


Low Prevalence but High Impact of COVID-19 Positive Status in Adult Trauma Patients: A Multi-institutional Analysis of 28 904 Patients

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Abstract

Background: Few large investigations have addressed the prevalence of COVID-19 infection among trauma patients and impact on providers. The purpose of this study was to quantify the prevalence of COVID-19 infection among trauma patients by timing of diagnosis, assess nosocomial exposure risk, and evaluate the impact of COVID-19 positive status on morbidity and mortality.

Methods: Registry data from adults admitted 4/1/2020–10/31/2020 from 46 level I/II trauma centers were grouped by: timing of first positive status (Day 1, Day 2–6, or Day \geq 7); overall Positive/Negative status; or Unknown if test results were unavailable. Groups were compared on outcomes (Trauma Quality Improvement Program complications) and mortality using univariate analysis and adjusted logistic regression.

Results: There were 28 904 patients (60.7% male, mean age: 56.4, mean injury severity score: 10.5). Of 13 274 (46%) patients with known COVID-19 status, 266 (2%) were Positive Day 1, 119 (1%) Days 2–6, 33 (.2%) Day \geq 7, and 12 856 (97%) tested Negative. COVID-19 Positive patients had significantly worse outcomes compared to Negative; unadjusted comparisons showed longer hospital length of stay (10.98 vs 7.47; $P < .05$), higher rates of intensive care unit (57.7% vs 45.7%; $P < .05$) and ventilation use (22.5% vs 16.9%; $P < .05$). Adjusted comparisons showed higher rates of acute

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respiratory distress syndrome (1.7% vs .4%; $P < .05$) and death (8.1% vs 3.4%; $P < .05$).

Conclusions: This multicenter study conducted during the early pandemic period revealed few trauma patients tested COVID-19 positive, suggesting relatively low exposure risk to care providers. COVID-19 positive status was associated with significantly higher mortality and specific morbidity. Further analysis is needed with consideration for care guidelines specific to COVID-19 positive trauma patients as the pandemic continues.

Keywords

COVID-19, wounds and injuries, mortality, patient outcomes, traumatic injury

Key Takeaways:

- Previous studies have described the impact of COVID-19 infection on outcomes in trauma patients with a specific injury, such as hip fracture, but there is limited data on the prevalence of COVID-19 infection among large groups of trauma patients on arrival and during their stay.
- In this study of 28 904 trauma patients, few tested positive for COVID-19, suggesting low exposure risk to care providers.
- COVID-19 positive status was associated with increased morbidity and mortality.

Introduction

The impact of the coronavirus disease (COVID-19) has been devastating. As of mid-July 2022, there were over 570 million infections worldwide, and roughly 6.4 million deaths.¹ The US experienced over 89.6 million infections and one million deaths.² Many states implemented “lockdown” periods, and elective surgeries were placed on hold.^{3,4} Initially, trauma volumes decreased; however, injuries still occurred and trauma services remained busy.⁵⁻⁷ Healthcare facilities were challenged with balancing trauma patient care while remaining cognizant of potential clinical impacts of COVID-19 infection, including nosocomial spread of the virus between both patients and staff. For trauma activations, there is generally little opportunity for the trauma team to await COVID-19 testing results, and patients must be treated expeditiously, regardless of infection status.

COVID-19 prevalence among large numbers of injury victims is not well described, and the impact of active COVID-19 infection on trauma outcomes remains unclear. Studies have reported an increased risk of mortality when undergoing any surgical procedure in patients with a positive COVID-19 diagnosis.⁸⁻¹⁰ In hip fracture repairs, Egol et al found a mortality rate of 35.3% in COVID-19 positive patients compared to .9% in COVID-19 negative patients⁹ while Muoz Vives et al reported a 30.4% mortality rate in COVID-19 positive patients compared to 10.3% in patients who tested negative.¹⁰ There have been relatively few data on COVID-19

infection prevalence among large groups of trauma patients on arrival and during their stay. Consequently, it is unknown if clinical characteristics and outcomes of trauma patients infected with COVID-19 are different from trauma patients not infected with the virus. The potential for nosocomial transmission is also of concern for patients and healthcare workers alike, as over 80% of all individuals infected with COVID-19 have mild symptoms or are asymptomatic.¹¹

The purpose of this study was to quantify the prevalence of COVID-19 infection among trauma patients by timing of infection diagnosis, assess nosocomial exposure risk of infection, and evaluate the impact of COVID-19 positive status on trauma patient morbidity and mortality.

Methods

This research was determined to be exempt/excluded from Institutional Review Board (IRB) oversight in accordance with current regulations. Adult patients from trauma registries of 46 US level I and II trauma centers were included if they were ≥ 18 years of age, a trauma activation or consultation, and had an inpatient admission date between April 1, 2020, and October 31, 2020. Patients were excluded if they were discharged from the emergency department (ED) or died in the ED. Trauma registry data were retrospectively reviewed to collect patient demographics, injury details, complications, and patient outcomes. COVID-19 status was determined from the electronic medical records based on laboratory test results from any type of COVID-19 test, including rapid and polymerase chain reaction testing. Patients were grouped by the timing of their first positive status and by overall status as Positive/Negative, or as Unknown if no COVID-19 test result was available (Table 1). Length of time used for grouping was the time from ED sign-in to time a positive test was collected.

The primary purpose of this study was to quantify the prevalence of COVID-19 infection among trauma patients and estimate the nosocomial exposure risk of infection. The prevalence of infection was assessed among those tested and among all trauma patients meeting inclusion criteria. Potential suspected nosocomial incidence was

Table 1. COVID-19 Patient Grouping Definitions.

COVID-19 group	Definition
Positive Day 1	First positive status within 24 hours of ED admit
Positive Day 2-6	First positive status within >24-168 hours of ED admit
Positive Day ≥ 7	First positive status more than 168 hours after ED admit, but prior to discharge
Positive	One or more documented positive results at any time during hospitalization
Negative	One or more documented negative results with no positive results any time during hospitalization
Unknown	No documented test result for COVID-19 status in medical record

Abbreviations: ED, emergency department

defined as the subgroup of patients who had their first positive test on or later than 7 days following presentation. Secondary outcomes evaluated included hospital length of stay (LOS), intensive care unit (ICU) utilization (defined as days in the ICU), ventilator utilization (defined as days on mechanical ventilation), in-hospital mortality, and complications. In-hospital mortality was determined using hospital discharge information. Complications were identified using Trauma Quality Improvement Program definitions.

The daily percentage of patients testing positive between April 1, 2020, and October 31, 2020, was plotted using a bar graph and locally weighted scatter plot smoother curve, with emphasis on surge periods corresponding to periods of high community spread, which included April 1-30, June 16-31, and October 1-31, 2020. Community spread was estimated using data from the Johns Hopkins University Coronavirus Resource Center dataset.¹² The dataset utilizes Federal Information Processing Standard county codes to count positive cases in each area. Daily sums of positive counts in the county areas surrounding the study hospitals were calculated to provide comparative data.

Although the retrospective design of this study does not permit a reliable, comprehensive assignment of mortality attribution, the authors performed a limited chart review of patients who died, whereby an experienced trauma surgeon and nurse performed a limited review of electronic admission history and physical examination and discharge summary documentation. Patients were then assigned to one of the following categories: mortality attributable to COVID-19, mortality not attributable to COVID-19, and indeterminate.

Data were summarized and analyzed using the univariate summary statistics Pearson χ^2 tests of association and Wilcoxon rank-sum. Within each COVID-19 status timing group, the proportion of patients who had each outcome were presented and compared to the COVID-19 negative group (referent) using Pearson χ^2 tests of association (Independence). The associations between COVID-19 infection status and outcomes were also estimated using multivariable logistic regression adjusting for potential confounders, including age and injury

severity score (ISS). Both age and ISS were included in the model using restricted cubic splines with 3 knots. The effect of each was summarized using an odds ratio with 95% confidence interval (CI) and tested for statistical significance using the associated Wald test. For all adjusted models, *P* values less than .05 were considered statistically significant. R software version 3.6.2 was used for all statistical analyses.¹³

Results

A total of 28 904 trauma patients met inclusion criteria and were included in the analysis. The patient sample included 17 514 (60.7%) males, with a mean age of 56.4 (SD:22.5) years, and mean ISS of 10.5 (SD:8.3) (Table 2). There were 15 630 (54.1%) patients that did not have documentation of COVID-19 testing and 13 274 (46%) patients with a known COVID-19 status. There was no standard testing guideline and hospitals varied in their methods for whom they chose to test. Testing rates were initially low for trauma patients admitted early in the pandemic (April 2020: 20.5%) and increased significantly over the duration of the study (October 2020: 52.3%), consistent with evolving guidelines, resources, and practices (Figure 1). Of those with a known status, 418 (3.1%) were COVID-19 positive and 12 856 (96.9%) had a documented negative result. The distribution of COVID-19 positive patients by timing of their first known positive status was 266 (2%) positive on Day 1, 119 (.9%) positive between Days 2 and 6, and 33 (.2%) positive on Day 7 or later. Positive rates were consistently low over the study period, with small fluctuations that paralleled community prevalence rates (Figure 2). Patients testing positive on Day 1 were more likely to be younger than patients who tested negative, and patients who tested positive Days 2-6 were slightly older. The sex distribution was similar for all groups, as were the mean ISS scores. Patient characteristics stratified by timing and result of COVID-19 testing are described in Table 2.

Patients who tested positive for COVID-19 had significantly worse outcomes compared to the group who tested negative (Table 3). Unadjusted comparisons showed longer LOS (10.98 vs 7.47, *P* < .001) and

Table 2. Patient Characteristics by COVID-19 Status and Timing.

	Hospital day of first positive test			Status for all tested patients		Unknown status
	Day 1	Day 2-6	Day ≥ 7	Positive	Negative	
No. (%) of those tested	n = 266 (2.0%)	n = 119 (.9%)	n = 33 (.2%)	n = 418 (3.1%)	n = 12 856 (96.9%)	n = 15 630
Age, mean (SD), y	56.0 (24.6)*	64.7 (22.8)*	59.5 (21.2)	58.7 (24.1)	60.5 (22.6)	53.0 (21.8)*
Male, No. (%)	159 (59.8%)	58 (48.7%)	20 (60.6%)	237 (56.7%)	7327 (57.1%)	9950 (63.7%)*
ISS, mean (SD)	11.5 (7.9)	11.3 (9.6)	11.8 (8.3)	11.5 (8.5)	11.5 (8.8)	9.7 (7.6)*

Abbreviations: SD, standard deviation; ISS, injury severity score.

*Indicates group differs statistically from Negative group at $P < .05$.

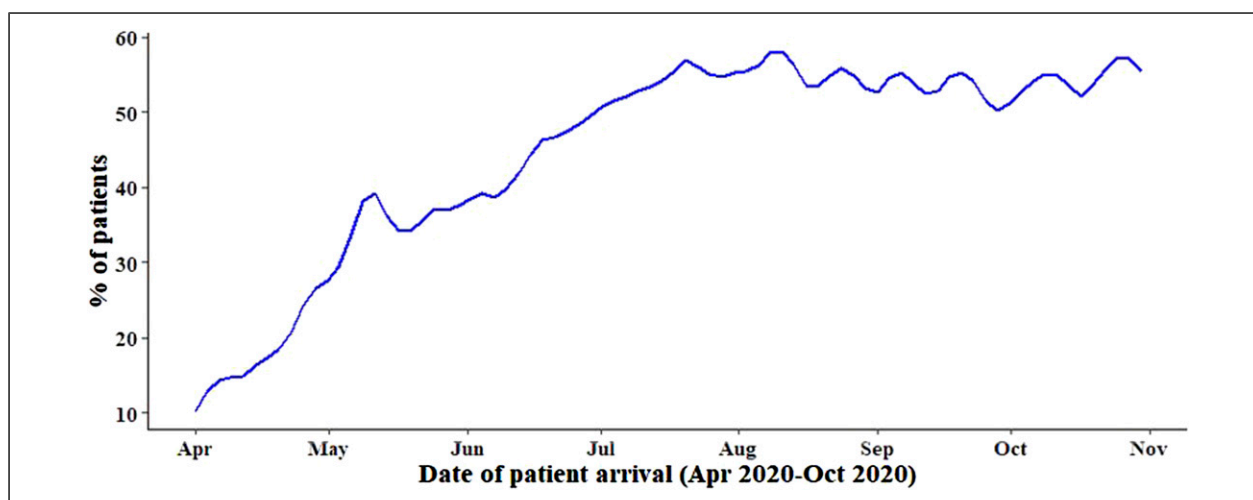


Figure 1. Percentage of trauma patients tested for COVID-19 by date of admission. Testing rates were initially low for trauma patients who were admitted early in the pandemic (April 2020: 20.5%) and increased significantly over the duration of the study (October 2020: 52.3%). This increase is consistent with evolving guidelines, resources, and practices.

higher rates of ICU use (57.7% vs 45.7%, $P < .001$) and mechanical ventilation use (22.5% vs 16.9%, $P = .003$). Comparisons of complications and mortality showed higher rates of acute respiratory distress syndrome (ARDS) (1.7% vs .4%, $P < .001$) and death (8.1% vs 3.4%, $P < .001$). Similar rates of death and complications were found among the groups regardless of timing of status. Patients whose first test was found to be positive on or after Day 7 had more ICU utilization (78.8% vs 56.4%, $P = .014$) and mechanical ventilation use (36.4% vs 21.8%, $P = .062$) than patients whose first positive status was on Day 1 (Table 3). This unadjusted analysis does not consider the inherent bias associated with patients who were discharged prior to Day 7, so additional adjusted analyses were performed.

Adjusted logistic regression (adjusted for age and ISS) to predict mortality, venous thromboembolism (VTE) incidence, and ARDS was performed. These analyses showed an increased odds of mortality in patients who had a COVID-19 positive status during their stay (adjusted

odds ratio [aOR]: 2.86, 95%CI: 1.95-4.21; $P < .0001$). Positive status was associated with increased odds of ARDS (aOR: 5.95, 95%CI: 2.40-14.78; $P = .0005$). Significant differences were not found for rates of VTE, which included deep vein thrombosis and pulmonary embolism (aOR: 1.40, 95%CI: .08-2.88; $P = .2433$).

In the limited review of electronic chart documentation of patients who died, 14 patients were assigned to the “Mortality attributable to COVID-19” category; 19 patients were assigned to the “Mortality not attributable to COVID-19” category; 1 patient was assigned to the “Indeterminate” category. Notably, 23 of 34 (67.6%) were over age 60. Nearly all those assigned to the “Mortality attributable to COVID-19” category had severe respiratory failure as a prelude to death, consistent with the clinical course of patients with advanced COVID-19 infection. Patients in the “Mortality not attributable to COVID-19” category succumbed to their injuries (or complications thereof) with severe traumatic brain injury being the most frequent injury.

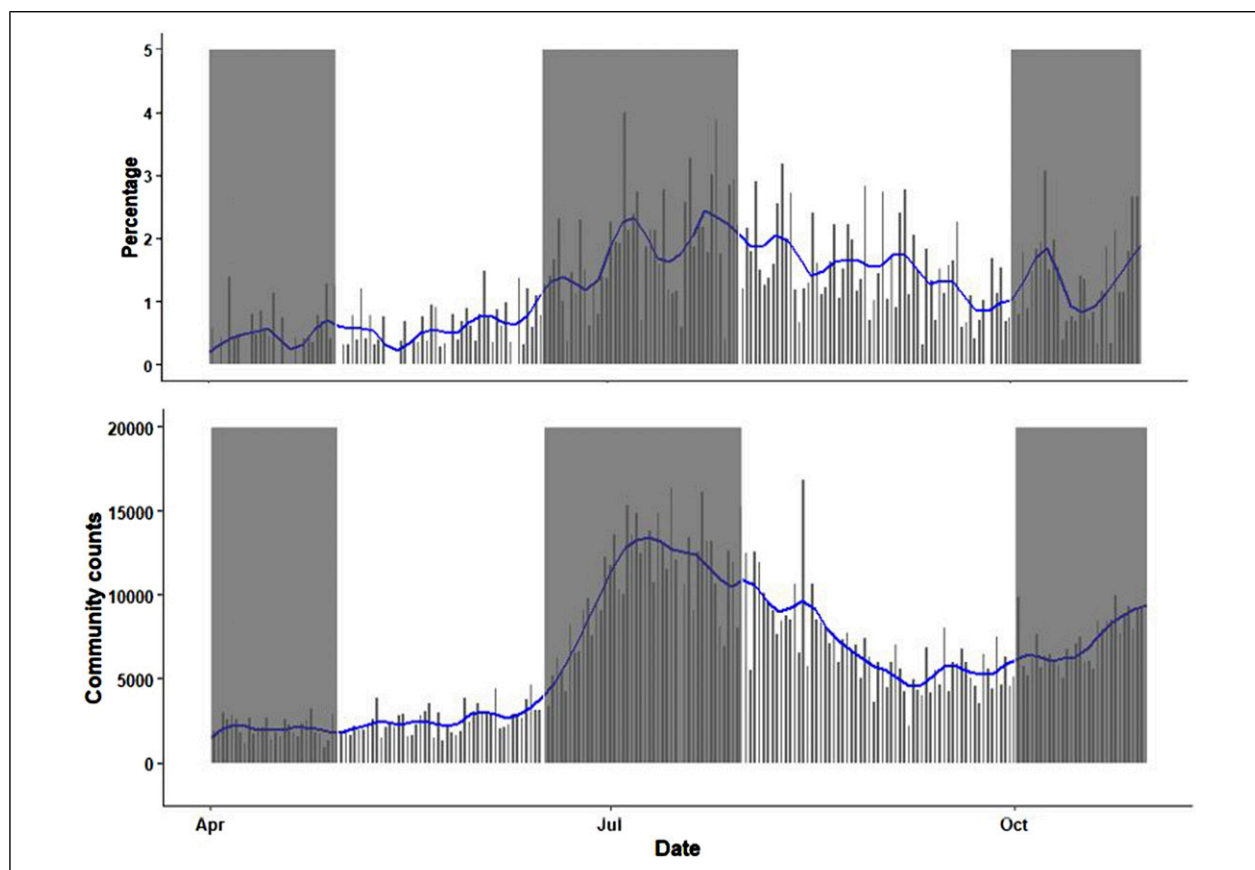


Figure 2. Daily percentage of patients testing positive for COVID-19 (top) and daily counts of community cases in the areas surrounding the trauma centers included in the study (bottom)^a. Positive rates in trauma patients were consistently low over the study period, with small fluctuations that paralleled the community prevalence rates. ^a Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. *Lancet Infect Dis.* 2020; 20(5):533-534.

Discussion

This multicenter study of Level I and II trauma centers from a large, nationwide trauma system demonstrated the prevalence of COVID-19 infection in patients presenting as trauma activations/consultations in the first year of the pandemic was relatively low (approximately 2%), and a subsequent positive test for COVID-19 appeared in a small number of additional inpatients (approximately 1%). Compared to patients who tested negative for COVID-19, patients who tested positive at any time had significantly worse outcomes (longer hospital LOS, longer ICU LOS, increased ventilator use, higher rates of ARDS). A significant difference in VTE was not observed between the two groups. Patients testing positive for COVID-19 had significantly greater mortality rates, regardless of the timing of diagnosis.

A late 2020 scoping review of 57 studies from around the world by Waseem et al confirmed the finding of generally low COVID-19 prevalence in patients testing positive.⁶ Other studies of COVID-19 infection rates in trauma patients reported similar findings in

smaller, geographically limited samples. The ICON study from the United Kingdom reported a low prevalence of COVID-19 (1.69%) among 237 patients from early 2020, as well as a 2-fold increase in mortality rates compared to a matched cohort from the previous year.⁷ Sheets et al evaluated trauma patient volumes from January to December 2020 and found that mortality increased during the early stages of the COVID-19 pandemic.¹⁴ In a statewide, retrospective study of 15 550 patients from April to July of 2020, Kaufman et al found that COVID-19 positive trauma patients had an increased risk of death (OR 6.05; 95% CI: 2.29-15.99), any complication (OR 1.85; 95% CI: 1.08-3.16), and pulmonary complications (OR 5.79; 95% CI: 2.02-16.54).¹⁵ In a study of 20,448 trauma patients in California (January to June, 2020), Yeates et al reported .8% COVID-19 positive patients.¹⁶ Those testing positive for COVID-19 had worse outcomes including mortality (9.4% vs 1.9%, $P = .029$), pneumonia (7.5% vs .0%, $P = .011$), and increased mean LOS (7.47 vs 3.28 days, $P < .001$), and ICU LOS (1.40 vs .80 days, $P = .008$).¹⁶

Table 3. Patient Outcomes by COVID-19 Status and Timing.

	Hospital day of first positive test			Status for all tested patients		Unknown status
	Day 1	Day 2-6	Day ≥7	Positive	Negative	
No. (%) of those tested	n = 266 (2.0%)	n = 119 (.9%)	n = 33 (.2%)	n = 418 (3.1%)	n = 12 856 (96.9%)	n = 15 630
Hospital LOS, mean (SD), d	8.1 (8.8)	11.3 (14.6)*	33.4 (20.1)*	11.0 (13.6)*	7.5 (9.3)	3.7 (4.4*)
Hospital LOS						
<1 day, No. (%)	20 (7.5%)	4 (3.4%)*	0 (.0%)*	24 (5.7%)*	725 (5.6%)	2717 (17.4%)*
1-3 days, No. (%)	84 (31.6%)	32 (26.9%)	0 (.0%)	116 (27.8%)	4663 (36.3%)	8392 (5.7%)
4-7 days, No. (%)	76 (28.6%)	32 (26.9%)	0 (.0%)	108 (25.8%)	3913 (30.4%)	3098 (19.8%)
<8 days, No. (%)	86 (32.3%)	51 (42.9%)	33 (100%)	170 (40.7%)	3555 (27.7%)	1423 (9.1%)
Any ICU use, No. (%)	150 (56.4%)*	65 (54.6%)	26 (78.8%)*	241 (57.7%)*	5871 (45.7%)	5377 (34.4%)*
Ventilator use, No. (%)	58 (21.8%)*	24 (20.2%)	12 (36.4%)*	94 (22.5%)*	2175 (16.9%)	1336 (8.5%)*
Death, No. (%)	22 (8.3%)*	10 (8.4%)*	2 (6.1%)	34 (8.1%)*	440 (3.4%)	454 (2.9%)*
ARDS, No. (%)	4 (1.5%)*	1 (.8%)	2 (6.1%)*	7 (1.7%)*	47 (.4%)	3 (.0%)*
VTE, No. (%)	5 (1.9%)	1 (.8%)	2 (6.1%)*	8 (1.9%)	195 (1.5%)	53 (.3%)*

Abbreviations: SD, standard deviation; ICU, intensive care unit; ARDS, acute respiratory distress syndrome; VTE, venous thromboembolism; LOS, length of stay.

*Indicates group differs statistically from Negative group at P<.05.

In this study, adjusted odds of mortality for patients who tested positive for COVID-19 were 2.9 times higher than those without infection when controlling for age and ISS, consistent with other reports of trauma patients in the literature,^{6,7,9,11,14-16} and with the relatively high fatality rates in patients with severe COVID-19 infection. The adjusted analysis in this study revealed a nearly 6-fold higher rate of ARDS in COVID-19 positive patients, which suggests trauma patients are similar to other patients with serious COVID-19 infection whose mortality rates are roughly 40%.¹⁷ Since serious pulmonary dysfunction with ARDS is likely a major contributor to mortality in all patients with COVID-19, added focus on the early diagnosis and state-of-the-art management of respiratory failure in trauma patients may represent an opportunity to mitigate the effects of the disease and reduce mortality.

Testing for COVID-19 in hospitalized patients has been broadly adopted and the findings of this study support a similar approach for trauma patients.¹⁸ The relatively low rate of infection in trauma patients presenting to trauma centers in this study is consistent with reports from others,^{6,7,9,11,14-16} and suggests that nosocomial transmission to those caring for these patients is likely not a higher risk than other areas within the hospital. Together with existing guidelines for the protection of healthcare workers,¹⁹ these relatively low rates provide some reassurance that the care of trauma patients can proceed with relatively low risk to healthcare providers, even when the results of testing are not available. This

may be somewhat reassuring given the many other burdens that trauma team members and other healthcare workers encounter in the treatment of COVID-19 patients.

The majority of patients in this study who tested positive for COVID-19 did so either on arrival or within the first 6 days of admission. Since the incubation period of the virus is thought to be between 2 and 14 days,²⁰ the risk of nosocomial transmission to patients within the hospital appears low, as the rate of positive tests in the second week was only .2%. The vast majority of patients who tested positive most likely contracted the disease prior to hospitalization. The low positive test rate in the second week may also be related to the measures hospitals and healthcare workers have taken to protect themselves and their patients from the infection and supports continued application of these measures.¹⁹

This study has several limitations. Despite its large size and the inclusion of 46 trauma centers from around the United States, the generalizability of these findings may be limited by both the skewed geographic distribution of the centers included in the study and by the varying prevalence rates of COVID-19 infection in different communities related to timing of surges by location. Only patients who had trauma activation/consultation were included and other injured patients may have differing prevalence rates. Limitations related to the extent of testing and test accuracy should be considered in interpreting these data, as only about half of the patients were tested and not all test technologies are equally accurate. Finally, this study reflects findings from the first 7 months

of the COVID-19 pandemic and may or may not apply to subsequent phases of the pandemic due to biologic variation in virus behavior, as well as changing susceptibility of various populations related to vaccination and other mitigation measures.

In this large, multicenter study in the first year of the pandemic, few trauma patients were COVID-19 positive, suggesting relatively low exposure risk to trauma care providers. COVID-19 positive status was associated with significantly higher mortality and specific morbidity. Further analysis of associations with poorer outcomes is needed with consideration for care guidelines specific to COVID-19 positive trauma patients.

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Author Contribution

All authors certified they made contributions in design, data acquisition, data analysis/interpretation and drafting/revising the manuscript. Authors have given approval of the version to be published.

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Supplemental Material

Supplemental material for this article is available online.

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