Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.JournalofSurgicalResearch.com

Social Vulnerability and COVID-19: Changes in Trauma Activations at a Safety-Net Hospital

Miriam Y. Neufeld, MD, MPH,[a,b,c,1,*] *Hyerim Jang, BA,*[a,1] *Elisa Caron, BA,*[a] *Reece Golz, MA,*[c] *Tejal S. Brahmbhatt, MD,*[a,b,c] *and Sabrina E. Sanchez, MD, MPH*[a,b,c]

[a] *Boston University School of Medicine, Boston, Massachusetts*
[b] *Department of Surgery, Boston University School of Medicine, Boston, Massachusetts*
[c] *Department of Surgery, Boston Medical Center, Boston, Massachusetts*

ARTICLE INFO

Article history:
Received 12 May 2021
Received in revised form
5 January 2022
Accepted 28 January 2022
Available online 22 February 2022

Keywords:
COVID-19
Social vulnerability
Trauma
Violent injury

ABSTRACT

Introduction: Following the declaration of the COVID-19 pandemic, there were reports of decreased trauma hospitalizations, although violent crime persisted. COVID-19 has had the greatest impact on minoritized and vulnerable communities. Decreases in traumatic events may not extend to these communities, given pandemic-related socioeconomic and psychological burdens that increase the risk of exposure to trauma and violence.

Materials and methods: This was a retrospective cohort study ($n = 1634$) of all trauma activations presenting to our institution January 1, 2020 to May 31, 2020, and same time periods in 2018 and 2019. Census tracts and associated Social Vulnerability Index quartiles were determined from patient addresses. Changes in trauma activations pre and post Massachusetts' state-of-emergency declaration compared to a historical control were analyzed using a difference-in-differences methodology.

Results: Weekly all-cause trauma activations fell from 26.44 to 8.25 (rate ratio = 0.36 [0.26, 0.50]) postdeclaration, with significant difference-in-differences compared to a historical control ($P < 0.0001$). Nonviolent trauma activations significantly decreased from 21.11 to 5.17 after the declaration (rate ratio = 0.27 [0.37, 0.91]; $P < 0.0001$), whereas there was no significant decrease in violent injury (5.33 to 3.08 rate ratio = 0.69 [0.39, 1.22]; $P = 0.20$). Stratified by vulnerability, the most vulnerable quartile had an increased proportion of all-cause trauma postdeclaration and had no decrease in violent trauma activations following the declaration compared to the historical control (rate ratio = 0.84 [0.38-1.86]; $P = 0.67$).

Conclusions: The state-of-emergency declaration was associated with significant decreases in overall trauma, to a greater extent in nonviolent injuries. Among those living in the most socially vulnerable communities, there was no decrease in violent trauma. These findings highlight the need for violence and injury prevention programs in vulnerable communities, particularly in times of crisis.

* *Corresponding author*. Clinical Instructor, Boston Medical Center/Boston University School of Medicine, C500 Collamore, 88 East Newton Street, Boston, MA 02118. Tel.: +1 317 410 5721; fax: +1 617 638 8607.
E-mail address: Miriam.Neufeld@bmc.org (M.Y. Neufeld).
[1] Authors 1 and 2 contributed equally to this manuscript.
0022-4804/$ – see front matter © 2022 Elsevier Inc. All rights reserved.
https://doi.org/10.1016/j.jss.2022.01.033

Introduction

In March 2020, many state and local governments in the United States announced a state-of-emergency and issued stay-at-home orders in response to the COVID-19 pandemic, confining people to their homes to reduce the spread of the disease. In addition, many hospitals ceased elective operations and saw decreases in the volume of surgical consultations and trauma cases.[1-4] Although the scale of the current pandemic is unprecedented, studies from prior pandemics, including Severe Acute Respiratory Syndrome (SARS) and Middle East Respiratory Syndrome (MERS) outbreaks in Hong Kong, Taiwan, and South Korea, all demonstrate this trend.[5-8]

Simultaneously, many cities across the United States reported persistently high firearm violence and spikes in domestic violence cases within the first few weeks after the pandemic declaration.[4,9-12] In Boston, the police department reported that overall crime in the city had decreased by 5%, but shootings had increased by 29% in 2020 compared to 2019.[13] This rise in violence has been attributed to the loss of youth programs, increased economic stress, and overall psychological trauma resulting from the current pandemic.[13,14] Several studies have observed the effects of emergencies, such as natural disasters, on violence, specifically domestic violence.[15,16] These studies propose that disasters increase the risk of violence due to heightened stress, displacement, and remaining confined for extended periods of time.

In the United States, COVID-19 has only added to social disparities by increasing financial strains on families, exacerbating housing and food insecurity, and illuminating divisions in class that affect neighborhood resources and safety. Its harshest impacts are being felt by vulnerable populations, including communities living in socially disadvantaged areas. Our urban safety-net hospital and level-1 trauma center largely serves these communities. While overall surgical and trauma volume have decreased during the current pandemic, it is not clear whether traumatic injuries, including those caused by community and interpersonal violence, among our patients from socially disadvantaged areas have similarly decreased. The objective of the present study was to (1) investigate overall trends in our trauma activations from January 2020 through May 2020, (2) compare volume, mechanism, and intent before and after the Massachusetts' state-of-emergency order compared to the same periods in previous years, and (3) determine if trends of trauma activations for those patients living in socially disadvantaged areas differed from those living in more resourced communities. We hypothesized that although overall trauma activations would decrease, there would not be a decrease in violent trauma for those patients residing in more socially disadvantaged areas.

Materials and Methods

Study approval and data sources

The study was deemed exempt with a waiver of consent by the Boston University Medical Campus Institutional Review Board. Our institution's trauma registry was used to identify trauma activations from January 1 to May 31 of 2018, 2019, and 2020. Patient demographics and injury characteristics for each activation were collected from the hospital's electronic health records in compliance with the Health Insurance Portability and Accountability Act guidelines. Census tract data were obtained from the 2010 United States Decennial Census and corresponding levels of social vulnerability of patients' census tracts, based on home address, were obtained from the Centers for Disease Control's Social Vulnerability Index (SVI).[17]

Cohort description

This retrospective study identified 1634 trauma activations, representing patients of all ages and mechanisms of injury presenting to our institution. Those activations involving patients from states other than Massachusetts were excluded from the analysis with the exception of those contiguous with the state (New York, New Hampshire, Vermont, Connecticut, and Rhode Island). Activations from January 1 to May 31 of 2018 and 2019 were grouped together to represent a historical control and then compared to patients from the same time period in 2020 in a difference-in-differences (DID) analysis.

Exposures

The primary exposure of interest was the time period following Massachusetts' state-of-emergency declaration on March 10, 2020. To compare trauma activations before and after the declaration, we designated January 1 to March 9 of 2020 as the "predeclaration" period and March 10 to May 31 as the "postdeclaration" period. The same time periods were used from 2018 to 2019 as a historical control. Other exposures of interest included trauma due to interpersonal violence and level of social vulnerability of our patients' communities as classified by census tracts corresponding to their residential address and the Center for Disease Control's SVI.[17] The SVI uses census tracts to map and analyze neighborhood vulnerability to natural and man-made disasters based on 15 social vulnerability factors, grouped into the following themes: socioeconomic, housing composition and disability, representation of racial and ethnic minority groups, and housing and transportation.[18] We grouped SVI scores into quartiles, as is done in CDC mapping, to analyze the resilience of communities to the effects of the COVID-19 pandemic on traumatic injuries.[17] The first SVI quartile was ascribed to the quartile of communities that is the most resilient and most appropriate in responding to natural disasters or harmful human-made events. The fourth SVI quartile was ascribed to the quartile that is the least resilient and most vulnerable to the deleterious effects of the mentioned external stressors.

Primary outcomes

There were three main outcomes of interest. The first was the difference in mean weekly trauma activations before and after the declaration of state emergency in 2020 as compared to the same time period in the historical control (created by taking the average of weekly trauma counts from 2018 to 2019). Second was the change in mean weekly trauma activations based on the

cause of injury (violent *versus* nonviolent) before and after the state-of-emergency in 2020 as compared to the historical control. Violent traumas included gunshot wounds, stab wounds, and blunt assaults. Nonviolent traumas were the remainder and included mechanisms such as falls, motor vehicle crashes, bicycle crashes, pedestrian strikes, etc. Third was the change in mean weekly trauma activations, both violent and nonviolent, among communities of varying levels of social vulnerability (stratified by quartiles) before and after the declaration.

Covariates

Demographic variables included gender, age, and race/ethnicity. Injury characteristic variables included mechanism of injury, injury severity score (ISS), and cause of injury (violent *versus* nonviolent).

Statistical analysis

All statistical analyses were conducted using SAS Studio 3.8 software (SAS Institute, Inc, Cary, NC). Significance was set at $\alpha = 0.05$ and hypothesis tests were two-sided. Categorical variables are reported as numbers and percentages, whereas continuous variables are reported as medians and interquartile ranges (IQR), given the non-normal distribution. To compare activations before and after the Massachusetts' state-of-emergency declaration, we used the χ^2 test for categorical variables and Wilcoxon rank sum test for non-normally distributed continuous variables. DID is a quasi-experimental analysis often used to measure the effects of an event or health policy intervention by comparing a group exposed to policy changes to an unexposed group over time.[19] In our study, the event was the March 10th Massachusetts declaration of state-of-emergency and the exposed and unexposed groups were trauma patients before and after this time point, respectively. Critical to this methodology is pre-event parallel trends, which assumes that, prior to the event, the two groups were the same (i.e., the average difference between the weekly trauma activations in the historical control and 2020 was constant prior to exposure).[19] The use of a historical control in the DID analysis helps to control for secular trends and takes into account the well-known seasonal variations in trauma activations.[20] The DID analysis of Poisson regressions was performed to compare weekly trauma activations prior to and after the state-of-emergency declaration in 2020 as compared to the historical control. For all analyses, the parallel trends assumption was met with no significant difference in trauma activations prior to the March 10th declaration. Changes in mean weekly activations were compared using crude rate ratios (RRs) with corresponding 95% confidence intervals and those adjusted for percent Black race and average ISS, given the statistically significant differences between 2020 and the historical control. This analysis was repeated with the cohort stratified into nonviolent and interpersonal violence-related trauma and stratified into SVI quartiles 1-3 and SVI quartile 4. Finally, a subgroup analysis of those patients residing in census tracts in the fourth SVI quartile with violent injuries was assessed to determine changes in trauma activations before and after the state-of-emergency declaration.

Results

Cohort characteristics

We included 1634 activations in the DID analysis. Demographics such as age and gender were not significantly different between the historical and 2020 groups (Table 1). However, there was a significant difference in patient race/ethnicity between the two groups. While the percentage of trauma activations involving White patients decreased from 40.93% in the historical group to 32.27% in 2020, there was a corresponding increase in the percentage of those involving Black patients, from 30.08% in the historical group to 42.73% in 2020 ($P < 0.0001$). The change in the percentages of non-Hispanic, other, and Hispanic patients was not as drastic, decreasing from 12.79% to 9.30% and from 16.20% to 15.70%, respectively. The proportions of each mechanism of injury between the two groups did not differ significantly ($P = 0.31$). Although the median ISS was 5 (IQR 8) in each, the distributions of ISS did differ significantly between the two groups ($P < 0.0001$). Trauma activations among SVI quartiles also

Table 1 – Demographic and trauma characteristics of patients in historical control and 2020.

Variable	Historical ($n = 1290$)	2020 ($n = 344$)	P value
Age (median, IQR)	44.00 (37.00)	44.50 (35.00)	0.78
Female (*n*,%)	440 (34.11)	120 (34.88)	0.79
Race/Ethnicity (*n*,%)			<0.0001
NH-White	528 (40.93)	111 (32.27)	
NH-Black	388 (30.08)	147 (42.73)	
NH-other	165 (12.79)	32 (9.30)	
Hispanic	209 (16.20)	54 (15.70)	
Mechanism of injury (*n*,%)			0.31
MVC	222 (17.21)	57 (16.57)	
Fall	555 (43.02)	144 (41.86)	
Pedestrian struck	107 (8.29)	26 (7.56)	
GSW	87 (6.74)	32 (9.30)	
SW	88 (6.82)	33 (9.59)	
Blunt assault	126 (9.77)	26 (7.56)	
Other	105 (8.14)	26 (7.56)	
Injury severity score* (median, IQR)	5.00 (8.00)	5.00 (8.00)	0.0001
Violent intent (*n*,%)	303 (23.01)	92 (26.51)	0.19
SVI (*n*,%)†			0.0009
1st	254 (19.91)	48 (14.16)	
2nd	214 (16.77)	37 (10.91)	
3rd	245 (19.20)	72 (21.24)	
4th	563 (44.12)	182 (53.69)	

NH = non-Hispanic; MVC = motor vehicle crash; GSW = gunshot wound; SW = stab wound; SVI = social vulnerability index.
* ISS is not normally distributed, thus median (IQR) is presented. Although these values are the same, the distributions are significantly different as reflected by the *P* value.
† There are missing SVI data, as such, $n = 1615$ for this variable.

showed a significant difference ($P = 0.0009$) between the historical and 2020 groups. The third and fourth SVI quartiles, representing more vulnerable populations, experienced higher proportions of trauma in 2020 compared to the historical control (21.24% *versus* 19.20% and 53.69% *versus* 44.12%, respectively). The first and second SVI quartiles, the more resilient communities, experienced a decrease in proportion of trauma activations (14.16% *versus* 19.91% and 10.91% *versus* 16.77%, respectively).

All trauma activations prestate-of-emergency and poststate-of-emergency declaration

When examining all-cause trauma activations, there was a significant negative DID between the predeclaration and postdeclaration periods when comparing 2020 and the corresponding dates in the historical control (β −1.26 [SE = 0.14]; $P < 0.0001$) (Fig. 1). The mean weekly trauma activations in the postdeclaration period were 8.25 *versus* 26.44 prior to the declaration (RR = 0.36 [0.26, 0.50]; $P < 0.0001$) compared to no change (28.44 *versus* 31.29) for the historical control (RR = 1.10 [0.97, 1.25]; $P = 0.13$) (Table 2).

Trauma activations due to violence prestate-of-emergency and poststate-of-emergency declaration

When examining only injuries due to violence, there was a significant negative DID (β −0.74 [SE = 0.25]; $P = 0.003$) between the predeclaration and postdeclaration period in 2020 compared to the same period in the historical control (Fig. 2).

When comparing violent trauma activations predeclaration and postdeclaration in 2020, the mean count decreased, although not significantly from 5.33 to 3.08 (RR = 0.69 [0.39, 1.22]; $P = 0.20$). In the historical control, weekly violent trauma activations increased from 6.17 to 7.54, although this was also not significant (RR = 1.21 [0.94, 1.54]; $P = 0.13$) (Table 2).

Nonviolent trauma activations prestate-of-emergency and poststate-of-emergency declaration

There was a significant negative DID (β −1.41 [SE = 0.16]; $P < 0.0001$) between the predeclaration and postdeclaration period in 2020 compared to the same period in the historical control for nonviolent trauma activations (Fig. 2). In 2020, these decreased significantly before and after the state-of-emergency declaration from 21.11 to 5.17 (RR = 0.27 [0.91, 0.37]; $P < 0.0001$). Nonviolent trauma activations did not significantly differ in the historical control (22.28 *versus* 23.63, RR = 1.07 [0.93, 1.23], $P = 0.33$) (Table 2).

Trauma activations among first-third social vulnerability index quartiles prestate-of-emergency and poststate-of-emergency declaration

Among those activations representing patients in the first-third SVI quartiles (more resilient), there was a significant negative DID (β −1.62 [SE = 0.21]; $P < 0.0001$) between the predeclaration and postdeclaration periods in 2020 compared to those in the historical control (Fig. 3). Trauma activations

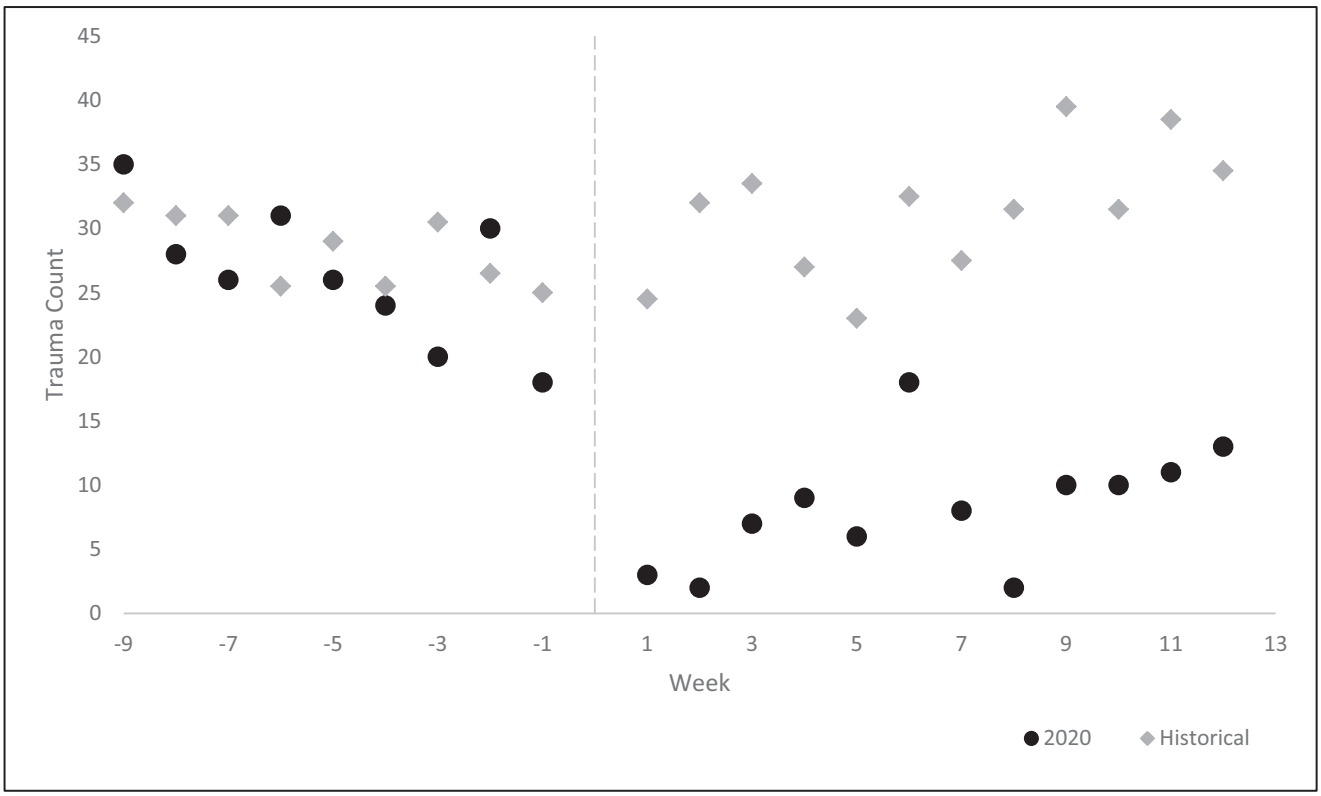

Fig. 1 – Weekly trauma counts predeclaration and postdeclaration in 2020 and corresponding dates in historical control. Dashed line corresponds to the state-of-emergency declaration in Massachusetts on March 10, 2020.

Table 2 – Average trauma counts stratified by violent intent, nonviolent intent, and SVI quartiles. March 10 corresponds to the date of the Massachusetts' state of emergency declaration in 2020.

Trauma	Historical				2020			
	Premarch 10th mean (SD)	Postmarch 10th mean (SD)	RR (95% CI)	P value	Premarch 10th mean (SD)	Postmarch 10th mean (SD)	RR (95% CI)	P value
All cause ($n = 1600$)*	28.44 (6.90)	31.29 (7.65)	1.10 (0.97, 1.25)	0.13	26.44 (5.34)	8.25 (4.71)	0.36 (0.26, 0.50)	<0.0001
Violent intent ($n = 377$)	6.17 (2.60)	7.54 (2.99)	1.21 (0.94, 1.54)	0.13	5.33 (1.12)	3.08 (2.39)	0.69 (0.39, 1.22)	0.20
Nonviolent intent ($n = 1220$)	22.28 (6.10)	23.63 (6.87)	1.07 (0.93, 1.23)	0.33	21.11 (5.37)	5.17 (3.76)	0.27 (0.91, 0.37)	<0.0001
Among SVI 4th quartile ($n = 728$)	12.11 (4.04)	13.88 (4.18)	1.13 (0.95, 1.35)	0.16	12.89 (3.41)	5.08 (3.58)	0.44 (0.30, 0.64)	<0.0001
Among SVI 1st-3rd quartile ($n = 853$)	16.00 (4.46)	17.08 (5.17)	1.12 (0.96, 1.32)	0.16	13.22 (5.54)	3.00 (2.00)	0.26 (0.17, 0.40)	<0.0001
Violent intent among SVI 4th quartile ($n = 225$)	3.56 (2.15)	4.50 (2.19)	1.30 (0.95, 1.78)	0.10	3.00 (1.00)	2.17 (1.85)	0.84 (0.38, 1.86)	0.67

*Rate ratios were determined from models adjusted for race and ISS. As such, the total number of included cases is reflective of those activations with complete covariate data.

among these SVI quartiles in 2020 decreased significantly from 13.22 to 3.00 after the state-of-emergency declaration (RR = 0.26 [0.17, 0.40]; $P < 0.0001$) (Table 2). Weekly trauma activations involving patients in the first-third SVI quartiles in the historical control did not differ significantly, increasing from 16.00 to 17.08 (RR = 1.12 (0.96, 1.32); $P = 0.16$).

Trauma activations among the fourth social vulnerability index quartile prestate-of-emergency and poststate-of-emergency declaration

There was a significant negative DID between the predeclaration and postdeclaration periods in 2020 compared to those in the historical control for trauma activations among the fourth SVI quartile (β −1.03 [SE = 0.19], $P < 0.0001$) (Fig. 3). Activations in 2020 decreased significantly from 12.89 to 5.08 after the declaration of state emergency (RR = 0.44 [95% CI 0.30-0.64]; $P < 0.0001$) (Table 2). Trauma among the fourth SVI quartile in the historical control did not differ significantly, increasing from 12.11 to 13.88 (RR = 1.13 [0.95-1.35]; $P = 0.16$). Among this SVI quartile, the proportion of all trauma activations increased from 44.96% (683 of 1519) predeclaration to 64.15% (68 of 106) postdeclaration ($P = 0.001$).

Nonviolent and violent trauma activations and social vulnerability index quartile

While nonviolent trauma activations decreased between the predeclaration and postdeclaration periods in 2020 when compared to those in the historical control (Fig. 2), the proportion of those nonviolent injuries coming from communities in the fourth SVI quartile significantly increased from 40.99% (482 of 1176) to 56.92% (37 of 65) after the declaration. The proportion of nonviolent trauma counts in all other quartiles decreased, including the first quartile, in which the proportion of trauma nearly halved following the declaration (21.77% to 10.77%) ($P = 0.02$).

Violent injury trauma activations among the fourth SVI quartile were specifically analyzed. The proportion of violent injury trauma activations from communities in the fourth SVI quartile increased from 58.96% (204 of 346) predeclaration to 75.61% (31 of 41) postdeclaration. The proportion of violent injury activations from communities in all other quartiles decreased, although this was not significant ($P = 0.19$). Among violent injury trauma activations in the fourth SVI quartile, there was no significant difference in DID (β −0.56 [SE = 0.34]; $P = 0.09$) between the predeclaration and postdeclaration periods in 2020 compared to those in the historical control (Fig. 4). Trauma activations for violent injuries among the fourth SVI quartile in 2020 did not differ significantly before and after the declaration of state emergency, decreasing from 3.00 to 2.17 (RR = 0.84 [0.38-1.86]; $P = 0.67$) (Table 2). Violent trauma activations among the fourth SVI quartile in the historical control increased from 3.56 to 4.50, although this was not significant (RR = 1.30 [CI 0.95-1.78]; $P = 0.10$).

Discussion

Our study using robust quasi-experimental DID methodology highlights several important changes in trauma activations during the COVID-19 pandemic in our region. First, we found that the number of all-cause trauma activations fell significantly in the period immediately following the state-of-emergency declaration in Massachusetts on March 10, 2020. In addition to this, however, we found that the demographics of our trauma population shifted after the declaration, particularly with an increasing representation of Black patients, irrespective of the mechanism of injury. Second, our analyses of trauma stratified by SVI quartile demonstrated that our most vulnerable patients, those from the fourth SVI quartile, experienced a higher share of all-cause trauma following the pandemic declaration. Finally, while there was a

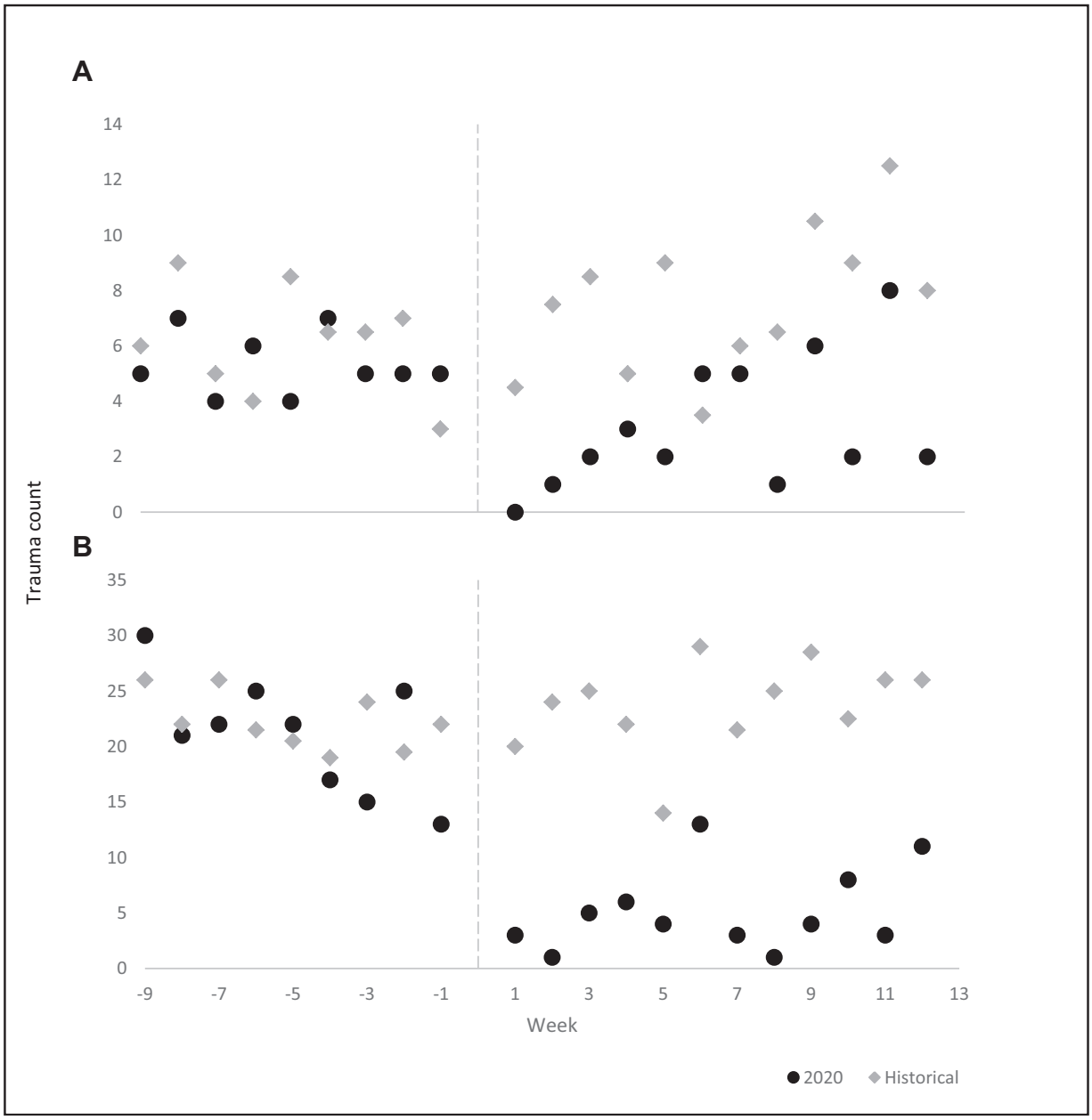

Fig. 2 – Violent injury (panel A) and nonviolent injury (panel B) weekly trauma counts predeclaration and postdeclaration in 2020 and corresponding dates in historical control. Dashed line corresponds to the state-of-emergency declaration in Massachusetts on March 10, 2020.

significant decrease in nonviolent injuries among all SVI groups, violent injuries persisted throughout the pandemic, affecting particularly patients from communities in the fourth SVI quartile. These findings support our original hypothesis that although overall trauma would decrease after the declaration of a state emergency, violent trauma, particularly among the most vulnerable, would persist.

When examining all-cause trauma activations in 2020 compared to the historical control, the decrease noted following the Massachusetts' state-of-emergency declaration supports the existing studies that have reported overall decreases in trauma volume after the issuance of stay-at-home orders.[2,3] In addition, similar patterns have been seen during previous pandemics including SARS and MERS.[5-8] These studies point to reduced demand or availability of services, patient perception of the risk of emergency department visits, and avoidance of public places as probable causes for these decreases.[21] However, while trauma activations decreased, we noted a significant shift in the burden of trauma, with the proportion of activations involving Black patients rising by approximately 12%. Worsening pandemic-related disparities in employment opportunities, access to

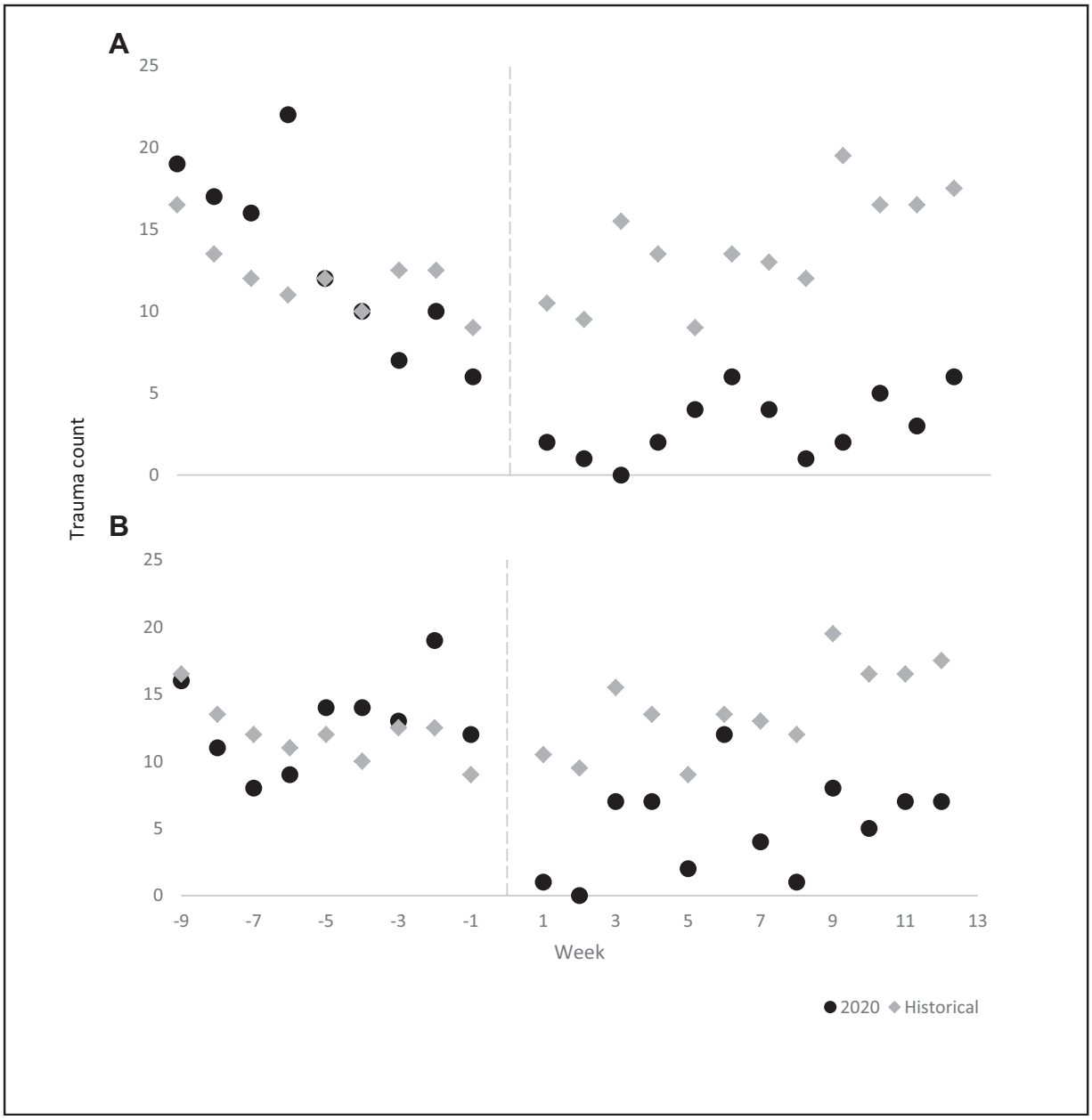

Fig. 3 – Weekly trauma counts among the first to third SVI quartiles (panel A) and fourth SVI (panel B) predeclaration and postdeclaration in 2020 and corresponding dates in historical control. Dashed line corresponds to the state-of-emergency declaration in Massachusetts on March 10, 2020.

stable food sources, and housing insecurity may have resulted in members of minoritized and marginalized communities needing to engage in work or activities exposing them to the risks of violence and injury.[22] In addition to the risk of violence exposure, compared to their White counterparts, more Black individuals have been in jobs where remote work is not feasible during the pandemic.[23] Continued exposure to commuting-related and workplace-related risks may help account for Black patients bearing an even larger share of traumatic injuries in 2020 despite overall decreases in trauma activations.

Neighborhood socioeconomic status (SES), in our study represented by SVI, has been shown to be a social determinant of health (SDH) independent of individual SES.[24,25] The socioeconomic characteristics of a community can determine access to goods and services, infrastructure, employment opportunities, level of residential stability, crime, and tolerance of deviant behavior.[26] Increasing area-level SES has strong inverse associations with the risk of both intentional and unintentional fatal injuries and nonfatal injuries.[26-29] Similarly, multiple studies looking at specific mechanisms of injury, including traffic-related injuries, head injuries,

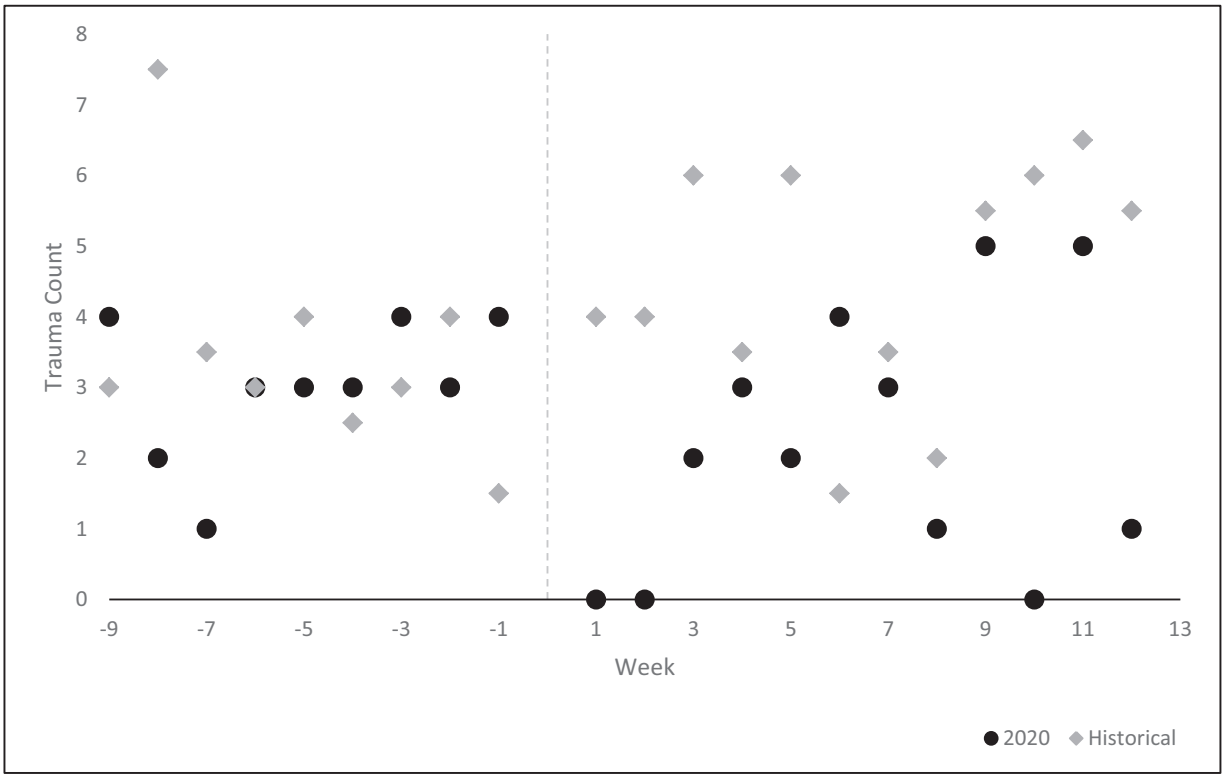

Fig. 4 – Violent injury weekly trauma counts among the fourth SVI quartile predeclaration and postdeclaration in 2020 and corresponding dates in historical control. Dashed line corresponds to the state-of-emergency declaration in Massachusetts on March 10, 2020.

domestic violence, and violent injury have all demonstrated an inverse association between injury and SES.[30-33] Our results add to this literature by demonstrating that residing in a neighborhood with high social vulnerability during the immediate months after the declaration of pandemic was associated with an increased risk of traumatic injury despite an overall decrease in trauma activations.

A growing body of evidence shows that the COVID-19 pandemic has disproportionately affected minoritized and marginalized communities.[34-36] Similarly, it is well established that violent trauma disproportionately affects vulnerable communities.[37,38] Our study highlights the compounding burden of the COVID-19 pandemic and traumatic injury on this population. The increased vulnerability of these communities during times of stress makes it unsurprising that while significant and substantial decreases were seen in nonviolent trauma, these same decreases were markedly less noticeable among violent trauma activations. This is emphasized by our analysis of violent injury activations representing those from neighborhoods in the fourth SVI quartile. This group was the only one to have no significant negative DID when comparing 2020 to the historical control. Interestingly, when comparing various SVI quartiles, the burden of nonviolent injury was also greater in vulnerable communities. Recent data have shown that throughout the pandemic, a majority of upper-income employees were able to work from home while lower-income and middle-income workers could not.[39] In addition, many of these essential workers primarily relied on public transportation to commute to work.[40] Again, this ongoing exposure to workplace-related and transportation-related risks may account for the disparities seen in nonviolent traumatic injury in this group.

Limitations

This is a single-center study and, as such, our results may not be generalizable to institutions or cities with different patient populations. We are, however, in the process of working toward a multicenter collaboration to examine these trends more thoroughly. In addition, we did not compare injuries by a specific mechanism, reducing our granularity. It may be that there were shifts particular to specific mechanisms, as seen in a recent study of trauma during this same period in California, that we are not fully capturing.[41] Our trauma activations may also have been impacted by individuals' unwillingness to come to the hospital due to a fear of becoming infected with COVID-19, as previously experienced by emergency departments during the SARS and MERS outbreaks.[5-8,21] Counts, therefore, may be underestimated. Similarly, we may be underestimating the burden of domestic violence because the pandemic itself makes it difficult for victims to leave their houses and find support.

Conclusion

Our study underscores the pervasive effects of racial and socioeconomic inequalities during the COVID-19 pandemic, extending far beyond pulmonary illness, and illuminates the

breadth of its impact. The state-of-emergency declaration was associated with significant decreases in all-cause trauma activations compared to the historical control, but these trends were less or nonsignificant among violent injury activations and vulnerable communities. The occurrence of crises such as the one brought about by the COVID-19 pandemic is unpredictable and we are obligated to take the lessons learned and create safeguards to prevent similar outcomes in the future. The development of a comprehensive approach to provide resources to vulnerable communities is essential and should include robust violence and injury prevention efforts. A focus by policy makers on the social determinants that perpetuate trauma, violence, and overall poor healthcare outcomes including food and housing insecurity, access to education, and economic opportunity is always necessary. Safeguards to prevent these social determinants from further negatively impacting communities during catastrophes such as the COVID-19 pandemic are compulsory.

Author Contributions

M.Y.N. contributed to study design, data analysis, data interpretation, manuscript writing, and critical revision. H.J. contributed to study design, data collection, data interpretation, and manuscript writing. E.C. contributed to data acquisition and critical revision. R.G. contributed to data collection, data interpretation, and critical revision. T.S.B. contributed to study design, data interpretation, and critical revision. S.E.S. contributed to study design, data interpretation, and critical revision.

Acknowledgments

The authors would like to acknowledge the Socially Responsible Surgery, a nonprofit organization based in Boston, MA, dedicated to achieving surgical equity through pillars of education, research, service, and advocacy which helped guide our research questions.

Disclosure

None declared.

Funding

Miriam Y Neufeld is supported, in part, by a T32 training grant (GM86308). The funder had no influence in study design, collection, analysis or interpretation of data, the writing of the report, or the decision to submit.

REFERENCES

1. Kaye K, Paprottka F, Escudero R, et al. Elective, non-urgent procedures and aesthetic surgery in the wake of SARS-COVID-19: considerations regarding safety, feasibility and impact on clinical management. *Aesthetic Plast Surg*. 2020;44:1014–1042.
2. Kamine T, Rembisz A, Barron R, et al. Decrease in trauma admissions with COVID-19 pandemic. *West J Emerg Med*. 2020;21:819–822.
3. Jacob S, Mwagiru D, Thakur I, et al. Impact of societal restrictions and lockdown on trauma admissions during the COVID-19 pandemic: a single-centre cross-sectional observational study. *ANZ J Surg*. 2020;90:2227–2231.
4. Chodos M, Sarani B, Sparks A, et al. Impact of COVID-19 pandemic on injury prevalence and pattern in the Washington, D.C. metropolitan region: a multicenter study by the American College of Surgeons Committee on Trauma. *Trauma Surg Acute Care Open*. 2021;6:e000659.
5. Man CY, Yeung R, Chung J, Cameron P. Impact of SARS on an emergency department in Hong Kong. *Emerg Med*. 2003;15:418–422.
6. Lu TH, Chou YJ, Liou CS. Impact of SARS on healthcare utilization by disease categories: implications for delivery of healthcare services. *Health Policy*. 2007;83:375–381.
7. Paek SH, Kim DK, Lee JH, Kwak YH. The impact of middle east respiratory syndrome outbreak on trends in emergency department utilization patterns. *J Korean Med Sci*. 2017;32:1576–1580.
8. Lee SY, Khang YH, Lim HK. Impact of the 2015 middle east respiratory syndrome outbreak on emergency care utilization and mortality in South Korea. *Yonsei Med J*. 2019;60:796–803.
9. Kaufman E. Please, stop shooting. We need the beds. The New York Times. 2020. Available at: https://www.nytimes.com/2020/04/01/opinion/covid-gun-violence-hospitals.html. Accessed March 29, 2021.
10. Gupta AH, Stahl A. For abused women, a pandemic lockdown holds dangers of its own. The New York Times. 2020. Available at: https://www.nytimes.com/2020/03/24/us/coronavirus-lockdown-domestic-violence.html. Accessed March 29, 2021.
11. Hatchimonji JS, Swendiman RA, Seamon MJ, Nance ML. Trauma does not quarantine: violence during the COVID-19 pandemic. *J Craniofac Surg*. 2020;272:53–54.
12. Sutherland M, McKenney M, Elkbuli A. Gun violence during COVID-19 pandemic: paradoxical trends in New York City, Chicago, Los Angeles, and Baltimore. *Am J Emerg Med*. 2020;39:225–226.
13. Ottolini M. Pandemic gun violence: shootings in Boston jump 29 percent in 2020. Boston Herald. 2020. Available at: https://www.bostonherald.com/2020/08/18/pandemic-gun-violence-shootings-in-boston-jump-29-in-2020/. Accessed March 29, 2021.
14. World Health Organization. *COVID-19 and Violence Against Women: What the Health Sector/System Can Do*; 2020. Geneva, Switzerland: World Health Organization; 2020. Available at: https://apps.who.int/iris/bitstream/handle/10665/331699/WHO-SRH-20.04-eng.pdf?ua=1. Accessed March 29, 2021.
15. Schumacher J, 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.
16. Harville E, Taylor CA, Tesfai H, Xiong X, Buekens P. Experience of hurricane katrina and reported intimate partner violence. *J Interpers Violence*. 2011;26:833–845.
17. Centers for Disease Control and Prevention. CDC social vulnerability index 2010 database US. Atlanta, Georgia: Centers for Disease Control and Prevention. 2020. Available at: https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html. Accessed March 29, 2021.
18. Centers for Disease Control. *SVI Fact Sheet*; 2019. Atlanta, GE: Centers for Disease Control and Prevention; 2019. Available

at: https://www.atsdr.cdc.gov/placeandhealth/svi/fact_sheet/fact_sheet.html. Accessed March 29, 2021.
19. Dimick J, Ryan A. Methods for evaluating changes in health care policy: the difference-in-differences approach. *JAMA*. 2014;312:2401–2402.
20. Rising W, O'Daniel J, Roberts C. Correlating weather and trauma admissions at a level I trauma center. *J Trauma*. 2006;60:1096–1100.
21. Tsai MC, Arnold JL, Chuang CC, et al. Impact of an outbreak of severe acute respiratory syndrome on a hospital in Taiwan, ROC. *Emerg Med J*. 2004;21:311–316.
22. Neufeld MY, Poulson M, Stolarski AE, Dunnington C, Burke PA, Allee L. Amplifying inequity: the compounding impact of COVID-19 and violence. *J Natl Med Assoc*. 2021. https://doi.org/10.1016/j.jnma.2021.04.003. epub ahead of print.
23. Bureau of Labor Statistics Monthly Labor Review. Ability to work from home: evidence from two surveys and implications for the labor market in the COVID-19 pandemic. Washington, DC: Bureal of Labor Statistics. Available at: https://www.bls.gov/opub/mlr/2020/article/ability-to-work-from-home.htm. Accessed May 12, 2021.
24. Bosma H, Dike van de Mheen H, Borsboom G, Mackenbach J. Neighborhood socioeconomic status and all-cause mortality. *Am J Epidemiol*. 2001;153:363–371.
25. Winkleby M, Cubbin C. Influence of individual and neighborhood socioeconomic status on mortality among black, Mexican-American, and white women and men in the United States. *J Epidemiol Community Health*. 2003;57:444–452.
26. Cubbin C, Smith G. Socioeconomic inequalities in injury: critical issues in design and analysis. *Annu Rev Public Health*. 2002;23:349–375.
27. Singh GK, Yu SM. US childhood mortality, 1950 through 1993: trends and socioeconomic differentials. *Am J Public Health*. 1996;86:505–512.
28. Cubbin C, LeClere FB, Smith GS. Socioeconomic status and injury mortality: individual and neighbourhood determinants. *J Epidemiol Community Health*. 2000;54:517–524.
29. Hussey J. The effects of race, socioeconomic status, and household structure on injury mortality in children and young adults. *Matern Child Health J*. 1997;1:217–227.
30. Dougherty G, Pless B, Wilkins R. Social class and the occurrence of traffic injuries and deaths in urban children. *Can J Public Health*. 1990;81:204–209.
31. Reid SR, Roesler JS, Gaichas AM, Tsai AK. The epidemiology of pediatric traumatic brain injury in Minnesota. *Arch Pediatr Adolesc Med*. 2001;155:784–789.
32. Orr C, Preen D, Fisher C, Sims S, O'Donnell M. Trends in hospital admissions for intimate partner violence in Australian mothers with children born from 1990-2009. *J Interpers Violence*. 2021;36:6998–7017.
33. Kyriacou DN, Hutson HR, Anglin D, Peek-Asa C, Kraus JF. The relationship between socioeconomic factors and gang violence in the city of Los Angeles. *J Trauma*. 1999;46:334–339.
34. Karaye IM, Horney JA. The impact of social vulnerability on COVID-19 in the US: an analysis of spatially varying relationships. *Am J Prev Med*. 2020;59:317–325.
35. Centers for Disease Control and Prevention. *Health Equity Considerations and Racial and Ethnic Minority Groups*; 2021. Atlanta, GE: Centers for Disease Control and Prevention; 2021. Available at: https://www.cdc.gov/coronavirus/2019-ncov/need-extra-precautions/racial-ethnic-minorities.html. Accessed March 29, 2021.
36. Millett G, Jones AT, Benkeser D, et al. Assessing differential impacts of COVID-19 on black communities. *Ann Epidemol*. 2020;47:37–44.
37. Chong VE, Lee WS, Victorino GP. Neighborhood socioeconomic status is associated with violent reinjury. *J Surg Res*. 2015;199:177–182.
38. Zarzaur BL, Croce MA, Fabian TC, Fischer P, Magnotti LJ. A population-based analysis of neighborhood socioeconomic status and injury admission rates and in-hospital mortality. *J Am Coll Surg*. 2010;211:216–223.
39. Parker K, Horowitz JM, Minkin R. How the coronavirus outbreak has - and hasn't - changed the way Americans work. Pew Research Center. 2020. Available at: https://www.pewresearch.org/social-trends/2020/12/09/how-the-coronavirus-outbreak-has-and-hasnt-changed-the-way-americans-work/#fn-29356-2. Accessed March 29, 2021.
40. Rogers TN, Rogers CR, VanSant-Webb E, et al. Racial disparities in COVID-19 mortality among essential workers in the United States. *World Med Health Policy*. 2020. https://doi.org/10.1002/wmh3.358. epub ahead of print.
41. Chiba H, Lew M, Benjamin ER, et al. "Safer at home": the effect of the COVID-19 lockdown on epidemiology, resource utilization, and outcomes at a large urban trauma center. *J Trauma Acute Care Surg*. 2021;90:708–713.