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Original Research Article

## The impact of the COVID-19 pandemic on functional and mental health outcomes after trauma

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## ABSTRACT

**Background:** The COVID-19 pandemic has led to decreased access to care and social isolation, which have the potential for negative psychophysical effects. We examine the impact of the pandemic on physical and mental health outcomes after trauma.**Methods:** Patients in a prospective study were included. The cohort injured during the pandemic was compared to a cohort injured before the pandemic. We performed regression analyses to evaluate the association between the COVID-19 pandemic and physical and mental health outcomes.**Results:** 1,398 patients were included. In adjusted analysis, patients injured during the pandemic scored significantly worse on the SF-12 physical composite score (OR 2.21; [95% CI 0.69–3.72]; P = 0.004) and were more likely to screen positive for depression (OR 1.46; [1.02–2.09]; P = 0.03) and anxiety (OR 1.56; [1.08–2.26]; P = 0.02). There was no significant difference in functional outcomes.**Conclusions:** Patients injured during the COVID-19 pandemic had worse mental health outcomes but not physical health outcomes.

## 1. Introduction

The novel coronavirus (SARS-CoV-2) and its associated disease, COVID-19 has placed an unprecedented stress on our society. Consequences of the disease itself, including fear and uncertainty regarding prognosis and treatment, disease mitigation tactics, such as social distancing and quarantine, as well as its socioeconomic impact have the potential for adverse psychophysical effects.

The negative health consequences of disaster situations are multiple. Not only do disasters pose direct health threats, but their impact on healthcare infrastructure can compromise the treatment of chronic disease.<sup>1</sup> Prior studies have shown that trauma patients with less access

to care demonstrate increased disability.<sup>2</sup> Conversely, trauma patients who receive physical rehabilitation demonstrate improved functional outcomes.<sup>3</sup> Additionally, reports of the social impacts of COVID-19 have shown increased reports of loneliness and isolation.<sup>4</sup> Poor perceived social support, social isolation, and loneliness are associated with higher morbidity and mortality and adverse functional outcomes after trauma.<sup>5–8</sup>

Traumatic injuries also often result in loss of function and declining mental health.<sup>9</sup> Post-traumatic stress disorder (PTSD) is common among trauma patients and its rates are higher among this group (7%) than the general population (4%).<sup>10,11</sup> Similarly, the median incidence of anxiety disorders in the general population is 7.3%, but trauma patients report

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levels from 40.2% to 23.9% at 3 and 6 months following injury, respectively.<sup>12,13</sup> Importantly, the treatment of mental health disorders after traumatic injury has been shown to be the most expensive portion of this population's healthcare.<sup>14</sup>

Some studies have suggested that this pandemic, like other natural disasters, will lead to elevated levels of anxiety, depression, and PTSD among those affected.<sup>15</sup> These increased rates in mental health disorders have been linked to fear over loss of income, loss of social support, and loss of life.<sup>16</sup> Furthermore, the life-style modifications widely encouraged to limit the spread of SARS-CoV-2 have led to an upheaval of daily routines, which presents challenges for those that rely on predictability, such as patients suffering from traumatic isolation.<sup>17</sup>

There is still much to be understood about how different psychosocial factors influence long-term outcomes after traumatic injury. Here, we aim to examine the impact of the COVID-19 pandemic on both functional and mental health outcomes (defined as screening positive for PTSD, anxiety, and/or depression) 6 months after traumatic injury. We hypothesize that individuals injured during the COVID-19 pandemic will have significantly worse functional and mental health outcomes compared to those injured in prior years.

## 2. Methods

### 2.1. Study setting and population

The FORTE Project is a prospective multicenter study between three academic Level I trauma centers in Boston, Massachusetts: the Brigham and Women's Hospital (BWH), Massachusetts General Hospital (MGH), and Boston Medical Center (BMC). Adult, English or Spanish speaking trauma patients with injury severity scores (ISS) greater than or equal to 9 who were alive at the time of discharge are prospectively included in the FORTE database. Trained study staff conduct telephone interviews with patients meeting inclusion criteria 6 months post-injury including an initial screening and verbal consent followed by questions regarding the patient's functional status, health-related quality of life, and recovery experience. Patient data and interview responses are then entered into a HIPAA-compliant web-based application ([www.project-redcap.org](http://www.project-redcap.org)).<sup>18</sup> Demographic and clinical data, including injury characteristics, hospitalization variables, discharge disposition, and whether or not the patient received rehabilitation are extracted from the trauma registries of the participating institutions. Further details regarding the FORTE project have been described previously.<sup>19</sup> The Partners Human Research Committee, the institutional review board of Partners Healthcare, approved this study.

On March 11, 2020 the World Health Organization (WHO) declared COVID-19 to be a pandemic.<sup>20</sup> Therefore, the present study population included patients who were injured from March 2020 to July 2020 (during the COVID-19 pandemic). The comparison population included patients from the first date of FORTE mental health outcome collection, October 2018, through June of 2019. The end date for this population was selected such that 6-month patient interviews were completed prior to the start of the COVID-19 pandemic.

### 2.2. Outcome measures

#### 2.2.1. Functional limitations

The Trauma Quality of Life (TQoL) is a 5-domain instrument that measures quality of life in the trauma population with inter-item reliability and validity.<sup>21</sup> For this study, functional limitations were defined as a new positive response in one or more of the functional engagement domain questions of the TQoL (driving, walking upstairs, walking on flat surfaces, dressing, showering, eating, going to the bathroom, and cooking). Positive responses included self-reported "agree" or "strongly" agree on a 5-point Likert scale.

#### 2.2.2. Return to work or school

Patients were asked if they were working or attending school in the month prior to their injury and at the time of the interview. Patients who were working or attending school were included in the return to work or school analysis.

#### 2.2.3. Chronic pain

Chronic pain was defined as a positive response to the TQoL physical well-being domain question: "I have pain on a daily basis." Positive responses included self-reported "agree" or "strongly agree" on a 5-point Likert scale.

#### 2.2.4. Health related quality of life

The SF-12 Health Survey is a validated measure that uses 12 questionnaire items to assess generic health-related quality of life (HRQoL).<sup>22</sup> We used patient's SF-12 v2 responses to calculate the Physical Component Score (PCS) and Mental Component Score (MCS), which reflect a patient's overall physical and mental health. The PCS, MCS, and subdomain scores are represented as t-scores with a population mean of 50 and a standard deviation of 10, in which 0 represents the lowest level of health and 100 the highest.

#### 2.2.5. Mental health disorders

PTSD was assessed using the abbreviated 8-item version of the PTSD checklist for DSM-5 (PCL-5). A score of 19 or above was determined to be a positive screen for PTSD. Depression was assessed using the patient health questionnaire-8 depression scale (PHQ-8). A score of greater than or equal to 10 was determined to be a positive screen for depression. Lastly, anxiety was assessed using the generalized anxiety disorder-7 scale (GAD-7). A score of 10 or greater was determined to be a positive screen for anxiety. All of these scales have been previously validated.<sup>23–26</sup>

### 2.3. Data analysis

Descriptive statistics were used to summarize patient demographics, injury, and clinical characteristics, as well as study outcomes. Patient characteristics were compared between study groups using parametric tests (t-tests) or nonparametric tests (Wilcoxon rank sum) for continuous variables, and Fisher exact tests for categorical variables. Mean SF-12 PCS and MCS were described and compared with the U.S. population mean score of 50.

Multivariable linear and logistic regression models were fitted to assess for independent associations between the before and during pandemic time periods and each of the study outcomes. Regression models were adjusted for scientifically relevant characteristics used in previous studies,<sup>9,27–31</sup> including: age, sex, race, type of insurance, education level, prior psychiatric illness (including anxiety, depression, and PTSD), substance abuse, number of comorbidities, ISS, injury cause, extremity injury, length of stay, any surgical procedure, and study site. Inverse probability of treatment weighting (IPTW) adjusted analyses were also performed, with estimated propensity scores adjusting for covariates. We used STATA version 14.0 (StataCorp, TX) for all statistical analyses. Statistical significance was set at  $P < 0.05$ .

## 3. Results

A total of 1,301 patients were eligible for inclusion in the FORTE registry from the March–July 2020 cohort (during the COVID-19 pandemic). Of these, 928 patients were contacted, and 373 patients could not be contacted. Of the patients successfully contacted, 577 patients participated in the study and 351 patients declined to participate or were lost to follow-up. A total of 2,085 patients were eligible for inclusion in the FORTE registry from the October 2018–June 2019 cohort (before the COVID-19 pandemic). Of these, 1,390 patients were contacted, and 695 patients could not be contacted. Of the patients

successfully contacted, 812 patients participated in the study and 578 patients declined to participate or were lost to follow-up (Fig. 1).

### 3.1. Demographic characteristics

Demographic, clinical and injury characteristics of patients who suffered traumatic injury during the COVID-19 pandemic and before the COVID-19 pandemic are reported in Table 1. There were several significant differences between the groups. The mean age of patients injured during the pandemic ( $59.6 \pm 21.8$  years) was younger than that of patients injured before the pandemic ( $63.7 \pm 20.8$  years). White was the predominant race, though there was a greater proportion of white patients injured before the pandemic (77.3% vs 73.6%,  $P = 0.04$ ). Patients who were injured during the pandemic were more likely to have Medicaid insurance as compared to patients injured before (10.0% vs 13.6%,  $P = 0.04$ ). Injury severity score (ISS) was most commonly in the moderate range (ISS: 9–14) and was similar between groups. Falls were the most common cause of injury between groups, however there was a greater proportion of falls before the pandemic (69.8% vs 61.6%,  $P = 0.01$ ). The most common injury type among both groups was extremity injury. Patients injured during the pandemic were less likely to have medical comorbidities (16.7% vs 24.6%,  $P < 0.001$ ) but were more likely to have a history of major psychiatric illness (12.75% vs 16.0%,  $P < 0.001$ ) and substance use (9.9% vs 15.9%,  $P < 0.001$ ). Patients were most likely to be discharged to a rehabilitation facility among both groups, however more patients injured before the pandemic were discharged to a nursing home/skilled nursing facility than during the pandemic (20.8% vs 11.2%,  $P = 0.003$ ). Access to rehabilitation was preserved, however, more patients injured during the pandemic received inpatient rehabilitation than those injured before the pandemic (28.1% vs 39.2%,  $P < 0.001$ ).

### 3.2. Functional outcomes

On univariate analysis, we found comparable results between patients injured before and during the COVID-19 pandemic for functional outcomes (including new functional limitations) (37.7% vs 33.8%,  $P = 0.14$ ), no return to work/school (37.6% vs 37.8%,  $P = 0.97$ ), and chronic pain (50.9% vs 50.2%,  $P = 0.84$ ) (Table 2). However, patients injured during the pandemic scored significantly higher on the SF-12 PCS (11.6 vs 12.2,  $P = 0.002$ ). These results were confirmed on multivariate regression with patients injured before and during the pandemic having comparable functional outcomes (including new functional limitations) (OR 0.86, 95% CI 0.67–1.11,  $P = 0.24$ ), no return to work/school (OR 0.94, 95% CI 0.62–1.42,  $P = 0.78$ ), and chronic pain (OR 0.88, 95% CI 0.68–1.14,  $P = 0.33$ ) (Table 3). Additionally, the association between injury during the pandemic and higher SF-12 PCS held when adjusting for covariates in logistic regression (mean difference 2.21, 95% CI 0.69–3.72,  $P = 0.004$ ).

### 3.3. Mental health outcomes

On univariate analysis patients injured during the COVID-19 pandemic had significantly higher scores on the GAD-7 (12.2% vs 18.3%,  $P = 0.01$ ) and PHQ-8 (13.7% vs 18.3%,  $P = 0.04$ ) compared to patients injured before the COVID-19 pandemic (Table 2). Conversely, they had similar PCL-5 (11.0% vs 11.6%,  $P = 0.76$ ) and SF-12 MCS results (12.1 vs 11.7,  $P = 0.05$ ). Multivariate logistic regression confirmed a significant association between higher scores on the GAD-7 (OR 1.56, 95% CI 1.08–2.26,  $P = 0.02$ ) and PHQ-8 (OR 1.46, 95% CI 1.02–2.09,  $P = 0.03$ ) and being injured during the pandemic (Table 3). Additionally, it was confirmed that patients injured during the pandemic scored similarly on the PCL-5 (OR 0.82, 95% CI 0.54–1.27,  $P = 0.38$ ) and SF-12 MCS (mean difference  $-1.16$ , 95% CI  $-2.72$ – $0.40$ ,  $P = 0.15$ ).

Ther results of the IPTW analysis with estimated propensity scores adjusted for covariates were consistent with the regression analyses and

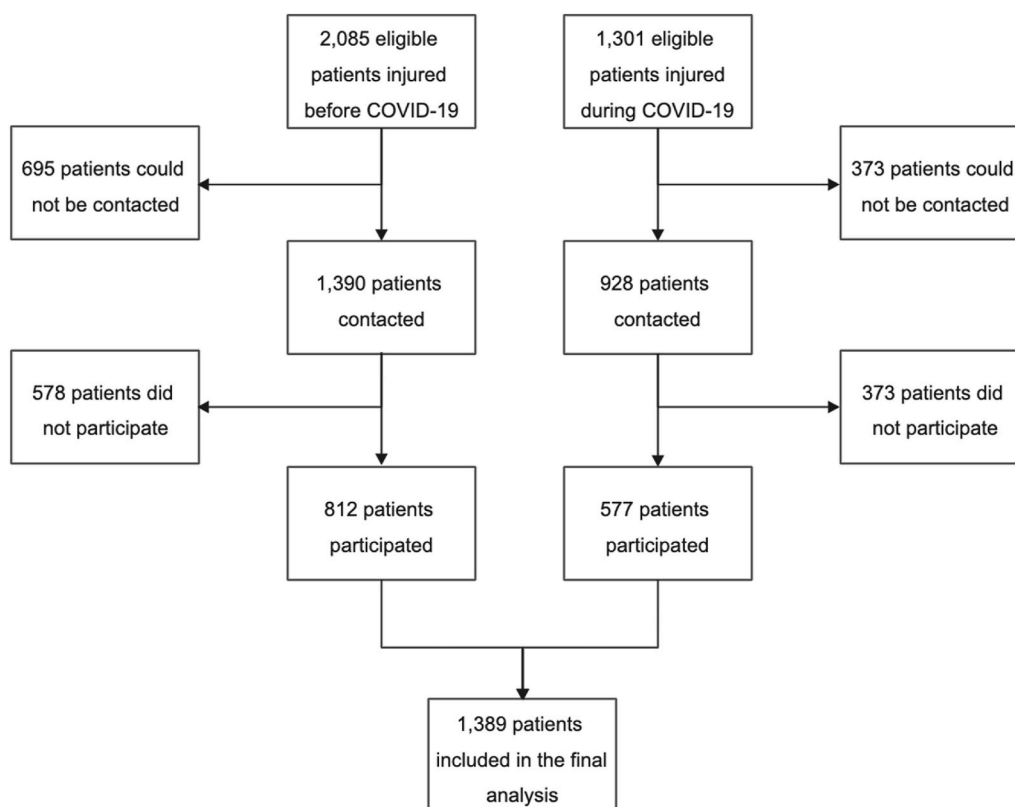


Fig. 1. Study flow diagram.

**Table 1**  
Demographics and patient characteristics.

Variable	Before COVID-19 (N = 812)	During COVID-19 (N = 577)	P value
Age, y, mean (SD)*	63.7 (±20.8)	59.6 (±21.8)	<0.001
Sex, male	436 (53.7%)	327 (56.7%)	0.27
Race/ethnicity			
White	615 (77.3%)	410 (73.6%)	0.04
Black or African-American	74 (9.3%)	76 (13.6%)	
Other	107 (13.4%)	71 (12.7%)	
Education, high school or lower	296 (37.8%)	218 (38.5%)	0.79
Medicaid insurance	81 (10.0%)	78 (13.6%)	0.04
Injury Severity Score (ISS)*			
Moderate (ISS: 9–14)	572 (70.4%)	388 (67.2%)	0.06
Severe (ISS: 15–24)	163 (20.1%)	111 (19.2%)	
Critical (ISS ≥25)	77 (9.5%)	78 (13.5%)	
Injury cause			
Falls	567 (69.8%)	354 (61.6%)	0.01
Road traffic accidents	175 (21.6%)	150 (26.1%)	
Blunt assault	43 (5.3%)	41 (7.1%)	
Other	27 (3.3%)	30 (5.2%)	
Head injury (AIS≥2)*	248 (30.5%)	175 (30.3%)	0.93
Extremity injury injuries (AIS≥2)	548 (67.5%)	414 (71.8%)	0.09
Number of comorbidities			
None	135 (16.7%)	141 (24.6%)	<0.001
One	267 (33.0%)	158 (27.5%)	
Two or more	408 (50.4%)	275 (47.9%)	
Major psychiatric illness	103 (12.7%)	92 (16.0%)	<0.001
Substance abuse	80 (9.9%)	91 (15.9%)	<0.001
Surgery	366 (45.1%)	289 (50.3%)	0.05
ICU* admission	295 (36.3%)	218 (37.8%)	0.58
Ventilator use	91 (11.2%)	81 (14.0%)	0.11
Length of stay, d, median (IQR)*	5 (3–7)	5 (3–9)	0.03
Discharge disposition			
Home	202 (25.1%)	87 (27.0%)	0.003
Home with health services	178 (22.1%)	81 (25.2%)	
Rehabilitation facility	233 (28.9%)	102 (31.7%)	
Nursing home/Skilled nursing facility	168 (20.8%)	36 (11.2%)	
Other	25 (3.1%)	16 (5.0%)	
Rehabilitation			
None	187 (23.0%)	126 (21.8%)	<0.001
Inpatient	228 (28.1%)	226 (39.2%)	
Outpatient	173 (21.3%)	82 (14.2%)	
Both	224 (27.6%)	143 (24.8%)	

\*SD: Standard Deviation, AIS: Abbreviated Injury Scale, ICU: Intensive Care Unit, IQR: Interquartile Range.

**Table 2**  
Physical and mental health outcomes.

Outcome	Before COVID-19 (N = 812)	During COVID-19 (N = 577)	P value
Physical Outcomes			
New functional limitations (TQoL)	306 (37.7%)	195 (33.8%)	0.14
No return to work/school	114 (37.6%)	82 (37.8%)	0.97
Chronic pain (TQoL)	327 (50.9%)	226 (50.2%)	0.84
SF-12 PCS*	40.4 (11.6)	42.8 (12.2)	0.002
Mental Outcomes			
Post-traumatic stress disorder (PCL-5)	70 (11.0%)	51 (11.6%)	0.76
Depression (PHQ-8)	88 (13.7%)	81 (18.3%)	0.04
Anxiety (GAD-7)	79 (12.2%)	82 (18.3%)	0.01
SF-12 MCS*	50.9 (12.1)	49.4 (11.7)	0.05

\*SF-12 PCS: Short Form-12 Physical Composite Score (SF-12 PCS), SF-12 MCS: Short Form-12 Mental Composite Score.

**Table 3**  
Adjusted analyses†.

Outcome	OR/Coefficient, (95% CI)	P value
Physical Outcomes		
New functional limitations (TQoL)	OR = 0.86 (0.67, 1.11)	0.24
No return to work/school	OR = 0.94 (0.62, 1.42)	0.78
Chronic pain (TQoL)	OR = 0.88 (0.68, 1.14)	0.33
SF-12 PCS*	Coefficient = 2.21 (0.69, 3.72)	0.004
Mental Outcomes		
Post-traumatic stress disorder (PCL-5)	OR = 0.82 (0.54, 1.27)	0.38
Depression (PHQ-8)	OR = 1.46 (1.02, 2.09)	0.03
Anxiety (GAD-7)	OR = 1.56 (1.08, 2.26)	0.02
SF-12 MCS*	Coefficient = -1.16 (-2.72, 0.40)	0.15

†Multivariate regression models adjusted for: age, sex, race, Medicaid insurance, education level, prior psychiatric illness, substance abuse, number of comorbidities, injury cause, ISS, extremity injury, length of stay, surgery (yes/no), and site (BWH/MGH/BMC).

‡Reference group: Pre-COVID-19 period.

\*SF-12 PCS: Short Form-12 Physical Composite Score (SF-12 PCS), SF-12 MCS: Short Form-12 Mental Composite Score.

can be found in [Appendix 1](#).

#### 4. Discussion

The negative impact of the COVID-19 pandemic on mental health has been an important topic of research.<sup>32</sup> In this study, we demonstrated that patients injured during the COVID-19 pandemic were significantly more likely to screen positive for depression and anxiety than those injured before the pandemic. Interestingly, patients injured during the pandemic were not more likely to screen positive for PTSD. Our data suggests that the COVID-19 pandemic had a significant impact on the mental health of patients recovering from traumatic injury. However, the COVID-19 pandemic did not significantly affect physical health outcomes.

In the literature, factors such as age, sex, race, medical or psychiatric comorbidity, injury cause, and ISS have been associated with increased rates of mental health disorders in patients recovering from traumatic injury.<sup>9,29,30</sup> In our study, patients injured during the pandemic had less comorbidities, were younger, had higher rates of pre-existing major psychiatric illnesses and substance abuse, and were more often victims of blunt assault or road traffic accidents. Even when controlling for these factors, our analysis demonstrated that patients injured during the pandemic were significantly more likely to screen positive for depression and anxiety. These results suggest that the COVID-19 pandemic was independently associated with worse mental health outcomes in trauma patients.

There are several potential mechanisms by which the COVID-19 pandemic may be associated with higher rates of adverse mental health outcomes. One mechanism is through decreased social support due to social and physical isolation. Inadequate social support can especially impact patients recovering from traumatic injury, and social support has been shown to be a core component of many patients' recovery in prior FORTE studies.<sup>6</sup> Another potential mechanism is through the stresses induced by the pandemic. During the pandemic, people have experienced stress about a wide range of topics, including fears of contracting the virus, mistrust of the medical system, and uncertainty about the future.<sup>33,34</sup> Specifically, uncertainty about the future has been previously linked to increased rates of anxiety and depression.<sup>34</sup>

Interestingly, PTSD symptoms did not vary significantly between the two cohorts. The FORTE project has previously demonstrated PTSD to be correlated to anxiety and depression outcomes as well as mechanism of injury, with intentional injury being associated with higher rates of PTSD.<sup>35</sup> Patients injured during the pandemic were more often injured by blunt assault or road traffic accidents than those injured before the

pandemic, and less likely to have experienced a fall. Thus, despite patients injured during the pandemic experiencing more anxiety, depression, and intentional injuries, they were not more likely to have PTSD. It is unclear why the reported rate of PTSD is not significantly higher in this study. However, one possible explanation is that the study population was not large enough to detect significant differences in rates of PTSD despite the differences in injury mechanism being statistically significant. Another possible explanation is that patients injured during the COVID-19 pandemic were forced to quarantine, and thus were less likely to experience triggering of PTSD symptoms, which occurs when patients are exposed to external cues related to the initial traumatic event.<sup>36</sup>

Prior studies have demonstrated that patients often feel they fail to receive adequate post-injury information, including potential psychological side effects and access to services to address these side effects, such as counseling.<sup>37</sup> Therefore, it is imperative that we implement strategies to increase patient access to mental health services to mitigate the effects of trauma on patients, particularly in patients injured during the COVID-19 pandemic. Telemedicine services are effective and have been utilized during the pandemic to better address the worsening mental health of the general population when in person meetings were not possible.<sup>38</sup> We recommend increasing awareness and access to telemedicine mental health services in trauma patients in order to combat the influence of the COVID-19 pandemic on mental health, as has been previously suggested.<sup>39</sup>

Patients injured during the COVID-19 pandemic demonstrated comparable functional outcomes to patients injured before the pandemic, including new functional limitations, no return to work/school, and chronic pain. Therefore, the COVID-19 pandemic was not independently associated with adverse functional outcomes. These results are interesting given that prior FORTE studies have demonstrated a positive association between adverse mental health outcomes and adverse functional outcomes.<sup>40</sup> A known protective factor of functional outcomes is access to physical therapy and our results suggest preserved access to rehabilitation with a higher proportion of patients injured during the pandemic receiving inpatient rehabilitation. Furthermore, additional survey questions of patients injured during the pandemic beginning in May 2020 (N = 327) suggest that our patients did not experience difficulty accessing healthcare during the pandemic (87%) or feel that their recovery was negatively impacted by the pandemic (74%). Therefore, a potential mechanism to explain preserved functional outcomes despite worse mental health outcomes is preserved access to

healthcare, and specifically, rehabilitation.

#### 4.1. Limitations

This study and its limitations should be interpreted in the context of its design. The FORTE study is a prospective database, and thus the possibility of selection bias due to loss of follow-up should be considered. Secondly, this study was comprised of patients who are older than the general trauma population and drew its patient cohorts from three large academic medical centers with mainly urban and suburban populations. Thus, our results may not be generalizable to the trauma population at large. Further studies should assess the effects of the COVID-19 pandemic on rural patients recovering from traumatic injury. Specifically, the association between physical distance, social isolation, and mental health outcomes should be examined. Additionally, this study only examined patients 6 months after injury. Longer follow-up is recommended to fully understand the recovery trajectories of trauma patients. Finally, the study was limited by the comparison of different month cohorts, rather than the comparison of the same months in different years. Thus, there is a potential for confounding based on the seasonal variability of traumatic injuries and mental health symptoms.

#### 5. Conclusions

This study found that patients injured during the COVID-19 pandemic had significantly worse mental health outcomes, including significantly higher rates of anxiety and depression, than patients injured prior to the COVID-19 pandemic. Physical health outcomes did not vary significantly between groups. Future work should aim at better understanding the mechanisms by which the COVID-19 pandemic is associated with increased risk for adverse mental health outcomes and developing strategies to mitigate such risks.

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#### Declaration of competing interest

The authors have no conflicts of interest in relationship to this manuscript.

### Appendix 1

Inverse Probability of Treatment Weighting Adjusted Analyses Results

Outcome	OR/Coefficient, (95% CI)	P value
Physical Outcomes		
New functional limitations	0.90 (0.71, 1.13)	0.37
No return to work/school	0.94 (0.64, 1.39)	0.76
Chronic pain	0.89 (0.69, 1.15)	0.37
SF-12 PCS††	2.14 (0.51, 3.77)	<b>0.01</b>
Mental Outcomes		
Post-traumatic stress disorder (PCL-5)	0.79 (0.53, 1.20)	0.28
Depression (PHQ-8)	1.44 (1.01, 2.08)	<b>0.04</b>
Anxiety (GAD-7)	1.50 (1.05, 2.16)	<b>0.03</b>
SF-12 MCS††	-1.16 (-2.77, 0.46)	0.16

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