Psychological Pain as a Risk Factor for Suicidal Ideation:

An Ecological Momentary Assessment Study on Inpatients With Depression With and Without Comorbid Borderline Personality Disorder

Ilya Baryshnikov, MD, PhD; Tom H. Rosenström, PhD; and Erkki T. Isometsä, MD, PhD

Abstract

Objective: Psychological pain (PP) is a potentially important risk factor for suicide. However, its temporal stability and association with suicidal ideation (SI) remain obscure. Whether PP represents a risk factor for SI independently of depression, anxiety, and hopelessness or is more prominent and temporally unstable in patients with depression and borderline personality disorder (BPD) is also unclear.

Methods: From November 2020 to December 2022, psychiatric inpatients with depression without (N = 37) and with (N = 30) BPD were recruited to an ecological momentary assessment (EMA) study, wherein their PP, severity of depression, SI, and hopelessness were assessed 3 times daily using visual analog scales. Multilevel regression models were estimated.

Results: Altogether, 4,320 EMA observations were collected. PP correlated with hopelessness ($r = 0.417$), depression ($r = 0.339$), and anxiety ($r = 0.496$), but the between-patient variance of PP remained at 1.26 (95% CI, 1.025–1.533) after controlling for these variables. The within-patient variance of PP was associated with SI (β = 0.17 [95% CI, 0.12–0.22]) with a magnitude comparable to hopelessness (β = 0.1 [95% CI, 0.05–0.15]) and depression (β = 0.12 [95% CI, 0.08–0.17]). Patients with depression and BPD reported higher daily PP and SI ($P < .001$) and a more prominent within-patient variation in PP.

Conclusions: In psychiatric inpatients with depression, besides depression and hopelessness, PP represents an independent risk factor for SI, varying within a timescale of days. Depressive patients with BPD may experience more prominent and temporally unstable PP, likely underlying their higher vulnerability to SI.

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Despite numerous psychological theories conceptualizing the suicidal process,[1] the factors underlying the emergence of suicidal ideation (SI) remain unclear, motivating researchers to investigate other potential psychological factors. Edwin Shneidman introduced the concept of psychological pain (PP) in his cubic model of suicide, postulating "psychache" as a central precondition for SI and suicide.[2] The Three-Step Theory (3ST) suggests that hopelessness and PP together cause SI.[3] Cross-sectional studies on nonclinical and clinical samples have shown higher PP in those with current and lifetime history of SI and suicide attempts, even at the same level of depression.[4] However, prospective clinical studies on PP are sparse and methodologically heterogeneous[5] and have yielded inconsistent results.[6,7]

The role of PP in the suicidal process remains unclear due to its inconsistent definition and partial overlap with other risk factors of suicide.[5] Shneidman defined "psychache" as "hurt, anguish, soreness, aching (...) in the psyche, the mind."[2] In the 3ST, PP is a broad concept, including depression, general distress, most mental disorders, physical pain, and financial distress.[3] PP strongly correlates and covaries with severity of depression.[7] Similarly, anxiety and hopelessness covary with depression.[8] Whether PP represents a distinct experiential concept, different from depression, anxiety, and hopelessness, is not evident. Furthermore, whether PP is associated with SI independently of hopelessness and depression remains unclear.

Ecological momentary assessment (EMA) studies have demonstrated temporal instability of SI,[9] revealing also that the risk factors predicting changes in SI over months and years do not predict SI over hours and days.[10] Temporal stability of a risk factor determines its state and trait characteristics.[11] While temporally stable

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Clinical Points

- Psychological pain (PP) is a potentially important risk factor for suicidal ideation (SI). However, the independence of risk from concurrent depression, anxiety, or hopelessness remains unknown.
- PP was found to be an independent risk factor for SI in depressed inpatients. It was more prominent and temporally unstable in inpatients with borderline personality disorder.

risk factors represent trait-like vulnerabilities and help clinicians to identify persons at risk, state-dependent, unstable risk factors may serve as proximal indicators of risk if they covary with the outcome. We are not aware of EMA studies examining temporal fluctuation of PP in patients with depression.

Patients with depression and comorbid BPD display a higher risk for current SI than depressed patients without BPD.[12] SI in patients with BPD is often related to unstable relationships and abandonment,[13] an experience probably provoking greater PP in patients with depression and comorbid BPD.[14,15] Furthermore, interpersonal hypersensitivity,[16] a feature attributed to BPD, may predispose to even more fluctuations of both PP and SI. PP in patients with BPD has been shown to be higher than in healthy controls,[15,17] but evidence for the hypothesis on PP being more prominent in depressed patients with BPD than those without BPD is sparse and only partially supported.[18]

In our EMA study on inpatients with depression, we tested the following hypotheses: (A) PP covaries with severity of depression, anxiety, and hopelessness but is also partly independent of these; (B) PP is associated with SI at least partly independently of depression and hopelessness; and (C) patients with depression and comorbid BPD report a higher level of PP than patients without BPD, and PP fluctuates over time in patients with depression such that the within-patient variation in PP is greater in patients with comorbid BPD.

METHODS

Setting

The study was conducted between November 6, 2020, and December 1, 2022, in the acute psychiatric inpatient ward of Jorvi Hospital, Helsinki University Hospital, Finland. The ethical committee of the Helsinki and Uusimaa Hospital District has approved the research protocol.

Sampling

Inclusion criteria were (1) patients' age ≥18 years, (2) provision of written informed consent, and (3) principal diagnoses F32.x or F33.x according to the *International Classification of Diseases, 10th Revision* (*ICD-10*).[19] Patients with (1) current psychotic symptoms, (2) principal *ICD-10* diagnoses other than depression, (3) current substance use disorder, (4) insufficient Finnish language skills, (5) any comorbid personality disorder other than BPD as a principal diagnosis, or (6) being treated involuntarily were excluded from the study.

Diagnoses

All patients had clinical *ICD-10* diagnoses of unipolar depression (F32.x or F33.x). We also confirmed the presence of *DSM-IV* major depressive disorder with the Mini-International Neuropsychiatric Interview, version 6.0.0,[20] and the diagnosis of BPD with the Structured Clinical Interview for *DSM-IV* Axis II Personality Disorders.[21]

Baseline Evaluation

At admission, the patients providing written informed consent filled in the following self-report questionnaires: the Patient Health Questionnaire-9 (PHQ-9),[22] the Overall Anxiety Severity and Impairment Scale (OASIS),[23] the Alcohol Use Disorders Identification Test (AUDIT),[24] the McLean Screening Instrument for Borderline Personality Disorder (MSI-BPD),[25] the Mood Disorder Questionnaire (MDQ),[26] the Beck Hopelessness Scale,[27] and the modified version of the Physical and Psychological Pain Visual Analog Scale (PPP-VAS).[28] In addition, we collected data on patients' demographic characteristics and history of lifetime suicide attempts and self-harming acts (including suicide attempts and nonsuicidal self-injury [NSSI]) before admission from medical records.

Modified Version of PPP-VAS

The PPP-VAS is a self-report scale for the measurement of current, mean, and worst physical (item 1) and psychological (item 2) pain during the last 15 days and current, mean, and worst SI (item 3) during the last 15 days on a visual analog scale (from no pain or SI to maximal intensity).[29] The patients were asked to draw a vertical line in the boxes (under each item), the length of which is 100 mm, to reflect the intensity. The PPP-VAS includes no explicit definition for PP. The PPP-VAS was translated into Finnish by the authors. In this study, we modified the original version of the PPP-VAS by adding 3 items measuring current, mean, and worst anxiety, depression, and hopelessness during the last 15 days.

Follow-up Evaluation

During the period of hospitalizations, the study patients were asked to fill in 3 times daily (at 8:00, 15:00, and 21:00) the paper-based follow-up questionnaire, including 6 items measuring the level of current physical

and psychological pain, SI, anxiety, hopelessness, and depression on a visual analog scale similar to the PPP-VAS. The length of the boxes in the follow-up questionnaire was also 100 mm. No systematic reminders of need to respond were used.

Statistical Analyses

We transformed the proportional scales, taking values in the range from 0 to 1 onto continuous-valued scales using Logit transformation. To avoid infinite transformed values, reported zero proportions (eg, no pain) were first set to 0.01 (or 1%) and reported unit proportions were set to 0.99. For example, only 81 (12%) and 23 (3%) of 696 PP values were zeros and ones, respectively. For depression, only 1% and 4% were zeros and ones, respectively. Because of the relatively few such observations, the overall sample size and the associated risk of convergence issues, and the lack of existing technical solutions, we avoided implementing the otherwise possible beta-distributed outcomes within multilevel models.

Regarding hypothesis A, complete dependence between variables is impossible due to measurement errors. However, in multilevel models,[30,31] the measurement errors are present in model residuals rather than in the random intercept (patient-specific means). Hence, we operationalize this question by asking whether there is a statistically significant random intercept in PP after controlling for the fixed effects of anxiety, depression, and hopelessness. A simple appendix (Supplementary Appendix 1) shows that this strategy is reasonable despite some measurement errors in the fixed-effect covariates. The strategy works if between-patient differences in PP exist, which is a safe assumption.

Regarding hypothesis B, we computed new covariates for the within-patient mean effect and within-patient centered effects.[32] For example, the within-patient mean of (Logit-)depression for a given patient was the mean of that patient's all depression reports, whereas the within-patient centered depression comprised from the original values minus the within-patient mean. Our hypothesis B is then supported by a finding where either within-patient mean or centered regression coefficients of PP remain significant when regressing SI on PP and anxiety, depression, and hopelessness.

Regarding hypothesis C, we needed to test for a group difference in the within-patient variation, ie, for a group difference in a "level 1 residual." This requires the so-called heterogeneous variance multilevel model,[33] wherein the within-patient residual can depend on the BPD group dummy variable.

For hypotheses A and B, we used the lme4 R package with its likelihood-profile 95% confidence intervals.[30] For hypothesis C, we used the nlme R package because it allows for the modeling of heterogeneous residuals. We also characterized data in terms of intraclass correlations (ICC), Levene's test for 2 homogeneous variances, and Welch's *t* test for differences in group means.

RESULTS

Patients' Characteristics

We included a total of 67 inpatients with depression, 30 of whom had a comorbid BPD. Clinicodemographic characteristics are presented in Table 1. The duration of the inpatient stay varied from 1 to 14 days, with a mean of 3.2 days. Of the 67 inpatients, 2 answered only the admission questionnaires but did not answer the EMA questions. The median amount of missing EMA data was 15% (range 0%–70%).

Baseline Assessment

At admission, patients with comorbid BPD reported higher levels of current and mean PP; current, mean, and worst SI; and current, mean, and worst anxiety than patients without BPD (Table 2). Patients with a history of suicidal behavior before admission reported higher levels of mean and worst PP and higher levels of mean SI and hopelessness within 15 days before admission (Supplementary Table 1).

Follow-up Assessment

Overall, we collected 4,159 EMA observations over 2–8 days, with a mean follow-up duration of 3.4 days. No difference in the duration of the recorded follow-up between the 2 groups emerged, nor did a group difference in duration variability ($\chi^2 = 0.237$, $df = 1$, $P = .626$ for a fixed effect of BPD on measurement points in a mixed-effects Poisson regression and $\chi^2 = 1.154$, $df = 2$, $P = .562$ for a random effect of BPD). Patients with depression and BPD reported higher daily levels of both PP and SI, particularly during the first days of hospitalization (Figure 1).

PP as an Independent Experience

We had altogether 686 full observations on the question. The estimated between-patient standard deviation in PP was 1.477 (95% CI, 1.215–1.79), whereas the (within-patient and error) residual was 1.467 (95% CI, 1.389–1.552), yielding an ICC of 0.504. When hopelessness, depression, and anxiety were added as fixed-effect covariates to this model, the estimated between-patient standard deviation was 1.26 (95% CI, 1.025–1.533), whereas the (within-patient and error) residual was 1.276 (95% CI, 1.205–1.348), yielding an ICC of 0.494. As the between-patient variance persisted as statistically significant despite the adjustment, we conclude that PP was partly independent of these other variables. To further verify this, we compared (like in the supplementary simulation, Supplementary Appendix 1)

Table 1.

Clinicodemographic Characteristics of 67 Inpatients With Depression at Admission

Variable	MDD (n = 37)	MDD + BPD (n = 30)	*P*
Gender			NS
Male	13	5	
Female	20	24	
Others	4	1	
Age (mean ± SD), y	43 ± 15.8	30.3 ± 8.4	<.0005
Marital status[a]			NS
Married or cohabiting	10	9	
Single	26	21	
Work status[b]			NS
Employed or studying	17	12	
Unemployed	4	1	
Sick leave or disability pension	10	12	
Suicidal behavior			
Lifetime suicide attempts (median)	1	3	<.0005
Suicide attempts and NSSI before admission (n)	7	18	.01
First principal diagnosis			
Major depressive disorder, single episode	3	7	NS
Recurrent depressive disorder	34	23	
Self-report scales			
PHQ-9 (mean ± SD)[c]	20 ± 4	21 ± 3	NS
OASIS (mean ± SD)[c]	15.2 ± 2.8	17.6 ± 4.7	.015
MSI (mean ± SD)[d]	2.7 ± 1.6	7.8 ± 2	<.0005
AUDIT (mean ± SD)[e]	4.1 ± 6	5.2 ± 7.9	NS
MDQ (mean ± SD)[f]	4 ± 4.8	6.6 ± 4.1	.02
BHS (mean ± SD)[d]	10.1 ± 2.5	11 ± 2.9	NS

[a]Data missing for 1/67.
[b]Data missing for 11/67.
[c]Data missing for 2/67.
[d]Data missing for 3/67.
[e]Data missing for 6/67.
[f]Data missing for 8/67.
Abbreviations: AUDIT = Alcohol Use Disorders Identification Test, BHS = Beck Hopelessness Scale, BPD = borderline personality disorder, MDD = major depressive disorder, MDQ = Mood Disorder Questionnaire, MSI = McLean Screening Instrument, NS = not significant, NSSI = nonsuicidal self-injury, OASIS = Overall Anxiety Severity and Impairment Scale, PHQ-9 = Patient Health Questionnaire-9, SD = standard deviation.

Table 2.

Means and SDs of the Modified Version of the PPP-VAS Items of 67 Inpatients With Major Depressive Disorder at Hospital Admission[a]

	MDD (n = 37) (mean ± SD)	MDD + BPD (n = 30) (mean ± SD)	*P*
Physical pain, mm			
Current[b]	26.4 ± 24	30.3 ± 26.3	NS
Mean of the last 15 days[c]	37.7 ± 25.7	40 ± 26.1	NS
Worst over the last 15 days[c]	52.2 ± 30.1	58.3 ± 30.4	NS
Psychological pain, mm			
Current[c]	51.6 ± 27.5	75.2 ± 18	.001
Mean of the last 15 days[b]	63.9 ± 22.4	74.8 ± 13.4	.025
Worst over the last 15 days[d]	81.9 ± 24.3	91.1 ± 9.2	NS
Suicidal ideas, mm			
Current[b]	35.1 ± 28.6	57.8 ± 26.9	.02
Mean of the last 15 days[b]	50.1 ± 24	68.8 ± 27.7	.05
Worst over the last 15 days[b]	70 ± 29.3	87 ± 23	.01
Hopelessness, mm			
Current[b]	62.6 ± 23.5	68.5 ± 22.3	NS
Mean of the last 15 days[b]	67.4 ± 19	69.3 ± 23.7	NS
Worst over the last 15 days[b]	84.5 ± 19	88 ± 13.4	NS
Depression, mm			
Current[b]	65 ± 22.2	78.6 ± 18.1	.009
Mean of the last 15 days[b]	68.3 ± 15	75.7 ± 20.7	NS
Worst over the last 15 days[b]	83 ± 16	90 ± 12	.05
Anxiety, mm			
Current[b]	56.4 ± 29.2	74.3 ± 23.4	.009
Mean of the last 15 days[b]	62.8 ± 24	79.6 ± 19	.003
Worst over the last 15 days[b]	81.6 ± 25.6	93 ± 7.3	.02

[a]Items are presented on the Likert scale 0–100 mm.
[b]Data missing for 2/67.
[c]Data missing for 3/67.
[d]Data missing for 4/67.
Abbreviations: BPD = borderline personality disorder, MDD = major depressive disorder, mm = millimeter, NS = not significant, PPP-VAS = Physical and Psychological Pain Visual Analog Scale, SD = standard deviation.

model 1 (random effects, no fixed effects), model 2 (random and fixed effects), and model 3 (no random effects, fixed effects only) in terms of Akaike's (2,632.2, 2,455.3, and 2,694.9, respectively) and Bayesian information criteria (2,645.8, 2,482.5, and 2,717.6, respectively). As lower values in the criteria indicate more parsimonious models, both the criteria support partly independent experience of PP across the patients (and excluding the measurement errors). PP correlated with hopelessness ($r = 0.417$), depression ($r = 0.339$), and anxiety ($r = 0.496$) across all data.

Comparative Strengths of Associations Between PP and SI

Table 3 shows that PP was associated with SI (model 1). Notably, the within-patient variation in PP was an independent predictor of SI even after adjusting for all other variables and BPD (Table 3, model 5, within-patient covariates).

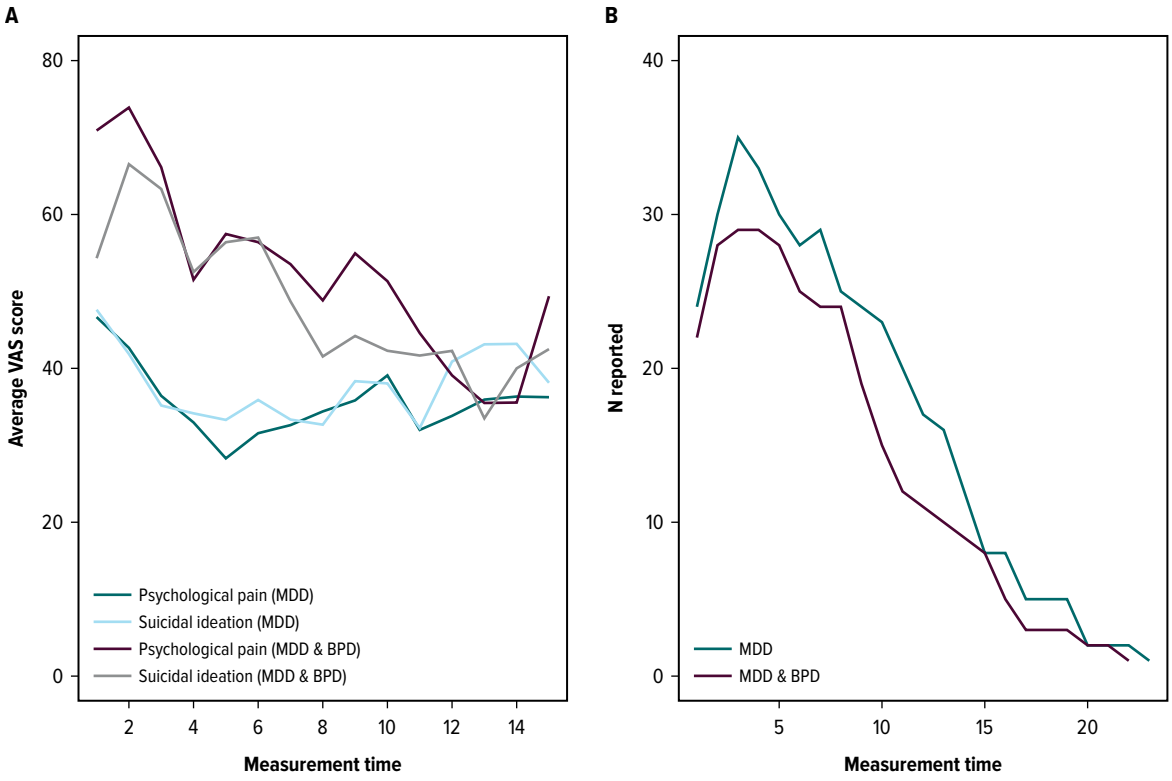
Heterogeneity of PP in Patients with Depression With and Without BPD

The BPD patients had clearly higher average PP than the others but only slightly less variance in their patient-specific averages (Figure 2A). By definition, the average patient-centered PP did not differ between the groups, but the variance clearly did (Figure 2B). These illustrative computations neglect the considerable uncertainty in the patient-specific means (the dots in Figure 2A), which were estimated from 11 reports on average (SD 4.8). Therefore, we did a formal test using the heterogeneous variance multilevel model.

We first tested the effects of BPD on between-patient variance in PP by comparing a PP model that had a fixed effect for BPD only (model a) to a model that also had a random effect for BPD (model b) and found none ($F = 0.000$, $df = 1$, $P = .999$ in a likelihood-ratio test). We then tested effects of BPD on within-patient variance in PP by comparing model a to a model that had a heterogeneous

Figure 1.

(A) Means of PP and SI Assessed on the VAS (Range 0–100 mm) in Patients With Depression With and Without Comorbid BPD; (B) Number of Reports[a]



[a]"Measurement time" indicates the ordinal number of the ecological momentary assessment.
Abbreviations: BPD = borderline personality disorder, MDD = major depressive disorder, N = number, VAS = visual analog scale.

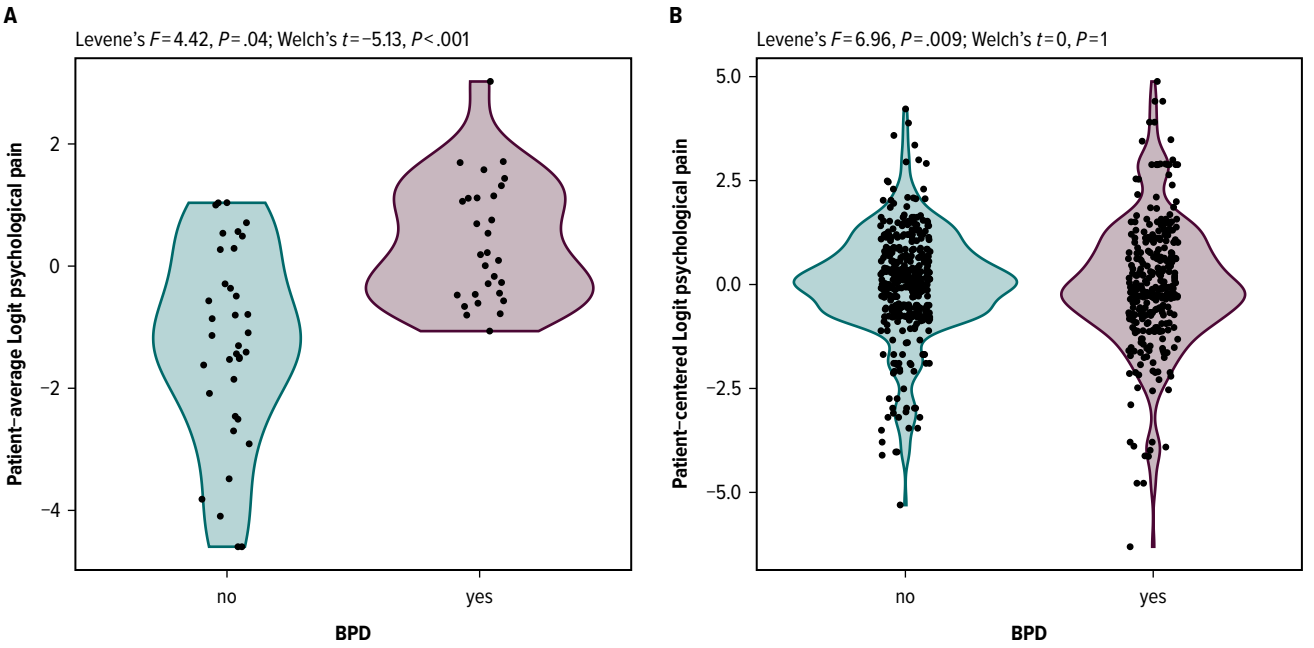
Table 3.

Multilevel Models Predicting SI (Standardized Variables/Coefficients)[a]

	Model 1	Model 2	Model 3	Model 4	Model 5
Fixed effects					
Within-patient covariates					
Psychological pain	0.25 (0.21 to 0.29)				0.17 (0.12 to 0.22)
Hopelessness		0.25 (0.21 to 0.29)			0.10 (0.05 to 0.15)
Depression			0.24 (0.19 to 0.28)		0.12 (0.08 to 0.17)
Anxiety				0.17 (0.13 to 0.22)	0.03 (−0.02 to 0.07)
Between-patient covariates					
Psychological pain	0.31 (0.14 to 0.48)				0.12 (−0.05 to 0.28)
Hopelessness		0.58 (0.45 to 0.71)			0.10 (0.05 to 0.15)
Depression			0.53 (0.4 to 0.66)		0.12 (0.08 to 0.17)
Anxiety				0.31 (0.12 to 0.5)	0.03 (−0.02 to 0.07)
BPD					0.15 (−0.15 to 0.44)
Random effects					
Between-patient	0.698	0.503	0.523	0.718	0.457
Within-patient	0.568	0.567	0.575	0.595	0.524

[a]Accurate 95% likelihood-profile confidence intervals are provided in parentheses. Models 1–4 present fixed effects for patient-specific time averages (between-patient covariates) and within-patient variations from their time averages (within-patient covariates) for 1 construct only, whereas model 5 includes all 9 fixed-effect covariates (including BPD status) in the same model. The between-patient random effect stands for the random-intercept standard deviation of psychological pain and the within-patient random effect for that of the residual.
Abbreviations: BPD = borderline personality disorder, SI = suicidal ideation.

Figure 2.
Violin Plots of PP Reports[a]



[a]Black dots show the actual observations, with random jitter added to the x-axis for visibility. Test statistic and *P* values are given for Levene's test of homogeneity in group variances and for Welch's *t* test for differences in group averages. A, Patient-specific averages. Each point corresponds to an average of a patient's all Logit-transformed psychological pain reports. B, Patient-centered values. Each point corresponds to a patient's Logit-transformed psychological pain score's deviation from that patient's time average. Thus, each patient has multiple values, one per experience-sampling report.
Abbreviations: BPD = borderline personality disorder, PP = psychological pain.

variance structure (a parameter for BPD multiplier of residual variance; model c). A clear difference was seen between these models ($F = 9.482$, $df = 1$, $P = .002$). Finally, a model combining all of the above effects (model d; Supplementary Table 2) significantly differed from model b ($F = 9.482$, $df = 1$, $P = .002$), but not from model c ($F = 0.000$, $df = 1$, $P = .999$), indicating that only the within-patient variance actually differed by BPD status; the between-patient variance did not. The BPD status increased the within-patient variance even when a linear fixed-effect trend for measurement number (ie, time) was added to models a and c ($F = 4.330$, $df = 1$, $P = .037$) and further, in practice, also when BPD moderation of that trend was allowed for ($F = 3.809$, $df = 1$, $P = .051$).

DISCUSSION

In this EMA study on inpatients with depression, we found support for our hypotheses: (A) During the brief period of follow-up, PP covaries and correlates with hopelessness, depression, and anxiety but appears as a distinct experience even after controlling for them. (B) PP is associated with the within-patient variation in SI independently of depression, hopelessness, and anxiety. Finally, (C) patients with depression and comorbid BPD reported higher PP and SI during hospitalization. PP fluctuates over a brief period of time, representing both state- and trait-dependent characteristics. Temporal fluctuation of PP is more prominent in patients with comorbid BPD.

Our study has several strengths. We collected prospective data on 67 psychiatric inpatients and more than 600 concurrent observations on their current PP, hopelessness, depression, anxiety, and SI, allowing us to examine short-term variations of these phenomena. The study patients do not differ from patients being treated in the acute psychiatric ward in terms of age or the duration of the inpatient stay. The diagnoses were verified with clinical interviews.

Our study has some limitations. First, the study was conducted in a busy inpatient ward; patients were not systematically reminded to answer the follow-up questionnaires, and some stopped responding. However, we collected prospective data on average for 3.4 successive days of hospitalization, allowing us to investigate the short-term variation in SI and its potential risk factors within this period during which inpatients were likely the most suicidal. Second, our sample is relatively small, limiting the generalizability of the findings. Replications in future studies with larger sample sizes are needed.[30] However, the number of

repeated observations was still sufficient for the analyses and statistical significance. Third, we have not studied the predictive value of PP for self-harming acts, but only SI. Fourth, the context of the study is the acute psychiatric ward, differing from patients' real-life circumstances, affecting generalizability to outpatients. Fifth, the effect of treatment was not considered. Sixth, we studied only depressed inpatients with BPD, and therefore, our findings do not necessarily apply to nondepressed BPD patients. Seventh, we did not use any validated clinician-rated scales for the evaluation of SI and depression.

In line with previous reports,[7,34,35] in our study, daily assessed PP moderately correlated and covaried with hopelessness, depression, and anxiety, underlying the conceptual overlap between them. However, when inpatients with depression were asked to assess their PP without defining it with the VAS, the patients seemed to be able to separate PP from hopelessness, depression, and anxiety. In other words, PP reported by suicidal inpatients in our study is not fully explained by depression, hopelessness, or anxiety, instead representing a separate quantifiable experience. Therefore, PP may be considered a potential distinct risk factor for suicidal behavior, partly different from them.

PP remained one of the significant predictors (besides depression and hopelessness) for the within-patient variation in SI, when adjusted for all 3 covariates: depression, anxiety, and hopelessness, and BPD. This finding is consistent with previous cross-sectional studies[4] and partly with a prospective study on psychiatric inpatients,[7] showing that the interaction between PP and hopelessness explains the variation in SI in psychiatric patients. However, while in the 3ST, depression is considered to be included in the concept of "Pain,"[3] in our study, in addition to PP and hopelessness, the severity of depression also remained as a significant predictor after controlling for the effect of hopelessness, anxiety, and PP. Furthermore, we have shown that PP fluctuates over time, representing a state- and trait-related risk factor for SI. Thus, PP together with depression and hopelessness may represent a predictor for the short-term within-patient variation in SI in suicidal inpatients with depression.

In line with our hypothesis C, inpatients with depression and BPD report higher levels of PP and SI, even though the severity of depression and hopelessness was the same as in patients with depression but without BPD. Stronger SI in patients with depression and BPD than in patients without BPD has been previously reported.[12] Our study is, to our knowledge, the first EMA study indicating higher daily experience of PP in inpatients with depression and BPD. More extensive PP in inpatients with depression and BPD supports the theory of an association between disrupted endogenous opioid system, alerted affiliative behavior, and higher PP in patients with BPD.[14,36] We have also found that the within-patient variation in PP is greater in patients with depression with BPD than in patients without BPD. This is consistent with previously reported temporal instability of some of the depressive symptoms in patients with comorbid BPD.[37] In accord with the theory of a relation between alerted affiliative behavior and BPD,[14] numerous social interactions during the inpatient treatment may partly explain the temporal instability of PP in patients with comorbid BPD.

To conclude, in this EMA study, PP represents an important predictor of the within-patient variation in SI, alongside severity of depression and hopelessness, in a sample of inpatients with depression. PP is more extensive and temporally unstable in inpatients with depression and comorbid BPD, probably making them vulnerable to higher suicidality. Future research with a greater sample size and longer follow-up should focus on the predictive value of PP for suicidal acts.

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Supplementary Material

Article Title: Psychological Pain as a Risk Factor for Suicidal Ideation: An Ecological Momentary Assessment Study on Inpatients With Depression With and Without Comorbid Borderline Personality Disorder

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LIST OF SUPPLEMENTARY MATERIAL FOR THE ARTICLE

1. **Table 1** Means and Standard Deviations (SD) of the Modified Version of the Physical and Psychological Pain - Visual Analog Scale (PPP-VAS) Items of 67 Inpatients With Major Depressive Disorder at Hospital Admission Depending on a History of Suicidal Behavior Shortly Before Admission
2. **Table 2** Fixed,Random, and Residual (Variance-Function) Effects in the Heterogeneous Variance Multilevel Model of Psychological Pain
3. **Appendix 1** A Simulation Test of the Procedure for the Hypothesis A

DISCLAIMER

Supplementary table 1. Means and standard deviations (SD) of the modified version of the Physical and Psychological Pain - Visual Analog Scale (PPP-VAS) items of 67 inpatients with Major Depressive Disorder at hospital admission depending on a history of suicidal behavior shortly before admission

	With a history of suicidal behavior before admission (n=25)	Without history of suicidal behavior before admission (n=42)	p
	Mean ± SD	Mean ± SD	
Physical pain (mm)			
Current[1]	26.7 ± 29	29.1 ± 22.6	ns
Mean of the last 15 days[1]	37.3 ± 29.2	39.7 ± 23.7	ns
Worst over the last 15 days[2]	56 ± 30.5	55 ± 30.3	ns
Psychological pain (mm)			
Current[2]	65.4 ± 23.9	59.1 ± 28.6	ns
Mean of the last 15 days[3]	77.3 ± 12.9	65 ± 21	0.008
Worst over the last 15 days[3]	93 ± 7	82.3 ± 22	0.032
Suicidal ideas (mm)			
Current[1]	49.5 ± 33.3	43.3 ± 27.9	ns
Mean of the last 15 days[1]	68.7 ± 26	52.9 ± 26.2	0.02
Worst over the last 15 days[1]	85.2 ± 26	73 ± 28	ns
Hopelessness (mm)			
Current[1]	65.9 ± 22	65 ± 24	ns
Mean of the last 15 days[1]	74.9 ± 18	64.4 ± 22.5	0.05
Worst over the last 15 days[1]	90.8 ± 11	83 ± 18	ns
Depression (mm)			
Current[1]	75 ± 22	69.3 ± 21.4	ns
Mean of the last 15 days[1]	71 ± 19	72 ± 17	ns
Worst over the last 15 days[1]	89 ± 13	85 ± 16	ns
Anxiety (mm)			
Current[1]	64 ±31.7	65 ± 26	ns
Mean of the last 15 days[1]	76 ± 23	67.4 ± 23.3	ns
Worst over the last 15 days[1]	89 ± 20.2	86 ± 20.3	ns

Items are presented as the Likert Scale 0-100 mm.

mm – millimeters.

[1]data missing for 1/67

[2]data missing for 3/67

[3]data missing for 4/67

Supplementary table 2. Fixed, random, and residual (variance-function) effects in the heterogeneous variance multilevel model of psychological pain.

	Estimate	**95 % Confidence interval**
Fixed-effect intercept	-1.255	(-1.7, -0.811)
Fixed-effect BPD	1.633	(0.948, 2.317)
Random-effect intercept	1.276	(1.047, 1.556)
Random-effect BPD	0	(0, 9.069×10^{18})
Variance-function intercept	1	(1, 1)
Variance-function BPD	1.189	(1.065, 1.328)

Note: BPD = Borderline Personality Disorder. Random-effects capture the between-patient variability, whereas the variance-function effects capture the relative within-individual (residual) variance, given the fixed-effect covariates. The confidence intervals are approximate only.

Supplementary Appendix 1

A simulation test of the procedure for the hypothesis A:

The below R code verifies that our procedure does not falsely detect independence of PP (y) from other variables (x1 and x2) when no true independent between-patient variance exist in y (i.e., the procedure is not biased):

```
library(lme4)

# simulate data
nO <- 10; nP <- 70 # Number of person observations and persons
# initialize random seed and data frame
set.seed(3729)
dsim <- data.frame(x1 = rep(0, nO*nP), x2 = rep(0, nO*nP),
                   y = rep(0, nO*nP), id = rep(1:nO, each = nP))
# simulate patient-specific means in covariates
x1 <- rnorm(nP)*sqrt(1/3); x2 <- rnorm(nP)*sqrt(1/3)
# simulate within-patient variations in covariates
for (ip in 1:nP){
  dsim$x1[(1+(ip-1)*nO):(ip*nO)] <- x1[ip] + rnorm(nO)*sqrt(1/3)
  dsim$x2[(1+(ip-1)*nO):(ip*nO)] <- x2[ip] + rnorm(nO)*sqrt(1/3)
}
# simulate measurement noise
dsim$y <- dsim$x1 + dsim$x2 + rnorm(nO*nP)*sqrt(1/3) # y is mainly x's
dsim$x1 <- dsim$x1 + rnorm(nO*nP)*sqrt(1/3) # measurement error in x1
dsim$x2 <- dsim$x2 + rnorm(nO*nP)*sqrt(1/3) # measurement error in x2

# Test whether y has a random effect before and after controlling x's
# An uncontrolled random effect (between-patient variability) exists:
mf1 <- lmer(y ~ 1 + (1|id), data = dsim)
confint(mf1)[".sig01",]

## Computing profile confidence intervals ...

##     2.5 %    97.5 %
## 0.2166574 0.6275432

# An adjusted random effect CI overlaps with zero (non-signif.)
mf2 <- lmer(y ~ 1 + x1 + x2 + (1|id), data = dsim)
confint(mf2)[".sig01",]

## Computing profile confidence intervals ...

##     2.5 %    97.5 %
## 0.0000000 0.2221984
```

```r
# AIC/BIC model selection favors regression without a random effect
mf3 <- lm(y ~ 1 + x1 + x2, data = dsim)
AIC(mf1,mf2,mf3)

##     df      AIC
## mf1  3 2330.180
## mf2  5 1876.145
## mf3  4 1862.356

BIC(mf1,mf2,mf3)

##     df      BIC
## mf1  3 2343.833
## mf2  5 1898.901
## mf3  4 1880.561
```