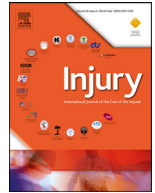




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## National evaluation of the association between stay-at-home orders on mechanism of injury and trauma admission volume

Arielle C. Thomas<sup>a,b,\*</sup>, Brendan T. Campbell<sup>b,c</sup>, Haris Subacius<sup>b,d</sup>, Claudia P. Orlas<sup>e</sup>, Eileen Bulger<sup>b,f</sup>, Ronald M. Stewart<sup>b,h</sup>, Anne M. Stey<sup>a,b</sup>, Angie Jang<sup>g</sup>, Doulia Hamad<sup>i</sup>, Karl Y. Bilimoria<sup>a,b</sup>, Avery B. Nathens<sup>b,i</sup>

<sup>a</sup> Medical College of Wisconsin, Milwaukee, WI, USA

<sup>b</sup> American College of Surgeons, Chicago, IL, USA

<sup>c</sup> Department of Pediatric Surgery, Connecticut Children's Medical Center and University of Connecticut School of Medicine, Hartford, CT, USA

<sup>d</sup> Society of Thoracic Surgeons, Chicago, IL, USA

<sup>e</sup> Center for Surgery and Public Health, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA

<sup>f</sup> Department of Surgery, University of Washington, Seattle, WA, USA

<sup>g</sup> Northwestern University, Chicago, IL, USA

<sup>h</sup> Department of Surgery, University of Texas Health Science Center at San Antonio, San Antonio, TX, USA

<sup>i</sup> Department of Surgery, Sunnybrook Health Sciences Center and the University of Toronto, Canada

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### ABSTRACT

**Background:** The COVID-19 pandemic had numerous negative effects on the US healthcare system. Many states implemented stay-at-home (SAH) orders to slow COVID-19 virus transmission. We measured the association between SAH orders on the injury mechanism type and volume of trauma center admissions during the first wave of the COVID-19 pandemic.

**Methods:** All trauma patients aged 16 years and older who were treated at the American College of Surgeons Trauma Quality Improvement Program participating centers from January 2018–September 2020. Weekly trauma patient volume, patient demographics, and injury characteristics were compared across the corresponding SAH time periods from each year. Patient volume was modeled using harmonic regression with a random hospital effect.

**Results:** There were 166,773 patients admitted in 2020 after a SAH order and an average of 160,962 patients were treated over the corresponding periods in 2018–2019 in 474 centers. Patients presenting with a pre-existing condition of alcohol misuse increased (13,611 (8.3%) vs. 10,440 (6.6%),  $p < 0.001$ ). Assault injuries increased (19,056 (11.4%) vs. 15,605 (9.8%)) and firearm-related injuries (14,246 (8.5%) vs. 10,316 (6.4%)),  $p < 0.001$ . Firearm-specific assault injuries increased (10,748 (75.5%) vs. 7,600 (74.0%)) as did firearm-specific unintentional injuries (1,318 (9.3%) vs. 830 (8.1%),  $p < 0.001$ ). In the month preceding the SAH orders, trauma center admissions decreased. Within a week of SAH implementation, hospital admissions increased ( $p < 0.001$ ) until a plateau occurred 10 weeks later above predicted levels. On regional sub-analysis, admission volume remained significantly elevated for the Midwest during weeks 11–25 after SAH order implementation, ( $p < 0.001$ ).

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### Introduction

Injury rates and patterns are known to be closely related to human behavior and are modified heavily by societal factors [1,2]. Society underwent a significant transformation in response to the COVID-19 pandemic when large-scale efforts were undertaken to mitigate the spread of the SARS-CoV-2 virus. These efforts included

social distancing, initially by school and business closures, bans on large gatherings, and transition to work from home, followed by more restrictive stay-at-home orders. These measures reduced the potential exposure to injury risk including less road traffic, limited in-person social interactions, and restricted hazardous outdoor or occupational activities. These factors should reduce the risk of injury. However, the social isolation associated with stay-at-home orders might also have adverse consequences on behavior with fewer opportunities to rely on social supports that might mitigate injury risk.

\* Corresponding author at: Medical College of Wisconsin, Milwaukee, WI, USA.

E-mail address: [acthomas@mcw.edu](mailto:acthomas@mcw.edu) (A.C. Thomas).

Given the potential diametric influences on injury risk associated with stay-at-home orders, we sought to evaluate the association of stay-at-home orders on the rate and type of injuries admitted trauma centers across the United States over the first wave of the COVID-19 pandemic. These data are critical to inform health care systems and emergency preparedness organizations in their planning for future pandemics.

## Materials and methods

### Study design

This is a retrospective observational cohort study of trauma center admissions across the United States over 2018–2020. We evaluated the rates of trauma center admissions and the types of injury after the initiation of stay-at-home orders in March 2020 compared to similar time intervals prior to the pandemic.

This study was approved by the university Institutional Review Board (IRB).

### Data sources

We used data derived from the American College of Surgeons Trauma Quality Improvement Program (ACS TQIP) to evaluate injury type and rates of trauma center discharges. ACS TQIP is a quality benchmarking program limited to centers that are verified and/or designated by the ACS or state/regional authorities as a trauma center. Over the time interval studied, over 850 trauma centers were submitting data to ACS TQIP, estimated to represent over 90% of all trauma centers in the United States. ACS TQIP inclusion criteria are limited to adults (age  $\geq 16$  years) who sustain at least one severe injury (Abbreviated Injury Scale  $\geq 3$  in at least one body region) [3]. Patients arriving without signs of life, who have an advanced directive limiting life sustaining therapy, or who have significant burn injuries (total body surface area  $\geq 20\%$ ) are excluded [3]. Data are abstracted from the medical record by trained registrars as mandated by the National Trauma Data Standard [4] and include patient and injury characteristics, processes of care, and in-hospital outcomes. Participating trauma centers were classified by census region [5] and rurality based on their zip code. Rurality was classified based on the Rural Urban Commuting Area Code [6] and dichotomized into urban (primary RUCA codes 1–3, Metropolitan) or non-urban (primary RUCA codes 4–10, Micropolitan and Small Town).

### Study population

We included all adult patients meeting TQIP inclusion criteria admitted to a US Level I, II, or III participating trauma centers between January 1, 2018 and September 30, 2020 (Fig. 1). For consistency, we excluded geriatric hip fractures as not all centers submit these patient records to ACS TQIP.

### Stay-at-home orders

Stay-at-home orders were implemented in most states during March to April 2020. Stay-at-home orders were defined as one that directed residents to limit mobility by staying at home except for essential activities, which were enabled by closure of non-essential services. Data on the implementation date of state stay-at-home orders were obtained from the National Academy for State Health Policy (NASHP) [7]. Where no data were available on the NASHP website, we sought data through state press releases and government websites. Where there was a conflict between dates, the official press releases and state government resources served as the date used for analyses.

Only states that had stay-at-home orders contributed to the primary analysis. States that did not have stay-at-home orders were analyzed separately: Arkansas, Iowa, Nebraska, North Dakota, South Dakota, Utah, and Wyoming. For the analysis of these states, we used the week representing the mode stay-at-home order within that state's census region.

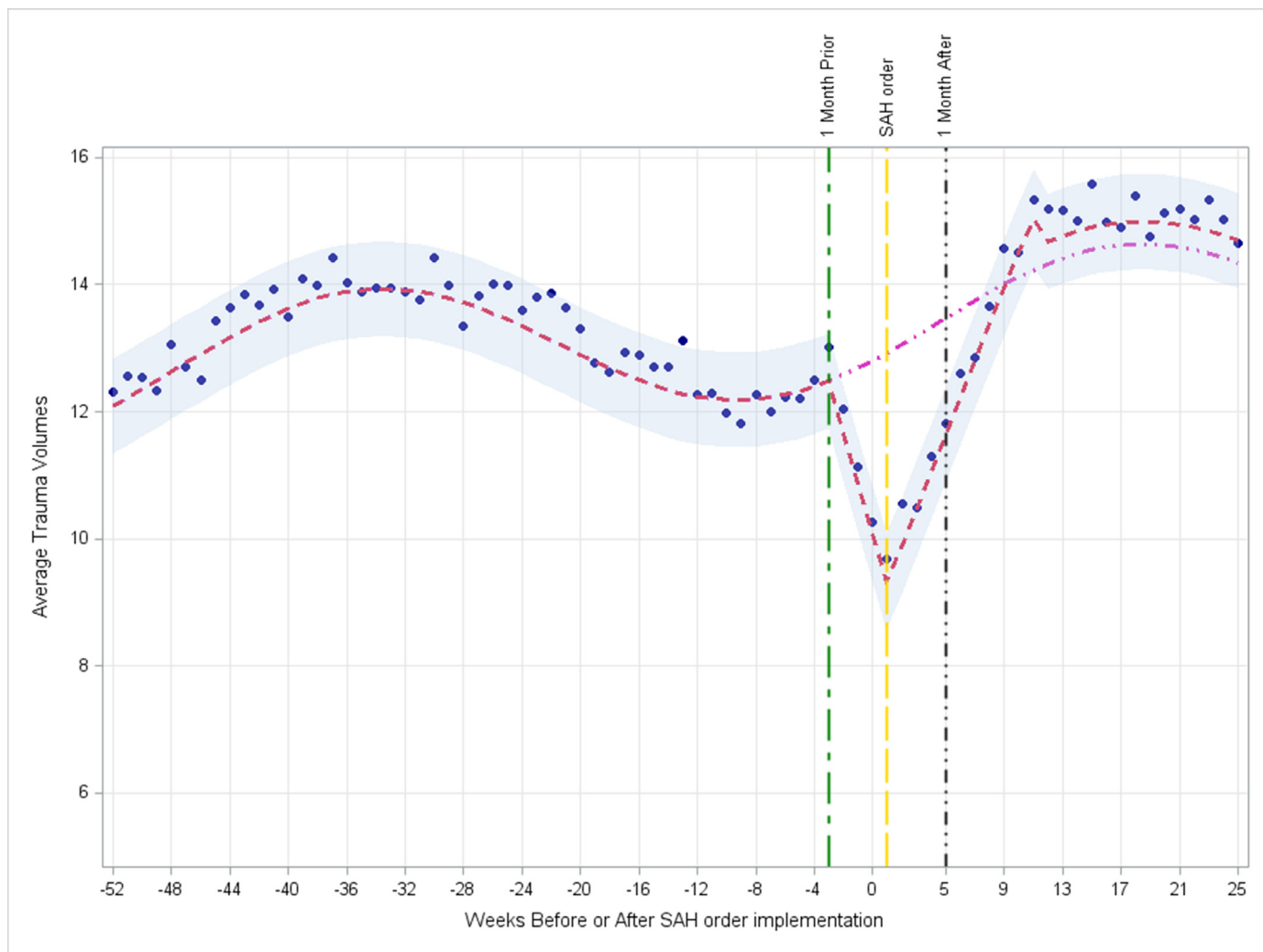
### Trauma center discharge rates and injury types

The rate of injury admissions was reported as the admission count per week per trauma center. Injury types were classified using the CDC E-code matrix [8] by mechanism (Fall, Cut/Pierce, Firearm, Motor Vehicle Crash, Pedestrian/Cyclist, Struck, and Motorcycle) and intent (Unintentional, Self-Inflicted, Assault, Undetermined, Other). We also considered the possibility that the pandemic and associated stay-at-home orders might have differentially impacted selected disadvantaged populations including those with mental health disorders. To determine whether stay-at-home orders influenced mobility in the injured population, we also evaluated the proximity of injuries to residence by comparing the zip code of injury location with the zip code of residence. [9]

### Statistical methods

Descriptive analyses were performed using chi-square for categorical variables and ANOVA for continuous variables to compare injury type and patient characteristics during the period after the stay-at-home orders were implemented in 2020 with the same calendar weeks over 2018–2019. Continuous variables included in the analysis were age and Injury Severity Score (ISS). Categorical variables included were sex, insurance status (Government, Self-Pay, Private, Other), pre-existing conditions (inclusive of substance and alcohol misuse) and mental health disorders, as well as injury characteristics including presence of shock on ED arrival, transfer status, and the proportion of patients who were injured within 10 miles of their home zip code. Missing data was treated as missing-at-random and not imputed.

Trauma admissions rates were analyzed using a harmonic regression model with a random hospital effect to account for clustering of patients within hospitals [10]. This approach acknowledges the cyclic nature of trauma admissions over the course of a calendar year and determines whether the observed event rate is different than what would be expected based on seasonality and secular trends alone. The weekly trauma admission count was modeled by setting the week of the stay-at-home order initiation as “Week 0”. Each week was then counted in relation to the order initiation start week backwards to 2018 and forward to September 2020 (when data were last available). To model the seasonal pattern of trauma admissions, we included both a sine and cosine transformed variable containing the weekly trauma admissions in order to account for the periodic oscillations that occur throughout the year [11]. The final model included the following parameters: [1] baseline annual trauma admission seasonal oscillation which was modeled using both a sine and cosine parameter, [2] the longitudinal trauma admission change slope, [3] the slope change in the month preceding the order implementation, [4] the slope change of the 10 weeks following the order implementation, and [5] the change in admission volume during weeks 11 to 25 after the order. These weeks were selected based on the deviations from the baseline oscillations of trauma admissions that would be expected based on seasonality that was evident after examining the graphical trends of the data. Our secondary analyses used the same modeling technique and evaluated whether the pandemic and stay-at-home orders differed across US census regions or between metropolitan and micropolitan/small towns.



**Fig. 1.** Average ACS TQIP admissions in the weeks before and after stay-at-home order implementation from January 2019 to September 2020. The month before and after implementation of stay-at-home are marked for clarity. 2018 is not included for brevity of graph but pattern is identical to 2019. The month before and after implementation of stay-at-home are marked for clarity. The red dashed line represents the observed volumes and the purple dashed/dotted line represents the predicted volumes based on the harmonic regression analysis.

For states without official stay-at-home orders, we replicated the approach described above to evaluate for similar patterns. We used the week representing the mode stay-at-home order within that state’s census region. Secondary analyses evaluating metropolitan vs. micropolitan/small towns and US census regions were not performed due to small sample size.

We compared trauma center admission rates in states with stay-at-home orders to those without by creating an interaction term between the presence of an order and the previously described modeled parameters. All analyses were performed using SAS 9.4 (Cary, NC). A two-tailed alpha level of 0.05 was considered significant. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist was used for study design creation, analysis, and preparation of this article. [12]

**Results**

There were 877,323 injured patients admitted to 504 ACS verified Level 1-3 and state designated trauma centers participating in ACS TQIP from January 1, 2018 to September 30, 2020. (eFig. 1). Over 93% (474) of centers were in states with official stay-at-home orders and 30 centers were in states without official orders. The order start date varied between states but were all within 2.5

weeks (range from March 19th to April 6th). There were 166,773 patients admitted in 2020 after a stay-at-home order was in place to the month of September and a mean of 160,962 patients using the same time interval over the two prior years. Table 1 summarizes the patient and injury characteristics of the study population. In 2020, the average age of patients was younger: 52.8±22 years compared to 54.2±21.9 years in 2018 and 2019, p<0.001. There was a higher proportion of Black patients admitted after orders were implemented, (28,176 (17.3%) vs 23,007 (14.6%) p<0.001. There was an increase in patients who presented to the hospital with a pre-existing condition of alcohol misuse 13,611 (8.3%) compared to 10,440 (6.6%), p<0.001. Patients had similar injury severity scores (ISS) and abbreviated injury score (AIS) body region patterns across all years. There was an increase in assault injuries (19,056 (11.4%) vs. 15,605 (9.8%) and firearm related injuries (14,246 (8.5%) vs. 10,316 (6.4%)), p<0.001 associated with the pandemic after the stay-at-home orders were implemented. Firearm specific assault injuries increased (10,748 (75.5%) vs. 7,600 (74.0%)) as did firearm specific unintentional injuries (1,318 (9.3%) vs. 830 (8.1%)), p<0.001. There was a minimal decrease in motor vehicle crash injuries (9,870 (36.9%) vs. 10,052 (37.2%)), p<0.001.

Using the model estimates presented in Table 2, in the month before the initiation of the stay-at-home order, there were 4,261

**Table 1**  
Patient demographic and injury characteristics presenting after stay-at-home order compared to prior years.

	2018–19Average (n=160,962)	2020 (n=166,773)	P-Value
Age, mean (SD)	<b>54.2 (21.9)</b>	<b>52.8 (22.0)</b>	<b>&lt;0.001</b>
Sex, n (%)			
Male	<b>104,860 (65.2)</b>	<b>111,299 (66.8)</b>	<b>&lt;0.001</b>
Comorbidities, n (%)			
Alcohol	<b>10,440 (6.6)</b>	<b>13,611 (8.3)</b>	<b>&lt;0.001</b>
Mental Illness	<b>17,309 (11.0)</b>	<b>19,369 (11.8)</b>	<b>&lt;0.001</b>
Substance Abuse	<b>12,243 (7.8)</b>	<b>14,736 (9.0)</b>	<b>&lt;0.001</b>
Race, n (%)			
Black	<b>23,007 (14.6)</b>	<b>28,176 (17.3)</b>	<b>&lt;0.001</b>
White	<b>118,638 (75.1)</b>	<b>117,753 (72.2)</b>	<b>&lt;0.001</b>
Hispanic	<b>17,468 (11.3)</b>	<b>18,561 (11.6)</b>	<b>0.0004</b>
Asian	<b>3,324 (2.1)</b>	<b>3,021 (1.9)</b>	<b>&lt;0.001</b>
American Indian	<b>1,328 (0.8)</b>	<b>1,342 (0.8)</b>	<b>0.53</b>
Pacific Islander	<b>411 (0.3)</b>	<b>405 (0.3)</b>	<b>0.45</b>
Matched Home and Injury Zip Codes, n (%)	<b>71,628 (56.9)</b>	<b>77,943 (58.2)</b>	<b>&lt;0.001</b>
Proportion of patients injured ≥10 miles from residence*, n (%)	<b>27,702 (21.6)</b>	<b>26,762 (20.1)</b>	<b>&lt;0.001</b>
Proportion of patients injured ≥10 miles from residence by Mechanism, n (%)			
Fall	<b>6,733 (24.9)</b>	<b>6,020 (22.5)</b>	<b>&lt;0.001</b>
Firearm	<b>1,196 (4.4)</b>	<b>1,689 (6.3)</b>	<b>&lt;0.001</b>
MVC	<b>10,052 (37.2)</b>	<b>9,870 (36.9)</b>	<b>0.38</b>
Motorcycle	<b>3,483 (12.9)</b>	<b>3,583 (13.4)</b>	<b>0.05</b>
Pedestrian <sup>‡</sup>	<b>1,958 (7.2)</b>	<b>1,837 (6.9)</b>	<b>0.05</b>
Stab	<b>488 (1.8)</b>	<b>587 (2.2)</b>	<b>0.0002</b>
Struck	<b>1,133 (4.2)</b>	<b>962 (3.6)</b>	<b>&lt;0.001</b>
Other	<b>1,979 (7.3)</b>	<b>2,210 (8.3)</b>	<b>&lt;0.001</b>
Insurance, n (%)			
Government	<b>77,682 (49.4)</b>	<b>83,334 (51.1)</b>	<b>&lt;0.001</b>
Self-Pay	<b>17,150 (10.9)</b>	<b>19,045 (11.7)</b>	
Private	<b>57,486 (36.6)</b>	<b>56,211 (34.5)</b>	
Other	<b>4,792 (3.1)</b>	<b>4,533 (2.8)</b>	
AIS (≥3), n (%)			
Head	<b>55,948 (34.8)</b>	<b>55,507 (33.3)</b>	<b>&lt;0.001</b>
Face	<b>1,420 (0.9)</b>	<b>1,516 (0.9)</b>	<b>0.34</b>
Neck	<b>2,256 (1.4)</b>	<b>2,584 (1.6)</b>	<b>&lt;0.001</b>
Chest	<b>54,822 (34.1)</b>	<b>56,941 (34.1)</b>	<b>0.56</b>
Spine	<b>16,650 (10.4)</b>	<b>17,701 (10.6)</b>	<b>0.003</b>
Abdomen	<b>14,429 (9.0)</b>	<b>15,633 (9.4)</b>	<b>&lt;0.001</b>
Lower Extremity	<b>44,049 (27.4)</b>	<b>47,501 (28.5)</b>	<b>&lt;0.001</b>
Upper Extremity	<b>5,081 (3.2)</b>	<b>5,865 (3.5)</b>	<b>&lt;0.001</b>
ISS, mean (SD)	<b>16.0 (8.6)</b>	<b>16.1 (8.6)</b>	<b>0.001</b>
Intent, n (%)			
Unintentional	<b>141,139 (88.2)</b>	<b>144,070 (86.4)</b>	<b>&lt;0.001</b>
Self-Inflicted	<b>2,284 (1.4)</b>	<b>2,355 (1.4)</b>	
Assault	<b>15,605 (9.8)</b>	<b>19,056 (11.4)</b>	
Undetermined	<b>722 (0.5)</b>	<b>1,035 (0.6)</b>	
Mechanism, n (%)			
Fall	<b>70,213 (43.6)</b>	<b>70,639 (42.4)</b>	<b>&lt;0.001</b>
Firearm	<b>10,316 (6.4)</b>	<b>14,246 (8.5)</b>	<b>&lt;0.001</b>
MVC	<b>35,660 (22.2)</b>	<b>35,387 (21.2)</b>	<b>&lt;0.001</b>
Motorcycle	<b>12,337 (7.7)</b>	<b>12,779 (7.7)</b>	<b>0.99</b>
Pedestrian <sup>‡</sup>	<b>12,070 (7.5)</b>	<b>12,058 (7.2)</b>	<b>0.001</b>
Stab	<b>4,433 (2.8)</b>	<b>5,038 (3.0)</b>	<b>&lt;0.001</b>
Struck	<b>8,138 (5.1)</b>	<b>7,493 (4.5)</b>	<b>&lt;0.001</b>
Other	<b>7,779 (4.8)</b>	<b>9,089 (5.5)</b>	<b>&lt;0.001</b>
Shock in ED, n (%)	<b>7,000 (4.4)</b>	<b>7,559 (4.5)</b>	<b>0.003</b>
Transfer, n (%)	<b>48,285 (30.0)</b>	<b>48,750 (29.2)</b>	<b>&lt;0.001</b>
Major Complications <sup>‡</sup> , n (%)	<b>7,855 (5.1)</b>	<b>8,336 (5.2)</b>	<b>0.12</b>
Mortality, n (%)	<b>11,666 (7.3)</b>	<b>12,688 (7.6)</b>	<b>&lt;0.001</b>

(AIS=Abbreviated Injury Score, ISS=Injury Severity Score, MVC=Motor Vehicle Crash).

\* Missingness in this variable ranged from 20–22% from years 2018–2020.<sup>1</sup>Missingness in this variable ranged from 1.8 to 3.1% from years 2018 to 2020.

<sup>‡</sup> Pedestrian and Cyclist injuries.

<sup>‡</sup> Major Complications: composite score including presence of acute renal failure, acute respiratory distress syndrome, cardiac arrest with CPR, decubitus ulcer, deep surgical site infection, myocardial infarction, organ/space surgical site infection, ventilator associated pneumonia/pneumonia, pulmonary embolism, stroke/CVA, catheter-related bloodstream infection, unplanned return to the OR, unplanned return to the ICU, severe sepsis.

fewer seriously injured trauma patients than would be expected compared to 2018–2019 ( $p < 0.001$ ; Fig. 1). This trend reversed after the orders were initiated. In the month following the order initiation, there were 2,085 more seriously injured patients who were admitted to TQIP facilities relative to what was expected, for a total

of 11,470 more patients over 10 weeks after order implementation. Finally, from weeks 11 to 25 after the stay-at-home order there were 2,328 more admissions over the course of 14 weeks compared to predicted volumes based on average rates in 2018–2019 ( $p < 0.001$ ). Overall, there were 9,538 more admissions for serious

**Table 2**  
Model estimates for the overall trauma population, by region, and by urbanicity.

Model Description (# of centers)	4 weeks prior to stay-at-home order Estimate (CL)	P-value	4 weeks following stay-at-home order Estimate (CL)	P-value	Weeks 11-25 following stay-at-home order Estimate (CL)	P-Value
Overall Sample (n=474)	-0.899 (-0.956,-0.842)	<0.001	0.440 (0.405, 0.475)	<0.001	0.351 (0.186,0.516)	<0.001
South (n=151)	-0.879 (-0.993,-0.765)	<0.001	0.477 (0.407,0.546)	<0.001	-0.0117 (-0.344,0.320)	0.945
Midwest (n=111)	-0.937 (-1.047,-0.828)	<0.001	0.521 (0.454,0.588)	<0.001	1.182 (0.866,1.497)	<0.001
West (n=112)	-0.776 (-0.886,-0.666)	<0.001	0.319 (0.252,0.385)	<0.001	0.113 (-0.205,0.432)	0.485
Northeast (n=100)	-1.035 (-1.147,-0.922)	<0.001	0.441 (0.373,0.510)	<0.001	0.282 (-0.045,0.608)	0.091
Metropolitan (n=463)	-0.898 (-0.956,-0.841)	<0.001	0.442 (0.407,0.477)	<0.001	0.375 (0.208,0.542)	<0.001
Micropolitan/Small Town* (n=10)	-0.912 (-1.212,-0.612)	<0.001	0.424 (0.240,0.608)	<0.001	-0.102 (-0.962,0.759)	0.817
States without stay-at-home orders (n=30)	-0.613 (-0.797,-0.429)	<0.001	0.334 (0.222,0.446)	<0.001	0.0363 (-0.500,0.572)	0.894

Note: Estimates of the 4 weeks before and after stay-at-home order represent average patient volume loss or gain per center per week. Estimate of weeks 11-25 represent volume per center over the entire period.

\* Combination of Micropolitan and Small Town as defined in the Rural-Urban Commuter Area Code (Codes 4-9).

injury than would have been predicted over 7 months (between one month prior to order initiation and ending 25 weeks after order initiation,  $p<0.001$ ).

By region, centers in the Midwest experienced a significant decrease of 1040 seriously injured patients in the month prior to the stay-at-home orders and admitted 578 more seriously injured patients in the month following ( $p<0.001$ ; Fig. 2) for a total of 3,181 more admissions than predicted over the course of 10 weeks after stay-at-home order implementation. The Midwest was the only region that experienced significantly higher admissions in weeks 11-25 following the stay-at-home orders after the disruptions in the admission volumes due to COVID and stay-at-home orders had stabilized ( $p<0.001$ ) compared to centers in the south, west, and northeast.

For the 463 centers with metropolitan zip codes (eFig. 3), there was a significant decrease of 4,159 admissions in the month preceding the orders, which reversed in the month following ( $p<0.001$ ) with 2,045 additional admissions. These centers continued to experience significantly higher admissions in the weeks 11-25 ( $p<0.001$ ). The 10 centers with Micropolitan/Small Town zip codes saw a decrease in admissions of 91 seriously injured patients in the month prior and an increase of 42 more patients than expected in the month following ( $p<0.001$ ).

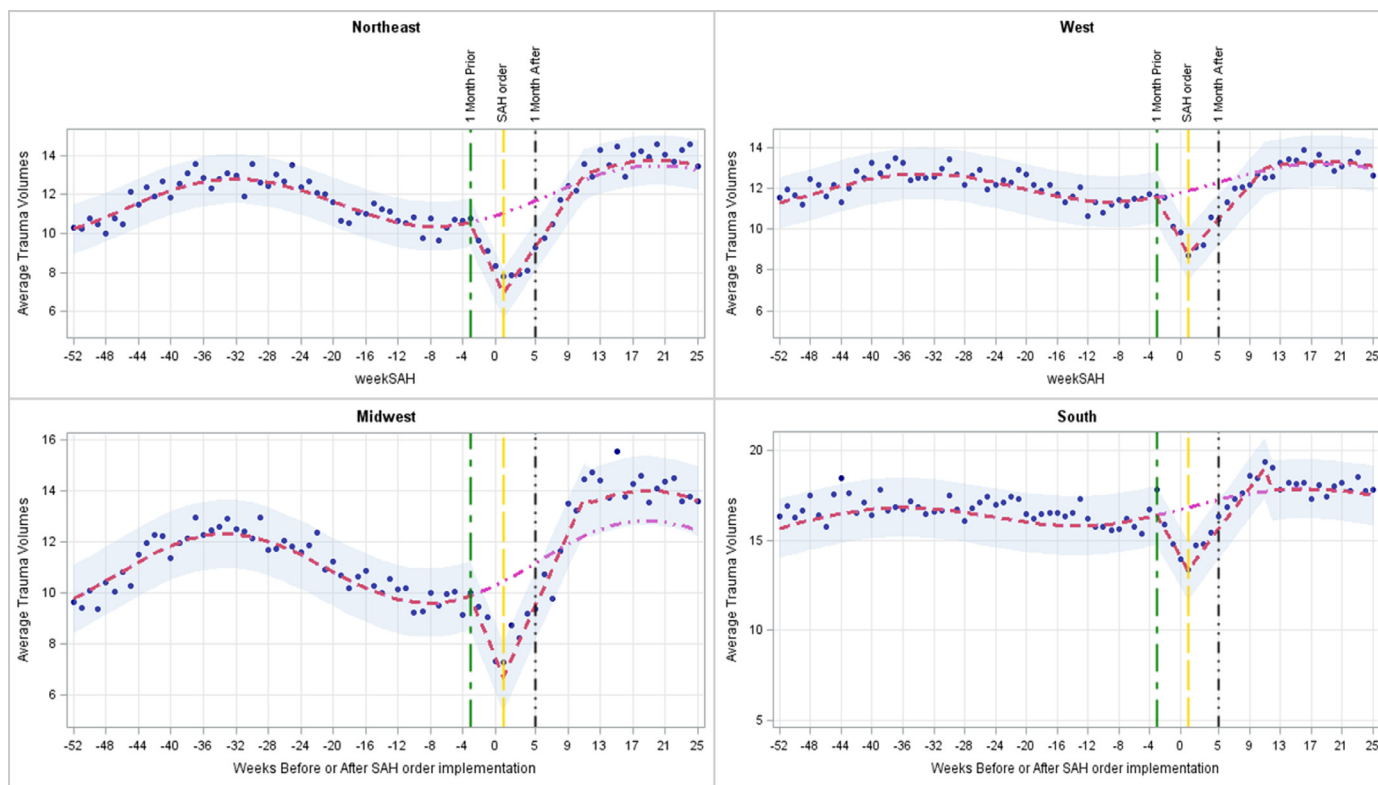
There were 30 trauma centers in the 7 states that contributed to the analysis of states without official orders (Fig. 3). There was a significant decrease in trauma admissions of 184 patients before the time of the order using the mode date of the region as described in *Methods* in the surrounding states compared to 100 more patients in the month after ( $p<0.001$ ). There was no significant increase in trauma admissions in weeks 11-25 ( $p=0.89$ ) among states that did not have orders.

Comparing the states with and without an order, there were similar reductions in trauma admissions in the month prior to order initiation (again, utilizing the mode date of the region for the states without an order ( $p=0.1$ ); however, the rate of decrease was higher in states with orders than in states without orders (eTable 3). When evaluating the increase in patients after the orders were in place, the states with orders experienced a decreased rate of patient admissions than states without orders but the difference did not reach statistical significance ( $p=0.39$ ). Finally, when evaluating the weeks 11-25, there was no significant difference between states with or without orders in admission volumes ( $p=0.16$ ).

## Discussion

This study assessed the association between patient demographic, injury characteristics, and overall volume of seriously injured patients after the stay-at-home orders were implemented. We showed that trauma center admission rates decreased significantly in the month before the stay-at-home orders were implemented and remained elevated for weeks in states where these orders were enacted. We demonstrated that this change in rates was not uniform across the country, with the most evident impact in the Midwest that was not accounted for by differences in urbanicity. The change in rate of admissions based on the presence of an order was driven predominantly by increases in interpersonal violence.

The COVID-19 pandemic created unforeseen and unanticipated challenges in understanding how best to allocate limited health-care resources such as infrastructure, healthcare workers, and PPE to avoid overwhelming the system without compromising on quality. Although many outpatient visits and elective procedures were postponed, hospitals with trauma centers reported that admissions due to trauma with only a slight decrease in volume at the beginning of the pandemic [13,14]. Our results show that penetrating injuries due to firearms, and less dramatically due to stab wounds,



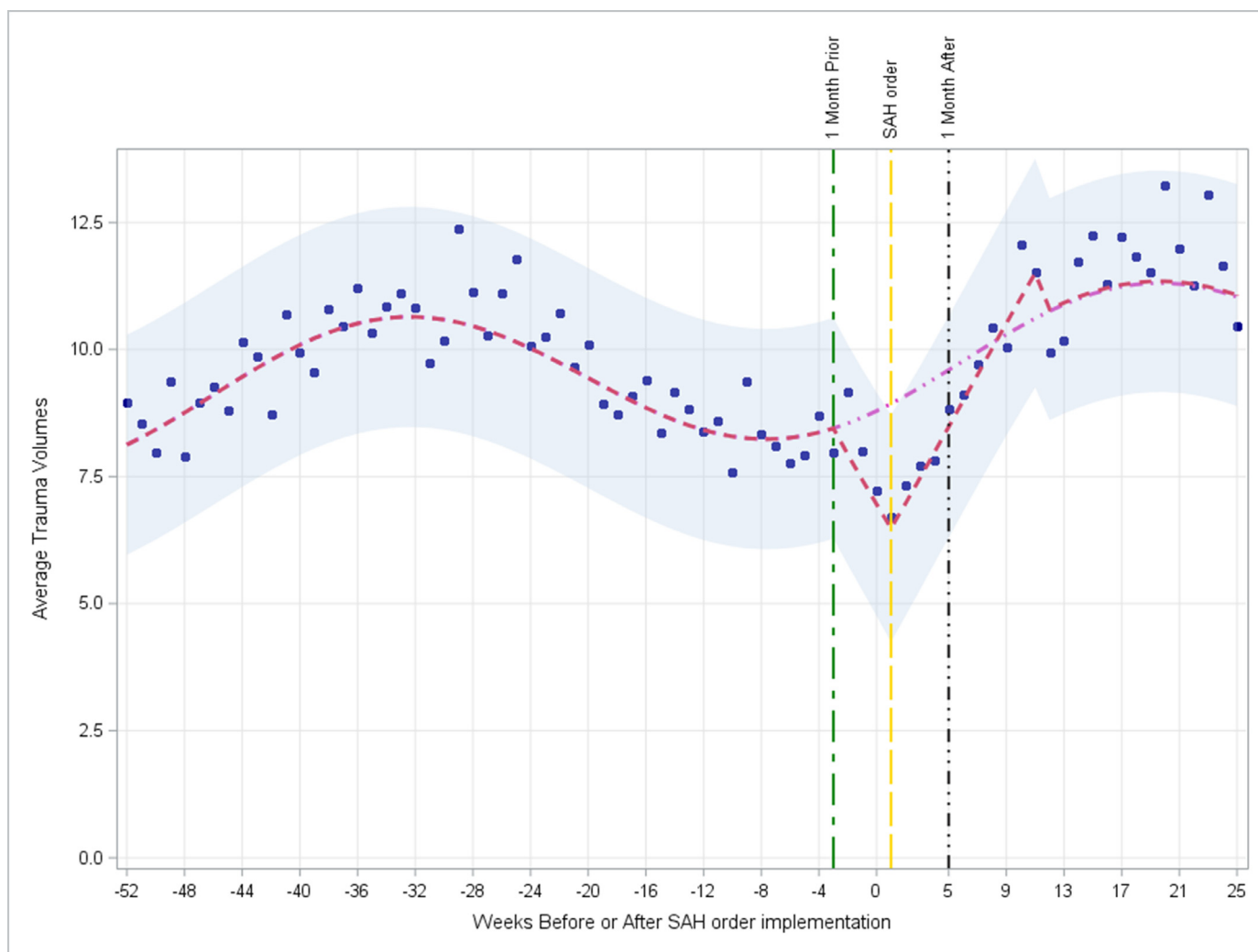
**Fig. 2.** Average ACS TQIP admissions in the weeks before and after stay-at-home order implementation from January 2019 to September 2020 by census region (Northeast, West, Midwest, South). The month before and after implementation of stay-at-home are marked for clarity. The red dashed line represents the observed volumes and the purple dashed/dotted line represents the predicted volumes based on the harmonic regression analysis.

increased during 2020. The pattern of unintentional injury, which showed a steep decrease and then gradual rise to expected levels after a SAH order was put in place was not the same as for assault injuries which rose unabated during the lockdowns (eFig. 2) This corroborates on a national scale previous reports in 2020 on the increase of firearm violence during the pandemic [14–17]. What is evident is that stay-at-home orders do not significantly reduce trauma admission rates, implying the need to maintain trauma center readiness including adequate human and physical resources in spite of the pressures imposed by the pandemic. These data suggest that regional planning should maintain capabilities for complex trauma care during times of increased patient volumes [18,19].

Our results demonstrated that the effect of the pandemic on trauma volumes across the US regions was not uniform. The Midwest continued to have significantly higher trauma volume while other regions returned to their expected levels of trauma volume in the weeks following the implementation of the stay-at-home order. Previous data demonstrated regional variation in the decrease in mean weekly Emergency Department visits across the United States with the highest decrease being in Region 1 (CT, ME, MA, NH, RI,VT), and the lowest decrease being in Region 8 (CO, MT, ND, SD, UT, WY) [20]. A 2020 study looking at the distribution of COVID-19 and projected healthcare burden across the United States revealed that rural areas might bear the brunt over the urban areas due to concentration of trauma centers away from rural environments [21]. This difference may have been exacerbated during the pandemic and is not reflected within our data. Further research needs to be done to evaluate the specific regional differences that contributed to the differential impact of the COVID-19 pandemic on trauma admission volumes.

Our data shows that using a national dataset, the main increase in seriously injured trauma volume was attributed to assaults resulting from firearm injury. Additionally, more patients presented with a diagnosis of alcohol misuse than would have been predicted. There are known underlying risk factors for violence including limited formal education, early exposure to violence, lack of socioeconomic opportunities, and mental health/substance abuse conditions [22–24]. At baseline, these risks differs widely across the US with a greater risk burden for minorities and rural populations [25–27]. Thus, further limiting accessibility to social support systems and mental health support should be minimized during times of social and economic uncertainty and community isolation. Furthermore, patients who are injured through interpersonal violence are at risk of increased rates of PTSD, new physical disabilities related to injury, decreased quality of life, and low rates of returning to work [28]. Allocation of societal resources should consider these challenges when developing risk-mitigation strategies. Our study was limited by the retrospective nature of the dataset and describes associations without being able to determine causality.

This is a dataset that focuses on seriously injured individuals from designated trauma centers and as such this limits the generalizability of the data for all traumatic injury. This dataset does not capture individuals with injuries who were evaluated and discharged from the emergency department, or those who died before reaching a trauma center. Most of the trauma centers in our dataset were located in metropolitan areas and while they may receive interfacility transfers from rural areas, we are not able to fully assess the impact on injury volumes in areas of the US without trauma center access.



**Fig. 3.** Average ACS TQIP admissions in the weeks before and after stay-at-home order implementation from January 2019 to September 2020 for states that did not have an official order. The month before and after implementation of stay-at-home are marked for clarity. The red dashed line represents the observed volumes and the purple dashed/dotted line represents the predicted volumes based on the harmonic regression analysis.

**Conclusion**

Nationally, trauma volume decreased in the month preceding the stay-at-home orders and returned to baseline within 2 months. There was an increase in traumatic injury specifically related to interpersonal violence. This effect was not uniform across all regions. Hospitals should have policies in place to account for the fact that serious trauma is unlikely to decrease even with an expected decrease in mobility of a population. Regional planning for future pandemics should account for the need to maintain trauma center access for injured patients during large patient surges. Implementation of Regional Medical Operations centers to coordinate patient distribution is one strategy to support this need [18,29]. In addition, the increase in violent injury further highlights the need to address the social determinants of violence which have been exacerbated by the economic impact of the pandemic on a societal level.

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**Supplemental Digital Content**

We provide a derivation of the study population in eFig. 1. Average TQIP admissions in the weeks before and after stay-at-home order implementation from January 2019 -September 2020 by intent is provided in eFig. 2 as well as by urbanicity in eFig.3. The complete listing of US Census Regions utilized for the analysis is provided in eTable 1. Finally, eTable 2 contains the results from Difference-in-Difference model with three modeled parameters and associated interaction effects

**Declaration of Competing Interest**

None.

**CRediT authorship contribution statement**

**Arielle C. Thomas:** Conceptualization, Supervision, Validation, Data curation, Investigation, Methodology, Validation, Formal anal-



ysis, Visualization, Writing – original draft, Writing – review & editing, Validation. **Brendan T. Campbell:** Conceptualization, Supervision, Validation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Validation. **Haris Subacius:** Conceptualization, Supervision, Validation, Data curation, Investigation, Methodology, Validation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Validation. **Claudia P. Orlas:** Conceptualization, Supervision, Validation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Validation. **Eileen Bulger:** Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Validation. **Ronald M. Stewart:** Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Validation. **Anne M. Stey:** Conceptualization, Supervision, Validation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Validation. **Doulia Hamad:** Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Validation. **Karl Y. Bilimoria:** Conceptualization, Supervision, Validation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Validation. **Avery B. Nathens:** Conceptualization, Supervision, Validation, Data curation, Investigation, Methodology, Validation, Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Validation.

### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.injury.2022.09.012](https://doi.org/10.1016/j.injury.2022.09.012).

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