the aforementioned 12 centered and scaled measures to derive profiles assuming Gaussian mixture distribution, using the R library mclust.[33] A 4-profile solution was retained based on the optimal Bayes

Information Criterion with the condition of having a minimum of 10 subjects per profile.

Profile comparisons. Baseline demographics and clinical characteristics were compared among the profiles. For continuous variables, we employed analysis of variance (ANOVA) followed by post hoc tests with the Tukey honestly significant difference (HSD) correction; for ordinal or highly skewed data, we used the Kruskal-Wallis test followed by Wilcoxon tests with Holm's correction; for count data, we employed χ^2 test followed by post hoc pairwise χ^2 tests with Bonferroni correction. Additional sensitivity analyses included baseline age as a covariate and adjustment for multiple testing using the Benjamini-Hochberg procedure (Supplementary Table 2).

Suicide risk comparisons. We compared profiles for the incidence of suicide attempt or death during the follow-up using competing risk survival analysis models to adjust the risk of suicide attempt/death for the risk of death from other causes. These models are applied when the assumption of random censoring for the survival analysis models may be violated, as some underlying factors may affect the risk of both kinds of events. Subjects with unverified cause of death (n = 2) were classified as non-suicide for the purpose of this analysis. Using the R library cmprsk,[34] we tested profiles with and without adjusting for age at baseline due to profile differences in average age.

Characteristic	Low/Non-Ideators (LI) (n = 77)	Chronic Severe Ideators (CI) (n = 93)	Highly Variable Ideators (VI) (n = 63)	Fast-Remitting Ideators (RI) (n = 104)	P Value	Pairwise Comparison
Age, mean (SD), y	66.68 (8.96)	62.89 (7.55)	64.05 (8.14)	66.62 (9.52)	.006	CI < LI and RI
Sex (female)	47 (61.04)	56 (60.22)	33 (52.38)	47 (45.19)	.098	
Race (White)	62 (80.52)	79 (84.95)	53 (84.13)	87 (85.29)	.904	
Education, mean (SD), y	14.44 (2.67)	14.16 (2.53)	14.30 (3.17)	14.40 (2.83)	.909	
Income, mean (SD), thousands ($)	21.32 (16.39)	19.95 (14.45)	20.05 (17.17)	27.32 (21.11)	.045	None
Depression severity score, mean (SD)[b]	17.84 (3.96)	21.05 (5.06)	19.19 (5.67)	19.50 (5.67)	.001	LI < CI
Intellectual functioning score, mean (SD)[c]	119.89 (107.32)	114.30 (101.78)	109.39 (14.54)	116.06 (102.54)	.951	
Physical illness severity score, mean (SD)[d]	9.31 (4.44)	8.67 (3.96)	9.11 (4.93)	8.99 (4.44)	.836	
Borderline traits score, mean (SD)[e]	24.30 (11.06)	35.36 (11.97)	30.23 (15.42)	24.67 (10.90)	< .001	LI and RI < CI
Dementia Rating Scale score, mean (SD)	134.89 (5.45)	134.65 (5.64)	134.58 (7.36)	132.48 (6.54)	.053	
Anxiety disorder (lifetime)[f]	45 (58.44)	65 (71.43)	47 (78.33)	56 (54.90)	.007	RI < VI
Anxiety disorder (current)[f]	40 (51.95)	58 (63.74)	40 (66.67)	46 (45.10)	.015	RI < CI and VI
Substance use disorder (lifetime)[f]	23 (29.87)	49 (53.85)	31 (51.67)	42 (41.18)	.009	LI < CI and VI
Substance use disorder (current)[f]	4 (5.19)	15 (16.48)	8 (13.33)	10 (9.80)	.121	
History of baseline attempt	…	56 (60.22)	38 (60.32)	50 (48.08)	< .001	LI < CI, VI, and RI
No. of attempts, mean (SD)	…	1.38 (1.83)	0.97 (1.15)	0.74 (1.01)	.006	RI < CI
Maximum lethality[g]	…	4.05 (2.11)	3.54 (2.10)	3.41 (2.32)	.269	
Baseline ideation score, mean (SD)[h]						
Current	0.14 (0.74)	19.14 (6.74)	17.91 (9.53)	16.41 (11.04)	< .001	LI < CI, VI, and RI
Worst	0.04 (0.19)	24.11 (6.77)	22.37 (8.68)	17.35 (11.06)	< .001	LI < RI < CI and VI
Follow-up ideation score, mean (SD)[h]						
Current	0.04 (0.11)	8.91 (5.21)	0.78 (0.97)	0.47 (0.52)	< .001	LI < RI < VI < CI
Worst	0.08 (0.26)	12.10 (6.31)	6.23 (5.54)	0.52 (0.87)	< .001	LI < RI < VI < CI
Follow-up ideation variability, mean (SD)[h]						
Current	0.11 (0.33)	6.91 (4.09)	1.48 (2.11)	0.65 (1.36)	< .001	LI < RI < VI < CI
Worst	0.20 (0.59)	7.44 (4.87)	7.25 (5.72)	0.69 (1.39)	< .001	LI < RI < VI and CI

Table 1. Demographic and Clinical Characteristics for the 4 Groups (N = 337)[a]

[a]Values are shown as n (%) unless otherwise noted. Any apparent discrepancies in percentages are due to missing data for those variables.
[b]Hamilton Depression Rating Scale (HDRS).
[c]Wechsler Test of Adult Reading.
[d]Cumulative Illness Rating Scale–Geriatric (CIRS-G).
[e]Personality Assessment Inventory–Borderline Scale (PAI-BOR).
[f]Structured Clinical Interview for *DSM-IV* (SCID).
[g]Beck Lethality Scale (BLS).
[h]Beck Scale of Suicidal Ideation (SSI).

In secondary analyses, we fit log rank test and Cox proportional hazards regression by censoring the follow-up time at the last visit for each subject. This analysis did not include death outcomes, as these occurred after the last recorded visit (for some cases, several years later).

RESULTS

A total of 337 depressed older adults were assessed for suicidal ideation and behavior for a period ranging between 3 months and 14 years (median = 3 years; interquartile range [IQR], 1.6–4 years; see Supplementary Appendix 1 for comparisons and correlates). The number of assessments ranged between 2 and 16 (median = 5; IQR, 3–6). A total of 92 subjects died during the study period: 72 of natural causes, 5 of accidents, 13 of suicide (or suspected suicide), and 2 of undetermined causes.

Time Trends in Suicidal Ideation During Follow-Up

No time trends were found in worst ideation since the last assessment during follow-up (conditional model: b = −0.10/log-month, SE = 0.11, $z = −0.85$, $P = .394$; zero-inflation: b = 0.27, SE = 0.21, $z = 1.27$, $P = .206$). For current ideation, the likelihood of having any ideation decreased over time, but severity did not (conditional model: b = 0.21, SE = 0.14, $z = 1.49$, $P = .137$; zero-inflation: b = 0.64, SE = 0.25,

$z = 2.58$, $P = .010$). Both current and worst ideation declined from baseline to follow-up (see Table 1, Figure 2, and Supplementary Appendix 2).

Ideation Profiles

As detailed in Figure 1, two rule-based subgroups were defined as the no ideation group (n = 61, 18.1%) and the baseline-only ideation group (n = 61, 18.1%). Four profiles were derived from the remaining subjects using LPA: low ideators (n = 16), chronic severe ideators (n = 93), highly variable ideators (n = 63), and remitting ideators with mild and/or rare ideation after baseline (n = 43). As there were no significant demographic, clinical, and cognitive differences between the low and the no ideation group, as well as between the baseline-only and the remitting group (Supplementary Table 1), these two pairs of groups were merged, resulting in 4 final profiles: low/non-ideators (22.8%), chronic severe ideators (27.6%), highly variable ideators (18.7%), and fast-remitting ideators (30.9%) (see centroids in Supplementary Tables 4 and 6). The 4 profiles were ordered in terms of average ideation during follow-up from lowest to highest as follows: low/non-ideators, fast-remitting ideators, highly variable ideators, and chronic severe ideators (see Table 1 and Figures 2 and 3), while only low/non-ideators differed from the other groups on current ideation at baseline. Highly variable ideators had comparable variability of worst ideation

Figure 2. Comparison of (A) Current and (B) Worst Suicidal Ideation Over Time Among Ideation Profiles as Indicated by Score on the Beck SSI
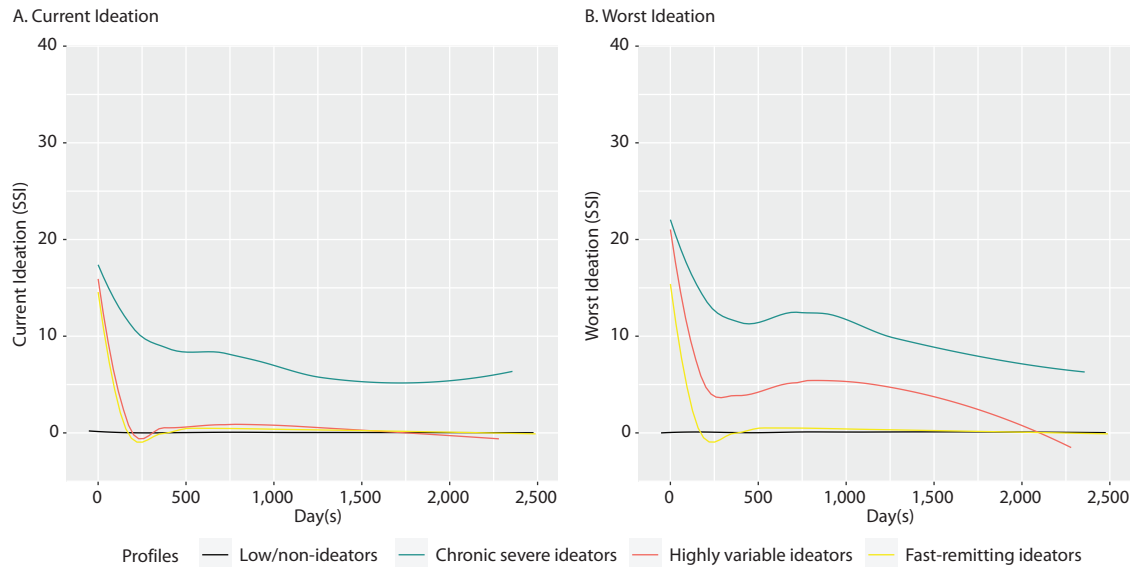
Abbreviation: SSI = Scale for Suicidal Ideation.

to chronic severe ideators (Table 1) and resembled that group on all post-baseline worst ideation aggregates while being closer to fast-remitting ideators on current ideation aggregates (Figure 3).

Clinical Comparison at Baseline

Profiles differed in age, income level, and most psychiatric characteristics, but not in cognition or physical comorbidities (Table 1). Chronic severe ideators were younger at baseline than low/non-ideators and fast-remitting ideators, but age-adjusted models for the group comparisons mostly remained significant, even after adjustment for multiple testing (Supplementary Tables 2 and 3). Chronic severe ideators were more depressed than low/non-ideators. Chronic severe and highly variable ideators were more likely to have a current anxiety disorder than the fast-remitting group and a lifetime substance abuse disorder than low/non-ideators.

Chronic severe ideators displayed the most severe dysfunction based on scores across personality, social characteristics, and impulsivity measures (see Figure 2 and Supplementary Tables 2 and 3). Highly variable ideators and fast remitters displayed specific dysfunctions: low self-esteem, high negative problem orientation, high neuroticism, and high rates of anxiety and substance use disorders in highly variable ideators, in contrast to social problem–solving deficits in fast remitters.

In terms of history of suicidal behavior, 60% of both the chronic severe and the highly variable groups and 48% of the fast-remitting group had past suicide attempt; these were significantly higher than for the low/non-ideator profile (0%). The former 3 profiles did not differ significantly on maximum lethality of suicide attempts. The number of past suicide attempts at baseline was significantly higher in
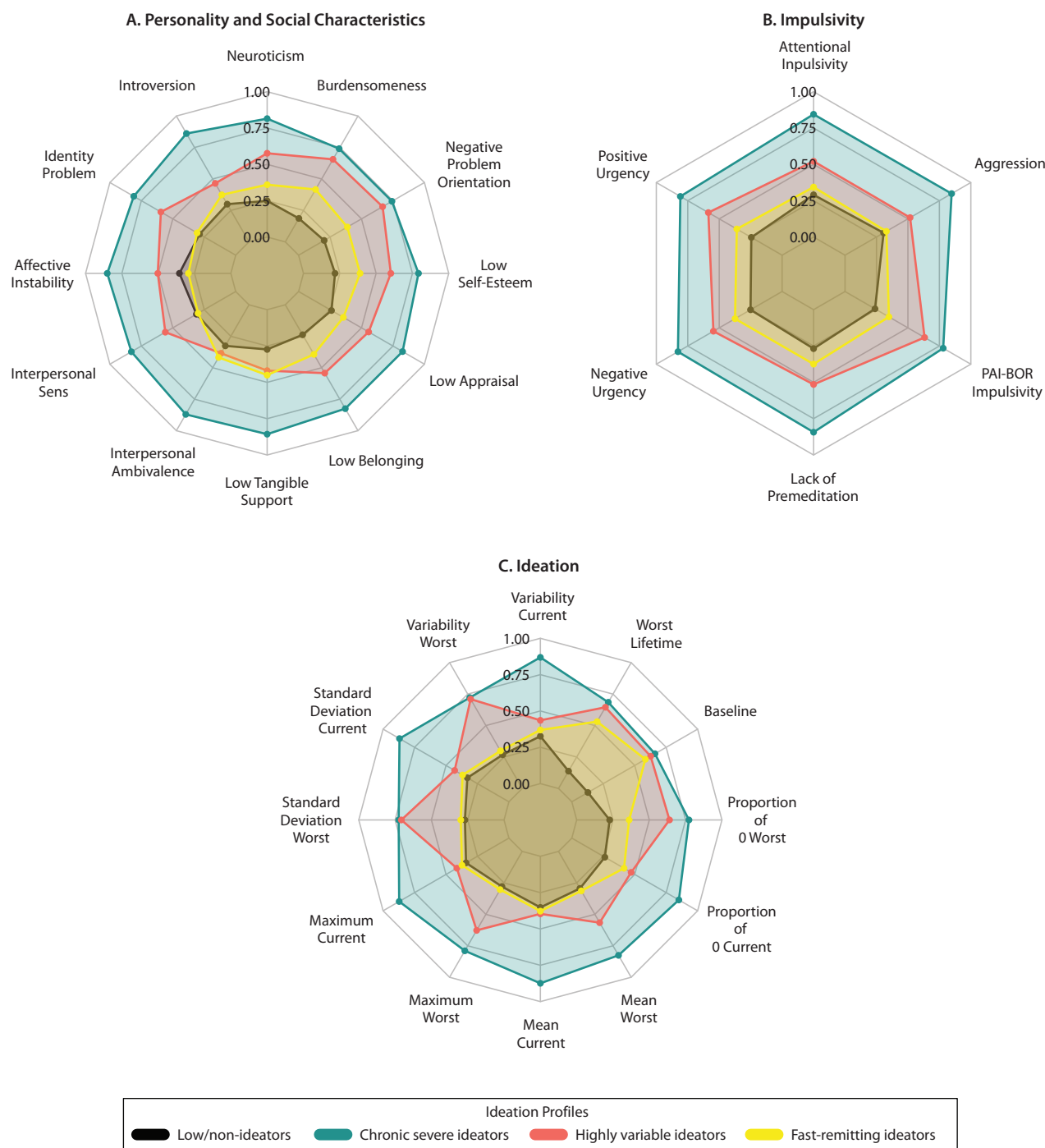
the chronic severe group than in the fast-remitting group (mean = 1.4 vs 0.74, $P = .006$).

Comparison of Suicidal Behavior During the Study

Time from baseline until death or the end of study period ranged between 3 months and 18 years (median = 6 years; IQR, 3–10 years). Forty subjects had a suicide attempt during the study period or died by suicide. Twenty-five (62.5%) were from the chronic severe group, 9 (22.5%) from the highly variable group, and 6 (15%) from the fast-remitting group. None of them were from the low/non-ideator group.

The competing risk analysis found significant profile differences for the cumulative incidence of suicidal behavior (statistic = 34.18, $df = 3$, $P < .001$; Figure 4) but not for natural/accidental death (statistic = 4.03, $df = 3$, $P = .258$). Pairwise comparisons showed lower risk in low/non-ideators than in the other groups ($P < .05$ for all 3 comparisons; Supplementary Table 5), and these differences were robust to covarying for age (all $P < .001$). The risk in chronic severe ideators was higher than in fast-remitting ideators (age-adjusted HR = 5.75; 95% CI, 2.25–14.7; $z = 3.65$; $P < .001$), but not higher than in highly variable ideators (HR = 2.02; 95% CI, 0.91–4.49; $z = 1.73$; $P = .083$), while highly variable ideators were at higher risk than fast-remitting ideators (HR = 3.21; 95% CI, 1.03–10.1; $z = 2.01$; $P = .045$). Covarying for baseline cognition measured by the DRS total score did not change any of the profile differences, although impaired global cognition was a risk factor for suicidal behavior (HR = 0.96/point; 95% CI, 0.92–0.997; $z = -2.12$; $P = .034$).

In the secondary survival analysis, 37 subjects had at least one suicide attempt. There were significant profile differences (log rank test $\chi^2 = 28.2$, $df = 3$, $P < .001$), with similar pairwise differences as in the competing risk model,

Figure 3. Comparison of (A) Personality and Social Characteristics, (B) Impulsivity, and (C) Ideation Among Ideation Profiles[a]

A. Personality and Social Characteristics

Neuroticism, Burdensomeness, Negative Problem Orientation, Low Self-Esteem, Low Appraisal, Low Belonging, Low Tangible Support, Interpersonal Ambivalence, Interpersonal Sens, Affective Instability, Identity Problem, Introversion

1.00, 0.75, 0.50, 0.25, 0.00

B. Impulsivity

Attentional Inpulsivity, Aggression, PAI-BOR Impulsivity, Lack of Premeditation, Negative Urgency, Positive Urgency

1.00, 0.75, 0.50, 0.25, 0.00

C. Ideation

Variability Current, Worst Lifetime, Baseline, Proportion of 0 Worst, Proportion of 0 Current, Mean Worst, Mean Current, Maximum Worst, Maximum Current, Standard Deviation Worst, Standard Deviation Current, Variability Worst

1.00, 0.75, 0.50, 0.25, 0.00

Ideation Profiles
Low/non-ideators — Chronic severe ideators — Highly variable ideators — Fast-remitting ideators

[a]All profile means have been scaled and graphically displayed on a range of 0 to 1, corresponding to 2 standard deviations below and above the overall mean, respectively.
Abbreviations: PAI-BOR = Personality Assessment Inventory–Borderline Scale, Sens = sensitivity.

with the exception of fast-remitting ideators and highly variable ideators no longer being different ($\chi^2_1 = 2.7$, $P = .103$).

DISCUSSION

We examined the longitudinal course of suicidal ideation among depressed older adults and found evidence of 4 distinct profiles associated with substantive differences in baseline clinical presentations, including personality characteristics, psychiatric comorbidities, and, most importantly, history of suicidal behavior. Specifically, we identified a chronic severe and a highly variable profile with high rates of suicide attempts and death by suicide that contrasted with a fast-remitting and a low/non-ideator profile. As

Figure 4. Comparison of Cumulative Incidence of Suicidal Behavior (Suicide Attempt/Death) Among Ideation Profiles During the Study
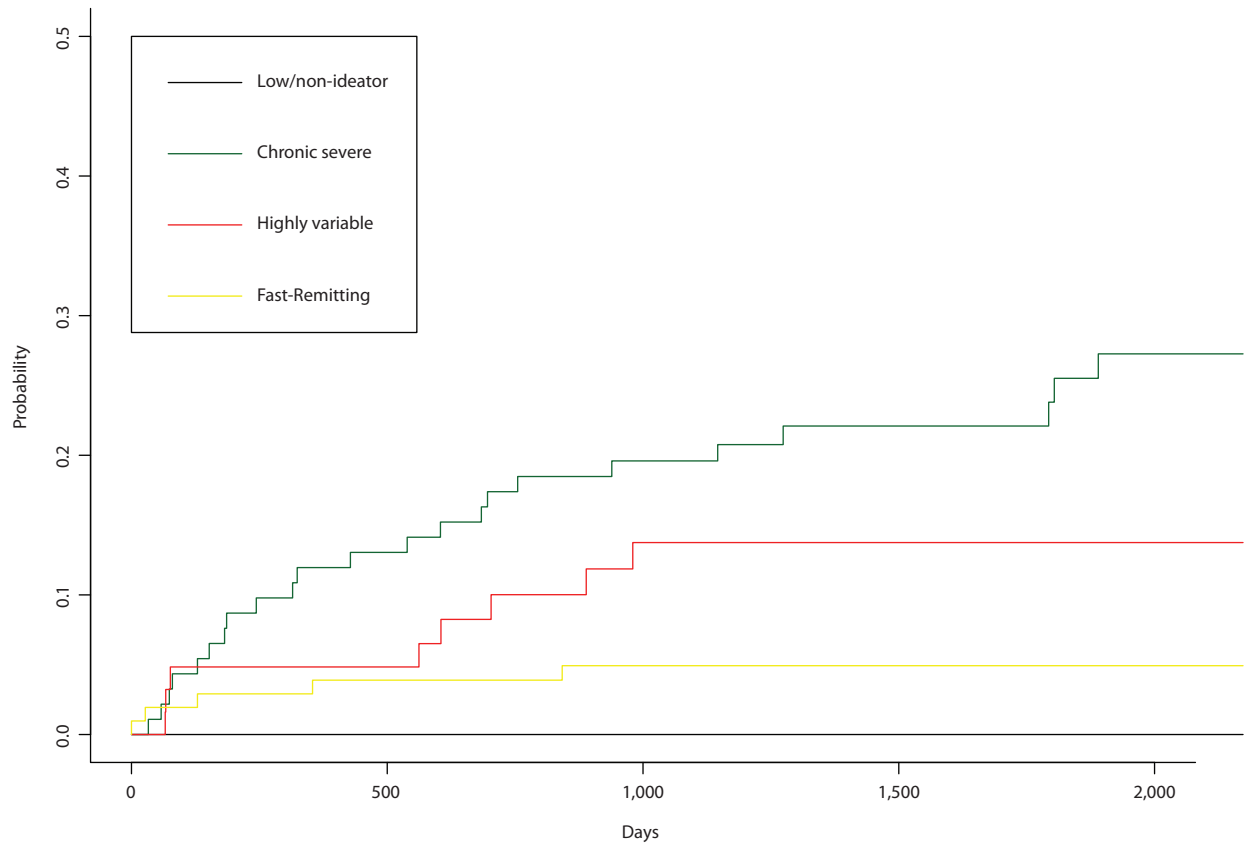
profiles included ideation values that occurred after a suicide attempt, the results of the competing risk analysis cannot be considered prospective validation; nevertheless, they test long-term association between ideation and behavior.

The present study confirms the importance of worst lifetime suicidal ideation above current ideation in late life, similarly to prior findings in young adults.[35] It further corroborates that the ideation's evolution is associated with risk of suicidal behavior more than single-timepoint assessments[4,5]: fast-remitting ideators reported suicidal ideation at baseline comparable to that of chronic severe and highly variable ideators, yet they had significantly lower worst ideation scores, fewer past attempts, and lower risk of attempting during follow-up. It is possible that fast-remitting ideators represent a resilient group for whom suicidal ideation was precipitated by a major life event (eg, loss of family member) but who had low ideation scores during follow-up and lower suicide risk. Highly variable ideators were similar to fast-remitting ideators in terms of their current ideation trajectory during follow-up, but resembled chronic ideators in terms of their worst between-assessment ideation. This profile may have short, intense ideation periods that are severe enough to be recalled, but are unlikely to coincide with yearly assessments; more frequent assessment like EMA may be needed for this profile.

Our study used summary indices for ideation similar to those in a previous EMA study[13] that derived 5 profiles, but

examined changes over months/years instead of daily fluctuations and computed summary indices for worst ideation since last contact in addition to current ideation. A published LPA of 9 weeks of ideation from the STAR*D study[14] identified 4 profiles very similar to ours (variable suicidal ideation, little-to-no suicidal ideation, persistent suicidal ideation, improving suicidal ideation). We further extended their analysis by linking these profiles to long-term suicidal behavior. Although the large difference in timeframes makes it unrealistic to quantitatively compare the derived profiles between studies, we conclude that examining longer periods may be as valuable for identifying ideation patterns as monitoring daily or weekly fluctuations. This has clinical relevance, as longer periods match real-life assessment opportunities better, eg, during medical appointments.

Cognitive factors did not significantly discriminate between the ideation profiles, although, as we reported previously[12] and replicated here, lower global cognitive performance predicted suicidal behavior during follow-up. This finding aligns with prior studies indicating that late-life suicidal ideation may not be related to cognition even if suicidal behavior is,[36,37] and instead ideation and cognition may act as independent risk factors for suicidal behavior.

Limitations

The lack of granularity of follow-up made it impossible to tie suicidal ideation values to the period immediately

preceding subjects' suicide attempts. As data on psychiatric treatment were not systematically available, we were unable to determine whether treatment was associated with the positive evolution of the fast-remitting group.

Our findings highlight the need to conduct repeated assessments of suicide risk and to include worst suicidal ideation measures in clinical screening tools, as most psychometric questionnaires exclusively assess current suicidal ideation.[38] The ideation profiles identified can contribute to the development of more refined assessment tools, especially for older populations in which prior attempt history is scarce.[1]

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Editor's Note: We encourage authors to submit papers for consideration as a part of our Focus on Suicide section. Please contact Philippe Courtet, MD, PhD, at pcourtet@psychiatrist.com.

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Supplementary Material

Article Title: Long-Term Suicidal Ideation Profiles in Late-Life Depression and Their Association With Suicide Attempt or Death by Suicide

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List of Supplementary Material for the article

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Appendix 1 Missing data, censoring, follow-up times

Proportion of missing data was aggregated by group and time and inspected for any trends or patterns. Missingness of suicidal ideation scores took 3 forms: missing both current and worst ideation when other information was collected at an assessment, missing either the current or the worst ideation when the other was reported for the same assessment point, and censoring of follow-up (because of the unequal time in study, or because of death). The first two types of missingness occurred in 3% and 1% of the assessment points, respectively, and no differences were found among recruitment groups in these types of missingness. Censoring due to late enrollment in the study was considered to be random. Censoring by death could not be considered random, as the risk factors for death, whether natural death or suicide, are not independent from those for suicidal ideation or behavior, and was considered a competing risk when comparing risk of suicide attempt among profiles.

Differences in the number of assessment points and in overall time in study may lead to bias and incorrect conclusions both in the LPA analysis of subject level aggregates, and in the survival analysis models. Such imbalances were tested for baseline age, suicidal ideation, and suicidal behavior. The number of assessment points was mildly inversely correlated with baseline age (Spearman r= -0.14, p=0.011), and, partly as a consequence, for all group comparisons. Sensitivity analyses adjusting for baseline age were run and their results are reported in the main text or in this Supplement. If subjects at higher levels of ideation and higher risk of attempt were more likely to die earlier, one would expect an inverse correlation between number of assessment points, and risk or ideation severity, however, baseline suicide attempters and suicide ideators had significantly more follow-up assessments than non-suicidal depressed controls (median=5.5 vs. 4, Kruskal-Wallis χ^2=9.79, df=2, p=0.007).

The four ideation profiles derived in this study did not differ on the length of time from baseline until the end of follow-up suicidal ideation assessments (Kruskal-Wallis

χ^2=6.00, df=3, p=0.111), or the length of time in study for the competing risk model (time from baseline until death or February 19, 2021, whichever was earlier (Kruskal-Wallis χ^2=3.69, df=3, p=0.297). Of note, significantly more assessment points were used for the aggregated ideation measures for *Chronic severe ideators* than for the other subjects (median= 6 vs. 5, Wilcoxon W=8985, p=0.003), and the difference persisted after adjusting for the profile's younger baseline age (b=0.83, SE=0.28, t=2.95, df=334, p=0.003). However, the absence of differences in the number of assessment points among the three other profiles indicates that classification was likely independent from the amount of ideation timepoints available per subject.

Appendix 2. Time trend analysis

Time trends in ideation were tested in a subsample of N=276, including the *Fast-remitting* group, but excluding the *Low/non-ideator* group, and also subjects with fewer than 3 assessment points. Both current and worst ideation for the remaining subjects was severely zero-inflated and also right-skewed. Zero-inflated Poisson mixed-effects regression identified significant decreasing trend in the severity and increase in zero-inflation of worst ideation over (log-transformed) time in study measured in months (conditional model: b=-0.81/log-month, SE=0.07, z=-11.9, p<0.001; zero-inflation: b=0.39, SE=0.09, z=4.19, p<0.001). However, no significant time trend remained after the baseline assessment was removed (conditional model: b=-0.10/log-month, SE=0.11, z=-0.85, p=0.394; zero-inflation: b=0.27, SE=0.21, z=1.27, p=0.206), indicating that the declining ideation time trend was mostly due to differences between baseline and follow-up. For current ideation there was a similar significant decline in severity and increase in zero-inflation when baseline was included (conditional model: b=-1.14, SE=0.09, z=-12.7, p<0.001; zero-inflation: b=0.43, SE=0.10, z= 4.49, p<0.001), however, the increased zero-inflation over time persisted after removing the baseline point (conditional model: b=0.21, SE=0.14, z=1.49, p=0.137; zero-inflation: b=0.64, SE=0.25, z=2.58, p=0.010).

Supplementary Table 1. Comparison of Baseline Characteristics of 4 derived profiles (P1-P4) and 2 pre-defined clusters (C0 and C5)

	No ideation (C0) N=61	Low ideators (P1) N=16	Chronic severe ideators (P2) N=93	Highly variable ideators (P3) N=63	Remitting ideators (P4) N=43	Baseline ideation only (C5) N=61	P-value	Post-hoc pairwise differences
Age	66.97 (9.35)	65.56 (7.47)	62.89 (7.55)	64.05 (8.14)	65.91 (9.59)	67.13 (9.51)	0.020	P2<C5
Gender (M):	24 (39.34%)	6 (37.50%)	37 (39.78%)	30 (47.62%)	23 (53.49%)	34 (55.74%)	0.273	
Caucasian	49 (80.33%)	13 (81.25%)	79 (84.95%)	53 (84.13%)	35 (83.33%)	52 (86.67%)	0.627	
Education	14.52 (2.69)	14.12 (2.66)	14.16 (2.53)	14.30 (3.17)	14.47 (3.00)	14.36 (2.73)	0.974	
SES per capita	20460.14 (15008.55)	24526.79 (21088.31)	19951.97 (14452.85)	20048.91 (17172.88)	24560.48 (19393.77)	29402.43 (22321.95)	0.076	
Depression severity[a] (no suicide item)	17.48 (3.43)	19.12 (5.43)	21.05 (5.06)	19.19 (5.67)	20.24 (6.12)	19.00 (5.34)	0.002	P2>C0
Premorbid IQ[b]	124.07 (119.46)	103.14 (19.53)	114.30 (101.78)	109.39 (14.54)	104.82 (14.53)	124.95 (136.67)	0.884	
Physical Illness Severity[c]	9.21 (4.43)	9.71 (4.60)	8.67 (3.96)	9.11 (4.93)	10.19 (4.85)	8.15 (3.97)	0.277	
Current Ideation	0.00 (0.00)	0.69 (1.54)	19.14 (6.74)	17.91 (9.53)	17.16 (11.22)	15.89 (10.97)	<0.001	C0 & P1< P2 & P3 & P4 &C5
Worst Ideation	0.00 (0.00)	0.19 (0.40)	24.11 (6.77)	22.37 (8.68)	17.32 (11.24)	17.38 (11.02)	<0.001	C0 & P1< P4 & C5 < P2 & P3
Anxiety Disorder (Lifetime)[d]	37 (60.66%)	8 (50.00%)	65 (71.43%)	47 (78.33%)	25 (60.98%)	31 (50.82%)	0.016	P3>C5
Anxiety Disorder (Current)[d]	33 (54.10%)	7 (43.75%)	58 (63.74%)	40 (66.67%)	19 (46.34%)	27 (44.26%)	0.052	
Substance Use Disorder (Lifetime)[d]:	19 (31.15%)	4 (25.00%)	49 (53.85%)	31 (51.67%)	21 (51.22%)	21 (34.43%)	0.012	No pairwise differences
Substance Use Disorder (Current)[d]:	4 (6.56%)	0 (0.00%)	15 (16.48%)	8 (13.33%)	5 (12.20%)	5 (8.20%)	0.275	
Baseline history of attempt	0 (0.00%)	0 (0.00%)	56 (60.22%)	38 (60.32%)	19 (44.19%)	31 (50.82%)	<0.001	C0 & P1< P2 & P3 & P4 &C5

Number of baseline attempts	0.00 (0.00)	0.00 (0.00)	1.38 (1.83)	0.97 (1.15)	0.77 (1.11)	0.72 (0.94)	0.016	P2>C5
Maximum lethality of baseline attempts[e]	-	-	4.05 (2.11)	3.54 (2.10)	3.35 (2.43)	3.45 (2.28)	0.450	

Notes: [a]Hamilton Rating Scale for Depression - 17 Item (HRSD); [b]Wechsler Test of Adult Reading; [c]Cumulative Illness Rating Scale-Geriatric (CIRS-G); [d]Structured Clinical Interview for DSM-IV (SCID); [e]Beck Lethality Scale (BLS)

Supplementary Table 2. Differences among the 4 final profiles, covarying for baseline age. P-values were adjusted using Benjamini adjustment for multiple testing, and pairwise comparisons used Tukey's HSD method.

Dependent Variable	F(3)	P-value	Effect size	Adjusted P-value	Pairwise comparison
Personality & Social Characteristics					
Personality Dimensions[a]					
Neuroticism	11.78	<0.001	0.42	<0.001	CI>RI&LI, VI>LI
Introversion	8.06	<0.001	0.35	<0.001	CI>VI&RI&LI
Openness	1.64	0.1808	0.16	0.2213	
Agreeableness	1.58	0.1961	0.15	0.2324	
Conscientiousness	3.64	0.0136	0.23	0.022	RI>CI
Borderline Traits[b]					
Total	9.07	<0.001	0.39	<0.001	CI>RI&LI
Identity Problems	8.53	<0.001	0.38	<0.001	CI>RI&LI
Affective Instability	8.19	<0.001	0.37	<0.001	CI>VI&RI&LI
Negative Relationships	2.83	0.0397	0.23	0.0568	
Impulsivity	5.05	0.0022	0.29	0.0044	CI>RI&LI
Interpersonal Problems[c]					
Interpersonal Sensitivity	10.81	<0.001	0.38	<0.001	CI>RI&LI
Interpersonal Ambivalence	6.49	<0.001	0.26	<0.001	CI>VI&RI&LI
Interpersonal Aggression	4.4	0.0048	0.25	0.009	CI>RI&LI
Interpersonal Support[d]					
Low Self Esteem	11.92	<0.001	0.38	<0.001	CI>RI&LI, VI>LI
Low Belonging	7.85	<0.001	0.33	<0.001	CI>RI&LI
Low Appraisal	5.26	0.0015	0.26	0.0032	CI>RI&LI
Low Tangible	10.14	<0.001	0.33	<0.001	CI>VI&RI&LI
Social Problem Solving[e]					
Total	6.48	<0.001	0.28	<0.001	CI&RI>LI
Positive Problem Orientation	3.77	0.0111	0.23	0.0185	RI&LI>CI
Negative Problem Orientation	6.88	<0.001	0.28	<0.001	CI>RI&LI, VI>LI
Rational Problem-Solving	2.02	0.1667	0.17	0.1386	
Impulsivity/Carelessness	4.88	0.0025	0.23	0.0048	CI>RI&LI
Avoidance	3.49	0.016	0.20	0.0247	CI>LI

Burdensomeness[f]	11.83	<0.001	0.41	<0.001	CI>VI&RI&LI

Impulsivity

Barratt Impulsiveness Scale[g]					
Attentional	5.2	0.002	0.35	0.0042	CI>RI&LI
Motor	1.25	0.2937	0.17	0.3325	
Nonplanning	3.47	0.0167	0.22	0.025	CI>RI&LI
Impulsive Behavior Scale[h]					
Negative Urgency	9.61	<0.001	0.36	<0.001	CI>RI&LI
Lack of Premeditation	4.07	0.0076	0.26	0.0131	CI>RI&LI
Lack of Perseveration	2.67	0.0485	0.20	0.0676	
Positive Urgency	7.54	<0.001	0.30	<0.001	CI>RI&LI

Suicidal Ideation

Current					
Baseline ideation	92.08	<0.001	0.92	<0.001	CI&VI&RI>LI
Variability (RMSSD)	140.48	<0.001	1.15	<0.001	CI>VI&RI&LI; VI>LI
Mean	197.36	<0.001	1.37	<0.001	CI>VI&RI&LI
Maximum	310.59	<0.001	1.72	<0.001	CI>VI&RI&LI; VI>LI
Proportion of 0	131.31	<0.001	1.12	<0.001	CI<VI&RI<LI
Standard Deviation	125.16	<0.001	1.09	<0.001	CI>VI&RI&LI; VI>LI
Worst					
Baseline ideation	141.98	<0.001	1.15	<0.001	CI&VI>RI>LI
Variability (RMSSD)	93.22	<0.001	0.95	<0.001	CI&VI>RI&LI
Mean	160.93	<0.001	1.27	<0.001	CI>VI>RI&LI
Maximum	240.9	<0.001	1.54	<0.001	CI>VI>RI&LI
Proportion of 0	176.31	<0.001	1.3	<0.001	CI<VI<RI<LI
Standard Deviation	93.29	<0.001	0.95	<0.001	CI&VI>RI&LI

Cognition

Dementia Rating Scale[i]					
Total	2.35	0.0729	0.18	0.0951	
Attention	1.08	0.3569	0.11	0.4040	
Initiation and perseveration	2.05	0.1072	0.17	0.1368	
Construction	1.01	0.3904	0.11	0.4183	
Conceptualization	0.29	0.8304	0.05	0.8591	
Memory	2.49	0.0608	0.18	0.0829	
Executive Function[j]	1.57	0.1975	0.12	0.2324	
Premorbid IQ (WAIS-IV)[k]	1.16	0.3273	0.12	0.3637	

Notes: [a]NEO Five Factor Inventory; [b]Personality Assessment Inventory- Borderline; [c]Inventory of Interpersonal Problems; [d]Interpersonal Support Evaluation List; [e]Social Problem Solving Inventory; [f]Perceived Burdensomeness; [g]Barratt Impulsiveness Scale (BIS-11); [h]Urgency, Premeditation, Perseverance, Sensation seeking and Positive urgency impulsive behavior scale; [i]Dementia Rating Scale total score; [j]Executive Interview; [k]Wechsler Test of Adult Reading

Abbreviations: CI=Chronic severe ideators; LI=Low/non-ideators; RI=Fast-remitting ideators; RMSSD= root mean successive squared deviations, VI=Highly variable ideators,

Supplementary Table 3. Differences among the 4 profiles in binary characteristics, covarying for baseline age

Dependent Variable	Deviance (df=3)	P-value
Presence of Past Suicidal Behavior	353.67	0.1815
Gender	458.38	0.0678
Substance Use Disorders		
Lifetime	440.84	<0.001
Current	225.47	0.0012
Anxiety Disorder		
Lifetime	416.56	<0.001
Current	442.63	0.0025

Supplementary Table 4. Mean score of variables on radar plots

Dependent Variable	Low/non-ideators (N=77) M (SD)	Chronic severe ideators (N=93) M (SD)	Highly variable ideators (N=63) M (SD)	Fast-remitting ideators (N=104) M (SD)
A. Personality & Social Characteristics				
Neuroticism	34.34 (8.45)	43.95 (9.03)	39.91 (11.00)	36.23 (8.50)
Introversion*	37.32 (6.94)	31.02 (7.08)	35.47 (8.35)	36.48 (7.55)
Identity Problems	6.97 (3.66)	10.42 (3.73)	9.00 (4.69)	7.10 (3.76)
Affective Instability	6.47 (3.19)	9.31 (3.25)	7.32 (4.36)	6.12 (3.76)
Interpersonal Sensitivity	6.23 (4.14)	9.78 (4.37)	7.93 (4.42)	6.15 (4.02)
Interpersonal Ambivalence	4.53 (4.23)	7.54 (4.98)	4.86 (4.76)	5.04 (4.74)
Low Tangible*	8.64 (2.78)	5.95 (3.12)	7.96 (3.10)	7.82 (3.25)
Low Belonging*	8.08 (2.91)	5.53 (2.58)	6.75 (3.08)	7.40 (3.35)
Low Appraisal*	8.78 (2.64)	6.95 (2.93)	7.82 (2.69)	8.47 (2.89)
Low Self Esteem*	6.66 (2.78)	4.07 (2.42)	4.93 (2.43)	5.89 (2.85)
Negative Problem Orientation	6.21 (3.62)	9.38 (4.48)	8.95 (4.76)	7.30 (4.96)
Burdensomeness	1.19 (1.70)	3.90 (2.99)	3.49 (3.21)	2.32 (2.54)
B. Impulsivity				
Attentional Impulsivity	16.30 (3.47)	19.68 (3.17)	17.70 (4.00)	16.62 (4.99)
Positive Urgency	21.94 (7.05)	28.17 (9.00)	25.71 (9.20)	23.21 (8.59)
Negative Urgency	24.95 (6.82)	31.56 (6.93)	28.33 (7.62)	26.36 (7.69)
Lack of Premeditation	20.42 (4.94)	24.21 (6.37)	22.04 (6.09)	21.12 (6.48)
PAIBOR - Impulsivity	3.34 (2.91)	5.97 (4.22)	5.25 (4.37)	3.88 (3.15)
Aggression	3.82 (3.45)	5.95 (3.96)	4.65 (3.89)	3.91 (3.53)
C. Ideation				
Current				

Baseline ideation	0.14 (0.74)	19.14 (6.74)	17.91 (9.53)	16.41 (11.04)
Variability (RMSSD)	0.11 (0.33)	6.91 (4.09)	1.48 (2.11)	0.65 (1.36)
Mean	0.04 (0.11)	8.91 (5.21)	0.78 (0.97)	0.47 (0.83)
Maximum	0.19 (0.65)	17.16 (6.99)	2.53 (3.53)	1.23 (2.45)
Proportion of 0	0.97 (0.08)	0.19 (0.24)	0.70 (0.31)	0.77 (0.34)
Standard Deviation	0.08 (0.25)	5.76 (3.76)	1.15 (1.69)	0.48 (1.02)
Worst				
Baseline ideation	0.04 (0.19)	24.11 (6.77)	22.37 (8.68)	17.35 (11.06)
Variability (RMSSD)	0.20 (0.59)	7.44 (4.87)	7.25 (5.72)	0.69 (1.39)
Mean	0.08 (0.26)	12.10 (6.31)	6.23 (5.54)	0.52 (0.87)
Maximum	0.35 (0.96)	19.98 (7.47)	13.74 (8.86)	1.30 (2.46)
Proportion of 0	0.96 (0.09)	0.12 (0.20)	0.33 (0.29)	0.75 (0.35)
Standard Deviation	0.16 (0.48)	5.78 (3.85)	5.55 (4.34)	0.51 (1.01)

Note: * indicates variables that have been reversed to risk direction on radar plots.
Abbreviations: PAIBOR= Personality Assessment Inventory-Borderline Scale, RMSSD= root mean successive squared deviations

Supplementary Table 5. Competing Risk model results for pairwise profile comparisons of the risk of suicidal behavior after baseline (unadjusted and age-adjusted models). Significance levels displayed were not adjusted for multiple comparisons.

Contrast	Group comparison of cumulative incidence[a]		Competing Risk Regression, adjusted by age[b]			
	Statistic	**P-value**	**HR**	**95%CI**	**z**	**P-value**
CI vs. LI	23.62	<0.001	99345[c]	-[c]	48.76	<0.001
VI vs. LI	10.92	0.001	48828[c]	-[c]	27.93	<0.001
RI vs LI	3.84	0.050	16758[c]	-[c]	20.88	<0.001
CI vs. VI	3.15	0.076	2.02	0.91-4.49	1.73	0.083
CI vs. RI	16.59	<0.001	5.75	2.25-14.7	3.65	<0.001
VI vs. RI	3.50	0.061	3.21	1.03-10.1	2.01	0.045

Notes: [a] Gray's test for the equality of cumulative incidence functions across groups. Not adjusted for any covariate, but adjusts for the competing risk of natural/accidental death.
[b] Proportional subdistribution hazards regression model of Fine and Gray (1999), with age as a covariate.
[c] Hazard ratios for comparisons to the Low/non-ideators (LI) approach infinity as there are no events of interest in that group
Abbreviations: CI=Chronic severe ideators; LI=Low/non-ideators; RI=Fast-remitting ideators; VI=Highly variable ideators,

Supplementary Table 6. Latent Profile Analysis: profile centroids (mean for each variable used to derive profiles). Only subjects used in the LPA are included, as opposed to similar statistics in table Supplementary Table 4.

Study Timepoint	Ideation aggregate	Timeframe	Low ideators (C1)	Chronic severe ideators (C2)	Highly variable ideators (C3)	Remitting ideators (C4)
Baseline		**Current**	0.69	19.14	17.91	17.16

		Worst	0.19	24.11	22.37	17.32
Follow-up	**Mean**	Current	0.17	8.91	0.78	1.14
		Worst	0.38	12.10	6.23	1.25
	Maximum	Current	0.94	17.16	2.53	2.98
		Worst	1.69	19.98	13.74	3.14
	Proportion of 0	Current	0.88	0.19	0.70	0.45
		Worst	0.80	0.12	0.33	0.40
	Standard. Deviation	Current	0.39	5.76	1.15	1.17
		Worst	0.78	5.78	5.55	1.24
	Variability (RMSSD)	Current	0.51	6.91	1.48	1.57
		Worst	0.95	7.44	7.25	1.68

Abbreviations: RMSSD= root mean successive squared deviations

Supplementary Figure 1. Graphs of current ideation over time in final 4 profiles

Current Ideation Over Time
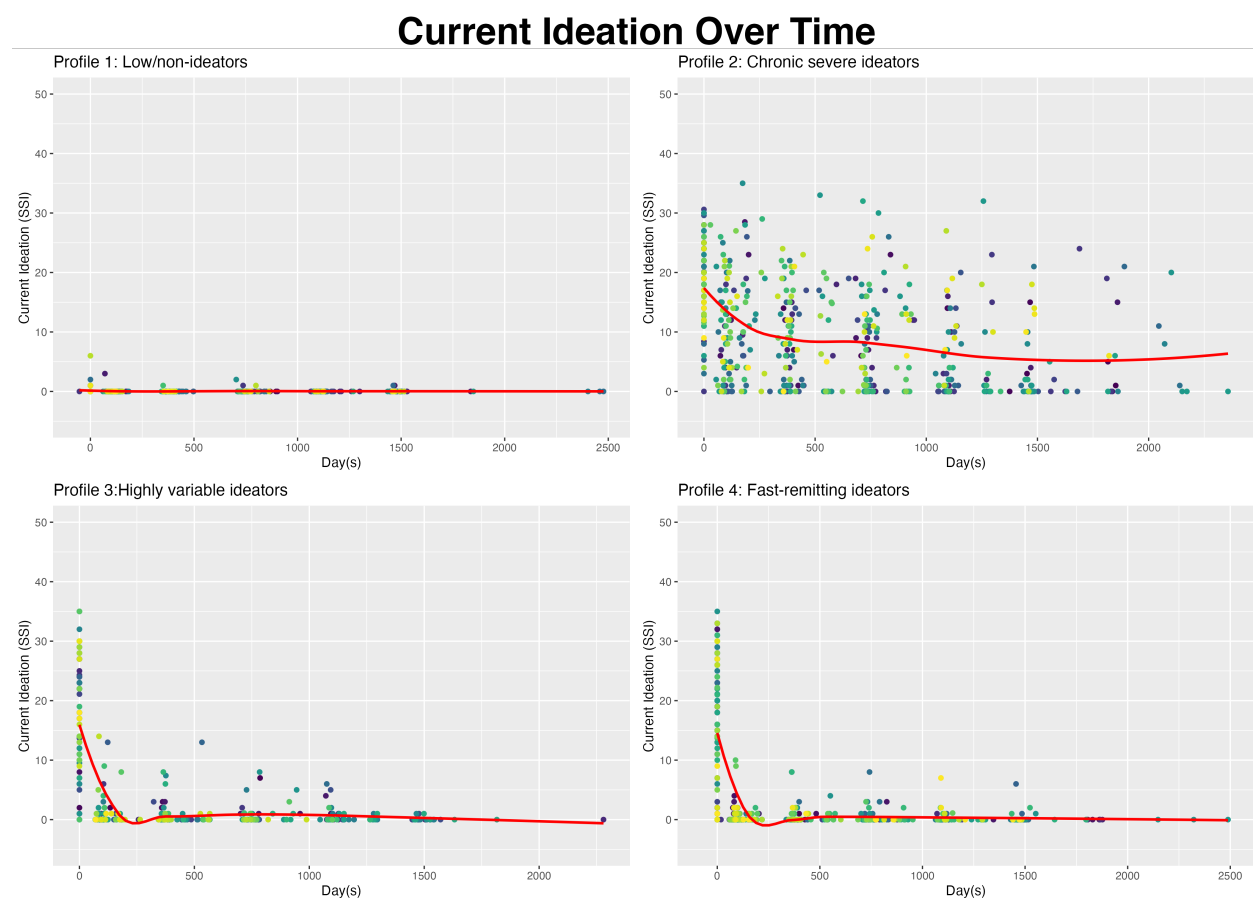
Supplementary Figure 2. Graphs of worst ideation over time

Worst Ideation Over Time