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The Association between Daily Posttraumatic Stress Symptoms and Pain over the First 14-days after Injury: An Experience Sampling Study

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Abstract

Objectives. Psychosocial factors and responses to injury modify the transition from acute to chronic pain. Specifically, posttraumatic stress disorder symptoms (PTSS; reexperiencing, avoidance, and hyperarousal symptoms) exacerbate and co-occur with chronic pain. Yet no study has prospectively considered the associations among these psychological processes and pain reports using experience sampling methods (ESM) during the acute aftermath of injury. This study applied ESM via daily text messaging to monitor and detect relationships among psychosocial factors and post-injury pain across the first 14-days after emergency department (ED) discharge.

Methods: We recruited 75 adults (59% male; *M* age = 33) who experienced a potentially traumatic injury (i.e., involving life threat or serious injury) in the past 24-hours from the EDs of two Level 1 trauma centers. Participants received 5 questions per day via text messaging from Day-1 to Day-14 post-ED discharge; three questions measured PTSS, one question measured perceived social support, and one question measured physical pain.

Results. Sixty-seven participants provided sufficient data for inclusion in the final analyses, and the average response rate per subject was 86%. Pain severity score decreased from a mean of 7.2 to 4.4 over 14 days and 50% of the variance in daily pain scores was within-person. In multilevel structural equation models, pain scores decreased over time, and daily fluctuations of hyperarousal ($b = 0.22$, 95% CI [0.08, 0.36]) were uniquely associated with daily fluctuations in reported pain level within each person.

Conclusions. Daily hyperarousal symptoms predict same-day pain severity over the acute post-injury recovery period. We also demonstrated feasibility to screen and identify patients at risk for pain chronicity in the acute aftermath of injury. Early interventions aimed at addressing hyperarousal (e.g. anxiolytics) could potentially aid in reducing experience of pain.

The Association between Daily Posttraumatic Stress Symptoms and Physical Pain over the First 14-days after Injury: An Experience Sampling Study

In the United States alone, traumatic injury is the leading cause of morbidity and mortality for people under the age of 47 [1, 2], and nonfatal injuries represent approximately 29% of annual emergency department (ED) visits [3]. Most injuries treated in the ED are mild in severity and do not require hospitalization [4], but mildly injured patients often report long-term complications, delayed recovery, and persistent pain following ED discharge [5-7]. Acute post-injury pain transitions into chronic pain when it persists beyond 3-months after the injury [8]. The factors that influence this transition may be therapeutic targets that could reduce the substantial individual and societal burden associated with chronic pain [7, 9, 10].

Physical injury triggers heightened emotions and maladaptive cognitions that impede trauma processing [11] and modify the experience and clinical presentation of pain [12, 13]. Specifically, up to 24% of injured trauma patients report a new-onset psychiatric disorder at 12-months post-injury [14], and an estimated 10-40% develop clinically significant symptoms characteristic of Posttraumatic Stress Disorder (PTSD) [15-17], including intrusive experiences (e.g., nightmares, flashbacks, or triggers), avoidance of trauma-related stimuli, negative changes in beliefs and feelings, and increased physiological arousal and reactivity [18, 19]. These psychological reactions are associated with chronic posttraumatic pain [20, 21], even more so than injury severity or characteristics [5, 9, 22-28]. Additionally, activation of support networks immediately after a traumatic event enhances adjustment to pain [29, 30], and poor social support predicts adverse psychological outcomes ([31, 32]).

Extant literature has focused largely on *chronic pain/disability* emerging at remote time-frames (e.g., 6-months to 3-years post-injury) among severely injured trauma patients [22, 23] and/or those admitted to the hospital for their injuries. Typically, symptom monitoring and assessments do not occur until 4- to 6-weeks [6, 25] or 3-months post-injury (for review, see [28]). Although recent studies focus on acute assessments after minor injury [5, 27, 33-35], large gaps between assessments (e.g., initial assessments in hospital/1-week, then gaps until 6-weeks, 6-months and 1-year post-injury) limit understanding of recovery trajectories and study populations have been in isolated injury sub-types (i.e. whiplash and/or motor vehicle accidents), limiting understanding in general injured patient populations. The subtle relationships between post-injury psychological processes and pain over the acute recovery period could be key in designing interventions to accelerate recovery [36] [37].

One way to elucidate the detailed relationships between psychological processes and pain is through experience sampling methodology (ESM) or ecological momentary assessment (EMA) methodology[38, 39], where an individual is prompted to report symptoms at frequent intervals. ESM/EMA measurements reduce recall bias and allow for greater understanding of trajectories and context-dependence compared to retrospective global survey data. ESM/EMA methods have been used to understand pain[40].

Therefore, the goals of this study were to use ESM methodology to detect relationships between daily PTSD symptoms, social support, and physical pain over the first 14-days after ED-discharge among trauma patients with minor injury. We used text messaging to conduct ESM/EMA given our prior success in collecting ESM/EMA pain data from ED patients[41]. We hypothesized that our average ESM/EMA response rate to daily text messages would be >70% over the course of the 14-days post-injury [42, 43]. We also hypothesized that PTSD symptoms would be positively associated with physical pain and perceived social support would be negatively associated with physical pain.

Method

The Human Research Protection Office of the University of Pittsburgh approved all procedures. The design is a prospective observational study with a feasibility component.

Participants

We recruited adult patients presenting to the EDs of two Level I trauma centers within 24 hours of injury. Eligibility criteria included that patients: 1) suffered a trauma-related injury (e.g., fall, MVA, trauma, assault etc.) within the past 24 hours; 2) were between the ages of 18-60 years old; 3) were medically and emotionally stable enough to provide informed consent; 4) were not being treated primarily for a mental health or substance use issue; 5) did not have a neurological disease (e.g., multiple sclerosis, stroke, brain tumor, seizure disorder, etc.); 6) did not endorse suicidal thoughts or present with a self-inflicted injury; and 7) met Criterion A of the PTSD diagnosis (e.g., patients self-reported that they were exposed to either threatened death [life threat] or actual or serious injury) per the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5[44]). Classification as a trauma alert in the ED was not necessary; trauma alerts are activated for more significant/severe injuries based on criteria related to the mechanism of injury, and physiological and anatomic criteria. Due to the relatively short time frame of enrollment (within 24 hours from the time of injury), severe injuries (such as long bone fractures) were excluded because those patients did not qualify as medically stable during their time in the ED.

Subjects included in this manuscript represent a subset of patients recruited for a parent study examining predictors of PTSD after injury. This subset of patients had to meet additional inclusionary criteria to be eligible for text messaging: to own a personal cell phone with text messaging capabilities, and to be discharged directly home from the ED. Admitted patients were excluded from texting to limit the variability in the timing of the text messages [43]; this method allowed Day 1 to be the same for all participants (e.g., the 1st day after ED discharge), to capture symptoms as close as possible to the time of injury, and to limit the amount of interference due to more complex medical issues and procedures that admitted patients may undergo.

Procedure

Recruitment was based on convenience sampling, and occurred primarily during weekdays in the afternoon-early evening shifts (12-7pm) based on research assistant (RA) availability. No recruitment occurred during late night shifts (after 9pm). An RA identified potential subjects through the ED tracking board based on a potentially trauma-related chief complaint (e.g., fall, MVA, crush, pain/injury, trauma, fracture, eye injury, etc.), age, and time in the ED. Following this initial screen, RA's then approached a member of the patient care team (physicians, nurses, residents, physician assistants) who then further screened the patient for eligibility. Only a member of the care team (vs. the RA) was granted permissions to access the patients chart to determine and confirm that potential subjects: 1) were medically and emotionally stable enough to provide informed consent, 2) had suffered a physical injury within the past 24 hours, 3) were not being treated primarily for a mental health or substance use issue, 4) did not have a neurological disease, and 5) did not endorse suicidal thoughts or present with a self-inflicted injury. Following these two stages of screening, and upon permission by the treating team for the RA to speak with the patient, the RA approached potential subjects in their treatment rooms during breaks in medical care to obtain informed consent, confirm eligibility, and complete a baseline survey.

An automated text-messaging program on a computer server sent daily symptom assessments. Subjects received five text messages daily at 5pm for 14 days following ED discharge (see Table 1 for specific message content): three messages inquired about the DSM-IV PTSD symptom clusters of reexperiencing, avoidance, and hyperarousal, one message inquired about social support, and one message inquired about physical pain. We used DSM-IV (vs. DSM-5) PTSD symptoms for the following reasons: 1) to parallel and replicate the study conducted by Price and colleagues [43]; and 2) at the time of study initiation (early 2015), brief screening assessments had yet to be established for the DSM-5 symptom criteria. The day after ED discharge was Day 1 for each participant. The text messages were sent based on a contingency schedule within each day, wherein message n+1 was contingent upon a response to message n. If a participant did not respond on a given day, they still received the text messages prompts on the following day. The first text message was personalized with their name, and stop functions were available for participants who wished to withdraw from the texting portion of the study. Participants who opted out of text messaging were still eligible to remain in the longitudinal portion of the study, wherein they were re-assessed for psychosocial responses to injury and quality of life at 1- and 6-weeks post-injury.

Participants received $10 compensation in the ED for completion of the baseline survey,

but did not receive any additional compensation for text message compliance. Participants were also compensated $10 for their survey responses at both 1- and 6-weeks post-injury.

Measures

Demographic Information. Participants completed a baseline survey including general demographic questions: sex, age, race, educational background, and employment.

Medical Record Review. The ED pain severity score (range = 0-10) and chief complaint / mechanism of injury were recorded from a medical record review. Chief complaint was later coded by the authors as related to a motor vehicle accident (e.g., car crash, motorcycle crash, or pedestrian/cyclist hit by vehicle), fall, work-related accident, or “other” general accident.

Daily symptoms. Price and colleagues [43] initially developed and tested the text message content to assess posttraumatic sequelae. Three items correspond to each DSM-IV symptom cluster of re-experiencing, avoidance/numbing, and hyperarousal, one item corresponds to social support, and one item to the outcome of physical pain. Table 1 includes the question content and response options. Items are coded such that higher values represent worse symptoms, greater social support, and more pain, respectively.

Data Analysis.

We analyzed data using Mplus version 8 [45]. All analyses were evaluated at an alpha level of $p = .05$. Descriptive statistics described the presence of psychological factors and pain in the ED and during 14-days post-injury. The Intraclass Correlation Coefficient (ICC) for daily pain in a null model described the percentage of variability in daily pain reports due to within vs. between-person variability. A growth curve analysis using multilevel structural equation modeling (MSEM) was also used to determine whether self-reporting a life-threatening injury, participant sex, and ED pain severity score were predictive of pain severity scores over time. Specifically, we created a single model (regressing pain on each covariate) and we also included the within-individual predictor of days since ED admission to examine change over time.

Finally, MSEM was used to examine the relationship between participants' physical pain and their levels of social support and PTSD symptoms on each day over 14 days. MSEM is a flexible statistical approach that encompasses the features of multilevel or mixed effects models and single-level structural equation modeling. For the current study, we chose this method because it partitions the variance of daily assessments into latent between- and within-person portions. Between-person differences as estimated in MSEM has been shown to be more reliable than other methods when individuals differ in the number of reported observations, as is the case in ESM/EMA studies [46].

For the primary analyses, we created four models (regressing pain on each of the 4 posttraumatic predictor variables separately) and we also included the within-individual predictor of days since ED admission to examine whether pain levels changed over time, and whether each of the predictors were uniquely associated with pain above and beyond the effect of time. We included random intercepts and random slopes, and decomposed the variance of observed variables into latent Level 2 (i.e., between-individual) variance and residual Level 1 (i.e., within-individual) variance. Random intercepts account for the dependency of daily observations within persons, and random slopes model expected heterogeneity in predictor-outcome relationships across individuals, both of which contribute to proper estimation of variance structures [47, 48]. We targeted a sample size >50 participants to conduct MSEM, given that level two sample sizes < 50 tend to produce biased standard error estimates (see [49]).

Results

We approached ED patients for the parent study between January 2016 and May 2017 based upon initial screening of age, time of injury, and chief complaint. One-hundred forty-eight patients refused to discuss research and were not screened (e.g., too much pain, not interested in research, no time, or too much other stress). Of the 386 patients screened for the study, 213 were not eligible to participate (e.g., did not meet Criterion A or the injury did not happen within the past 24 hours). Of the 173 eligible patients, 154 (59% male; n = 92; *Mean* age = 35) provided baseline data prior to being discharged.

Although recruitment for the parent study continued until May of 2017, only participants

recruited during January 2016-February 2017 were presented with the option to enroll in the texting portion of the study (*n* = 136). Seventy-five (59% male; *n* = 44*; Mean* age = 34) of the 136 patients recruited during this time-period were willing and eligible to participate in the texting protocol. Of the 61 not enrolled, 28 participants (46%) were deemed ineligible by their treating team due to hospital admission. Of the remaining 33 participants, 6 did not have texting available on their phone, 11 were interested in participants but they did not enroll in the program (reasons unknown), and 16 were not interested.

Comparison analyses using ANOVA between the texting (n = 75) and non-texting sample (n = 61) revealed no significant differences in ED pain score (F (1,111) = 0.19; p = 0.666) or age (F (1,134) = 3.25; p = 0.07). Although not significant, the pattern revealed for age suggests that texters were slightly younger in age (M = 33.56; SD = 11.73) than non-texters (M = 37. 48; SD = 13.59). Further, chi square analyses revealed no differences between the texting and non-texting sample based on sex (χ^2 = 0.19; p = 0.73). However, threat of death related to the injury was significant (χ^2 = 6.44; p = 0.01), such that texters vs. non-texters were less likely to report a threat of death related to the injury. Specifically, 28% (n = 21) of texters reported a threat of death compared to 49% (n = 30) of non-texters.

To determine feasibility of using text messaging to monitor posttraumatic sequelae and pain over the first 14 days post-ED discharge, we graphed the ESM/EMA response rates for 73 of the 75 participants who initially enrolled in the text message program and did not report any technical difficulties with the program (see Figure 1). Approximately 75% had a response rate of 70% or greater, 70% had a response rate of 75% or greater, and approximately 40% of participants responded to 100% of the text messages.

For the final analyses, we excluded 8 (11%) of the 75 participants for the following reasons: opted out of the text message protocol (n = 3); provided no text message data (n = 3); and inability to use text messaging on their mobile device (n = 2). From the 67 participants included in this final sample, the average ESM/EMA response rate was 86% (i.e., 12 out of 14 days), and we obtained a total of 938 ESM/EMA observations. The daily pain ESM/EMA had 114 missing observations (12.15%), the social support item had 119 missing observations (12.69%), the reexperiencing item had 123 missing observations (13.11%), the avoidance item had 128 missing observations (13.65%), and the hyperarousal item had 131 missing observations (13.97%). Linear models revealed that ESM/EMA response rate was not predicted by a variety of covariates measured in this study (i.e., age, sex, ED pain score, life threat, and head injury; all *p*-values > .05; please see Table 2 for data summaries). Additionally, an ANOVA revealed that missing data did not vary across the levels of mechanism of injury (e.g., MVA-related injury, falls, work-related and general accidents; (F (3, 69) = 0.745, p = 0.53).

Demographic and injury-related data for the final sample are summarized in Table 3. Table 4 provides descriptive statistics and within- and between-person correlations. Of note, mean ED pain score was 7.2 (SD = 2.0) out of 10, and 25.4% (n = 17) of subjects perceived their injury as life threatening. Mean ESM/EMA pain score decreased over 14 days but remained at a moderate level (*Mean* = 4.4). On average, participants felt well-supported (*Mean* = 5.5 out of 7), and reported relatively low levels of PTSD symptoms. Between-person correlation analyses revealed that moderate to high correlations emerged among daily PTSD symptoms, and that life threat was significantly associated with the psychosocial factors, but not with physical pain. As expected, social support was negatively associated with daily PTSD symptoms. Within-person correlations revealed that daily reports of avoidance, hyperarousal, and social support were associated with daily physical pain. The ICC for daily pain was 0.50, suggesting that 50% of the variance in daily pain reports was due to between-person variability (day-to-day), and the remaining 50% of the variance was due to within-person and error variance; see Figure 2 for a lattice plot depicting the change in pain over time for each participant).

Results from the growth curve analysis revealed that perceived baseline threat of death was associated with higher ESM/EMA reports of pain severity on Day 1 (B = 1.13, SE = 0.55; p-value = 0.04; 95% CI: 0.05 – 2.21). However, there were no other significant predictors of change in pain severity over time (i.e., non-significant results for ED pain severity score, perceived threat of death, and participant sex). As such, none of these variables were included in the primary MSEM analyses.

In the MSEM analyses (see Table 5), time predicted ESM/EMA pain severity score in each model (all p-values < .001), such that ESM/EMA pain severity scores decreased over 14 days. After accounting for the effect of time, daily fluctuations in hyperarousal were uniquely associated with daily fluctuations in reported pain severity score within each person; social support, intrusions, and avoidance were not associated with daily pain severity scores above and beyond the effect of time.

Discussion

This study tested the use of daily ESM/EMA to monitor psychosocial factors associated with post-injury pain across the first 14-days after ED discharge. Although patients did not require hospitalization for their injuries, they reported high initial pain scores upon ED presentation (an average of 7 out of 10). Further, despite being discharged from the ED, approximately one quarter of the sample perceived risk of death due to their injury. Pain decreased over time within each person, yet the average pain scores remained at a moderate level throughout 2-weeks post-injury. Using a modified text messaging protocol developed by Price and colleagues [43] to assess acute posttraumatic sequelae, we found that ESM/EMA is a feasible method of symptom monitoring across the first 14-days following a minor physical injury. Notably, we received a high response rate (86%) to 5 daily text messages per day for 14 days (up to 70 messages total), despite the lack of compensation for text messages responses. These results suggest that acutely injured ED patients are responsive to this modality for ESM/EMA. Although we did not detect any covariates related to non-response in this sample, additional work is warranted to determine the factors predictive of high or low response rates among injured trauma patients.

Our results extended prior research [43] that used ESM/EMA to study early PTSD symptoms and pain after injury. Extant research using ESM/EMA methods among acutely injured patients is extremely limited. Although Price and colleagues [43] were the first to demonstrate the feasibility of monitoring post-injury psychosocial symptoms via text message, their assessment of only a single text message per day precluded the ability to examine associations between *daily* levels of posttraumatic symptomology and pain, and the timing of the initial text message was based on hospital discharge which varied due to the inclusion of both hospitalized and non-hospitalized patients (e.g., Day 1 post-discharge ranged from 0 to 7-days post-injury)[43]. Despite prompting participants at a higher frequency, our average response rate (86%) was higher than that of Price and colleagues (63%) [43] in response to 1 text message per day, as was the percentage of participants that responded to over 75% of the messages (70% vs. 42%). Further, our response rate was also higher than that reported in a study of injured trauma patients who used palm pilots to respond to multiple prompts 3 times a day at 6-weeks post-injury (average of 72.6% across a 7-day period). This study design might be useful for measuring symptom fluctuations across time, and in-depth methodological studies should determine the appropriate timing, frequency, and

mode of delivery of daily prompts via ESM/EMA among injured trauma patients.

These data also revealed how daily levels of hyperarousal symptoms are associated with daily fluctuations in pain severity over time, within each person. The fact that daily avoidance and re-experiencing were not independently associated with pain severity score suggests that these observed associations with hyperarousal are specific. Contrary to prior research suggesting that social support networks enhance adjustment to pain [29, 30], the relationship between daily ratings of social support and pain severity did not emerge as significant. However, our single-item assessment of social support may not sufficient or detailed enough to detect an underlying effect [50].

In regards to PTSD symptoms, our findings are consistent with prior research suggesting that hyperarousal symptoms of PTSD the strongest contributors to persistent post-injury pain [35, 51]. Moreover, hyperarousal is a mediator between acute (within 1-week post-injury) and chronic (1-year) post-injury pain [51]. The strong association between hyperarousal and pain may emerge because the experience of a physical injury triggers physiological systems central to the expression of both pain and stressful reactions (i.e., the musculoskeletal system and the central and autonomic nervous systems) [51]. In turn, this increased physiological activity may manifest as classic hyperarousal symptoms (e.g., exaggerated startle response, difficulty sleeping, trouble concentrating, muscle tension/altered muscle use) which serve to maintain and trigger persistent pain [35, 51]. Additionally, hyperarousal symptoms also increase the likelihood of developing an attentional bias to both threatening *and* painful stimuli [51]. As such, the presence of posttraumatic symptomology may be particularly problematic among injured populations at risk for pain chronicity [22, 23], given that PTSD symptoms contribute to and/or exacerbate physical health symptoms [18, 19, 52] and are associated with lingering effects on health [53].

Although the comorbidity between PTSD and chronic pain is well established [54] and supported by several disease models (e.g., mutual maintenance model, shared vulnerability model, perpetual avoidance model) [55-58], less is known about the temporal evolution of these relationships in the acute (< 1 month) and subacute phases post-injury (< 3-months), prior to the development of chronic pain. These results highlight the need for focused assessments throughout the acute and subacute trajectory after injury, particularly in the context of prior research suggesting a time-dependent relationship between PTSD symptoms and post-injury pain [35]. For example, hyperarousal may be most strongly associated with pain immediately after injury, whereas the influence of reexperiencing and avoidance may become more relevant in the chronic phase after injury [35]. Given that avoidance involves a deliberate effort to evade and distance unpleasant thoughts and reminders of the event, the early days and weeks following injury may not allow sufficient timing for exposure(s) to distressing memories, thoughts or events that may prompt an avoidance response [59-61]. Conversely, acute symptoms of avoidance (assessed within 1-month post-injury) were a robust predictor of headache impairment at 6-weeks post-injury, but acute hyperarousal was a robust predictor of *chronic* headache impairment [62]; differences may be due to the timing of assessments (within days vs. 1 month of injury), and the types of patient populations (ED patients vs. trauma patients admitted for their injuries).

Advances in communication technology such as text messaging make it possible to overcome the multiple barriers associated with data collection in the immediate aftermath of injury (e.g., recall bias; clinical demands after an injury [63]; the burden of returning for lengthy, in-person assessments). A large-scale study (N = 5,778) conducted across three different EDs reported that 85% of ED patients owned a cell phone, and of these, 73% used their phone for texting. Notably, marginalized populations (e.g., minority and low-income patients) are no less likely to own a cell phone compared to the general population [64], and text messaging is frequently used among adults under the age of 50 (94-97%; [65]). Among ED patients specifically, automated text messaging protocols have also been used to reduce alcohol consumption, sex risk,

and to increase adherence to prescription medications following ED discharge [66-69].

Screening for hyperarousal symptoms of PTSD prior to hospital discharge may aid in the identification of high-risk trauma patients in need of intervention and/or further monitoring. Additional research is needed to characterize relationships between psychosocial symptoms and pain among varied trauma populations over time, and to inform the design of acute interventions (delivered in person or by mobile health technology/ESM/EMA) targeted at preventing the development of chronic pain. There is also a need to identify phenotypes of injured patients at risk for delayed recovery and most likely to benefit from acute intervention [70].

Limitations. This study has several limitations: our use of text messages warranted a brief, single-item assessment of each daily construct related to pain and PTSD, however, a more comprehensive assessment would allow for more robust item validity. Specifically, the items that comprised the daily text messages consisted of multiple symptoms collapsed into a single item (e.g., the hyperarousal item includes symptoms of startle, hypervigilance, and difficulty concentrating) which precludes conclusions about which specific hyperarousal-complaint is uniquely related to pain. Further, the PTSD messages were based on DSM-IV criteria, and do not include symptoms that reflect the additional symptom cluster in DSM-5 of negative trauma-related thoughts and feelings. Moving forward, future ESM/EMA research is warranted to isolate the specific complaints most strongly associated with pain, and to determine the utility of symptom assessments via abbreviated versions of the PTSD checklist 5 (e.g., the 4- or 8-item versions [71]).

The present analysis cannot conclude causality with results limited to associations between psychosocial factors and pain level. Future research could provide stronger evidence for directionality of effects (including multiple assessments of PTSD symptoms and pain across each day and lagged effects models), and whether directionality may change across the recovery trajectory. Our study design had a short follow-up period of 14-days post-injury;

longer follow-up assessments would allow for determination of how posttraumatic sequelae and pain evolve over time. Further, injury causes both physical and psychological symptoms, and it is difficult to distinguish the source of the symptoms [59]. In particular, hyperarousal may result appropriately from pain or physical injury, and is not necessarily a psychological disturbance [59]. Despite the source, its relationship to pain in the immediate aftermath of injury remains problematic, and interventional studies will need to test whether reducing hyerparousal can prevent persistence, and/or development of full PTSD and pain chronicity.

To our knowledge, this study is also the first to utilize the DSM-5 Criterion A (e.g., patient self-report of whether the event involved actual or threatened death, serious injury, or sexual violence) to screen for a potentially traumatic event among injured patients. To date, one of the standard screening instruments to determine eligibility for early cognitive-behavioral intervention studies has been satisfying Criterion A of the DSM-IV PTSD diagnosis [72, 73]. This screening based on DSM-IV included a subjective assessment of emotions associated with the event (e.g. fear, helplessness, or horror). However, with the publication of the DSM-5, this subjective emotional component was removed from due to research demonstrating its low clinical utility in identifying patients with PTSD (see [74, 75]). Currently, it is unknown whether Criterion A of the DSM-5 PTSD diagnosis is sensitive enough to accurately identify individuals at high risk for psychological problems and/or pain chronicity. Given that threat of death was associated with higher self-reported pain on Day 1, this area is worth further exploration. **Conclusion.**

ED patients discharged from the hospital after acute injuries have large within-person and between-person variability in pain severity and psychosocial factors during the acute recovery period. ESM/EMA using automated text messaging systems can efficiently detect early relationships between psychosocial symptoms and pain among recently injured ED patients. Consistent with prior research, acute hyperarousal symptoms and PTSD symptoms predict development of persistent pain.

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Table 1. Daily text message content.

Daily item	Response Range	Question Content
Pain	1= None; 10 = A lot	How much physical pain were you in today?
Social Support	1= Not at all; 7= Completely	How supported, close, and/or connected to friends & family have you felt today?
Intrusions	1= Not at all; 7= A lot	How often did you have negative memories or thoughts about the trauma today?
Avoidance	1=Not at all; 7=Completely	How much have you avoided people, places or activities that may remind you of the trauma today?
Hyperarousal	1=Not at all; 7= All the time	How much did you feel overly alert, jumpy, and/or have difficulty concentrating today?

Table 2. Regression models predicting each participant's number of missing text responses

Predictor Variable	*N*	*β*	*SE*	95% CI	p-value
Age	70	0.17	0.10	[-0.02, 0.36]	.079
Sex	70	0.25	0.19	[-0.14, 0.64]	.209
ED pain score	59	-0.07	0.11	[-0.29, 0.15]	.534
Life threat	70	-0.34	0.21	[-0.76, 0.08]	.114
Head injury	67	-0.21	0.25	[-0.70, 0.28]	.396
Prescribed opiate	70	0.21	0.21	[-0.21, 0.63]	.314

Note: β = standardized regression coefficient; SE = standard error of β; CI = confidence interval.

Table 3. Descriptive statistics of the final sample ($n = 67$)

Demographics	N (%) M (SD)
Age	33.3 (11.4); Range 18-60
Sex	
Male	40 (59.7%)
Female	27 (40.3%)
Race	
Caucasian	40(59.7%)
African American	19 (28.4%)
Other	8 (12.0%)
Education	
High school/GED or less	29 (43.4%)
Some college/technical or vocational school	24 (35.8%)
College degree or higher education	11 (16.4%)
Other	2 (2.9%)
Declined to answer	1 (1.5%)
Mechanism of Injury/Chief Complaint variables	
Motor-vehicle/cycle-related accident	18 (26.9%)
Falls	18 (26.9%)
Work-related accidents	15 (22.4%)
General Accidents (e.g., sports, minor trips, interpersonal physical assault, etc.)	16 (23.9%)

* *Note*. Continuous variables are presented as *M (SD)*, dichotomous variables are presented as *n* (%).

Table 4. Within- and between-person correlations across all study variables.

	M (SD) n (%)	1	2	3	4	5	6
1. Life threat	17 (25.4%)	—	0.15	-0.26*	0.64***	0.42***	0.43***
2. Physical Pain	4.07 (2.67)	-	—	-0.03	0.33*	0.23^{+}	0.29*
3. Social Support	5.53 (2.03)	-	0.10**	—	-0.37**	-0.32*	-0.52***
4. Re-experiencing	2.55 (1.84)	-	0.14^{+}	0.07	—	0.72***	0.85***
5. Avoidance	2.39 (2.03)	-	0.14**	0.13*	0.19**	—	0.62***
6. Hyperarousal	2.55 (1.92)	-	0.18***	-0.01	0.34***	0.24***	—
7. Time (day)	7.50 (16.25)	-	-0.37***	-0.15**	-0.21**	-0.16**	-0.14***

Note = Within-person correlations are displayed below the diagonal. Between-person correlations are displayed above the diagonal. Correlations between the between and the within person variables represent the average of the variables across all assessments (*n* = 67); Correlations between the within-person variables represent the average within each person across all observations (*n* = 807).

$^{+}$ P < .07; *P ≤ .05; **P ≤ .01; ***P ≤ .001

Table 5. Summary of multilevel analysis demonstrating the daily associations of psychological factors with physical pain (n = 67)

Variables	***B***	***SE B***	**95% CI**	**p-value**
Outcome: Physical Pain				
Social Support Random Slope	0.06	0.05	[-0.03, 0.16]	0.190
Intrusions Random Slope	0.09	0.09	[-0.08, 0.26]	0.294
Avoidance Random Slope	0.10	0.06	[-0.02, 0.22]	0.095
Hyperarousal Random Slope	0.22	0.07	[0.08, 0.36]	0.002

Note: *B* = unstandardized beta coefficient; SE B = standard error of *B*.

Figure 1. This figure represents the response rates graphed for participants enrolled in the text message program (*n* = 73). Example interpretation: Approximately 75% of participants had a response rate of 70% or greater.

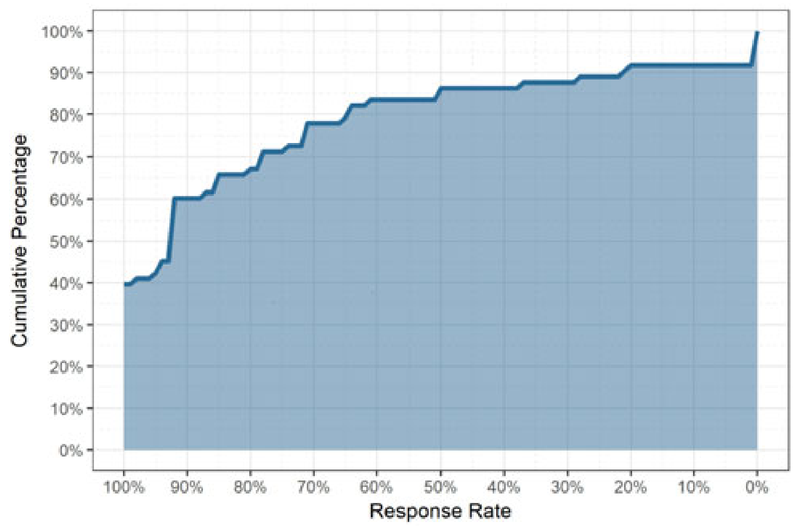

Figure 2. A lattice plot with linear regression lines demonstrating the change in pain over time. Each box represents a single participant ($n = 67$). Note that, although a linear regression line was used for simplicity, many patients do not appear to fit a linear pattern.