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Shift in Pre-Hospital Mode of Transportation for Trauma Patients during the COVID-19 Pandemic

Short Title: COVID Pandemic and Pre-Hospital Transport

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**Abstract****Background:**

Since the start of the COVID-19 pandemic, we experienced alterations to modes of transportation amongst trauma patients suffering penetrating injuries. Historically, a small percentage of our penetrating trauma patients use private means of pre-hospital transportation. Our hypothesis was that the use of private transportation among trauma patients increased during the COVID-19 pandemic and was associated with better outcomes.

**Methods:**

We retrospectively reviewed all adult trauma patients (Jan. 1, 2017 to Mar. 19, 2021), using the date of the shelter-in-place ordinance (Mar. 19, 2020) to separate trauma patients into pre-pandemic and pandemic patient groups. Patient demographics, mechanism of injury, mode of pre-hospital transportation, and variables such as initial ISS, Intensive Care Unit (ICU) admission, ICU length of stay (LOS), mechanical ventilator days, and mortality were recorded.

**Results:**

We identified 11,919 adult trauma patients, 9,017 (75.7%) in the pre-pandemic group and 2,902 (24.3%) in the pandemic group. The number of patients using private pre-hospital transportation also increased (from 2.4% to 6.7%,  $p < 0.001$ ). Between the pre-pandemic and pandemic private transportation cohorts, there were reductions in mean ISS (from  $8.1 \pm 10.4$  to  $5.3 \pm 6.6$ ;  $p = 0.02$ ), ICU admission rates (from 15% to 2.4%;  $p < 0.001$ ) and hospital LOS (from  $4.0 \pm 5.3$  to  $2.3 \pm 1.9$ ;  $p = 0.02$ ). However, there was no difference in mortality (4.1% and 2.0%,  $p = 0.221$ ).

**Conclusion:**

We found that there was a significant shift in pre-hospital transportation among trauma patients toward private transportation after the shelter-in-place order. However, this did not coincide with a change in mortality despite a downward trend. This phenomenon could help direct future policy and protocols in trauma systems when battling major public health emergencies.

Keywords: Trauma; COVID-19; transportation; penetrating; Outcomes; safety net hospital

Main Text

Introduction

The COVID-19 pandemic has placed a massive strain on the general public and health systems in the United States. It has forced hospitals to manage a large influx of patients and the public to make difficult decisions regarding their health and well-being. Given the overall disruption of COVID-19, we have seen exacerbations of medical issues outside of acute infections of the virus<sup>2</sup>. Interestingly, one such phenomenon has been an increase in patients presenting to Emergency Departments secondary to penetrating traumatic injuries<sup>3</sup>.

There are many factors that are associated with the outcomes of trauma patients. While there is large focus on post-hospital care, pre-hospital management of trauma has been the subject of study for many years<sup>4</sup>. It has been demonstrated that pre-hospital care plays a large role in patient outcomes<sup>7,8</sup>. One such component is the mode of pre-hospital transportation. For example, there is a lower likelihood of death in penetrating trauma patients who presented via private transportation to level 1 and level 2 trauma centers in urban environments<sup>9</sup>. We have also seen that COVID-19 has placed a large burden on Emergency Medical Services (EMS) and has been associated with increased call volumes and ambulance response delays<sup>10</sup>. Additionally, it has led to risk-averse behavior causing people to be reluctant to call for EMS assistance due to fear of the virus<sup>10</sup>.

Despite these changes, limited data exists on the impact of this pandemic on pre-hospital transportation among trauma patients and their outcomes. We aimed to assess associations of the pandemic with rates of private transportation and its effect on outcomes. Our hypothesis was that the use of private transportation among trauma patients increased during the COVID-19 pandemic and was associated with better outcomes.

## Materials and Methods

Our institution is a university-based level one trauma center serving Oakland, California and the surrounding cities in the East Bay with a diverse population. We performed this study with approval by the Alameda Health System Institutional Review Board (IRB 20-05081A) with a waiver of the requirement for informed consent.

## Study Population

We reviewed all trauma patients arriving at our university-based level 1 trauma center from January 1, 2017 through March 19, 2021. We included all adult trauma patients ( $\geq 15$  years old).

## Study Design

Our state's shelter-in-place order went into effect on March 19, 2020, so we separated patients into two comparison groups: those arriving prior to this date and those arriving on or after this date. We included a larger time period prior to the shelter-in-place in order to account for year-to-year variation prior to the pandemic. Additionally, we chose to include one full year after the shelter-in-place order to fully analyze results specific to the state ordinance which lasted through to June 15, 2021. We collected variables including mode of transportation, age, sex, race/ethnicity, mechanism of trauma, and injury severity score (ISS). Our primary predictor was the mode of pre-hospital transportation. This was recorded by our Emergency Department as either private or EMS. We also collected information regarding hospital length of stay (LOS), ICU admission and LOS, days on mechanical ventilation, and mortality to be analyzed as secondary outcomes. Our primary outcome was mortality.

## Statistical Analysis

Chi-squared and Fisher's Exact tests were used to compare categorical variables. Mann-Whitney U tests were used to compare non-normally distributed continuous variables. Plots of normality and Shapiro-Wilk tests were used to evaluate distributions for normality. A p-value of less than 0.05 was

considered significant. All analyses were performed using IBM SPSS Statistics for Windows, version 27.0 (IBM Corp., Armonk, NY, USA).

## Results

During the study period, 11,919 adult trauma patients presented to our Emergency Department. We divided them into two cohorts: 9,017 patients (75.7%) in the pre-pandemic group and 2,902 (24.3%) in the pandemic group (Table 1).

Table 1 lists baseline characteristics of the two comparison groups, pre-pandemic and pandemic. The majority of patients in both pre-pandemic and pandemic groups were male as compared to female ( $p=0.002$ ). Additionally, blunt mechanisms of trauma predominated in both groups. However, there was an increase in the number of trauma patients who presented secondary to penetrating mechanisms of injury (from 14.8% to 23.1%:  $p<0.001$ ) in the pre-pandemic and the pandemic cohort, respectively (Figure 1). This coincided with an increase in the rate of patients using private means of pre-hospital transport between the two groups (from 2.4% to 6.7%:  $p<0.001$ ) (Figure 1). In overall outcomes, there was an increase in mortality (from 3.2% to 4.7%:  $p<0.001$ ) (Figure 2) and mean ventilator days (from  $6.3 \pm 7.9$  to  $6.9 \pm 7.1$ :  $p=0.036$ ) between pre-pandemic and pandemic groups. Mean ISS scores were slightly different between the two groups ( $7.0 \pm 8.9$  and  $7.5 \pm 9.3$ :  $p=0.03$ ) (Table 1).

When comparing subgroups of patients based on mode of pre-hospital transportation, we found some interesting associations. Table 2 shows that within the Private Transportation subgroup, between pre-pandemic and pandemic groups, there were decreases in ICU admission rates (from 15% to 2.4%:  $p<0.001$ ) and hospital LOS (from  $4.0 \pm 5.3$  to  $2.3 \pm 1.9$ :  $p=0.02$ ). This coincides with a decrease in mean ISS (from  $8.1 \pm 10.4$  to  $5.3 \pm 6.6$ :  $p=0.02$ ). However, despite a downward trend, we did not identify a significant difference in mortality rate (4.1% to 2.0%:  $p=0.2$ ) (Figure 2).

In the EMS subgroup, there was a slight increase in the mean ventilator days between pre-pandemic and pandemic groups (from  $6.4 \pm 7.9$  to  $6.9 \pm 7.2$ :  $p=0.04$ ) (Table 3). There was also an increase

in mortality (from 3.2% to 4.9%:  $p < 0.001$ ) (Figure 2) which coincided with an increase in mean ISS (from  $7.0 \pm 8.8$  to  $7.6 \pm 9.4$ :  $p = 0.003$ ) (Table 3).

## Discussion

The aim of this study was to investigate and characterize components of pre-hospital trauma care during the COVID-19 pandemic. Specifically, we were interested in evaluating the trends of pre-hospital transportation and its associations with patient outcomes. There has been no inquiry into trends of pre-hospital transportation during the COVID-19 pandemic despite evidence of an increase in the rate of penetrating trauma. Such investigation would be relevant because, as mentioned, this represents the subset of patients who have been demonstrated to have outcomes impacted by pre-hospital transportation. To our knowledge, this is the first attempt to categorize these changes. Our results demonstrated that there was indeed an increase in the utilization of private transportation at our urban, safety net, level 1 trauma hospital. We also witnessed an increase in overall morbidity and mortality among patients who arrived to the Emergency Department via EMS, but no difference in mortality among trauma patients who used private transportation.

A continued investigation into pre-hospital trauma care is valuable, especially during unique times, as previous literature has demonstrated that varying aspects can have a significant impact on patient outcomes. These include things such as interventions (endotracheal intubation, spine mobilization), intravenous fluid administration or even mode of transportation<sup>7,8,9,11,12</sup>. Several studies have demonstrated that private transportation has been associated with improved outcomes in certain subgroups of trauma patients<sup>9,11,12</sup>. One study in particular illustrated that patients who suffered GSW had two-fold increase in mortality if transported via EMS<sup>12</sup>.

The COVID-19 pandemic has impacted the health and safety of the general public in a myriad of ways. Not only from an infectious disease perspective, but it has put severe strain on healthcare resources including EMS<sup>10</sup>. This has forced patients to make difficult decisions when it comes to seeking care, such as providing their own transportation to the hospital. Also, we have witnessed an unexpected rise in

penetrating trauma since the beginning of the pandemic. Our group has demonstrated that since the shelter-in-place order put forth by the State of California, there has been a significant increase in the rate of penetrating and high-level trauma when compared to those of similar months in prior years<sup>4</sup>. This phenomenon has been seen in other urban cities across America as well<sup>5,6</sup>. It is likely the cause of this increase is multifactorial due to various aspects such as socioeconomic changes and a demonstrated rise in firearm purchases during this time<sup>13,14</sup>.

Interestingly, we identified some changes consistent with the idea of a protective effect associated with private transportation. Our cohort of trauma patients that used private transportation had a decrease in ICU admission rates and reduced LOS between pre-pandemic and pandemic groups. However, it is important to consider this may have been impacted by hospital wide efforts to maintain availability for potential COVID patients. Finally, while our results did not demonstrate a significant change in mortality amongst patients using private transportation, we did find a downward trend whereas the overall cohort and EMS subgroup experienced significant increases in mortality. These findings are likely related to the associated changes in ISS identified in each cohort. Despite a marginal change in ISS within the EMS subgroup between pre-pandemic and pandemic groups, the associated change in mortality is consistent with established mortality rates predicted by ISS. Mortality rates range between 2-4% among patients with ISS<9<sup>15</sup>. It is possible that the increase in mortality within the EMS subgroup from 3.2% to 4.9% despite marginal increase in ISS may have been affected by factors unique to the pandemic. These could include delays in EMS response time or an impacted hospital and health system. Furthermore, it is possible there may be a component of unconscious bias. This could result from the trauma team letting their guard down when a trauma patient is transported by EMS with stable appearing vitals as opposed to heightened awareness in the case of a patient arriving via private transportation with minimal data.

There are a few limitations of our study. While we have analyzed a large overall cohort, we were unable to detect a significant difference in mortality of our Private Transportation cohort. With further analysis of additional data as we move further from the initial shelter-in-place order, we might be able to find such a difference. Additionally, as our study design is a retrospective, single center study, we are



only able to identify possible associations with outcomes and our generalizability is limited. Despite these limitations, our investigation contributes to the understanding of variations of pre-hospital dynamics created by the COVID-19 pandemic and how these impact outcomes. This may encourage further study to elucidate areas in which trauma systems and policies may intervene to improve patient care during such unprecedented times.

### Conclusions

We found that there was a significant shift in pre-hospital transportation among trauma patients toward private transportation after the shelter-in-place order. This was not associated with a change in mortality among patients using private transportation despite a downward trend. It is possible the strain on EMS and resultant risk-averse behavior secondary to the COVID-19 pandemic may have influenced these variations. Further investigation is required to continue to clarify the effects of a pandemic on pre-hospital components of trauma care to help inform personnel and resource distribution in the future. Such findings may help direct future policies in EMS triage or public health directives regarding hospital transportation during times of public health emergency.

### COI/Disclosures

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Tables

Table 1. Demographics and Outcomes Among Level One Trauma Center Patient Activations Three Years Before and One Year After the Start of the COVID-19 Pandemic

	Total (N= 11,919)	Pre-Pandemic (N= 9,017)	Pandemic (N= 2,902)	P-value
Age, mean years (SD)	48.2 (22.4)	48.8 (22.4)	46.3 (22.0)	<0.001
Male, %	100%	66.6%	69.6%	0.002
Mechanism				
Penetrating, %	100%	14.8%	23.1%	<0.001
Traumas per Day, mean (SD)	7.8 (3.2)	7.7 (3.2)	8.0 (3.3)	0.2
Mean ISS, (SD)	7.1 (9.0)	7.0 (8.9)	7.5 (9.3)	0.03
Pre-Hospital Transportation				
Private EMS	100%	2.4% 97.3%	6.7% 93.3%	<0.001
Length of Stay, mean days (SD)	4.0 (8.0)	4.1 (8.4)	3.8 (6.4)	0.4
ICU Admission, %	12.3%	12.4%	11.7%	0.3
ICU Length of stay, mean days (SD)	6.8 (8.0)	6.9 (8.3)	6.7 (7.1)	0.4
Ventilator days, mean (SD)	6.5 (7.7)	6.3 (7.9)	6.9 (7.1)	0.04
Mortality, %	3.5%	3.2%	4.7%	<0.001

ISS: Injury Severity Score; ICU: Intensive Care Unit; EMS: Emergency Medical Services; SE: Standard Error

Table 2. Subgroup Outcomes Among Level One Trauma Center Patient Activations Utilizing Private Transportation in the Three Years Before and One Year After the Start of the COVID-19 Pandemic

	Pre-Pandemic (N=217)	Pandemic (N=196)	P-value
Mean ISS (SD)	8.1 (10.4)	5.3 (6.6)	0.02
Length of Stay, mean days (SD)	4.0 (5.3)	2.3 (1.9)	0.02
ICU Admission, %	15.2%	3.1%	<0.001
ICU Length of stay, mean days (SD)	5.5 (4.0)	3.0 (1.3)	0.01
Ventilator days, mean (SD)	4.1 (5.0)	3.0 (1.7)	1.0
Mortality, %	4.1%	2.0%	0.2

ISS: Injury Severity Score; ICU: Intensive Care Unit; SE: Standard Error

Table 3. Subgroup Outcomes Among Level One Trauma Center Patient Activations Transported by Emergency Medical Services in the Three Years Before and One Year After the Start of the COVID-19 Pandemic

	Pre-Pandemic (N=8815)	Pandemic (N=2715)	P-value
Mean ISS (SD)	7.0 (8.8)	7.6 (9.4)	0.003
Length of Stay, mean days (SD)	4.1 (8.5)	4.0 (6.6)	0.9
ICU Admission, %	12.4%	12.4%	0.9
ICU Length of stay, mean days (SD)	6.9 (8.4)	6.8 (7.2)	0.5
Ventilator days, mean (SD)	6.4 (7.9)	6.9 (7.2)	0.04
Mortality, %	3.2%	4.9%	<0.001

ISS: Injury Severity Score; ICU: Intensive Care Unit; SE: Standard Error

Figure 1. Rates of penetrating trauma and patients using private transportation among level one trauma center patient activations three years before and one year after the start of the COVID-19 pandemic.

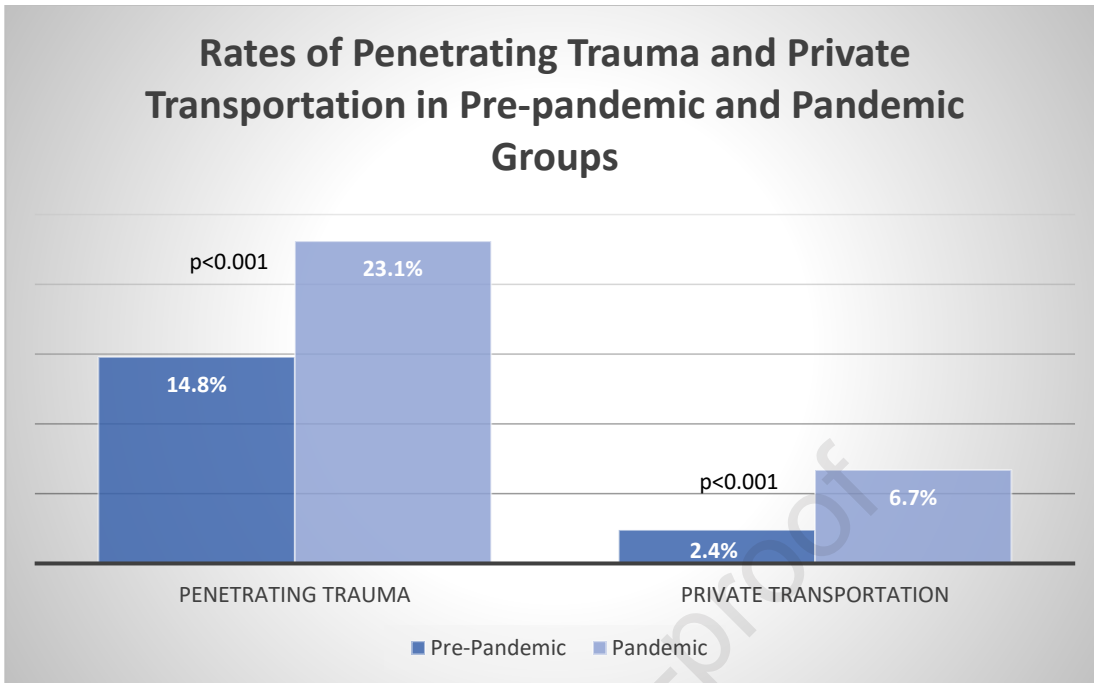


Figure 2. Comparison of mortality rates of overall cohort, and sub-groups of patients brought in by emergency medical services and private transportation among level one trauma center patient activations three years before and one year after the start of the COVID-19 pandemic.

