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## Rising incidence of interpersonal violence in Pennsylvania during COVID-19 stay-at home order

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### ABSTRACT

**Background:** The coronavirus disease 2019 pandemic and associated policies have had important downstream consequences for individuals, communities, and the healthcare system, and they appear to have been accompanied by rising interpersonal violence. The objective of this study was to evaluate the incidence of injuries owing to interpersonal violence after implementation of a statewide stay-at-home order in Pennsylvania in March 2020.

**Methods:** Using the Pennsylvania Trauma Outcome Study registry, we conducted a retrospective cohort study of patients with gunshot wounds, stab wounds, and blunt assault-related injuries attributable to interpersonal violence treated at Pennsylvania trauma centers from March 16 to July 31 of 2018, 2019, and 2020.

**Results:** There were fewer total trauma admissions in 2020 (17,489) vs 2018 (19,290) and 2019 (19,561). Gunshot wounds increased in 2020 to 737 vs 647 for 2019 and 565 for 2018 ( $P = .028$ ), whereas blunt assault injuries decreased ( $P = .03$ ). In all time periods, interpersonal violence primarily impacted urban counties. African American men were predominantly affected by gunshot wounds and stab wounds, whereas Caucasian men were predominantly affected by blunt assault injuries. There were more patients with substance abuse disorders and positive drug screens during coronavirus disease than in comparison periods: (stab wound population 52.3% vs 33.9% vs 45.9%, coronavirus disease era vs 2018 vs 2019, respectively  $P = .0001$ ), (blunt assault injury population 41.4% vs 33.1% vs 33.5%, coronavirus disease era vs 2018 vs 2019, respectively  $P < .0001$ ). There was no correlation between the incidence of interpersonal violence and coronavirus disease 2019 rates at the county level.

**Conclusion:** The implementation of a stay-at-home order was accompanied by rising incidence of gunshot and stab wound injuries in Pennsylvania. Preparedness for future resurgences of coronavirus disease 2019 and other pandemics calls for plans to address injury prevention, recidivism, and access to mental health and substance abuse prevention services.

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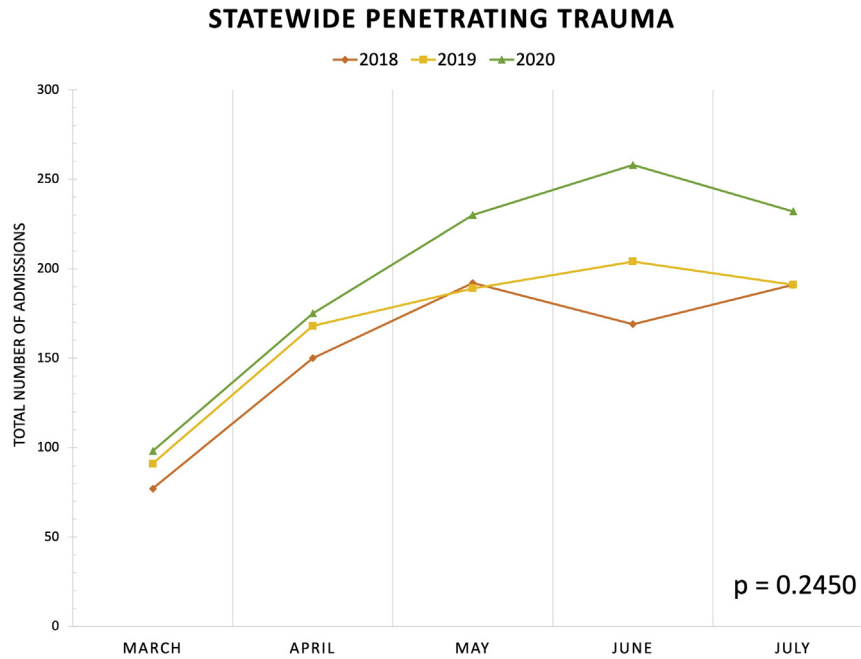
### Introduction

The novel coronavirus disease 2019 (COVID-19) causing severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) initially was discovered in December 2019.<sup>1</sup> As of the end of December

2020, there were 20.9 million cases and 329,000 deaths in the United States. In Pennsylvania, there were 639,513 confirmed cases and 17,770 COVID-19-related deaths.<sup>2</sup> SARS-CoV-2 is transmitted primarily via respiratory droplets. Owing to its high transmissibility, social distancing interventions were implemented to isolate COVID-19 patients, to quarantine those exposed, and to limit large gatherings and business operations.<sup>3</sup> The governor of Pennsylvania (PA) enacted a stay-at-home (SAH) order on March 16, 2020.<sup>4</sup> The SAH order was lifted on June 4, 2020, though various restrictions remained in place thereafter. Early single-center or

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**Figure 1.** Incidences of penetrating trauma in the State of Pennsylvania.

single-city reports indicate that SAH orders in the United States were accompanied by an increase in interpersonal violence.<sup>5–16</sup> Although the causes of rising violence are unknown, they may include economic stress, lack of access to structured social support such as schools and employment, and access to firearms.<sup>3,17</sup> The impact of community interpersonal violence has negative effects on individuals, communities, and strained health systems during a public health crisis such as the COVID-19 pandemic. Understanding the secondary impacts of this pandemic and our responses to it is necessary for a comprehensive public health response. To our knowledge, this study is the first statewide evaluation of the impact of COVID-19-related restrictions on interpersonal violence.

## Materials and methods

### Study population

We performed a retrospective analysis of patients treated at all 42 PA trauma centers from the onset of SAH on March 16, 2020 through July 31, 2020 and compared this cohort to patients seen during analogous time periods in 2018 and 2019. The research was approved by the Pennsylvania Trauma System Foundation (PTSF) research committee and the University of Pennsylvania Institutional Review Board. Data were collected from the Pennsylvania Trauma Outcomes Study (PTOS) registry, a statewide, prospectively collected trauma registry. The PTOS registry is maintained by dedicated trauma registrars and undergoes the highest levels of validation both locally and at the state level. The data was provided by the PTSF, Mechanicsburg, PA. PTSF specifically disclaims responsibility for any analyses, interpretations, or conclusions.

The PTOS registry includes all patients admitted to a PA trauma center with an injury diagnosis for  $\geq 36$  hours, or for  $\geq 24$  hours with an injury severity score (ISS) of  $\geq 9$ . All deaths, including deaths on arrival, are included, as are all transfers, intensive care unit (ICU) admissions, and step-down admissions. Patients with isolated hip fractures are excluded, as are those discharged from the

emergency department with no injuries identified and those with a mechanism of asphyxiation, drowning, or poisoning.

The International Statistical Classification of Disease 10th revision diagnosis codes were used to identify patients injured via interpersonal violence, including codes and subcodes for gunshot wound (GSW) (X93, X94, X95), stab wound (SW) (X99), and blunt assault (X92, X96, X97, X98, Y00, Y01, Y02, Y03, Y04, Y07, Y08, Y09, Y21, Y22, Y23, Y24, Y25, Y26, Y28, Y29, Y30, Y31, Y33).

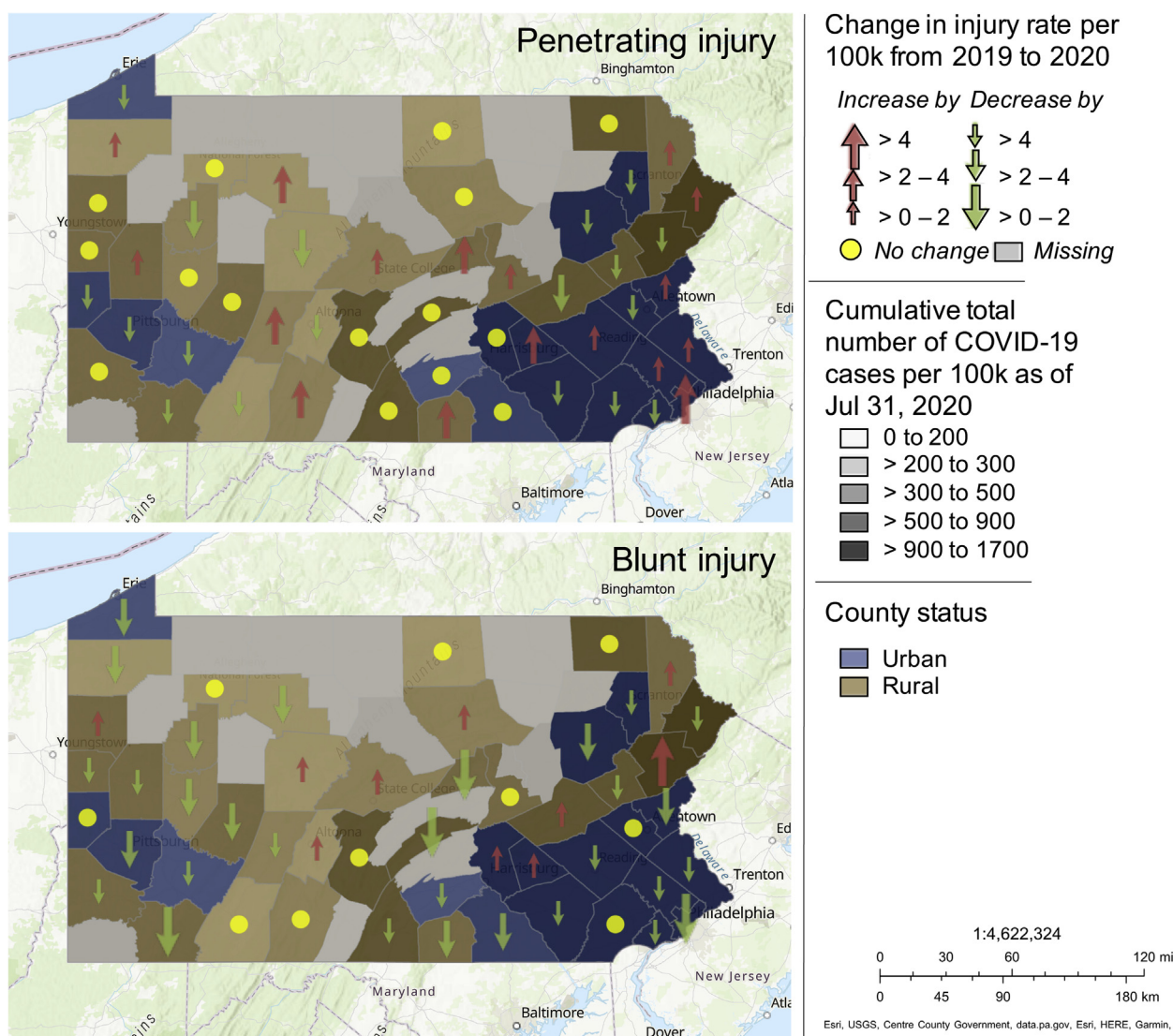
The primary outcome was the incidence of injuries owing to GSW, SW, and blunt assault between all 3 time periods. GSW injury rates were also calculated yearly and for racial subgroups based on population estimates of PA<sup>18</sup> and PTOS data on demographics. Secondary outcomes included interventions to examine massive transfusion protocol activations, ICU length of stay, ventilator days, hospital length of stay, discharge destinations, complications, and mortality. We collected demographics (age, sex, race, county of residence), injury characteristics and severity (ISS, trauma injury severity score [TRISS], and abbreviated injury score), and admitting physiology (systolic blood pressure, respiratory rate, heart rate, Glasgow Coma Scale score, and oxygen saturation). Alcohol level, urine toxicology, and patient comorbidities were examined.

### Geographical analysis

We used ArcGIS software (Esri, Chesterbrook, PA) to map Pennsylvania-county-specific rates of change in interpersonal violence between the COVID era and the prior years. We overlaid these rates with a choropleth map showing county-level rates of COVID cases per 100,000 people at the conclusion of the study period (Jul 31, 2020), as well as with an indicator of urban versus rural status for each county.<sup>19</sup>

### Statistical analysis

Descriptive analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC). Statistics include measures of central tendency (mean, median) and variation (standard deviation, interquartile range, range) for continuous measures, and frequencies and



**Figure 2.** Pennsylvania County specific rates of change in interpersonal violence between the COVID era and prior years.

percentages for dichotomous and categorical measures. Statistical comparisons were accomplished using 1-way analysis of variance F-statistics, Kruskal-Wallis, and  $\chi^2$  statistics for normally distributed continuous, non-normally distributed continuous, and categorical variables, respectively. For pairwise comparisons of continuous measures, 2-sample *t* tests and Wilcoxon tests were used for normally and non-normally distributed variables, respectively. To determine any association of COVID-19 era with mortality after injury, we constructed a multivariable logistic regression model adjusting for patient demographics, comorbidities, presenting physiology, injury mechanism and severity, and transfer status based on previously validated risk adjustment models.<sup>20</sup>

**Results**

*Incidence of injuries owing to interpersonal violence*

From March 16 to July 31 in 2018, 2019, and 2020, there were a total of 1,949 admissions with GSW, 667 admissions with SW, and 2,419 admissions with blunt assaults. Although the total number of admissions decreased in 2020 ( $n = 17,489$ ) compared with 2018 ( $n = 19,290$ ) and 2019 ( $n = 19,561$ ), GSW admissions increased

from 565 in 2018 and 647 in 2019 to 737 in 2020,  $P = .028$ . GSW injury rates per 100,000 population in the state of PA<sup>18</sup> was analyzed with an observed statistically significant increase in rates in 2018, 2019, and 2020 (4.41 vs 5.05 vs 5.66 GSW injuries per 100,000 population in 2018, 2019, and 2020, respectively,  $P < .001$ ). There was no significant change in SW (256 in 2020, 215 in 2018, and 196 in 2019,  $P = .34$ ). There were significantly fewer blunt assaults in 2020 (660 in 2020, 903 in 2018, and 856 in 2019,  $P = .030$ ). [Figure 1](#) shows the seasonal distribution of GSW and SW.

*Geographic distribution*

We categorized 19 PA counties as urban and 48 as rural.<sup>21</sup> Five of 19 (26.3%) urban and 10 of 48 (20.8%) rural counties, which accounts for 36.2% of the total state population showed increases in interpersonal violence. SWs increased in 22.6% of rural counties, GSWs increased in 25.8% of rural counties, and blunt assaults increased in 25.8% of rural counties. Analyzing urban PA counties by month, we noted a significant rise in GSW volume in 2020 ( $P = .010$ ) that peaked in June ( $n = 173$ , 5.8%). This was in contrast to peaks in previous years ( $n = 148$  [5.2%] June 2019;  $n = 137$  [4.62%] July 2018). Incidences of SW also increased in urban counties

**Table I**  
Demographics and outcomes of patients with gunshot-related injuries from March 16 to July 31

Demographics	2018 (n = 565)	2019 (n = 647)	2020 (n = 737)	Total (n = 1949)	P value
Age, median (Q1, Q3)	27(21, 35)	27(22, 37)	26(20, 32)	26 (21, 34)	<b>.0001*</b>
Sex, n (%)					.91 <sup>†</sup>
Male	511 (90.4%)	585 (90.4%)	662 (90.0%)	1758 (90.2%)	
Female	54 (9.6%)	62 (9.6%)	75 (10.1%)	191 (9.8%)	
Race, n (%)					.27 <sup>†</sup>
White	61 (10.8%)	78 (12.1%)	79 (10.7%)	218 (11.2%)	
African American	418 (74.0%)	495 (76.5%)	524 (71.1%)	1437 (73.7%)	
Asian	5 (0.9%)	1 (0.2%)	4 (0.5%)	10 (0.5%)	
Other	26 (4.6%)	19 (2.9%)	35 (4.7%)	80 (4.1%)	
Unknown	55 (9.7%)	54 (8.3%)	95 (12.9%)	204 (10.5%)	
ISS, median (Q1, Q3)	10 (6, 21)	10 (5, 22)	10 (6, 19)	10 (5, 21)	.72*
TRISS, median (Q1, Q3)	0.99 (0.93, 0.99)	0.99 (0.96, 0.99)	0.99 (0.96, 0.99)	0.99 (0.96, 0.99)	.50*
Comorbidities, n (%)					
Mental/Personality disorder	34 (6.0%)	39 (6.0%)	35 (4.7%)	108 (5.5%)	.49 <sup>†</sup>
Current tobacco use	132 (23.3%)	156 (24.1%)	169 (22.9%)	457 (23.4%)	.87 <sup>†</sup>
Chronic alcohol use	15 (2.6%)	12 (1.8%)	8 (1.1%)	35 (1.8%)	.11 <sup>†</sup>
Substance abuse disorder	55 (9.7%)	34 (5.2%)	71 (9.6%)	160 (8.2%)	<b>.003<sup>†</sup></b>
Admission vitals, median (Q1, Q3)					
GCS	15 (5, 15)	15 (12, 15)	15 (13, 15)	15 (11, 15)	.46*
Heart rate	89 (69, 110)	91 (71, 110)	91 (72, 109)	90 (70, 110)	.34*
Systolic blood pressure	124 (90, 148)	122 (92, 146)	122 (92, 141)	122 (92, 144)	.83*
Alcohol level 0.08+, n (%)	54 (9.5%)	78 (12.1%)	52 (7.1%)	184 (9.4%)	<b>.005<sup>†</sup></b>
Positive drug screen, n (%)	216 (38.2%)	268 (41.4%)	288 (39.1%)	772 (39.6%)	<b>.009<sup>†</sup></b>
Outcomes					
MTP activation, n (%)	96 (17.0%)	111 (17.2%)	125 (16.9%)	332 (17.0%)	.99 <sup>†</sup>
Hospital days, median (Q1, Q3)	3 (1, 8)	3 (1, 8)	3 (1, 7)	3 (1, 8)	.27*
ICU days, median (Q1, Q3)	0 (0, 2)	0 (0, 2)	0 (0, 1)	0 (0, 2)	.87*
Ventilator days, median (Q1, Q3)	0 (0, 1)	0 (0, 1)	0 (0, 1)	0 (0, 1)	<b>.048*</b>
Complications, n (%)	95 (16.8%)	107 (16.5%)	103 (13.9%)	305 (15.6%)	.28 <sup>†</sup>
Discharge Destination, n (%)					<b>.016<sup>†</sup></b>
Home	322 (57.0%)	370 (57.2%)	442 (59.9%)	1,134 (58.2%)	
Rehab/SNF/LTAC	70 (12.4%)	86 (13.3%)	53 (7.2%)	209 (10.7%)	
Transfer	14 (2.5%)	22 (3.4%)	28 (3.8%)	64 (3.3%)	
Mortality, n (%)	125 (22.1%)	128 (19.7%)	160 (21.7%)	413 (21.2%)	.55 <sup>†</sup>

ISS, injury severity score; TRISS, trauma injury severity score; GCS, Glasgow Coma Scale; MTP, massive transfusion protocol; ICU, intensive care unit; SNF, skilled nursing facility; LTAC, long-term acute care facility.

\* P values are based on a 1-way ANOVA test for continuous variables.

† P values are based on chi-square tests for categorical variables.

( $P = 2.50$ ), peaking in 2020 in June ( $n = 64$ , 2.2%) as compared with 2019 (peak in July, 42 [1.4%] SW) and 2018 (peak in May, 44 [1.6%] SW). Assault-related injuries were less common in urban counties of PA in 2020. The highest number of assault related admissions was 140 (4.9%) in June 2020, compared with 168 (5.8%) in July 2019 and 167 (6.0%) in May 2018 ( $P = .059$ ). There was no clear association between incidence of COVID-19 infection and interpersonal violence (Fig 2).

#### GSW characteristics and outcomes

A total of 1,949 admissions with GSW were identified across the time periods with 565 in the 2018 group, 647 in the 2019 group, and 737 in the COVID-era group. Demographics and injury characteristics were similar among the 3 time periods, as shown in Table I. Outcomes after GSW were similar across time periods, including length of stay and complications. The majority of the patients in all 3 time periods were discharged home ( $P = .016$ ), and no significant differences in mortality was observed ( $P = .55$ ).

#### SW characteristics and outcomes

There was a total of 667 admissions with SW, including 215 in 2018, 196 in 2019, and 256 patients in the COVID era. Patients injured during the COVID era had a significantly higher ISS (9 vs 5 in 2018 and 6 in 2019,  $P < .0001$ ), as shown in Table II. There were significantly higher numbers of patients with positive drug screens in the COVID era compared with the 2018 and 2019 groups (52.3%

vs 33.9% vs 45.9%, COVID era vs 2018 vs 2019, respectively  $P = .0001$ ). The majority of patients with SW were discharged home ( $P = .024$ ). No differences in mortality were observed across the 3 groups.

#### Assault characteristics and outcomes

A total of 2,419 admissions involved blunt assault-related injuries. There were 660 admissions in the COVID era, 903 in the 2018 group, and 856 in the 2019 group. Caucasian males comprised the majority of the assaulted population (35%), and characteristics were similar across time periods, as shown in Table III. There were no significant differences in injury severity as measured by ISS and TRISS across the 3 groups. Similarly, a significantly higher incidence of substance abuse disorders (21.8% vs 17.6% vs 11.3%, COVID era vs 2018 vs 2019, respectively,  $P < .0001$ ) and chronic alcohol abuse (11.8% vs 9.7% vs 7.4%, COVID era vs 2018 vs 2019, respectively,  $P = .012$ ) was prevalent among patients in the COVID era compared with the 2018 and 2019 groups. A significantly higher number of patients with positive drug screens were also found in the COVID era compared with the 2018 and 2019 groups (41.4% vs 33.1% vs 33.5%,  $P < .0001$ ). Outcomes were similar across all 3 time periods.

#### Racial disparities in incidence of GSWs

Given the disproportionate impact of penetrating trauma on African American populations,<sup>22–25</sup> we specifically examined rates of interpersonal violence in African Americans in our cohort to

**Table II**  
Demographics and outcomes of patients with stab-related injuries from March 16 to July 31

Demographics	2018 (n = 215)	2019 (n = 196)	2020 (n = 256)	Total (n = 667)	P value
Age, median (Q1, Q3)	32 (25,44)	32(25.5,42.5)	34 (26,45)	33 (26, 44)	.16 <sup>†</sup>
Sex, n (%)					.67 <sup>†</sup>
Male	179 (83.3%)	162 (82.6%)	219 (85.5%)	560 (84.0%)	
Female	36 (16.7%)	34(17.3%)	37 (14.4%)	107 (14.7%)	
Race, n (%)					.62 <sup>†</sup>
White	71 (33.0%)	64 (32.6%)	83 (32.4%)	218 (32.7%)	
African American	115 (53.5%)	109 (55.6%)	127 (49.6%)	351 (52.6%)	
Asian	1 (0.4%)	3 (1.5%)	1 (0.4%)	5 (0.7%)	
Other	12 (5.6%)	6 (3.1%)	8 (3.1%)	26 (3.9%)	
Unknown	16 (7.4%)	14 (7.1%)	367(14.4%)	67 (10.0%)	
ISS, median (Q1, Q3)	5 (1, 10)	6 (2.5, 10)	9 (4, 13.5)	5 (2, 10)	<.0001 <sup>*</sup>
TRISS, median (Q1, Q3)	0.99 (0.99, 0.99)	0.99 (0.98, 0.99)	0.99 (0.98, 0.99)	0.99 (0.98, 0.99)	.003 <sup>*</sup>
Comorbidities, n (%)					
Mental/Personality disorder	42 (19.5%)	28 (14.1%)	45 (17.6%)	115 (17.2%)	.36 <sup>†</sup>
Current tobacco use	64 (29.8%)	57 (29.1%)	105 (41.0%)	226 (33.9%)	.011 <sup>†</sup>
Chronic alcohol use	13 (6.0%)	8 (4.1%)	19 (7.4%)	40 (6.0%)	.33 <sup>†</sup>
Substance abuse disorder	35 (16.3%)	25 (12.8%)	53 (20.7%)	113 (16.9%)	.07 <sup>†</sup>
Admission vitals, median (Q1, Q3)					
GCS	15 (15, 15)	15 (14, 15)	15 (15, 15)	15 (15, 15)	.005 <sup>*</sup>
Heart rate	95 (80, 108)	98 (86, 114)	96 (83, 111)	97 (83,111.5)	.60 <sup>*</sup>
Systolic blood pressure	130 (115, 144)	130 (110,144)	125.5 (110, 140.5)	128 (110, 142)	.50 <sup>*</sup>
Alcohol level 0.08+, n (%)	54 (25.1%)	53 (27.0%)	61 (23.8%)	168 (25.2%)	.09 <sup>†</sup>
Positive drug screen, n (%)	73 (33.9%)	90 (45.9%)	134 (52.3%)	297 (44.5%)	.0001 <sup>†</sup>
Outcomes					
MTP activation, n (%)	13 (6.0%)	22 (11.2%)	23 (9.0%)	58 (8.7%)	.17 <sup>†</sup>
Hospital days, median (Q1, Q3)	3 (1, 5)	2 (1, 5)	3 (2, 5)	3 (1, 5)	.15 <sup>†</sup>
ICU days, median (Q1, Q3)	0 (0, 1)	0 (0, 1)	0 (0, 1)	0 (0, 1)	.55 <sup>*</sup>
Ventilator days, median (Q1, Q3)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	.16 <sup>†</sup>
Complications, n (%)	7 (3.2%)	24 (12.2%)	20 (7.8%)	51 (7.6%)	.003 <sup>†</sup>
Discharge destination, n (%)					.024 <sup>†</sup>
Home	175 (81.4%)	150 (76.5%)	207 (80.9%)	532 (79.8%)	
Rehab/SNF/LTAC	1 (0.5%)	7 (3.6%)	56 (2.3%)	14 (2.1%)	
Transfer	10 (4.6%)	10 (5.1%)	3 (1.2%)	23 (3.4%)	
Mortality, n (%)	10 (4.6%)	12 (6.1%)	5 (2.0%)	27 (4.0%)	.07 <sup>†</sup>

ISS, injury severity score; TRISS, trauma injury severity score; GCS, Glasgow Coma Scale; MTP, massive transfusion protocol; ICU, intensive care unit; SNF, skilled nursing facility; LTAC, long-term acute care facility.

\* P values are based on a 1-way ANOVA test for continuous variables.

† P values are based on chi-square tests for categorical variables.

assess how this pattern corresponded in the setting of COVID-19. African Americans comprise approximately 12% of the population of the state of PA, and 90% of that population lives in urban counties.<sup>20</sup> GSW injury rates per 100,000 population in the state of PA were significantly higher in the African American population compared with Caucasian and Asian populations (Fig 3).

#### Mortality after interpersonal violence

Overall, 9.65% of patients injured owing to interpersonal violence died. Multivariable analysis showed equivalent risk of death in the 3 time periods studied. Risk of mortality was most closely associated with presenting physiology, degree of injury, and transfer status.

#### Discussion

In this statewide study of interpersonal violence in PA, we identified an increase in GSW injuries and a decrease in blunt assaults. We compared equivalent time periods in 3 years to account for the seasonal variations in the epidemiology of trauma. The incidence of SW was stable, but the severity was higher in 2020. Overall, patient and injury characteristics, interventions, and outcomes were similar across the years studied. An equivalent risk of mortality was demonstrated during all time periods examined, which is consistent with previous reports.<sup>8–12</sup> In each time period, African Americans and men were at highest risk of GSW injuries.

GSW injury rates per 100,000 population was significantly higher in the African American population when compared with the Asian and Caucasian populations, further signifying racial disparities of GSW injuries in the African American population in the state of PA. Geospatial analysis did not identify any relationship between county-level incidence of COVID-19 and violent injury, suggesting that the cause of rising violence may be less the pandemic itself than the associated policies and stresses. Our data also suggest that circumstances surrounding injuries were different during the pandemic than in prior years. We note, for example, a higher severity of SWs, increased substance use among assault patients, and less alcohol use among SW and blunt assault patients during the pandemic, despite evidence suggesting increases in alcohol consumption in the population at large.<sup>26</sup> The mechanisms of these differences are unknown but are likely related to decreases in large social gatherings including social drinking.

Our results corroborate reports from around the country that have identified a rising incidence of interpersonal violence during the pandemic.<sup>10,27–29</sup> Single-center studies by Sherman et al<sup>30</sup> and Rhodes et al<sup>16</sup> demonstrated a higher volume of penetrating trauma during a SAH order and a shift in injury patterns. Cannon et al<sup>8</sup> and Abdallah et al<sup>12</sup> demonstrated a sharp rise in penetrating injuries in a level 1 academic trauma center in Philadelphia, PA. A recent study from southern California also demonstrated increased rates of penetrating injuries.<sup>13</sup> The COVID-19 pandemic has led to numerous societal disruptions that may play a role in these findings. Many individuals were affected with financial strain,

**Table III**  
Demographics and outcomes of patients with blunt assault-related injuries from March 16 to July 31

Demographics	2018 (n = 903)	2019 (n = 856)	2020 (n = 660)	Total (n = 2419)	P value
Age, median (Q1, Q3)	36 (25,51)	38 (26,52)	38 (29,53)	37 (26,52)	<b>.022*</b>
Sex, n (%)					.62†
Male	669 (74.1%)	619 (72.3%)	490 (74.2%)	1778 (73.5%)	
Female	234 (25.9%)	237 (27.7%)	170 (25.8%)	641 (26.5%)	
Race, n (%)					.054†
White	471 (52.2%)	424 (49.5%)	290 (43.9%)	1185 (49.0%)	
African American	319 (35.3%)	319 (37.3%)	261 (39.5%)	899 (37.2%)	
Asian	9 (1.0%)	14 (1.6%)	5 (0.8%)	28 (1.2%)	
Other	50 (5.5%)	32 (3.7%)	34 (5.1%)	116 (4.8%)	
Unknown	54 (6.0%)	67 (7.8%)	70 (10.6%)	191 (7.9%)	
ISS, Median (Q1, Q3)	6 (4, 10)	6 (4, 11)	5 (4, 10)	6 (4, 10)	.33*
TRISS, Median (Q1, Q3)	0.99 (0.98, 1.00)	0.99 (0.98, 1.00)	0.99 (0.98, 1.00)	0.99 (0.98, 1.00)	.78*
Comorbidities, n (%)					
Mental/Personality disorder	246 (27.2%)	188 (22.0%)	157 (23.8%)	591 (24.4%)	<b>.032†</b>
Current tobacco use	376 (41.6%)	376 (43.9%)	305 (46.2%)	1057 (43.7%)	.19†
Chronic alcohol use	88 (9.7%)	63 (7.4%)	78 (11.8%)	229 (9.5%)	<b>.012†</b>
Substance abuse disorder	159 (17.6%)	97 (11.3%)	144 (21.8%)	400 (16.5%)	<b>&lt;.0001†</b>
Admission vitals, median (Q1, Q3)					
GCS	15 (15, 15)	15 (15, 15)	15 (15, 15)	15 (15, 15)	.63*
Heart rate	88 (77, 104)	89 (76, 104)	89 (77, 104)	89 (76, 104)	.47*
Systolic blood pressure	134 (121, 150)	133 (119,148)	132 (120,146)	133 (120,148)	.11*
Alcohol level 0.08+, n (%)	199 (22.0%)	167 (19.5%)	109 (16.5%)	475 (19.6%)	<b>.0003†</b>
Positive drug screen, n (%)	299 (33.1%)	287 (33.5%)	273 (41.4%)	859 (35.5%)	<b>&lt;.0001†</b>
Outcomes					
MTP activation, n (%)	4 (0.4%)	5 (0.6%)	6 (0.9%)	15 (0.6%)	.50†
Hospital days, median (Q1, Q3)	2 (1, 4)	2 (1, 4)	2 (1, 4)	2 (1, 4)	.18*
ICU days, median (Q1, Q3)	0 (0, 1)	0 (0, 1)	0 (0, 1)	0 (0, 1)	.12*
Ventilator days, median (Q1, Q3)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	.26*
Complications, n (%)	53 (5.9%)	41 (4.8%)	36 (5.4%)	130 (5.4%)	.60†
Discharge Destination, n (%)					<b>.026†</b>
Home	620 (68.7%)	576 (67.3%)	451 (68.3%)	1647 (68.1%)	
Rehab/SNF/LTAC	78 (8.6%)	79 (9.2%)	59 (8.9%)	216 (8.9%)	
Transfer	42 (4.6%)	64 (7.5%)	32 (4.8%)	138 (5.7%)	
Mortality, n (%)	19 (2.1%)	17 (2.0%)	10 (1.5%)	46 (1.9%)	.68†

ISS, injury severity score; *TRISS*, trauma injury severity score; GCS, Glasgow Coma Scale; *MTP*, massive transfusion protocol; *ICU*, intensive care unit; *SNF*, skilled nursing facility; *LTAC*, long-term acute care facility.

\* P values are based on a 1-way ANOVA test for continuous variables.

† P values are based on chi-square tests for categorical variables.

particularly those already living on the margins.<sup>31</sup> School closures left children and students without access to a structured, supervised social and academic environment.<sup>32–34</sup> Surges in COVID-19 prompted public health measures and healthcare systems to allocate resources to the care of patients affected by SARS-CoV-2 and away from other medical conditions,<sup>35</sup> including mental health services.<sup>34,36,37</sup> Additional contributors may include sociopolitical turmoil related to racial injustices<sup>37,38</sup> and increased firearm sales.<sup>39,40</sup> Indeed, our findings mirror those associated with natural disasters, when social disruption can lead to increased interpersonal violence, domestic violence, and child abuse.<sup>41–45</sup> This was demonstrated by rising interpersonal violence during Hurricane Katrina in New Orleans, Louisiana in 2005.<sup>46,47</sup>

To our knowledge, this is the largest and first statewide study examining the incidence of interpersonal violence incidences during COVID-19. These results speak to the far-reaching implications of the pandemic and our responses to it, though we cannot establish the causes of the rising incidence of interpersonal violence that we demonstrate here. In addition to establishing resources required to care for patients suffering from SAR-CoV-2, this finding must prompt epidemiologists, public health officials, and government systems to not only focus on disease containment and prevention during COVID-19 and future pandemics, but also to maintain sight on mental health services, drug rehabilitation programs, and injury prevention. These findings must inform our responses not only to this pandemic, but to future disasters, natural and manmade.

### Study limitations

There were a number of limitations to this study, including the potential for miscoding or misregistering of data. Clinical granularity was limited regarding treatment, progress, and services provided to patients. The PTOS registry only includes patients meeting prespecified criteria who are treated at trauma centers. We cannot account for minor injuries that resulted in ED discharge or for patients treated at other hospitals. We suspect that circumstances leading to injury were different during the pandemic compared with prior years, but we have no data on these circumstances, or on the assailants involved in these violent injuries. We identified positive drug and alcohol screens, but not all patients were screened. Further, we used the time period of March 16 to July 31 owing to the availability of completed records from PTOS and cannot account for the impact of the second wave of the pandemic or further policy changes. The associated rise in the incidence of interpersonal violence incidences in the setting of COVID-19 should further be examined with data from post-COVID-19 years, to examine a true causal relationship. We assessed clinical outcomes of the population during the study periods yearly rather than monthly, to enhance our assessment of outcomes in detail.

In conclusion, the COVID-19 pandemic may have had unexpected and far-reaching effects on the incidence of interpersonal violence in the Commonwealth of PA. Geospatial variances and associations with social factors such as increased substance abuse suggest the opportunity for focused interventions. Ongoing

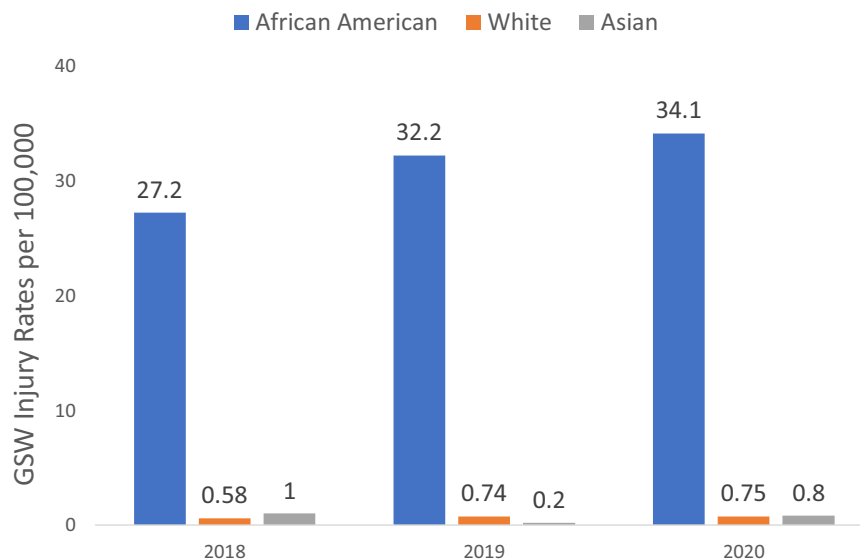


Figure 3. GSW injury rates amongst races per 100,000 population in the State of Pennsylvania.

epidemiologic monitoring and psychosocial research and intervention is warranted.

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#### Conflict of interest/Disclosure

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#### References

- Hui DS, Azhar EI, Madani TA, et al. The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health: the latest 2019 novel coronavirus outbreak in Wuhan, China. *Int J Infect Dis*. 2020;91:264.
- Department of Health. COVID-19 data for Pennsylvania. <https://www.health.pa.gov/topics/disease/coronavirus/Pages/Coronavirus.aspx>. Accessed January 10, 2021.
- Stawicki SP, Jeanmonod R, Miller AC, et al. The 2019–2020 novel coronavirus (severe acute respiratory syndrome coronavirus 2) pandemic: a joint American College of Academic International Medicine-World Academic Council of Emergency Medicine multidisciplinary COVID-19 working group consensus paper. *J Global Infect Dis*. 2020;12:47.
- Gov Wolf Puts Statewide COVID-19 Mitigation Efforts in Effect, Stresses Need for Every Pennsylvanian to Take Action to Stop the Spread. An Official Pennsylvania Government Website. <https://www.governor.pa.gov/newsroom/gov-wolf-puts-statewide-covid-19-mitigation-efforts-in-effect-stresses-need-for-every-pennsylvanian-to-take-action-to-stop-the-spread>. Accessed July 23, 2020.
- NBC News. Meet the Press Blog: Gun violence grows during coronavirus pandemic group's data shows. <https://www.nbcnews.com/politics/meet-the-press/blog/%20meet-press-blog-latest-news-analysis-data-driving-political-discussion-n988541/ncrd1223551#blogHeader>. Accessed November 10, 2020.
- NPR. The coronavirus crisis: crime has declined overall during the pandemic, but shootings and killings are up. <https://www.npr.org/2020/07/20/892418244/crime-has-declined-overall-during-the-pandemic-but-shootings-and-killings-are-up>. Updated July 20, 2020. Accessed November 10, 2020.
- Hatchimonji JS, Swendiman RA, Seamon MJ, Nance ML. Trauma does not quarantine: violence during the COVID-19 pandemic. *Ann Surg*. 2020;10:1097.
- Cannon JW, Martin ND, Qasim Z. Violence unchecked by social distancing [published online ahead of print, 2020 Jul 28]. *J Emerg Med*. 2020. S0736-4679(20)30607-7.
- Beard JH, Jacoby SF, Maher Z, et al. Changes in shooting incidence in Philadelphia, Pennsylvania, between March and November 2020. *JAMA*. Published online February 10, 2021. <https://doi.org/10.1001/jama.2021.1534>
- Christey G, Amey J, Campbell A, Smith A. Variation in volumes and characteristics of trauma patients admitted to a level one trauma centre during national level 4 lockdown for COVID-19 in New Zealand. *N Z Med J*. 2020;133:81–88.
- Sutherland M, McKenney M, Elkbuli A. Gun violence during COVID-19 pandemic: paradoxical trends in New York City, Chicago, Los Angeles and Baltimore [published online ahead of print, 2020 May 7]. *Am J Emerg Med*; 2020. S0735-6757(20)30344-2. <https://doi.org/10.1016/j.ajem.2020.05.006>
- Abdallah H, Zhao C, Kaufman E, Seamon M, Schwab W, Pascual J. Increased firearm injury during the COVID-19 pandemic: a hidden urban burden. *J Am Coll Surgeons*. 2020 Nov 6.
- Yeates E, Grigorian A, Barrios C, et al. Changes in traumatic mechanisms of injury in southern California related to COVID-19: penetrating trauma as a second pandemic. *J Trauma Acute Care Surg*. 2021;90:714–721.
- Mohler G, Bertozzi AL, Carter J. Impact of social distancing during COVID-19 pandemic on crime in Los Angeles and Indianapolis. *J Crim Justice*. 2020;68:101692.
- Olding J, Zisman S, Olding C, Fan K. Penetrating trauma during a global pandemic: changing patterns in interpersonal violence, self-harm and domestic violence in the Covid-19 outbreak. *Surgeon*. Epub 2020 Jul 30.
- Rhodes HX, Petersen K, Lunsford L, Biswas S. COVID-19 Resilience for survival: occurrence of domestic violence during lockdown at a rural American College of Surgeons Verified Level One Trauma Center. *Cureus*. 2020;12, e10059.
- Schleimer JP, McCort CD, Pear VA, et al. Firearm purchasing and firearm violence in the first months of the coronavirus pandemic in the United States: a cross-sectional study. *Inj Epidemiol*. 2021;8:43.
- United States Census Bureau. Quick facts Pennsylvania. <https://www.census.gov/quickfacts/PA>. Accessed April , 2021.
- COVID-19 Aggregate Cases Current Daily County Health. <https://data.pa.gov/Health/COVID-19-Aggregate-Cases-Current-Daily-County-Health/j72v-r42c>, Pennsylvania Department of Health. Copyright 2021, Commonwealth of Pennsylvania. Accessed January 11, 2021.
- Wiebe DJ, Holena DN, Delgado MK, McWilliams N, Altenburg J, Carr BG. The Pennsylvania Trauma Outcomes Study risk-adjusted mortality model: results of a statewide benchmarking program. *Am Surg*. 2017;83:445–452.
- Rural/Urban PA. The Center for Rural Pennsylvania. <https://www.rural.palegislature.us/>. Accessed February 8, 2021.
- Beard JH, Morrison CN, Jacoby SF. Quantifying disparities in urban firearm violence by race and place in Philadelphia, Pennsylvania: a cartographic study. *Am J Public Health*. 2017;107:371–373.
- Wintemute GJ. The epidemiology of firearm violence in the twenty-first century United States. *Ann Rev Public Health*. 2015;36:5–19.
- Walker GN, McLone S, Mason M, Sheehan K. Rates of firearm homicide in Chicago by region, age, sex, and race/ethnicity, 2005–2010. *J Trauma Acute Care Surg*. 2016;81:S48–S53.
- Kalesan B, Vyliparambil MA, Bogue E, et al. Race and ethnicity, neighborhood poverty and pediatric firearm hospitalizations in the United States. *Ann Epidemiol*. 2016;26:1–6.e62.
- Pollard MS, Tucker JS, Green HD. Changes in adult alcohol use and consequences during the COVID-19 pandemic in the US. *JAMA Netw Open*. 2020;3, e2022942.



27. Jeltsen M. As nation stays home, early indicators suggest rise in domestic violence killings. *HuffPost*. [https://www.huffpost.com/entry/increase-domestic-violence-killings-coronavirus-stay-at-home\\_n\\_5e907808c5b63e73d7e38fe7](https://www.huffpost.com/entry/increase-domestic-violence-killings-coronavirus-stay-at-home_n_5e907808c5b63e73d7e38fe7). Accessed April 12, 2020.
28. Biggs J. Greensboro faced record-shattering number of killings in 2020. *News & Record*. Accessed February 8, 2021.
29. Spence MS. Cities need investment: not a theatrical federal policing “surge.” *Newsweek*. 2020 Aug 4.
30. Sherman W, Khadra H, Kale N, Wu V, Gladder P, Lee O. How did the number and type of injuries in patients presenting to a regional level I trauma center change during the COVID-19 pandemic with a stay-at-home order? *Clin Orthop Relat Res*. 2020 Sep 21.
31. Reyes JF. Couldn't get Pa. unemployment benefits? You might be eligible for this new coronavirus program. 2020 Apr 16. <https://www.inquirer.com/jobs/pennsylvania-unemployment-benefit-gig-workers-contractors-pandemic-assistance-20200416.html>. Accessed February 8, 2021.
32. Lee J. Mental health effects of school closures during COVID-19 [published correction appears in *Lancet Child Adolesc Health*. 2020 Apr 17]. *Lancet Child Adolesc Health*. 2020;4:421.
33. Masonbrink AR, Hurley E. Advocating for children during the COVID-19 school closures. *Pediatrics*. 2020, 146e20201440.
34. Singh S, Roy D, Sinha K, Parveen S, Sharma G, Joshi G. Impact of COVID-19 and lockdown on mental health of children and adolescents: a narrative review with recommendations. *Psychiatry Res*. 2020;293:113429.
35. Phua J, Weng L, Ling L, et al. Intensive care management of coronavirus disease 2019 (COVID-19): challenges and recommendations [published correction appears in *Lancet Respir Med*. 2020;8:e42] *Lancet Respir Med*. 2020;8:506–517.
36. Xiong J, Lipsitz O, Nasri F, et al. Impact of COVID-19 pandemic on mental health in the general population: a systematic review. *J Affect Disord*. 2020;277:55–64.
37. Torales J, O'Higgins M, Castaldelli-Maia JM, Ventriglio A. The outbreak of COVID-19 coronavirus and its impact on global mental health. *Int J Soc Psychiatry*. 2020;66:317–320.
38. Hatmaker J. Flames in Philadelphia as hundreds protest death of George Floyd and police brutality. *PennLive*. May 30, 2020.
39. Klemko R, Shepherd K, Ewing M, Berman M, Witte G. Philadelphia imposes curfew, calls in National Guard as protests continue over Walter Wallace shooting. *Washington Post*. Oct 28, 2020.
40. Pennsylvania's firearm background check system experiences record volume in third quarter Pennsylvania's firearm background check system experiences record volume in third quarter. Pennsylvania Pressroom. 2020 Oct 6. <https://www.media.pa.gov/pages/pa-state-police-details.aspx?newsid=663>. Accessed October 7, 2020.
41. Czeisler ME, Lane RI, Petrosky E, et al. Mental health, substance use, and suicidal ideation during the COVID-19 pandemic: United States, June 24–30, 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69:1049–1057.
42. Sacco MA, Caputo F, Ricci P, et al. The impact of the COVID-19 pandemic on domestic violence: the dark side of home isolation during quarantine. *Med Leg J*. 2020;88:71–73.
43. Aguero JM. COVID-19 and the rise of intimate partner violence. *World Dev*. Epub 2020 Sep 29.
44. Rezaeian M. The association between natural disasters and violence: a systematic review of the literature and a call for more epidemiological studies. *J Res Med Sci*. 2013;18:1103–1107.
45. Kovler M, Ziegfeld S, Ryan L, et al. Increased proportion of physical child abuse injuries at a level 1 pediatric trauma center during the COVID-19 pandemic. *Child Abuse Negl*. 2020:104756.
46. Schumacher JA, Coffey SF, Norris FH, Tracy M, Clements K, Galea S. Intimate partner violence and Hurricane Katrina: predictors and associated mental health outcomes. *Violence Vict*. 2010;25:588–603.
47. Harville EW, Taylor CA, Tesfai H, Xiong Xu, Buekens P. Experience of Hurricane Katrina and reported intimate partner violence. *J Interpers Violence*. 2011;26:833–845.