

# Effects of easing shelter-in-place restrictions and the lingering COVID-19 pandemic on orthopaedic trauma at a community level 2 trauma center

Jacob Best, BS<sup>a,b</sup>, Steven Stoker, DO<sup>a,c</sup>, Dalton McDaniel, DO<sup>a,c</sup>, Shawn Lerew, DO<sup>a,c</sup>, Gurkirat Jawanda, DO<sup>a,c</sup>, Neal Krentz, DO<sup>a,c</sup>, Mark Speicher, PhD<sup>d</sup>, Ryan Siwiec, DO<sup>a,c,e</sup>

## Abstract

**Objectives:** Evaluate the effect of easing “shelter-in-place” restrictions and coronavirus-2019 (COVID-19) cases on orthopaedic trauma encounters (OTEs) at a community level II trauma center.

**Methods:** A retrospective analysis was conducted of OTEs from March-June of 2016 to 2020. Injuries were classified by high or low severity. Admission and surgical intervention rates were also compared year to year. Data were statistically analyzed and compared with external data for traffic counts near the hospital and COVID-19 cases in Michigan as well as a timeline for enacting and easing of shelter-in-place orders in the state of Michigan.

**Results:** There was no difference in the number of OTEs May to June, 2020 compared with the average of those same months 2016 to 2019. March to June, 2020 showed no change in proportion of injury severity, admissions, or surgical interventions when compared with the average of March-June, 2016 to 2019, although the overall quantity of each was decreased in March and April. A significant negative correlation was found between the daily number of COVID-19 cases in Michigan and OTEs.

**Conclusions:** The quantity of OTEs normalized to pre-COVID-19 levels in May and June of 2020 compared with 2016 to 2019 despite a previously documented 45.1% drop in March and April. A negative correlation was noted between the number of reported Michigan COVID-19 cases and volume of OTEs. There were no significant changes noted to admission rates or rates of surgical intervention on OTEs throughout the time period studied.

**Keywords:** COVID-19, orthopaedic trauma, pandemic, shelter-in-place

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This study is an extension of a previously published manuscript out of McLaren Oakland Hospital regarding orthopaedic trauma encounters during the early months of the COVID-19 pandemic.

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The authors have no conflicts of interest to disclose.

<sup>a</sup>Department of Medical Education, McLaren Oakland, McLaren Healthcare, Pontiac, <sup>b</sup>College of Osteopathic Medicine, Michigan State University, East Lansing, <sup>c</sup>Department of Orthopedics, McLaren Oakland, McLaren Healthcare, Pontiac, Michigan, <sup>d</sup>American Association of Colleges of Osteopathic Medicine, Bethesda, Maryland, <sup>e</sup>Center for Advanced Orthopedics and Sports Medicine, Auburn Hills, Michigan.

\* Corresponding author. Address: 50 N. Perry Street, Pontiac, MI 48342. Tel: +701 899 3370; fax: +248 338 5567. E-mail address: [dalton.mcdaniel1@mcclaren.org](mailto:dalton.mcdaniel1@mcclaren.org) (D. McDaniel).

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## 1. Introduction

The coronavirus-2019 (COVID-19) pandemic has impacted individuals on a global scale without precedence. Behavior modifications, social distancing, and shelter-in-place restrictions have been implemented in an attempt to dampen the burden of viral spread.

The first suspected cases in Michigan appeared March 10, 2020.<sup>[1]</sup> The governor declared a state of emergency the same day.<sup>[2]</sup> A statewide shelter-in-place order followed on March 24, 2020.<sup>[3]</sup> Modifications to the shelter-in-place order were made over time, specifically multiple extensions through the months of April and May. Easing of restrictions within the shelter-in-place order began June 1, 2020 when indoor and outdoor gatherings of 10 and 100 people, respectively, were allowed. Additionally, restaurants and bars were allowed to open June 8, 2020 at 50% capacity while indoor recreation areas, theaters, gyms, and sporting venues remain closed as of August 15, 2020.<sup>[4]</sup>

Behavior modification and shelter-in-place restrictions have invoked unintended consequences on healthcare volumes and financial burden.<sup>[5-9]</sup> A previous study at McLaren Oakland Hospital (MOH) in Pontiac, Michigan showed a decrease in the volume of orthopaedic trauma encounters of 45.1% during the months of March and April, 2020 compared with the same time period of 2016 to 2019.<sup>[10]</sup>

Although studies have shown declines in orthopaedic volume associated with early experiences regarding the COVID-19 pandemic, no studies have discussed the change in healthcare

volume that occurs with normalization of society as COVID-19 case incidence decreases and shelter-in-place restrictions are relaxed. Unvalidated predictive models for the return of elective operative procedure volumes exist,<sup>[11]</sup> however they cannot be translated to orthopaedic trauma procedures as the associated backlog of elective procedures does not exist for trauma. Rather, there is generally a stable volume with smaller increases and decreases associated with factors such as local events and weather.<sup>[12–14]</sup>

This study aims to provide unprecedented evidence regarding orthopaedic trauma presenting to a community level II trauma center affected by COVID-19 early in the pandemic to assist similar orthopaedic departments in preparation for changes in work volume. Using available data regarding healthcare volumes will allow for evidence-based proactive decisions to be made regarding judicious allocation of resources in preparation for changes associated with a decrease in case incidence and relaxation of shelter-in-place orders.

**2. Materials and methods**

A retrospective analysis was performed of all electronic medical records (EMR) for orthopaedic surgery encounters between 2016 and 2020 at MOH in Pontiac, Michigan. The MOH Information Technologies Department staff queried the McKesson (Las Colinas, TX) Paragon EMR databases to retrieve orthopaedic consultation and history and physical documentation generated between 2016 and 2020. Comparing to previous years rather than preceding months limits the influence of seasonal variables and annual variation, consistent with other studies evaluating healthcare volumes during the COVID-19 pandemic.<sup>[15,16]</sup> These encounters came from the MOH Emergency Department, medical wards, or as transfers from a nearby hospital-affiliated stand-alone emergency department (ED). Orthopaedic trauma encounters (OTEs) at MOH that occurred in March through June of 2016 to 2020 were analyzed for this study. Of note, there were modifications to data previously categorized from March and April, 2016 to 2020 that are detailed in Appendix 1, <http://links.lww.com/OTAI/A15>. Data from February of 2020 were also collected and used as a baseline for prepandemic 2020 trauma volumes at MOH. Basic patient demographic data was calculated

and reported. Data were analyzed week by week from the first week of February (week 5) through the last week of June (week 26). The main outcomes of interest were the number of OTEs, injury severity for OTEs, proportion of OTEs requiring hospital admission, proportion of OTEs requiring surgical intervention, traffic patterns on major roadways surrounding MOH, and number of Michigan COVID-19 cases.

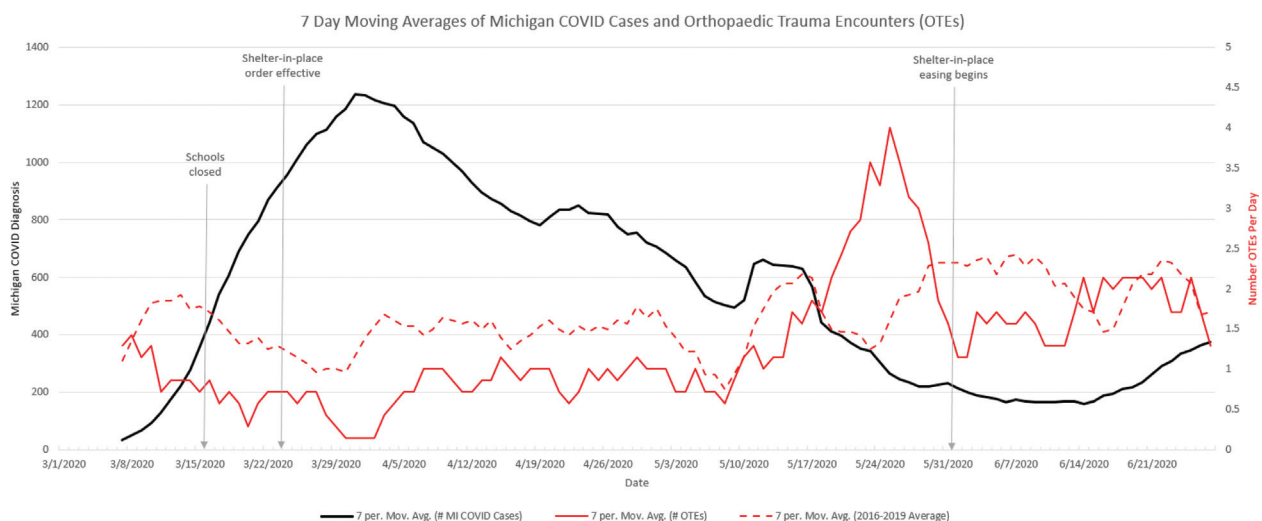
Only encounters for orthopaedic trauma were included in the study and subjected to further analysis. The following relevant variables were extracted from OTE documentation: patient age, patient sex, encounter origin, mechanism of injury, neurovascular status, diagnosis, disposition at time of presentation, and whether surgery was performed. Diagnosis and mechanism of injury were used to appropriately categorize all OTEs. To maintain consistency in the analysis, the same algorithm generated by the authors and used in a previous study at MOH was utilized to classify OTEs as high or low severity.<sup>[10]</sup>

Demographic data was averaged for each year 2016 to 2020. A Student *t* test was calculated to compare the average age for 2020 compared with the average age of years 2016 to 2020. A Pearson chi-square was used to perform interyear comparison of sex for study subjects.

Daily counts for OTEs were made and presented as weekly rates. All *t* tests performed assumed equal variance. Four separate year-over-year count analyses were performed using a Student *t* test: combined May and June (weeks 18–26) 2016 to 2019 against 2020, May 2016–2019 (weeks 18–22) against 2020, June 2016 to 2019 (weeks 23–26) against 2020 and March through June 2016 to 2019 (weeks 10–26) against 2020. To analyze 2020 OTEs before and after the easing of the shelter-in-place orders on June 1 (weeks 19–22 vs weeks 23–26), a Student *t* test was utilized. To remove the effects of day-to-day variation in OTEs, a 7-day moving average was calculated and graphed (Fig. 1).

A Pearson chi-square was calculated to compare the proportion of high severity trauma with fracture and/or dislocation (HWF) to the combined low severity trauma with fracture or dislocation (LWF) and low severity trauma without fracture or dislocation (LOF) in March-June of 2016 to 2019 and 2020.

Comparison of admission rates and surgical intervention rates in March through June of 2016 to 2020 was performed using a Pearson chi-square test. Only OTEs that originated from the ED



**Figure 1.** Seven-day moving averages of Michigan COVID-19 cases and orthopaedic trauma encounters (OTEs).

**Table 1**  
**Demographic data by year**

	2016	2017	2018	2019	2020	Overall	P value
Average age							.464
Age (years)	45.7	48.1	43.6	45.2	47.4	45.9	
Sex (%)							.968
Female	40	41.5	39.1	37.8	39.6	39.6	
Male	60	58.5	60.9	62.2	60.4	60.4	

were analyzed for admission rates as consults from the floors had already been admitted to a different service.

COVID-19 daily positive test counts were obtained from the state of Michigan<sup>[17]</sup> and a Pearson correlation was calculated to determine the association between the quantity of COVID-19 cases and the number of OTEs.

Finally, vehicle-related encounters (VREs) that include motor vehicle accidents, motorcycle accidents, and pedestrian versus auto accidents were compared with unpublished statistics obtained from the Michigan Department of Transportation regarding traffic counts around MOH (obtained July 9, 2020). Traffic counts were obtained from the 4 sensors closest to MOH. The weekday traffic counts for February through June 2020 were graphed with COVID-19 events overlaid to identify trends and relate them to the OTE data. Traffic counts from February to June 2020 were compared with 2016 to 2019. The changes in traffic counts during the pandemic and the various stages of shelter-in-place were analyzed.

### 3. Results

Electronic medical record review yielded 1288 orthopaedic encounters. Of those encounters, 298 were excluded for being unrelated to orthopaedic trauma, leaving 990 OTEs for further analysis. Final analysis was performed on 195, 188, 225, 185, and 156 OTEs for March through June of years 2016 to 2020 respectively. An additional 41 OTEs were reviewed for the month of February 2020.

#### 3.1. Demographics

The average patient age was 45.9 for 2016 to 2020 (Table 1). There was no difference (Table 1,  $P > .05$ ) in age between 2020

and the average of 2016 to 2019. 39.6% of patients were reported female while the remaining 60.4% were reported male (Table 1). There was no difference (Table 1,  $P > 0.05$ ) in sex between 2020 and the average of 2016 to 2019.

#### 3.2. Year-over-year encounter analyses

Weeks 19 to 26 (May and June) of 2020 showed no difference (Table 2,  $P > .05$ ) in the number of OTEs when compared with the 2016 to 2019 average. No difference ( $P > .05$ ) in number of OTEs was noted when separately analyzing weeks 19 to 22 (May) of 2020 (Table 2) and weeks 23 to 26 (June) of 2020 (Table 2) to the average of the same weeks 2016 to 2019. Weeks 10 to 26 (March through June) of 2020 altogether showed no difference (Table 2,  $P > .05$ ) in the number of OTEs compared with the average of 2016 to 2020.

#### 3.3. March through June 2020 intermonth analysis

Weekly analysis of weeks 19 to 26 (May and June) of 2020 showed a 112.50% increase ( $P = .003$ , Table 2) in the number of OTEs compared with weeks 10 to 18 (March and April) 2020. No change was found in the number of OTEs (Table 2,  $P > .05$ ) in weeks 19 to 22 (May) of 2020 compared with weeks 23 to 26 (June) of 2020.

#### 3.4. Severity analysis

Weeks 19 to 26 (May and June) of 2020 showed no difference in HWF, LWF, and LOF (Table 2,  $P > .05$ ) compared with 2016 to 2019. When LWF and LOF were combined, there also was no change (Table 2,  $P > .05$ ) compared with 2016 to 2019. The

**Table 2**  
**t test: 2-sample assuming equal variances for various date ranges**

	% change	Mean 1	Mean 2	Std Dev 1	Std Dev 2	Range 1	Range 2	Two tailed P value
OTEs* weeks 10–27 2016–2019 to 2020	–21.31%	11.66	9.18	2.93	5.21	7–17	2–20	.0962
OTEs weeks 19–26 2016–2019 to 2020	–3.77%	10.93	25.35	3.31	5.04	8–17	4–20	.818
OTEs weeks 19–22 2016–2019 to 2020	9.64%	12.31	13.50	3.59	7.19	8–16	4–20	.777
OTEs weeks 23–26 2016–2019 to 2020	–15.42%	14.19	12	3.21	2.45	11–17	9–15	.320
OTEs weeks 19–22 to 23–26 2020 (Easing)	–11.11%	13.5	12	7.19	2.45	4–20	9–15	.706
OTEs weeks 10–18 to weeks 19–26 2020	112.50%	6	12.75	2.83	5.04	2–12	4–20	.00348
HWF† weeks 10–26 2016–2019 to 2020	–2.70%	2.31	2.25	0.58	1.17	1.5–3.25	0–4	.894
LWF‡ weeks 10–26 2016–2019 to 2020	–6.14%	7.30	16.41	2.70	4.05	4.25–12.25	4–16	.762
LOF§ weeks 10–26 2016–2019 to 2020	4.11%	2.28	2.38	0.281	2.07	1.75–2.5	0–6	.901
Low severity combined Weeks 10–26 2016–2019 to 2020	–4.00%	5.47	5.25	1.48	2.19	3–7	2–9	.812

OTEs = orthopaedic trauma encounters.

\* Orthopaedic trauma encounter.

† High severity trauma with fracture and/or dislocation.

‡ Low severity trauma with fracture or dislocation.

§ Low severity trauma without fracture or dislocation.

**Table 3**  
Injury severity analysis

	High severity injuries (percent of total OTEs*)	Low severity injuries (percent of total OTEs)	Result compared with 2020
2016	30 (15.5%)	164 (84.5%)	$\chi^2 = .216$ ( $P = .642$ )
2017	44 (23.4%)	144 (76.6%)	$\chi^2 = 1.935$ ( $P = .164$ )
2018	49 (21.8%)	176 (78.2%)	$\chi^2 = 1.153$ ( $P = .283$ )
2019	27 (17.3%)	158 (82.7%)	$\chi^2 = .467$ ( $P = .464$ )
2020	27 (17.3%)	129 (82.7%)	

\* Orthopaedic trauma encounters.

proportion of HWF compared with combined LWF and LOF was not statistically significantly different in any year 2016 to 2019 when compared with 2020 (Table 3,  $P > .05$ ).

### 3.5. Hospital admissions

The proportion and mean (in parenthesis) of OTE admissions from the ED are as indicated. Weeks 10 to 26 (March through June) 2016 to 2019 and 2020 were 39.78% (73) and 39.16% (56) respectively. Weeks 10 to 18 (March and April) 2016 to 2019 and 2020 were 43.58% (36.25) and 42.55% (20) respectively. Weeks 19 to 26 (May and June) 2016 to 2019 and 2020 were 36.63% (36.75) and 37.50% (36) respectively. The proportion of patients who were admitted because of their OTE was not statistically significantly different in any year 2016 to 2019 when compare with 2020 (Table 4,  $P > .05$ ).

### 3.6. Surgical cases

The proportion and mean (in parenthesis) of OTEs that resulted in surgical intervention are as indicated. Weeks 10 to 26 (March through June) 2016 to 2019 and 2020 were 39.53% (78.5) and 44.87% (70) respectively. Proportions for weeks 10 to 18 (March and April) 2016 to 2019 and 2020 were 41.44% (38.25) and 46.30% (25) respectively. Proportions for weeks 19 to 26 (May and June) 2016 to 2019 and 2020 were 37.73% (40.25) and 44.12% (45) respectively. The proportion of patients who had surgical intervention because of their OTE was not statistically significantly different in any year 2016 to 2019 when compared with 2020 (Table 5,  $P > .05$ ).

### 3.7. COVID-19 association to OTEs

The number of Michigan COVID-19 cases and daily OTEs were found to be moderately negatively correlated,  $r(117) = -0.34$  ( $P < .001$ , Fig. 1).

**Table 4**  
Hospital admissions analysis

	Hospital admissions (percent of total OTEs)	No hospital admission (percent of total OTEs)	Result compared with 2020
2016	70 (38.9%)	110 (61.1%)	$\chi^2 = .000$ ( $P = 1.00$ )
2017	67 (39.0%)	105 (61.0%)	$\chi^2 = .000$ ( $P = .991$ )
2018	91 (42.7%)	122 (57.3%)	$\chi^2 = .521$ ( $P = .470$ )
2019	64 (38.6%)	102 (61.4%)	$\chi^2 = .004$ ( $P = .952$ )
2020	56 (38.9%)	88 (61.1%)	

**Table 5**  
Surgical intervention analysis

	Surgery performed (percent of total OTEs)	No surgery performed (percent of Total OTEs)	Result compared with 2020
2016	80 (42.8%)	107 (57.2%)	$\chi^2 = .364$ ( $P = .546$ )
2017	77 (42.5%)	104 (57.5%)	$\chi^2 = .413$ ( $P = .520$ )
2018	91 (42.3%)	124 (57.7%)	$\chi^2 = .502$ ( $P = .478$ )
2019	66 (37.3%)	111 (62.7%)	$\chi^2 = 2.590$ ( $P = .108$ )
2020	70 (46.1%)	82 (53.9%)	

### 3.8. Traffic data and VREs

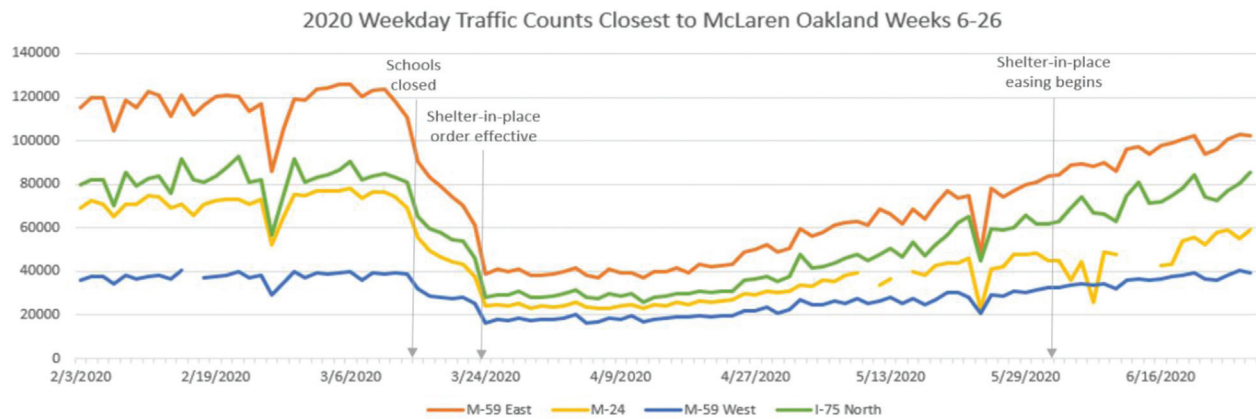
Traffic counts near MOH have been steadily increasing since mid-April 2020. Early in the COVID-19 pandemic, traffic volumes near MOH decreased by 68.3%. Since then, traffic on M-59 West has returned to its pre-COVID-19 levels. The M-59 East, I-75 North, and M-24 traffic volumes are 18.3%, 8.09%, and 24.1% lower than their pre-COVID-19 levels, respectively (Fig. 2). VREs as a proportion of OTEs were stable from March through June of 2020. The proportion of all OTEs and counts (in parenthesis) of VREs in weeks 10 to 18 (March and April), weeks 19 to 26 (May and June), and 10 to 26 (March through June) were 16.55% (70), 17.30% (91), and 16.97% (161) respectively.

## 4. Discussion

As society begins to normalize in different regions of the world, and with future outbreaks likely, it is imperative for hospital systems to have an accurate predication of how and when to allocate medical resources and personnel. This study sought to reveal how decreasing COVID-19 cases and easing of shelter-in-place orders would affect orthopaedic trauma at a community level II trauma center.

A previous study at MOH demonstrated that OTEs decreased by 45.1% during the months of March and April of 2020 when compared with 2016 to 2019.<sup>[10]</sup> A similar study out of a level one trauma center in Las Vegas, Nevada, also noted a decrease in OTEs during COVID-19 and statewide stay-at-home orders,<sup>[15]</sup> while a California study showed a 4.8-fold decrease in trauma activations at two level-one trauma centers after shelter-in-place orders went into effect.<sup>[18]</sup> A survey delivered to orthopaedic and trauma surgeons in Germany found a mean reduction in patient bed capacity for orthopaedic and trauma surgeries of 45% with a notable 29% loss of revenue in those departments.<sup>[19]</sup> Another survey of orthopaedic surgeons representing 84 different institutions in 19 European countries showed activity of orthopaedic surgeons was reduced in 72.6% of institutions.<sup>[20]</sup> In Iran, official shelter-in-place restrictions were never made, but the practice of self-quarantining contributed to a decrease in trauma-related surgeries and referrals to orthopaedic clinics.<sup>[21]</sup> A large-scale study of the publicly funded healthcare system in Hong Kong found the volume of emergent orthopaedic operations decreased by 21.2% while overall orthopaedic operations decreased by 44.2%. The incidence of operatively treated pelvic fractures remained similar, while the number of upper and lower limb fractures, including hip fractures, decreased by 20% to 23%.<sup>[16]</sup>

The analyzed OTEs showed similar admission proportions and rates of surgical intervention in March through June of 2020 compared with 2016 to 2019. These findings suggest that



**Figure 2.** 2016 to 2020 weekday traffic counts closest to McLaren Oakland for weeks 6 to 26 (obtained and published with permission from the Michigan Department of Transportation).

admitting and treating behavior of MOH orthopaedic surgeons did not change in response to the COVID-19 pandemic. It is possible that orthopaedic surgeons at other institutions would not change their behavior as well and thus hospital systems may not need to plan for a change in surgeon behavior at different stages of a pandemic.

This study demonstrates the overall quantity of OTEs normalized in May and June of 2020 compared with 2016 to 2019. It also shows that the proportion of HWF, LWF, and LOF did not change between March through June. These findings suggest that while hospitals may experience a change in quantity of OTEs, the proportion of high and low severity injuries remains unchanged.

As the volume of OTEs normalized compared with previous years, there was a steady increase in traffic counts around MOH to nearly pre-COVID-19 levels. VRE as a proportion of all OTEs remained steady throughout the pandemic, but the overall quantity increased along with traffic increases. Monitoring local traffic data may be a useful tool that hospitals can use to identify periods of time during a pandemic where orthopaedic trauma may increase.

Further analysis of Michigan COVID-19 cases and the daily quantity of OTEs at MOH showed a significant negative correlation. In March, as the number of COVID-19 cases rose, OTEs declined. The Michigan shelter-in-place order was enacted March 24, but OTEs were already near their lowest point by that date. OTEs increased on average from April 2 until peaking May 23, while Michigan COVID-19 cases peaked March 29 and subsequently decreased on average until June 14. The shelter-in-place order for Michigan began initial easing June 1, but OTEs generally continued to decrease when logically they should have been increasing due to easing restrictions. These trends in COVID-19 cases and OTEs (Fig. 1) in relation to government intervention to slow the virus spread suggest that OTEs are more correlated with the quantity of COVID-19 cases than official government intervention. With increasing COVID-19 cases in the United States in early June and continuing into July, it is possible that the number of OTEs will decrease.

The current study has limitations. First, there are many confounding variables, such as the protests at the end of May and beginning of June 2020, the amount of COVID-19 media coverage, the Memorial Day weekend, and lockdown fatigue combined with perception of COVID-19 danger, any combina-

tion of which could have impacted the number of OTEs. Second, this study does not account for variations in weather or seasonal variability which may affect orthopaedic trauma volumes. Additionally, this study was performed at a single center, though the previous study at MOH has been supported by other studies from outside institutions.<sup>[15,16,18,19,21]</sup> Finally, this study does not evaluate the impact of either easing or reimplementing restrictions on orthopaedic trauma with multiple waves of COVID-19 case incidence during the Fall or future time periods. Additional study into these limitations should be performed.

## 5. Conclusion

The COVID-19 pandemic has proved to be an unprecedented time for both the medical community and society at large. There is limited data to rely on from past pandemics to help create predictions for human behavior in response to these challenges. Multiple studies during the COVID-19 pandemic have shown decreases in the quantity of trauma in general<sup>[18,21]</sup> as well as OTEs<sup>[10,15,16,19]</sup> but this is the first study, to date, discussing the change in healthcare volume that occurs with normalization of society as COVID-19 case incidence decreases and shelter-in-place restrictions are relaxed.

Hospital systems located within a region afflicted by COVID-19 can anticipate an inverse correlation between COVID cases and OTEs without significant change in injury severity. The easing of shelter-in-place orders does not seem to have a significant effect on the volume of OTEs based on analysis of the timeline of orders and trends in OTE volume. The proportion of OTEs requiring hospital admission or resulting in surgical intervention were also not significantly influenced by COVID-19 cases or the shelter-in-place order. Future studies will likely be needed to determine if metrics such as local traffic volume or daily COVID cases can be utilized to predict a rise or fall in OTEs. Using available data regarding patterns in healthcare volume related to the COVID-19 pandemic should allow for evidence-based proactive decisions to be made regarding judicious allocation of resources.

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