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The Development of a Population-Based Automated Screening Procedure for PTSD in Acutely Injured Hospitalized Trauma Survivors

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Abstract

Objective—This investigation aimed to advance posttraumatic stress disorder (PTSD) risk prediction among hospitalized injury survivors by developing a population-based automated screening tool derived from data elements available in the electronic medical record (EMR).

Method—Potential EMR derived PTSD risk factors with the greatest predictive utilities were identified for 878 randomly selected injured trauma survivors. Risk factors were assessed using logistic regression, sensitivity, specificity, predictive values, and receiver operator characteristic (ROC) curve analyses.

Results—Ten EMR data elements contributed to the optimal PTSD risk prediction model including: *ICD-9-CM* PTSD diagnosis, other *ICD-9-CM* psychiatric diagnosis, other *ICD-9-CM* substance use diagnosis or positive blood alcohol on admission, tobacco use, female gender, non-White ethnicity, uninsured, public or veteran insurance status, E-code identified intentional injury, intensive care unit admission, and EMR documentation of any prior trauma center visits. The 10-item automated screen demonstrated good area under the ROC curve (0.72), sensitivity (0.71), and specificity (0.66).

Conclusions—Automated EMR screening can be used to efficiently and accurately triage injury survivors at risk for the development of PTSD. Automated EMR procedures could be combined with stepped care protocols to optimize the sustainable implementation of PTSD screening and intervention at trauma centers nationwide.

Keywords

PTSD; screening; injury; EMR; information technology

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1. Introduction

Traumatic life events are highly prevalent in the United States and are a major cause of medical and psychiatric morbidity [1–3]. Each year millions of Americans present to hospital and emergency department settings after incurring traumatic physical injuries [1, 4]. Hospitalized seriously injured patients are at high risk for developing posttraumatic stress disorder (PTSD). Across trauma exposed patient populations, greater early PTSD symptom levels in the days and weeks immediately after injury, consistently predict the development of later chronic PTSD symptoms months after injury hospitalization [5–9]. A number of readily identifiable clinical, injury, and demographic characteristics have been identified that are associated with the development of high early PTSD symptom levels after an injury including female gender, ethnic minority heritage, intentional injury, history of psychiatric or substance abuse disorders, intensive care unit admission, and multiple prior trauma [9, 10]. After injury, PTSD makes an independent contribution to subsequent posttraumatic functional limitations and diminished quality of life above and beyond the impact of injury severity and psychiatric and medical comorbidity [11–16].

Effective trauma focused early interventions delivered in real world non-specialty mental health settings face the challenge of incorporating both population-based screening procedures and evidence-based stepped care protocols targeting PTSD and related comorbidities [17–22]. Efficacy and effectiveness studies suggest that individuals with posttraumatic psychological symptoms, including injured trauma survivors, may respond to early cognitive behavioral psychotherapeutic (CBT) and psychopharmacologic interventions [17, 18, 23–31].

The emerging field of dissemination and implementation research has encouraged enhanced focus on understanding intervention population impact and clinical trial generalizability as a means of furthering the translation of treatments to real world practice settings [32–35]. The National Institute of Health and Center for Medicaid and Medicare Innovation grant requests have encouraged investigations that simultaneously target enhancements of treatment effects and screening and intervention procedures that optimize overall population impact [34, 36]. Just as the population impact of an intervention procedure is related to both effect size and breadth of applicability, the population impact of a screening procedure can be seen to be related to both screening diagnostics (e.g., area under receiver operator characteristic (ROC) curve, sensitivity, specificity) and the breadth of applicability of the procedure. Efficient, cost-effective automated screening procedures have excellent potential for widespread applicability across acute care medical settings [37, 38]. The American College of Surgeons has demonstrated its willingness to mandate broadly applicable screening and intervention procedures for alcohol use problems [39].

A series of investigations have developed screening instruments for the assessment of PTSD [5, 6, 40–48]; the majority of these efforts have produced PTSD screening measures for use across multiple trauma exposed patient populations. A handful of efforts have focused on measures targeting early post-event screening for use in acute care medical settings or other emergent non-specialty mental health settings [5, 6, 49, 50]. Winston Kassam-Adams and colleagues combined chart review data with questionnaire data to produce a screening tool for injured children [6].

Our literature review, however, revealed no investigations that have developed efficient PTSD screening procedures that rely exclusively on automated electronic medical record (EMR) data. The purpose of the current study was to develop a population-based automated screening tool that uses common EMR data elements to identify those inpatients that would most benefit from more in-depth PTSD assessment and intervention.

2. Method

2.1. Design and Setting

The University of Washington Institutional Review Board approved all study procedures prior to initiating the protocol. Study participants were injured trauma survivors who were being assessed for recruitment into a stepped care intervention trial [36]. Between April 2006 and September 2009, injured trauma survivors admitted to the University of Washington's Harborview Level I Trauma Center were randomly approached at bedside for participation by study research associates. Of 1281 patients 878 (69%) agreed to participate. Each weekday morning, a research associate downloaded a list of all newly admitted injured patients derived from the EMR (for a complete listing of all *International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)* diagnoses used, see Appendix 1). The research associate assigned random numbers for approach to all patients who met study eligibility criteria. The investigators screened English-speaking women and men ages 18 and older, who presented to the trauma center with injuries severe enough to require inpatient surgical admission. Patients who required immediate psychiatric intervention (e.g., active psychosis, suicidal patients who presented with self-inflicted injuries), or who were currently incarcerated, were excluded. Patients with severe spinal cord, head, or other injuries that prevented participation in study procedures were also excluded from the protocol, as were patients who lived at great distances from the trauma center (i.e., > 100 miles).

Research associates approached injured inpatients in the order dictated by the random number assignments. Patients included in the investigation were consented for the study a median of four hospital days (interquartile range = 7 days) after their surgical inpatient admission. After providing written informed consent, participants were assessed for the symptoms of PTSD.

2.2 PTSD Symptom Assessments

For all hospitalized inpatients, PTSD symptoms were assessed with the PTSD Checklist Civilian Version (PCL-C) [45, 51]. The PCL-C has established reliability and validity across trauma-exposed populations [10, 44, 52, 53]. The measure includes 17 items that assess the American Psychiatric Association Diagnostic and Statistical Manual (DSM-IV) PTSD criteria [54]. Participants were asked to report how bothered they had been by each of the 17 PTSD symptoms, "since the event in which they were injured", in order to ascertain high early PTSD symptom levels as surgical inpatients. Symptoms were rated on a five point Likert scale ranging from one ("not at all") to five ("extremely"). Based upon prior literature review and experience in early intervention studies, the investigation utilized a PCL-C cutoff of 35 as an indicator of high early PTSD symptom levels in the surgical inpatient ward [36].

For a subsample of 207 patients followed in the longitudinal portion of the investigation, PTSD symptoms were assessed both with the PCL-C at 1-, 3-, 6-, 9-, and 12-months post-injury, and with the Clinician Administered PTSD Scale (CAPS) at 1-, 6-, and 12-months post-injury [51, 52, 55–57]. Of the 207 patients followed longitudinally, 104 were randomized to intervention and 103 were randomized to the usual care control conditions [36].

2.3 Electronic Medical Record (EMR) Data

Data used for this investigation was extracted directly from the EMR. The first author worked in concert with project research assistants to clean the data and perform the analyses.

Variables included in the EMR analyses and their coding for the purposes of study data analyses are described below and in Table 1.

Demographic Characteristics—Demographic characteristics readily available from the EMR included: age, gender, race (coded white versus non-white), marital status (married versus single), insurance status (private versus uninsured/self-pay, public including active duty military or veteran status), and country of birth (USA versus others).

Psychiatric, Substance Abuse, and Other Medical Diagnoses—EMR *ICD-9-CM* diagnoses were used to capture PTSD, other psychiatric diagnosis, and alcohol, drug or tobacco use disorders for all hospitalized patients (Appendix 1). Similarly EMR *ICD-9-CM* codes were used to document co-morbid medical conditions common among injured trauma survivors including diabetes, obesity, epilepsy, HIV/AIDS, hypertension, carcinoma, disorders of blood coagulation, and other chronic cardiac, pulmonary, liver, neurologic and renal conditions (Appendix 1). All *ICD-9-CM* diagnostic categories were coded as either present or absent.

Substance Levels—Information regarding alcohol and drug intoxication at the time of the injury was derived from EMR recorded blood alcohol and urine drug screen data. Blood alcohol concentration (BAC) was coded as either positive or negative (negative test or not tested). Urine drug screen data included toxicology screen information on amphetamines, cocaine, opiates, cannabis (THC), benzodiazepines, barbiturates, and tricyclic anti-depressants.

Injury Etiology and Severity—Injury Etiology ICD-9-CM E Codes were extracted for all injury admissions and categorized as intentional (e.g., assault, gunshots, stabbings) and unintentional injuries (e.g., motor vehicle crashes, falls). For each of these categories, the number of having at least 1 injury E-code was calculated (Table 1). EMR *ICD-9-CM* codes were used to ascertain maximum Abbreviated Injury Score (AIS) and Injury Severity Score (ISS) ratings [58].

Pre-injury Emergency Department and Hospital Visits—The EMR documents the numbers of unique emergency department visits and inpatient visits at Harborview prior to the current injury hospitalization. From these data we calculated the number of prior inpatient hospitalizations, and emergency department visits. The number of prior inpatient hospitalizations and emergency visits as well as the total number of inpatient days was recorded (Table 1).

2.4 Data Analyses

The overarching aim of the analytic plan was to create a population-based risk prediction screen that allowed for the triage of patients at high risk for the development of PTSD for further mental health evaluation and treatment [59–61]. The entire sample of 878 inpatients was included in the risk prediction model. Because the screening procedure was to be performed in real time, EMR data that included the current hospitalization were used to construct the risk prediction model. All 878 patients had EMR records from the index injury admission. Twenty nine percent ($n = 257$) had medical records documenting previous Harborview inpatient and emergency department admissions.

The frequency distribution of each potential risk factor was first examined for floor and ceiling effects that could limit each risk factor's utility and could influence the need to recode or dichotomize variables derived from the EMR. To develop the prediction model we then assessed the association between each EMR derived predictor variable and high PTSD

symptom levels as indicated by a cutoff of 35 on the PTSD checklist. Bivariate logistic regression analyses were used to derive odds ratios (OR) and 95% confidence intervals (CIs). All EMR variables were tested. All risk factors associated with high PTSD symptom levels at $P < 0.10$ were advanced for testing in the multivariable logistic regression models.

Logistic regression analyses were used to produce multivariable risk prediction models. The approach to attaining the best multivariate risk prediction model combined psychometric and clinimetric principles [62–64]. The approach aimed to optimize log likelihood estimates, with the most parsimonious set of individual EMR variables. In selecting risk factors for the final models we sought to simultaneously optimize strength of the association between the EMR variable and high PTSD symptom levels, clinical rationale for inclusion of the variable in the model, consistency with prior PTSD risk prediction models, and acute care feasibility considerations such as ease of individual variable EMR aggregation.

Once an optimal prediction model was identified, ROC curve were used to determine PCL-C cutoffs that maximized the sensitivity and specificity of the combined risk prediction model in relation to PTSD. Finally, we examined the predictive validity of the risk factor screening tool on a sub-sample of 207 study subjects who were followed as part of the longitudinal arm of the investigation with the CAPS and PCL-C assessments.

Finally, we performed a validation study of the EMR screening procedure with a second independent sample of 142 injured inpatients. Patients included in this validation study were again injured trauma admitted to the Harborview Level I Trauma Center.

3. Results

The mean age of the 878 patients included to develop the risk prediction model was 38.2 (Standard Deviation [SD] = 13.7), 32.6 % were female, 11.2 % were survivors of intentional injury, 28.6% were blood alcohol concentration (BAC) positive on admission, and the mean length of stay was 7.5 days (SD = 9.0 days). The 878 patients in the study cohort were significantly more likely to be, younger, female, intentionally and less severely injured, have longer length of inpatient stays, and BAC positive when compared to the population of patients admitted to the trauma center during the time period of the study [36].

The optimal risk prediction model utilized 10 data elements that were readily available in the Harborview EMR system (Table 2). The 10 elements related to PTSD risk included were: 1) EMR PTSD *ICD-9-CM* diagnosis, 2) any other *ICD-9-CM* psychiatric diagnosis, 3) any *ICD-9-CM* substance use disorder diagnosis or positive BAC on admission, 4) tobacco use as evidenced by current or prior *ICD-9-CM* diagnosis, 5–7) demographic characteristics including female gender, non-White ethnicity, and any non-private insurance status (e.g., self-pay, public or active duty military or veteran insurance status), 8) injury E-code indicative of an intentional injury, 9) intensive care unit (ICU) admission during the current hospitalization, and 10) any prior EMR documentation of prior trauma center inpatient hospitalizations (Table 2).

A risk cutoff of 3 out of 10 retained good sensitivity (71%) and specificity (66%) while correctly classifying 68% of the population (Table 3). This cutoff score also yielded an area under the ROC curve of 0.72.

In longitudinal analyses, the risk scale cutoff of 3 or greater was associated with an area under the ROC ranging from 0.60–0.67 for the CAPS diagnosis of PTSD 1–12 months post-injury (Table 4). Sensitivity was also excellent ranging from 0.70–0.84. A cutoff of 3 on the 10 item screen was also associated with adequate to good area under the ROC curve ranging

from 0.57–0.74 between 1–12 months post-injury for prediction of symptoms consistent with a diagnosis of PTSD on the PCL-C.

In the validation sample (N = 142) a risk index score of 3 was associated with an ROC curve of 0.66 (95% CI = .057 – 0.75) for a PCL-C score 35. At this cutpoint of 3 the sensitivity was = 0.79 and the specificity was = 0.36, with 53% of the sample having a PCL-C 35.

4. Discussion

Acute care medical settings are the first point of contact for injured trauma survivors at risk for the development of PTSD and related co-morbid conditions. The current investigation documents that an efficient automated screening tool can be used at a population level to detect high early PTSD symptom levels among acutely injured hospitalized, trauma survivors. The automated nature of the triage tool suggests wide potential breadth of applicability and ultimately population impact of the PTSD screening procedure [34, 36]. The risk prediction tool was validated in a second independent sample of injured trauma survivors.

Ideally the automated screening procedure could be used to identify a sub-population at risk who could receive more intensive screening and intervention procedures. A series of investigations now document the effectiveness of PTSD screening and a stepped care algorithm of intervention procedures among injured trauma survivors hospitalized in acute care medical settings[59–61].

There are a number of important considerations in interpreting the results of this investigation. First, although the majority of clinical, injury, and demographic characteristics used in the composite PTSD risk prediction tool are readily derived in the EMR, only approximately 30% of patients had a history of previous Harborview Medical Center admission. This observation impacts the predictive utility of both the recurrent inpatient admission domain, and the ability to incorporate prior *ICD-9-CM* diagnostic codes into the risk prediction modeling. Second, *ICD-9-CM* diagnostic codes may not be entered into inpatient automated data bases until later on in the inpatient admission process (e.g., with discharge summaries); this can delay the availability of the diagnostic codes required for PTSD, co-morbid psychiatric conditions and substance related disorder elements. Psychiatric diagnoses however, that precede the current injury admission are readily available for inclusion in the automated screening procedure. Also, the sensitivity of the automated screen is diminished relative to other procedures that incorporate self-report assessments [5, 6]. However, the automated screen is likely to be much less costly for health care systems. In acute care and other trauma exposed population, varying PCL-C cutoff values above 35 have been used to demarcate high PTSD symptom levels [44, 48, 52]. Also, although the Harborview Level I Trauma Center may be generalizable with regard to the characteristics of the admitted patients, it may very well be considered an “innovator” or “early adopter” site with regard to the information technology capacity required for the automated EMR screening procedure [65].

Beyond these considerations, this investigation contributes to an evolving literature on early stepped PTSD screening and intervention procedures for injured trauma survivors treated initially in acute care medical settings. Ultimately, population level EMR based screening procedures could be included as “step 1”, in collaborative care intervention trials that target PTSD and related co-morbid conditions [59–61]. Time efficient automated screening procedures could be used to initially identify at risk patients who could then be assessed more formally with clinical assessment tools such as the PCL-C. The American College of Surgeons has demonstrated the capacity to mandate screening and intervention procedures

for alcohol use problems at US trauma centers based on the results of empiric investigations [38, 39, 66]. By establishing the accuracy of an automated PTSD screening procedure in predicting high early PTSD symptom levels, the investigative findings could potentially influence the development of national policy guidelines for the sustainable implementation of PTSD screening and intervention procedures.

5. Conclusion

This investigation advances PTSD risk prediction among hospitalized injury survivors through the development of a population-based automated screening tool derived from data elements readily available in the electronic medical record. The results of the investigation suggest that automated EMR screening can be used to efficiently triage injury survivors at risk for the development of PTSD. Automated EMR procedures could be combined with intervention protocols to optimize the sustainable implementation of PTSD screening and intervention throughout United States acute care medical settings.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Appendix 1: International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)*

1) Injury

Injury codes included were: fractures (800-829), dislocations (830-839), sprains and strains of joints and adjacent muscles (840-848), intracranial injury (850-854), internal injury of the chest, abdomen, and pelvis (860-869), open wound of the head, neck, and trunk (870-879),

open wound of the upper and lower limbs 880-897), injury to the blood vessels (900-904), late injury effects (905-909), superficial injury (910-919), contusions (920-924), crushing injury (925-929), foreign body injuries (930-939), burns (940-949), injury to nerves and spinal cord (950-957), and other injury complications (958-959). Specific ICD-9-CM codes used to identify traumatic brain injuries included 800.0–801.9, 803.0–804.9, 850.0–854.1 and 959.01 (45,46).

2) PTSD and other Psychiatric Diagnoses

PTSD 309.81, acute stress disorders 308.0–308.9, adjustment disorders 309.0–309.9, panic disorder 300.01, 300.21, 300.22, phobia 300.29, social anxiety 300.23, obsessive compulsive disorder 300.3, generalized anxiety disorder 300.02, other anxiety 300.00, 300.09, 300.2, 293.84, 313), depressive disorders (including major depressive disorder 296.2–296.99, dysthymia 300.4, and other depressive disorders 309.1 & 311), schizophrenia 295.0–295.99, bipolar disorders 296.0, pervasive developmental disorders 301.7 – 302.85, and psychosis not otherwise specified (NOS) 300.9.

3) Substance Use Disorders

Alcohol dependence 303.00–303.99, alcohol abuse 305.00–305.09, opioid dependence 304.00–304.01, opioid abuse 305.50–305.59, cocaine dependence 304.20–304.29, cocaine abuse 305.60–305.69, amphetamine dependence 304.40–304.49, amphetamine abuse 305.70–305.79, marijuana dependence 304.30–304.39, marijuana abuse 305.20–305.23, sedative abuse 305.4, poly-drug dependence 304.70–304.99, poly-drug abuse 305.90–305.99, and tobacco 305.1.

4) Etiology of Injury

Intentional or Other inflicted injuries E960, E960.1, E961, E962.0, E962.1, E962.2, E962.9, E963, E964, E965, E965.0 – E965.9, E966, E967, E967.0 – E967.9, E968, E968.0 – E968.9, E969, E970 – E978, E990 – E999.

5) Other Medical Co-morbidities

Neoplasm 140.00 – 209.99, liver 571.00–577.99, neurologic 332.00–333.99, 340, coagulation 286.00–286.99, pulmonary 491.00–496.99, CVD 430.00–438.99, diabetes 250.00–250.99, epilepsy 345.00–345.99, HTN 401.00–401.99, ischemic 420.00–429.99, obesity 278.00–278.02, renal 585.00–585.99, and AIDS 42.00.

Table 1

Bivariate relationships between PTSD symptom groups and risk predictors

Predictors	Total Sample	PCL-C < 35	PCL-C 35	OR (95% CI)
N	878	528 (60%)	350 (40%)	
<i>Demographics</i>				
Gender (female)	33.0% (290)	26.7% (141)	42.6% (149)	2.04 (1.53 – 2.71)
Age (year) mean (S.D.)	38.2 (13.7)	38.0 (14.1)	38.4 (13.1)	1.00 (.99 – 1.01)
Race (non-white)	38.3% (336)	32.6% (172)	46.9% (164)	1.82 (1.38 – 2.41)
Marital status (single)	68.9% (605)	65.2% (344)	74.6% (261)	1.57 (1.16 – 2.12)
Veteran	1.9% (17)	2.1% (11)	1.7% (6)	0.82 (.30 – 2.24)
Born in the USA	91.3% (802)	90.7% (479)	92.3% (323)	1.22 (.75 – 2.00)
Public, self pay and veterans insurance	68.6% (602)	62.5% (330)	77.7% (272)	2.09 (1.54 – 2.84)
<i>ED substance toxicology</i>				
BAC positive ^a	28.5% (250)	25.2% (113)	33.4% (117)	1.49 (1.11 – 2.01)
Methamphetamines ^a	4.0% (35)	3.8% (20)	4.3% (15)	1.14 (.57 – 2.25)
Amphetamines ^a	4.0% (35)	3.8% (20)	4.3% (15)	1.14 (.57 – 2.25)
Opiates ^a	43.6% (383)	43.2% (228)	44.3% (155)	1.05 (.80 – 1.37)
Cocaine ^a	9.0% (79)	7.4% (39)	11.4% (40)	1.62 (1.02 – 2.57)
THC ^a	15.7% (138)	15.5% (82)	16.0% (56)	1.04 (.72 – 1.50)
Benzos ^a	15.5% (136)	15.2% (80)	16.0% (56)	1.07 (.74 – 1.55)
Barbituates ^a	1.3% (11)	1.3% (7)	1.1% (4)	0.86 (.25 – 2.96)
TCA	1.4% (12)	1.1% (6)	1.7% (6)	1.52 (.48 – 4.74)
MDN	1.8% (16)	1.5% (8)	2.3% (8)	1.52 (.56 – 4.09)
Number of positive tox screens above-mean (S.D.)	0.95 (1.21)	0.92 (1.16)	1.00 (1.28)	1.06 (.95 – 1.18)
<i>Medical comorbidity</i>				
HIV/AIDS	1.1% (10)	0.2% (1)	2.6% (9)	13.91 (1.75 – 110.18)
Coagulation	0.9% (8)	0.6% (3)	1.4% (5)	2.54 (0.60 – 10.68)
CVD	3.3% (29)	1.9% (10)	5.4% (19)	2.97 (1.37 – 6.47)
Renal disease	0.9% (8)	0.9% (5)	0.9% (3)	0.90 (0.22 – 3.81)
Pulmonary disease	10.1% (89)	7.4% (39)	14.3% (50)	2.09 (1.34 – 3.25)
Diabetes	6.2% (54)	6.1% (32)	6.3% (22)	1.04 (0.59 – 1.82)
Epilepsy	1.9% (17)	1.3% (7)	2.9% (10)	2.19 (0.82 – 5.81)
HTN	15.9% (166)	17.2% (91)	21.4% (75)	1.31 (0.93 – 1.84)
Ischemic disease	14.1% (124)	13.8% (73)	14.6% (51)	1.06 (0.72 – 1.56)
Liver disease	3.8% (33)	2.1% (11)	6.3% (22)	3.15 (1.51 – 6.59)
Neoplasm	1.3% (11)	0.9% (5)	1.7% (6)	1.82 (0.55 – 6.02)
Neurologic disease	1.1% (10)	1.3% (7)	0.9% (3)	0.64 (0.16 – 2.50)
Number of chronic illnesses above-mean (S.D.)	0.64 (1.02)	0.54 (.88)	0.78 (1.18)	1.27 (1.11 – 1.45)
Tobacco use – current or history	32.3% (284)	27.3% (144)	40.0% (140)	1.78 (1.33 – 2.37)
Obesity – current or history	5.5% (48)	4.4% (23)	7.1% (25)	1.69 (0.94 – 3.03)
<i>ICD-9 psychiatric diagnoses</i>				

Predictors	Total Sample	PCL-C < 35	PCL-C 35	OR (95% CI)
N	878	528 (60%)	350 (40%)	
PTSD	3.6% (32)	1.1% (6)	7.4% (26)	6.98 (2.84 – 17.14)
Acute stress	1.0% (9)	0.4% (2)	2.0% (7)	5.37 (1.11 – 25.99)
Adjustment disorder	2.1% (18)	1.1% (6)	3.4% (12)	3.09 (1.15 – 8.31)
Anxiety disorders	6.5% (57)	4.0% (21)	10.3% (36)	2.77 (1.59 – 4.83)
Major depressive disorder	4.4% (39)	1.9% (10)	8.3% (29)	4.68 (2.25 – 9.73)
Depression NOS	11.0% (97)	6.4% (34)	18.0% (63)	3.19 (2.05 – 4.96)
Dysthymia	3.3% (29)	2.3% (12)	4.9% (17)	2.20 (1.04 – 4.66)
Bipolar disorders	7.3% (64)	4.0% (21)	12.3% (43)	3.38 (1.97 – 5.81)
Schizophrenia	1.5% (13)	1.1% (6)	2.0% (7)	1.78 (0.59 – 5.33)
Psychosis NOS	2.4% (21)	1.9% (10)	3.1% (11)	1.68 (0.71 – 4.00)
Personality disorders	1.4% (12)	0.2% (1)	3.1% (11)	17.10 (2.20 – 133.05)
Pervasive developmental disorder	0.1% (1)	0	0.3% (1)	0.40 (0.37 – 0.43)
Number of different psychiatric disorders - mean (S.D.)	0.45 (1.00)	0.24 (.71)	0.75 (1.27)	1.78 (1.50 – 2.11)
Any psychiatric disorder	24.5% (215)	15.0% (79)	38.9% (136)	3.61 (2.62 – 4.98)
<i>Substance use disorders (ICD-9)</i>				
Substance induced mood disorder	16.6% (146)	10.6% (56)	25.7% (90)	2.92 (2.02 – 4.21)
Alcohol abuse	18.3% (161)	14.6% (77)	24.0% (84)	1.85 (1.31 – 2.61)
Alcohol dependence	10.3% (202)	6.8% (36)	15.4% (54)	2.49 (1.60 – 3.89)
Alcohol abuse and/or dependence	23.0% (202)	18.2% (96)	30.3% (106)	1.96 (1.42 – 2.69)
Amphetamine abuse and/or dependence	3.8% (33)	2.3% (12)	6.0% (21)	2.74 (1.33 – 5.65)
Cocaine abuse	8.4% (74)	5.1% (27)	13.4% (47)	2.88 (1.76 – 4.72)
Cocaine dependence	3.3% (29)	2.1% (11)	5.19% (18)	2.55 (1.19 – 5.46)
Cocaine abuse and/or dependence	9.6% (84)	6.1% (32)	14.9% (52)	2.70 (1.70 – 4.30)
Either amphetamine or cocaine abuse and/or dependence	11.6% (102)	7.6% (40)	17.7% (62)	2.63 (1.72 – 4.01)
Cannabis abuse and/or dependence	5.6% (49)	4.4% (23)	7.4% (26)	1.76 (0.99 – 3.14)
Opioid abuse and/or dependence	5.9% (52)	4.5% (24)	8.0% (28)	1.83 (1.04 – 3.21)
Polydrug abuse and/or dependence	7.3% (64)	4.9% (26)	10.9% (38)	2.35 (1.40 – 3.95)
Any substance abuse diagnosis	28.0% (246)	21.2% (112)	38.3% (134)	2.30 (1.71 – 3.11)
Any substance use dependency	14.7% (129)	10.4% (55)	21.1% (74)	2.31 (1.58 – 3.37)
At least 1 substance use disorder	38.2% (335)	29.9% (158)	50.6% (177)	2.40 (1.81 – 3.17)
Number of substance abuse diagnoses out of 7	0.45 (0.89)	0.32 (0.72)	0.64 (1.08)	1.51 (1.28 – 1.77)
Number of substance de-pendency diagnoses out of 6	0.22 (0.63)	0.15 (0.52)	0.33 (0.75)	1.60 (1.27 – 2.02)
Number of different substance use disorders from 14	0.84 (1.55)	0.58 (1.34)	1.23 (1.87)	1.33 (1.21 – 1.47)
<i>Injury etiology (from ICD-9-CME codes)</i>				
At least 1 motor vehicle accident	49.8% (434)	50.8% (268)	47.4% (166)	0.88 (0.67 – 1.15)
At least 1 other accident	58.3% (512)	59.1% (312)	57.1% (200)	0.92 (0.70 – 1.21)
At least 1 intentionally inflicted injury	25.6% (225)	19.1% (101)	35.4% (124)	2.32 (1.70 – 3.16)
At least 1 self inflicted injury	3.0% (26)	2.1% (11)	4.3% (15)	2.10 (0.96 – 4.64)
<i>Utilization of emergency and inpatient stays</i>				
Prior inpatient hospitalizations				
0	72.3% (633)	78.0% (412)	63.5% (221)	1.56 (1.32 – 1.84)

Predictors	Total Sample	PCL-C < 35	PCL-C 35	OR (95% CI)
N	878	528 (60%)	350 (40%)	
1	7.3% (64)	7.6% (40)	6.9% (24)	
2+	20.4% (179)	14.4% (76)	29.6% (103)	
Prior inpatient hospitalizations at Harborview due to injury				
0	93.7% (853)	95.8% (506)	90.6% (317)	1.83 (1.20 – 2.80)
1	4.7% (41)	3.0% (16)	7.1% (25)	
2+	1.6% (14)	1.1% (6)	2.3% (8)	
Total number of inpatient days summed across all past visits	1.50 (7.12)	0.80 (5.24)	2.57 (9.17)	1.04 (1.02 – 1.07)
Number of emergency visits				
0	86.8% (762)	92.0% (486)	78.9% (276)	2.13 (1.64 – 2.77)
1	6.3% (55)	4.7% (25)	8.6% (30)	
2+	6.9% (61)	3.2% (17)	12.6% (44)	
<i>Injury Severity and ICU Admission</i>				
Patient was in the ICU	29.8% (262)	27.1% (143)	34.0% (119)	1.39 (1.04 – 1.86)
Maximum Abbreviated Injury Score	2.89 (0.87)	2.86 (0.82)	2.94 (0.93)	1.11 (0.95 – 1.30)
Head Injury	0.83 (1.28)	0.77 (1.26)	0.92 (1.32)	1.10 (0.99 – 1.22)
Injury Severity Score	13.09 (9.34)	12.49 (8.49)	14.00 (10.44)	1.02 (1.00 – 1.03)

^aFrom ED rapid toxicology - positive vs. negative or not given.

Table 2

Final indicators for the PTSD risk prediction model

Indicator	Entry OR* (95% CI)	Final model OR (95% CI)
Gender: female	2.04 (1.53 – 2.71)	2.66 (1.92 – 3.69)
Race: non-white	1.92 (1.44 – 2.54)	1.63 (1.19 – 2.24)
Funding: public, self pay and veterans insurance	2.18 (1.58 – 3.01)	1.47 (1.04 – 2.08)
ICU visit during hospitalization	1.39 (1.03 – 1.89)	1.37 (0.99 – 1.89)
Prior inpatient hospitalizations (2 or more)	2.09 (1.59 – 2.75)	1.31 (0.96 – 1.79)
Etiology: intentional injury	1.88 (1.31 – 2.69)	1.72 (1.18 – 2.50)
Tobacco use – current or history	1.42 (1.04 – 1.96)	1.24 (0.89 – 1.72)
BAC positive OR any substance disorder ICD-9	1.66 (1.21 – 2.28)	1.36 (0.97 – 1.90)
PTSD ICD-9	3.57 (1.38 – 9.22)	2.13 (0.81 – 5.64)
Any psychiatric disorder ICD-9 from EMR	2.30 (1.56 – 3.40)	2.30 (1.56 – 3.40)

^aOdds ratios when indicator was entered into the model

Table 3

Baseline PCL-C cutoffs and Sensitivity, Specificity and Risk Prediction

PTSD measure	Risk cut-off	Sensitivity	Specificity	PPV	NPV	% Correct classification
PCLC-35	3	0.71	0.66	58%	78%	68%
PCLC-35	4	0.47	0.81	62%	70%	68%
PCLC-35	5	0.27	0.93	70%	66%	66%

Table 4Longitudinal predictive utility of PCL-C 35 10-item automated PTSD risk screen: CAPS^{*}

Risk scale cut off	Indice	CAPS 1 month	CAPS 6 months	CAPS 12 months
3	ROC	0.60 (0.52 – 0.68)	0.65 (0.56 – 0.74)	0.67 (0.59 – 0.75)
	Sensitivity	0.70	0.81	0.84
	Specificity	0.40	0.38	0.36
	PPV	0.60	0.54	0.51
	NPV	0.52	0.69	0.74
4	Sensitivity	0.50	0.58	0.57
	Specificity	0.31	0.31	0.66
	PPV	0.48	0.42	0.54
	NPV	0.33	0.47	0.69
5	Sensitivity	0.28	0.32	0.28
	Specificity	0.86	0.85	0.83
	PPV	0.72	0.65	0.53
	NPV	0.48	0.60	0.66

^{*} Clinician Administered PTSD Scale