# Changes in traumatic mechanisms of injury in Southern California related to COVID-19: Penetrating trauma as a second pandemic

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**BACKGROUND:** The COVID-19 pandemic resulted in a statewide stay-at-home (SAH) order in California beginning March 19, 2020, forcing large-scale behavioral changes and taking an emotional and economic toll. The effects of SAH orders on the trauma population remain unknown. We hypothesized an increase in rates of penetrating trauma, gunshot wounds, suicide attempts, and domestic violence in the Southern California trauma population after the SAH order.

**METHODS:** A multicenter retrospective analysis of all trauma patients presenting to 11 American College of Surgeons levels I and II trauma centers spanning seven counties in California was performed. Demographic data, injury characteristics, clinical data, and outcomes were collected. Patients were divided into three groups based on injury date: before SAH from January 1, 2020, to March 18, 2020 (PRE), after SAH from March 19, 2020, to June 30, 2020 (POST), and a historical control from March 19, 2019, to June 30, 2019 (CONTROL). POST was compared with both PRE and CONTROL in two separate analyses.

**RESULTS:** Across all periods, 20,448 trauma patients were identified (CONTROL, 7,707; PRE, 6,022; POST, 6,719). POST had a significantly increased rate of penetrating trauma (13.0% vs. 10.3%, $p < 0.001$ and 13.0% vs. 9.9%, $p < 0.001$) and gunshot wounds (4.5% vs. 2.4%, $p = 0.002$ and 4.5% vs. 3.7%, $p = 0.025$) compared with PRE and CONTROL, respectively. POST had a suicide attempt rate of 1.9% and a domestic violence rate of 0.7%, which were similar to PRE ($p = 0.478$, $p = 0.514$) and CONTROL ($p = 0.160$, $p = 0.618$).

**CONCLUSION:** This multicenter Southern California study demonstrated an increased rate of penetrating trauma and gunshot wounds after the COVID-19 SAH orders but no difference in attempted suicide or domestic violence rates. These findings may provide useful information regarding resource utilization and a target for societal intervention during the current or future pandemic(s). (*J Trauma Acute Care Surg.* 2021;90: 714–721. Copyright © 2020 Wolters Kluwer Health, Inc. All rights reserved.)

**LEVEL OF EVIDENCE:** Epidemiological, level IV.
**KEY WORDS:** COVID-19; trauma; stay at home; firearm violence; penetrating trauma.

Severe acute respiratory syndrome coronavirus 2 causing COVID-19 has had a significant impact in the United States since the first community transmission in February 2020.[1–3] The individual states' responses to COVID-19 varied initially from minimal response to stay-at-home (SAH) orders.[4–7] On March 19, 2020, the California governor issued a SAH order, directing all Californians to remain at home except in cases of essential work or shopping for essential needs.[8,9]

These restrictions caused abrupt behavioral changes for millions of Californians and resulted in economic loss, social isolation, psychological stress, and barriers to nonemergent physical and mental health treatment.[10–13] As a consequence of these stressors, there is mounting evidence of an increase in suicidal ideation, drug abuse, domestic violence, and firearm sales in the United States during this period.[14–18] Given these new pressures, along with a decrease in population movement within the community, less driving, and fewer motor vehicle collisions (MVCs) (previously accounting for up to 26% of trauma

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activations), it has been hypothesized that there will be a resultant change in traumatic injury rates and patterns.[6,7,19–26] In the United States, many trauma surgeons also function as critical care physicians, possessing a unique skill set to care for both COVID-19 and traumatically injured patients.[27] Thus, characterization of the volume of trauma, traumatic mechanisms, injuries, and outcomes may help inform decisions regarding not only trauma prevention during a pandemic but also the use of hospital resources, including trauma surgeon allocation.[28]

To date, there have been conflicting reports, mostly single-center series that have begun to characterize the effects of COVID-19 on trauma volume and mechanisms.[22–26,29–35] Some of these studies have interestingly demonstrated an increase in penetrating trauma, gunshot wounds, domestic violence, and self-harm, as well as a decrease in MVC.[22–26] While these findings are compelling, the single center nature and/or small sample size of these data limit their interpretation and generalizability.

Thus, this regional collaboration of trauma centers sought to provide more generalizable data regarding changes in the trauma population during these unprecedented times with the aim of informing future resource allocation and injury prevention strategies during the current COVID-19 pandemic or any future pandemics. We hypothesized that there was a significant increase in the rates of penetrating trauma, suicide attempts, and domestic violence after the March 19, 2020, SAH order when compared with 2019 historical controls (March 19, 2019, to June 30, 2019) and the immediate time frame preceding the SAH orders (January 1, 2020, to March 18, 2020) in Southern California.

## PATIENTS AND METHODS

We performed a multicenter retrospective analysis of all trauma patients presenting to 11 American College of Surgeons levels I and II trauma centers spanning seven counties in Southern California between the dates of January 1, 2020, to June 30, 2020, and March 19, 2019, to June 30, 2019. Demographic data, injury characteristics, clinical data, and outcomes were collected. The study was approved by the Institutional Review Board of University of California, Irvine, and all participating centers' local institutional review boards and was deemed exempt from need for consent.

All patients included in each institution's trauma registry were included in this study. This included both trauma activations and trauma consults where a trauma surgeon evaluated the patient after arrival. The primary outcome was rate of penetrating trauma, which we defined as either gunshot wounds or stab wounds. Secondary outcomes were the rates of suicide attempts and domestic violence. Demographic data were collected including sex (self-reported), age, race (self-reported), insurance status, body mass index (BMI), and comorbidities, which included diabetes, congestive heart failure, cerebrovascular accident, myocardial infarction (MI), coronary artery disease, cancer, end-stage renal disease, chronic obstructive pulmonary disease, dementia, cirrhosis, and smoking status. Injury characteristics on admission were obtained, including blunt mechanisms such as ground level fall, pedestrian struck, motorcycle collision, MVC, assault, and sports injury. Penetrating mechanisms were classified as either gunshot wounds or stab wounds. Additional information collected included instances of a potential suicide attempt or domestic violence event. Injury profile characteristics were tabulated including the Injury Severity Score (ISS) and Abbreviated Injury Scale (AIS) scores of the head/neck, face, chest, abdomen, spine, extremity, and external regions. Vital signs and examination findings on arrival were collected including systolic blood pressure, respiratory rate (RR), heart rate (HR), temperature, and Glasgow Coma Scale score on arrival. Outcomes collected included length of stay (LOS), intensive care unit (ICU) LOS, ventilator days, packed red blood cells transfused within 4 hours, fresh frozen plasma transfused within 4 hours, and procedures performed (tracheostomy, laparotomy, thoracotomy, craniectomy or craniotomy, and vascular or endovascular surgery). Complications evaluated included sepsis, stroke, MI, pneumonia, ventilator-associated pneumonia, acute kidney injury, acute renal failure, deep venous thrombosis, pulmonary embolism, delirium tremens, and mortality. Discharge disposition was also collected which included home, skilled nursing facility (SNF), long-term acute care hospital, acute rehabilitation, and hospice.

Patients were divided into three groups based on their date of injury: before the SAH order from January 1, 2020, to March 18, 2020 (PRE), after the SAH order March 19, 2020, to June 30, 2020 (POST), and a historical control from March 19, 2019, to June 30, 2019 (CONTROL). Patient data entries missing a value for the blunt/penetrating mechanism variable were excluded. This accounted for 231 patients in total (46 in CONTROL, 59 in PRE, 126 in POST). Descriptive statistics were performed for all variables within each group. Categorical variables were reported as percentages of their respective group, and continuous variables were reported as means with SD. The POST group was compared with the PRE group and the CONTROL group in two separate analyses to account for both seasonal and annual variations. $\chi^2$ tests were used to compare categorical variables, and either a two-sample $t$ test or Mann-Whitney $U$ test was used to compare continuous variables. $p$ Values were two-sided and considered significant if <0.05. This analysis was performed using IBM SPSS Statistics for Windows (version 24; IBM Corp., Armonk, NY).

## RESULTS

A total of 20,448 trauma patients were identified across the three periods: 7,707 in the CONTROL group, 6,022 in the PRE group, and 6,719 patients in the POST group.

### PRE vs. POST Demographics and Comorbidities

Compared with the PRE group, the POST group was younger (46.4 vs. 48.0 years old, $p = 0.001$) and had a lower percentage of Asian patients (4.7% vs. 5.6%, $p = 0.015$). The POST group also had significantly higher rate of Medicaid (32.7% vs. 27.4%, $p < 0.001$) but lower rate of private insurance (29.5% vs. 38.5%, $p < 0.001$) and being uninsured (7.3% vs. 9.0%, $p < 0.001$), as well as a lower rate of patients with a history of cerebrovascular accident (2.0% vs. 2.6%, $p = 0.033$) or MI (0.5% vs. 1.1%, $p < 0.001$). Otherwise, the two groups were similar regarding sex, race, BMI, and comorbidities (all, $p > 0.05$) (Table 1).

 

**TABLE 1.** Demographics and Comorbidities of Trauma Patients Compared by Period

| Characteristic | POST (n = 6,719) | PRE (n = 6,022) | PRE vs. POST *p* | CONTROL (n = 7,707) | CONTROL vs. POST *p* |
|---|---|---|---|---|---|
| Male, n (%) | 4,522 (67.3) | 3,979 (66.1) | 0.135 | 5,133 (66.6) | 0.373 |
| Age, years, mean ± SD | 46.43 ± 23.92 | **48.01 ± 24.74** | **0.001** | 47.16 ± 24.15 | 0.085 |
| Race, n (%) | | | | | |
| White | 3,066 (45.6) | 2,761 (47.4) | 0.806 | **3,711 (48.2)** | **0.002** |
| Black | 597 (8.9) | 481 (8.0) | 0.069 | 625 (8.1) | 0.095 |
| Asian | 315 (4.7) | **340 (5.6)** | **0.015** | 402 (5.2) | 0.146 |
| American Indian | 23 (0.3) | 18 (0.3) | 0.666 | 15 (0.2) | 0.084 |
| Native Hawaiian | 20 (0.3) | 18 (0.3) | 0.990 | 23 (0.3) | 0.993 |
| Latino | **2,220 (33.0)** | 1,990 (33.0) | 0.995 | 2,282 (29.6) | **<0.001** |
| Middle Eastern | 26 (0.4) | 23 (0.4) | 0.963 | 17 (0.2) | 0.067 |
| Insurance status, n (%) | | | | | |
| Medicare | **1,376 (20.5)** | 1,274 (21.2) | 0.348 | 1,406 (18.2) | **0.001** |
| Medicaid | **2,195 (32.7)*** | 1,653 (27.4) | **<0.001*** | 2,313 (30.0) | **0.001*** |
| Private | 1,984 (29.5) | **2,316 (38.5)*** | **<0.001*** | **3,201 (41.5)*** | **<0.001*** |
| Uninsured | 489 (7.3) | **541 (9.0)** | **<0.001** | 565 (7.3) | 0.903 |
| Comorbidities, n (%) | | | | | |
| Diabetes | 692 (10.3) | 682 (11.3) | 0.062 | 872 (11.3) | 0.050 |
| Congestive heart failure | 205 (3.1) | 211 (3.5) | 0.151 | **283 (3.7)** | **0.040** |
| Cerebrovascular accident | 136 (2.0) | **156 (2.6)** | **0.033** | 175 (2.3) | 0.309 |
| MI | 36 (0.5) | **69 (1.1)** | **<0.001** | 40 (0.5) | 0.890 |
| Coronary artery disease | 121 (1.8) | 127 (2.1) | 0.209 | 150 (1.9) | 0.521 |
| Cancer | 34 (0.5) | 32 (0.5) | 0.842 | 34 (0.4) | 0.570 |
| End-stage renal disease | 91 (1.4) | 94 (1.6) | 0.330 | 93 (1.2) | 0.430 |
| COPD | 195 (2.9) | 171 (2.8) | 0.833 | 219 (2.8) | 0.828 |
| Dementia | 263 (3.9) | 254 (4.2) | 0.386 | 306 (4.0) | 0.863 |
| Cirrhosis | 75 (1.1) | 82 (1.4) | 0.210 | 89 (1.2) | 0.828 |
| Current smoker | 715 (10.6) | 642 (10.7) | 0.972 | **902 (11.7)** | **0.044** |
| BMI, mean ± SD, kg/m$^2$ | 26.61 ± 6.53 | 26.51 ± 6.46 | 0.450 | 26.51 ± 6.43 | 0.806 |

CONTROL, March 19, 2019, to June 30, 2019; PRE, January 1, 2020, to March 18, 2020; POST, March 19, 2020, to June 30, 2020. Bolded values are significantly different.
*Significantly different in both comparisons.
COPD, chronic obstructive pulmonary disease.

## CONTROL vs. POST Demographics and Comorbidities

Compared with the CONTROL group, the POST group had a lower percentage of White patients (45.6% vs. 48.2%, $p = 0.002$) and a higher percentage of Latino patients (33.0% vs. 29.6%, $p < 0.001$). The POST group had a higher rate of Medicare (20.5% vs. 18.2%, $p = 0.001$) and Medicaid (32.7% vs. 30.0%, $p = 0.001$) but lower rate of private insurance (29.5% vs. 41.5%, $p <$ 0001) and congestive heart failure (3.1% vs. 3.7%, $p = 0.04$). Otherwise, the two groups were similar regarding sex, age, BMI, and comorbidities (all, $p > 0.05$) (Table 1).

## PRE vs. POST Injury Characteristics and Vital Signs

Compared with the PRE group, the POST group had significantly lower rates of blunt injury (87.0% vs. 89.7%, $p < 0.001$), pedestrians struck (6.9% vs. 9.8%, $p < 0.001$), and MVC (20.2% vs. 22.5%, $p < 0.001$). However, the POST group had a higher rate of penetrating trauma (13.0% vs. 10.3%, $p < 0.001$), gunshot wounds (4.5% vs. 3.4%, $p = 0.002$), falls from height (8.6% vs. 7.4%, $p = 0.019$), and sports injuries (3.6% vs. 2.9%, $p = 0.029$). The POST group also had a lower systolic blood pressure (138.6 vs. 140.2, $p < 0.001$) but higher RR (19.1 vs. 18.9, $p = 0.005$) and HR (91.9 vs. 90.9, $p = 0.004$) on arrival. Otherwise, the groups were similar in terms of mechanism of injury, suicide attempts, domestic violence, ISS, AIS scores, and vital signs on arrival (all, $p > 0.05$) (Table 2).

## CONTROL vs. POST Injury Characteristics and Vital Signs

Compared with the CONTROL group, the POST group had lower rates of blunt injury (87.0% vs. 90.1%, $p < 0.001$), pedestrians struck (6.9% vs. 9.9%, $p < 0.001$), motorcycle collision (6.7% vs. 8.4%, $p < 0.001$), and MVC (20.2% vs. 22.9%, $p < 0.001$). Similar to the PRE versus POST comparison, POST had a higher rate of penetrating injury (13.0% vs. 9.9%, $p < 0.001$) and gunshot wounds (4.5% vs. 3.7%, $p = 0.025$) compared with CONTROL. The POST group also had a significantly lower AIS score of the abdomen (1.95 vs. 2.07, $p = 0.032$) and higher RR (19.12 vs. 18.84, $p < 0.001$) and HR (91.90 vs. 90.22, $p < 0.001$). Otherwise, the two groups were similar with regards to mechanism of injury, suicide attempts,

**TABLE 2.** Injury Characteristics and Vital Signs of Trauma Patients Compared by Period

| Characteristic | POST (n = 6,719) | PRE (n = 6,022) | PRE vs. POST *p* | CONTROL (n = 7,707) | CONTROL vs. POST *p* |
|---|---|---|---|---|---|
| Mechanism of injury, n (%) | | | | | |
| Blunt | 5,848 (87.0) | **5,401 (89.7)*** | **<0.001*** | **6,942 (90.1)*** | **<0.001*** |
| Ground level fall | 1,709 (25.4) | 1,620 (26.9) | 0.060 | 2,024 (26.3) | 0.258 |
| Fall from height | 575 (8.6) | 447 (7.4) | **0.019** | 618 (8.0) | 0.241 |
| Pedestrian struck | 463 (6.9) | **591 (9.8)*** | **<0.001*** | **764 (9.9)*** | **<0.001*** |
| Motorcycle collision | 447 (6.7) | 426 (7.1) | 0.347 | **650 (8.4)** | **<0.001** |
| Motor vehicle collision | 1,358 (20.2) | **1,357 (22.5)*** | **0.001*** | **1,767 (22.9)*** | **<0.001*** |
| Assault | 448 (6.7) | 369 (6.1) | 0.214 | 545 (7.1) | 0.339 |
| Sports injury | 244 (3.6) | 177 (2.9) | **0.029** | 254 (3.3) | 0.270 |
| Penetrating | **871 (13.0)*** | 621 (10.3) | **<0.001*** | 765 (9.9) | **<0.001*** |
| Gunshot | **300 (4.5)*** | 203 (3.4) | **0.002*** | 287 (3.7) | **0.025*** |
| Stab wound | 356 (5.3) | 277 (4.6) | 0.070 | 354 (4.6) | 0.051 |
| Suicide attempt, n (%) | 125 (1.9) | 102 (1.7) | 0.478 | 120 (1.6) | 0.160 |
| Domestic violence, n (%) | 50 (0.7) | 39 (0.6) | 0.514 | 63 (0.8) | 0.618 |
| ISS, mean ± SD | 7.72 ± 8.21 | 7.71 ± 8.40 | 0.577 | 7.92 ± 8.78 | 0.436 |
| AIS head/neck | 2.31 ± 1.16 | 2.29 ± 1.19 | 0.458 | 2.31 ± 1.13 | 0.797 |
| AIS face | 1.38 ± 0.56 | 1.35 ± 0.52 | 0.228 | 1.37 ± 0.53 | 0.871 |
| AIS chest | 2.33 ± 0.98 | 2.34 ± 0.97 | 0.988 | 2.36 ± 0.99 | 0.682 |
| AIS abdomen | 1.95 ± 1.05 | 1.98 ± 1.01 | 0.360 | **2.07 ± 1.11** | **0.032** |
| AIS spine | 2.16 ± 0.75 | 2.14 ± 0.68 | 0.923 | 2.19 ± 0.76 | 0.482 |
| AIS extremity | 1.90 ± 0.77 | 1.87 ± 0.78 | 0.160 | 1.92 ± 0.82 | 0.992 |
| AIS external | 1.03 ± 0.17 | 1.03 ± 0.18 | 0.609 | 1.02 ± 0.17 | 0.360 |
| Vitals on admission, mean ± SD | | | | | |
| Systolic blood pressure | 138.31 ± 25.47 | **140.15 ± 25.97** | **<0.001** | 138.55 ± 25.51 | 0.297 |
| RR | **19.12 ± 4.84*** | 18.90 ± 4.72 | **0.005*** | 18.84 ± 5.14 | **<0.001*** |
| HR | **91.90 ± 21.32*** | 90.85 ± 20.49 | **0.004*** | 90.22 ± 20.88 | **<0.001*** |
| Temperature, °F | 98.14 ± 1.41 | 98.13 ± 1.18 | 0.094 | 98.18 ± 1.07 | 0.883 |
| GCS score | 14.08 ± 2.53 | 14.12 ± 2.45 | 0.344 | 14.13 ± 2.43 | 0.249 |

CONTROL, March 19, 2019, to June 30, 2019; PRE, January 1, 2020, to March 18, 2020; POST, March 19, 2020, to June 30, 2020. Bolded values are significantly different.
*Significantly different in both comparisons.
GCS, Glasgow Coma Scale.

domestic violence, ISS, AIS scores, and vital signs on arrival (all, $p > 0.05$) (Table 2).

## PRE vs. POST Outcomes

Compared with the PRE group, the POST group had a shorter LOS (3.91 vs. 4.55 days, $p < 0.001$) and ICU LOS (0.93 vs. 1.14 days, $p = 0.019$) (Table 3). The POST group had a lower rate of laparotomy (2.0% vs. 2.7%, $p = 0.013$), pneumonia (0.2% vs. 0.5%, $p = 0.012$), and discharge to SNF (6.7% vs. 9.0%, $p < 0.001$). Otherwise, the two groups were similar in terms of ventilator days, transfusions within 4 hours, operations, complications, discharge disposition, and mortality (all, $p > 0.05$) (Table 3).

## CONTROL vs. POST Outcomes

Compared with the CONTROL group, the POST group had a significantly shorter LOS (3.91 vs. 4.45 days, $p = 0.003$) and ICU LOS (0.93 vs. 1.16 days, $p < 0.001$), fewer ventilator days (0.40 vs. 0.47, $p = 0.005$), and lower rates of laparotomy (2.0% vs. 2.8%, $p = 0.002$), deep venous thrombosis (0.4% vs. 0.6%, $p = 0.014$), pulmonary embolism (0.1% vs. 0.3%, $p = 0.024$), and discharge to SNF (6.7% vs. 8.6%, $p < 0.001$). Otherwise, the two groups were similar in terms of ventilator days, transfusions within 4 hours, operations, complications, discharge disposition, and mortality (all, $p > 0.05$) (Table 3).

## DISCUSSION

This retrospective multicenter study across Southern California indicates a shift in the demographics, mechanisms of injury, and outcomes of the trauma population after the California SAH orders. We identified a 21% increase in rates of penetrating trauma and a 24% increase in rates of gunshot wounds but no significant increase in rates of suicide attempts or domestic violence after the SAH orders. We also discovered a higher percentage of trauma patients with Medicaid, a lower percentage with private insurance, a shorter LOS, and a lower discharge rate to SNF after SAH orders.

The media has reported a troubling rise of firearm violence in the community during the COVID-19 pandemic, a trend that could potentially strain trauma systems.[36,37] This study identified an increase in the rate of penetrating trauma and gunshot wounds after the SAH orders when compared with the PRE and CONTROL groups, respectively. Increases in penetrating trauma rates were also noted by both Rhodes et al.[25] (8.2% vs.

**TABLE 3.** Outcomes of Trauma Patients Compared by Period

| Outcome | POST (n = 6,719) | PRE (n = 6,022) | PRE vs. POST *p* | CONTROL (n = 7,707) | CONTROL vs. POST *p* |
|---|---|---|---|---|---|
| LOS, mean ± SD, d | 3.91 ± 5.67 | **4.55 ± 7.88*** | **<0.001*** | **4.45 ± 8.58*** | **0.003*** |
| ICU LOS, mean ± SD, d | 0.93 ± 2.92 | **1.14 ± 3.66*** | **0.019*** | **1.16 ± 3.72*** | **<0.001*** |
| Ventilator, mean ± SD, d | 0.40 ± 2.27 | 0.52 ± 2.76 | 0.354 | **0.47 ± 2.56** | **0.005** |
| pRBCs in 4 h, mean ± SD | 4.70 ± 6.19 | 4.89 ± 6.75 | 0.751 | 4.77 ± 7.12 | 0.909 |
| FFP in 4 h, mean ± SD | 5.77 ± 7.07 | 5.88 ± 7.22 | 0.896 | 5.77 ± 7.77 | 0.996 |
| Operations, n (%) | | | | | |
| Tracheostomy | 79 (1.2) | 76 (1.3) | 0.657 | 96 (1.2) | 0.702 |
| Laparotomy | 134 (2.0) | **169 (2.7)*** | **0.013*** | **216 (2.8)*** | **0.002*** |
| Thoracotomy | 401 (6.0) | 392 (6.5) | 0.207 | 491 (6.4) | 0.316 |
| Craniectomy/craniotomy | 97 (1.4) | 93 (1.5) | 0.640 | 100 (1.3) | 0.451 |
| Vascular/endovascular | 86 (1.3) | 66 (1.1) | 0.340 | 97 (1.3) | 0.909 |
| Complications, n (%) | | | | | |
| Sepsis | 9 (0.1) | 15 (0.2) | 0.135 | 20 (0.3) | 0.093 |
| Stroke | 12 (0.2) | 15 (0.2) | 0.388 | 15 (0.2) | 0.824 |
| MI | 4 (0.1) | 7 (0.1) | 0.277 | 5 (0.1) | 0.898 |
| Pneumonia | 14 (0.2) | **28 (0.5)** | **0.012** | 29 (0.4) | 0.065 |
| Ventilator-associated pneumonia | 18 (0.3) | 15 (0.2) | 0.835 | 22 (0.3) | 0.841 |
| Acute kidney injury | 28 (0.4) | 23 (0.4) | 0.756 | 21 (0.3) | 0.137 |
| Acute renal failure | 15 (0.2) | 14 (0.2) | 0.913 | 11 (0.1) | 0.255 |
| Deep venous thrombosis | 24 (0.4) | 33 (0.5) | 0.107 | **50 (0.6)** | **0.014** |
| Pulmonary embolism | 10 (0.1) | 15 (0.2) | 0.202 | **26 (0.3)** | **0.024** |
| Delirium tremens | **19 (0.3)** | 13 (0.2) | 0.451 | 4 (0.1) | **0.001** |
| Discharge disposition, n (%) | | | | | |
| Home | 4,394 (65.4) | 3,862 (64.1) | 0.136 | 5,131 (66.6) | 0.136 |
| SNF | 450 (6.7) | **542 (9.0)*** | **<0.001*** | **660 (8.6)*** | **<0.001*** |
| Long-term acute care hospital | 83 (1.2) | 67 (1.1) | 0.521 | 109 (1.4) | 0.349 |
| Acute rehabilitation | 283 (4.2) | 289 (4.8) | 0.110 | 367 (4.8) | 0.112 |
| Hospice | **49 (0.7)*** | 27 (0.4) | **0.040*** | 30 (0.4) | **0.006*** |
| Mortality, n (%) | 243 (3.6) | 198 (3.3) | 0.311 | 280 (3.6) | 0.958 |

CONTROL, March 19, 2019, to June 30, 2019; PRE, January 1, 2020, to March 18, 2020; POST, March 19, 2020, to June 30, 2020. Bolded values are significantly different.
*Significantly different in both comparisons.
pRBCs, packed red blood cells; FFP, fresh frozen plasma.

6.0%) and Sherman et al.[22] (35% vs. 26%) in single-center studies in South Carolina and Louisiana, respectively. Sherman et al.[22] also demonstrated a significant increase in gunshot wounds (26% vs. 18%). We also reviewed California Department of Public Health data to identify the number of homicides during each period to account for penetrating trauma victims who died before presenting to a trauma center. There were 540 homicides in April to June 2020, 455 in January through March 2020, and 464 in April through June 2019, which further supports the findings of this study.[38] One potential explanation for this increase in penetrating trauma is an increase in economic and psychological pressure, with a reported unemployment rate in California rising to 16%.[10] There has also been a notable increase in firearms sales during the pandemic, another possible contributor to the risk of firearm injury and death.[17,18,39] Furthermore, we found a corresponding decrease in the rate of blunt trauma driven by decreased rates of MVC and pedestrians struck. Fewer MVC-related traumas is further corroborated by prior single-center studies and public vehicle collision data.[19,24] This finding, along with fewer pedestrian related injuries, is likely explained by decreased population movement as a result of SAH orders, remote work, and remote learning.[6,7,40] As the largest study to date on this topic, it provides generalizable data that, during the COVID-19 pandemic, there was an increase in violent penetrating mechanisms of injury, creating a secondary pandemic for trauma surgeons in Southern California to care for. This highlights not only the need to adjust resources but also the need to focus on violent injury prevention through community outreach and strengthening mental health services during any future resurgence of COVID-19 or other future pandemics.

Penetrating trauma typically comprises a minority of trauma but has a much higher operation rate, making it both labor and resource intensive for a trauma center.[41,42] However, contrary to expected, we found a decrease in laparotomy rate in the POST group despite a higher percentage of penetrating trauma. To further evaluate this, a post hoc analysis of only penetrating trauma patients was performed, which again demonstrated a decreased laparotomy rate for the POST group compared with the PRE (7.8% vs. 11.1%, $p = 0.029$) and CONTROL cohorts (7.8% vs. 12.2%, $p = 0.030$). Furthermore, the ISS between these penetrating trauma subgroups was similar ($p > 0.05$) suggesting that the overall injury burden was similar between the cohorts. Therefore, we are left to believe that the decreased laparotomy rate may be due to more patients sustaining nonabdominal injuries that were not captured in this analysis (i.e., tangential soft tissue injuries, penetrating neck trauma, orthopedic penetrating trauma, etc.). Another possible explanation, although we lack data to support this conjecture, is there could have been an increased use of nonoperative management to minimize risk to patients and health care providers as has been cited by previous authors, especially early in the COVID-19 pandemic.[43,44]

Both suicide and domestic violence are public health crises that impact trauma surgeons regularly. Contrary to our hypothesis, there was a similar rate of suicide attempts and domestic violence when comparing the POST group with historical controls and a PRE cohort. Prior single-center studies by Olding et al.[23] and Rhodes et al.[25] suggested a trend but failed to show a statistically significant increase in rates of overall suicide attempts in their respective trauma populations. This larger multicenter study more definitively demonstrates no difference in suicide attempts in the trauma population after SAH orders, despite the reported increase in suicidal ideation in the community.[14] Interestingly, Rhodes et al.[26] did demonstrate a significant increase in rates of domestic violence assaults related to SAH orders, something our larger study was unable to prove. This discrepancy could be the result of regional differences but is puzzling given the strong evidence that domestic violence is rising in the community.[16,45,46] One possible explanation is that this study focuses solely on the trauma population, which only accounts for a small subset of violent suicide attempts and domestic violence in society. Thus, it does not capture a majority of these events and leads the authors to believe that this topic requires future large multicenter collaborations that include all patients presenting to the emergency department.

In many cases, insurance status is used as a surrogate of a patient's socioeconomic status, although this is with significant limitation. This study elucidated an increased percentage of patients with Medicaid and a lower percentage of private insurance patients presenting after SAH orders. This change in insurance status in the trauma population has not been previously described but is certainly noteworthy, as we believe this highlights the fact that lower-income patients remain exposed to trauma because they are less likely able to shelter in place and/or be able to work from home during the COVID-19 pandemic.[47] The lower income population may also be disproportionally impacted by stressors inherent to the COVID-19 pandemic, like economic and psychological stress, and therefore be more susceptible to traumatic injury. Further research is indicated to explore the ramifications of SAH orders on people of lower socioeconomic status, including disparities outside of just contraction of COVID-19.

Lastly, this study identified a decreased LOS and lower rate of discharges to SNF corresponding to COVID-19 SAH orders. A single-center retrospective study out of Virginia by Leichtle et al.[35] had a similar finding of a significant decrease in median LOS (2 vs. 3 days) in trauma patients after SAH orders. This may be due to a push for earlier discharges related to COVID-19 resource utilization and/or a patient-directed desire to not remain in a hospital with potential exposure to an infectious pathogen.[48,49] Interestingly, we also found that the rate of discharge to SNF decreased after the SAH orders. We suspect that this is due to the growing difficulty of discharging to post–acute care during the COVID-19 pandemic.[50]

There are a number of limitations to this study. Given that the data collection depended on chart review in addition to the collection of trauma registry data, it is possible that key data were missing from our analysis. Second, because we depended on multiple trauma registries, electronic medical records, and data collectors, the data entry process was prone to potential miscoding and misclassification. In addition, there were several pertinent data points that were missing, including socioeconomic status. Another limitation is that the period after the California SAH orders, which we defined as March 19, 2020, to June 30, 2020, was diverse over time and across different counties. It contained periods of mandated SAH orders and others with partial reopening, making it possible that we either overestimated or underestimated the effects of the SAH order in this study. Also, although we used an earlier 2020 cohort and a historical control from 2019, this study does lack additional historical years to fully account for trends over time. With regards to our analysis, although we attributed most of the changes in the trauma population to COVID-19 and the subsequent SAH orders, it is possible that those changes were in part due to other ongoing societal issues, such as civil unrest related to racial injustice. Despite these and other limitations, this is the largest study to the knowledge of the authors to evaluate changes in trauma mechanisms during the COVID-19 pandemic.

In summary, this multicenter retrospective study of 11 American College of Surgeons level I and II trauma centers in Southern California demonstrated a significant increase in the rate of penetrating trauma and gunshot wounds but no difference in the rates of suicide attempts or domestic violence, after the COVID-19 SAH orders. We believe that this knowledge highlights the need for robust community and hospital-based violence prevention programs that continue to operate at full capacity during the current or future pandemics.

## AUTHORSHIP

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## DISCLOSURE

The authors declare no conflicts of interest.

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