Effect of Shelter-in-Place Orders and the COVID-19 Pandemic on Orthopaedic Trauma at a Community Level II Trauma Center

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Objectives: To evaluate the effect of the COVID-19 pandemic and the "shelter-in-place" order on orthopaedic trauma presenting to a community level II trauma center. It is hypothesized that the overall number of orthopaedic trauma encounters (OTEs), the number of OTEs related to both high and low severity injuries, and the proportion of OTEs related to high severity versus low severity injuries decreased compared with previous years.

Methods: A retrospective analysis was conducted of OTEs between 2016 and 2020. High and low severity OTEs were classified according to an algorithm created by the researchers. Data were statistically analyzed and compared with external data for traffic counts, motor vehicle accidents, and Transportation Security Administration checkpoints.

Results: A 45.1% decrease ($P = 0.0005$) was seen in OTEs from March and April 2016–2019 compared with 2020. The decrease began approximately 12 days before the shelter-in-place order. There was a 58.8% decrease in high severity injuries with a fracture ($P = 0.013$) and a 42.9% decrease in low severities injuries ($P = 0.0003$). The proportion of high to low severity OTEs was unchanged.

Conclusions: The quantity of OTEs was significantly affected by the COVID-19 pandemic and Michigan shelter-in-place order. A decrease in both high and low severity OTEs was found; however, there was no statistically significant change in the ratio of high to low severity OTEs compared with previous years. Although it is difficult to determine what portion of the decrease in OTE is attributable to the shelter-in-place order versus the COVID-19 pandemic in general, data suggest both play a role.

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INTRODUCTION

Individuals around the world have suffered from the effect of coronavirus-2019 (COVID-19) and have modified their behavior to try to slow its spread. The virus was first reported to the World Health Organization (WHO) office in China on December 31, 2019, and identified on January 7, 2020.[1] The first suspected cases in Michigan appeared on March 10, 2020.[2] The governor declared a state of emergency the same day.[3] On March 12, 2020, all Michigan schools were ordered to close effective March 16, 2020.[4] A "shelter-in-place order" was made effective March 24, 2020, by executive order[5] and extended over the course of additional orders.[6–8] As of May 18, 2020, there are more than 51,000 reported cases in the state of Michigan and more than 1.48 million cases reported in the United States.[9]

One study found that the trauma burden decreased for institutions because of COVID-19, likely attributable in part to social distancing and stay-at-home recommendations.[10] This may be of benefit for facilities facing the challenges of short-staffing and lack of operational facilities.[11] Studies assessing the effect of a lockdown in Wuhan, China, with travel restrictions and a stay-at-home movement showed a regulatory effect on the spread of COVID-19.[12–15] Another study showed a reduction in the overall number of injuries and fatalities associated with traffic accidents during a shelter-in-place order in California.[16] News releases have discussed health systems suffering revenue losses,[17,18] forcing employee furloughs,[18–20] and even permanent position restructuring.[19] To date, no published studies have analyzed the effect that COVID-19 and shelter-in-place restrictions have had on orthopaedic trauma.

The purpose of this study is to evaluate the effect of COVID-19 and a "shelter-in-place" order on orthopaedic trauma presenting to a community level II trauma center. It is hypothesized that the overall number of orthopaedic trauma encounters (OTEs) and the number of OTEs related to both high and low severity injuries significantly decreased compared with a similar timeframe from previous years. It is also hypothesized that the proportion of OTEs related to high severity

injuries compared with low severity injuries decreased. It is believed that the changes are related to a population who effectively changed their behavior to shelter-in-place, with low severity injuries more likely to occur within their shelter.

MATERIALS AND METHODS

A retrospective analysis was performed of all electronic medical records (EMRs) for orthopaedic surgery encounters between 2016 and 2020 at the McLaren Oakland Hospital (MOH) in Pontiac, MI. 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. These encounters came from the MOH Emergency Department, medical wards, or as transfers from a nearby hospital-affiliated stand-alone emergency department. Specific attention was focused on March and April of 2016–2020 because they coincide with the current COVID-19 pandemic in Michigan and the timing of the state's "shelter-in-place" orders. Because the data were analyzed week by week, the last week of February 2016–2019 was also collected to ensure that full weeks from March through April were available to compare. The last week of April was reported but not included in the statistical analysis because week 18 extended from April into May in 2017–2020, making it an incomplete week as data collection stopped on April 30, 2020. All of February 2020 OTEs were included to establish a baseline trauma volume and better determine the timing of events surrounding the pandemic. The main outcomes of interest were (1) the number of OTEs, (2) injury severity for OTEs, and (3) traffic-related accident dates and injuries.

OTEs were reviewed by diagnosis and mechanism of injury to appropriately categorize all orthopaedic injuries. Only encounters for orthopaedic trauma were included in the study and subjected to further analysis. The following relevant variables were extracted from OTE documentation: encounter origin, mechanism of injury, neurovascular status, diagnosis, disposition at time of presentation, and whether surgery was performed. OTEs were classified as high or low severity based on the algorithm created and agreed upon by the authors (Fig. 1). The creation of the algorithm was deemed necessary after a literature review produced no results, specifically classifying OTEs as either high or low severity.

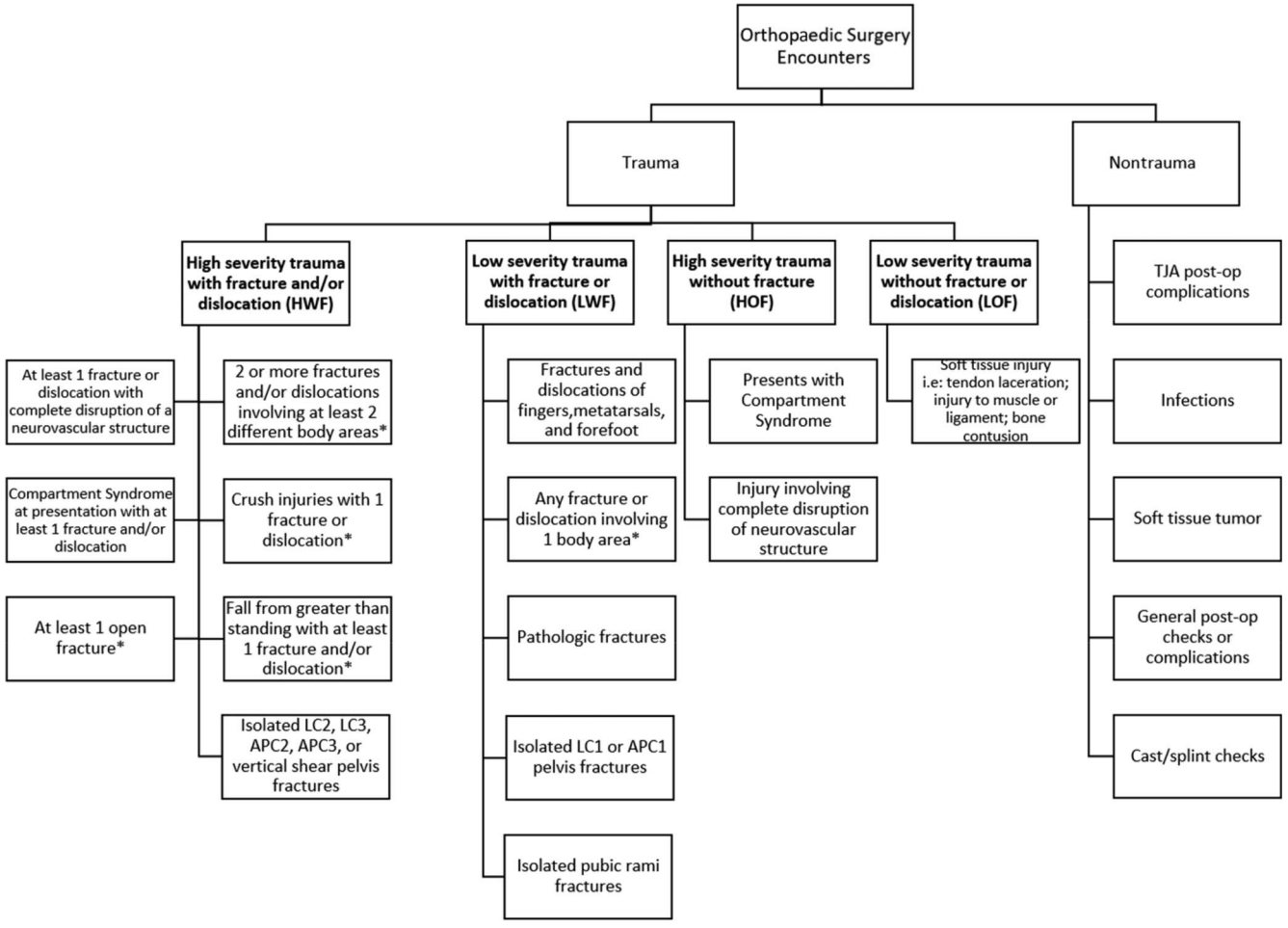

FIGURE 1. Encounter severity algorithm. *Fractures and dislocations of fingers, metatarsals, and forefoot excluded from fracture total. TJA, total joint arthroplasty.

Daily counts for OTEs were made and presented as weekly rates. All *t* tests performed assumed an equal variance. Three separate year-over-year count analyses were performed using a Student *t* test: combined March and April 2016–2019 (weeks 9–17) against March and April 2020, March 2016–2019 (weeks 9–13) against March 2020, and April 2016–2019 (weeks 13–17) against April 2020 (Table 1). The Student *t* test was also used to compare each year 2016–2019 individually with 2020. Because the results were expected to show a decrease in 2020 compared with previous years, a 1-tailed *t* test was reported for all comparisons in the results, but for robustness, 2-tailed results were included in Table 1. All other *P* values reported are 2-tailed.

An intermonth analysis of weekly OTE counts was performed for February–April 2020, comparing February (weeks 6–9) with March and April (weeks 10–17) using a Student *t* test. March 16, 2020, is the mid point of February–April 2020, and a separate comparison using a Student *t* test comparing OTE counts before (weeks 6–11) and after (weeks 12–17) the mid point was performed. To remove the effects of day-to-day variation, a 2-period 7-day moving average was calculated and graphed. Year-over-year analysis was performed on high severity trauma with fracture and/or dislocation (HWF), low severity trauma with fracture or dislocation (LWF), low severity trauma without fracture or dislocation (LOF), and a combined low severity using a 1-tailed Student *t* test (Table 1). Chi-square tests were performed on high severity to low severity injuries during March and April each year 2016–2019 and compared with 2020 injuries to analyze the change in the proportion of injury severities (see **Table**, **Supplemental Digital Content 1**, http://links.lww.com/JOT/B111). Vehicle-related encounters (VREs) [motor vehicle collision (MVC), motorcycle crash, and pedestrian vs. auto] were analyzed weekly using the Student *t* test to determine the decrease in counts (Table 1).

Finally, we compared our data with unpublished statistics obtained from the Michigan Department of Transportation regarding traffic counts around our institution (obtained May 5, 2020), unpublished statistics from the Michigan State Police (MSP) on MVCs (obtained May 5, 2020), and from publicly available Transportation Security Administration (TSA) data on airline passenger checkpoints.[21] Traffic counts were obtained from the 4 sensors closest to the MOH. The weekday traffic counts for March and April 2020 were graphed with COVID-19 events overlaid (Fig. 2) to identify trends and relate them to the OTE data. It should be noted that MVC data are complete for the month of March but remains preliminary for the month of April at the time of this writing. TSA checkpoint travel numbers were graphically displayed with COVID-19 events overlaid. A 1-tailed Student *t* test was performed on year-over-year MVC data for March 2020.

RESULTS

An EMR review yielded 614 orthopaedic encounters. Of those encounters, 127 were excluded for being unrelated to orthopaedic trauma, leaving 487 OTEs for further analysis. Final analysis was performed on 93, 94, 114, 95, and 50 OTEs for the combined last week of February 2016–2019 and months of March and April of years 2016–2020, respectively. An additional 41 OTEs were reviewed for the month of February 2020.

Year-Over-Year Encounter Analyses

Weeks 9–17 (March and April) of 2020 showed a 45.1% (P = 0.0005, Table 1 and see **Table**, **Supplemental Digital Content 2**, http://links.lww.com/JOT/B112) decrease in the number of OTEs when compared with 2016–2019. A 2-period 7-day moving average of OTEs year-over-year for 2016–2020 (Fig. 3) graphically represents this decrease. Weeks 9–13 (March) of 2020 showed a 38.6% decrease (P = 0.051, Table 1 and see **Table**, **Supplemental Digital Content 2**, http://links.lww.com/JOT/B112) in OTEs compared with 2016–2019. Weeks 13–17 (April) of 2020 had a 48.5% decrease (P = 0.0007, Table 1 and see **Table**, **Supplemental Digital Content 2**, http://links.lww.com/JOT/B112) in OTEs compared with 2016–2019.

TABLE 1. *t* Test: 2-Sample Assuming Equal Variances for Various Date Ranges

	% Change	Mean 1	Mean 2	SD 1	SD 2	Range 1	Range 2	1-Tailed *P*	2-Tailed *P*
OTEs weeks 9–17 2016–2019 to 2020	−45.1	10.111	5.556	1.833	2.833	6.75–12	2–12	0.0005	0.0009
OTEs weeks 9–13 2016–2019 to 2020	−38.6	9.450	5.800	2.314	3.768	6.75–12	2–12	0.051	0.102
OTEs weeks 13–17 2016–2019 to 2020	−48.5	10.100	5.200	1.909	1.304	6.75–11.5	3–6	0.0007	0.0015
OTEs weeks 6–9 to weeks 10–17 2020	−41.0	9.750	5.750	3.948	2.964	4–13	2–12	0.038	0.075
OTEs weeks 6–11 to 12–17 2020 (mid point)	−50.9	9.500	4.667	3.619	1.751	4–13	2–6	0.007	0.015
VREs weeks 9–17 2016–2019 to 2020	−67.2	1.694	0.556	0.788	1.333	0.5–2.75	0–4	0.021	0.042
VREs weeks 9–13 2016–2019 to 2020	−51.5	1.375	0.667	0.720	1.633	0.5–2.25	0.5–2.75	0.177	0.354
VREs weeks 13–17 2016–2019 to 2020	−88.2	1.700	0.200	0.959	0.447	0.5–2.75	0–1	0.007	0.013
HWF weeks 9–17 2016–2019 to 2020	−58.8	1.889	0.778	0.821	1.093	0.75–3	0–3	0.013	0.027
LWF weeks 9–17 2016–2019 to 2020	−36.0	6.944	4.444	1.580	2.007	4.5–8.5	2–9	0.005	0.010
LOF weeks 9–17 2016–2019 to 2020	−74.3	1.296	0.333	0.477	0.500	0.5–1.75	0–1	0.0004	0.001
Low severity combined weeks 9–17 2016–2019 to 2020	−42.9	4.183	2.389	0.786	0.993	3.5–5.14	1–4.5	0.0003	0.001

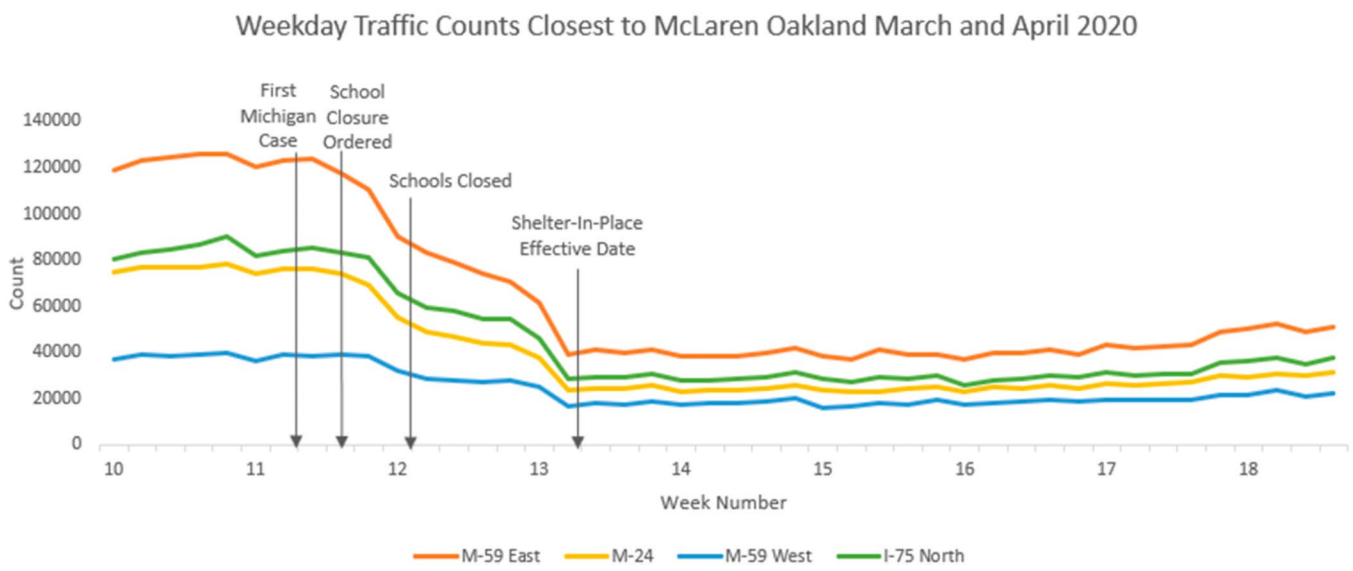

FIGURE 2. Weekday traffic counts March and April 2020—Michigan Department of Transportation (report accessed May 7, 2020).

February, March, and April 2020 Intermonth Analysis

Weekly analysis of weeks 10–17 (March and April) of 2020 showed a 41.0% decrease in OTEs compared with weeks 6–9 (February) 2020 (P = 0.038, Table 1). The data were also analyzed weekly from the mid point date period March 16, 2020. This date happened to be the day schools were closed in Michigan. There was a 50.9% decrease in OTEs after March 16, 2020, compared with before (P = 0.007, Table 1).

Vehicle-Related Encounter Analysis

Weekly analysis of weeks 10–17 (March and April) 2020 showed a 67.2% decrease in VREs compared with 2016–2019 (P = 0.021, Table 1). Weeks 9–13 (March) of 2020 showed a 51.5% decrease in VREs compared with 2016–2019 (P = 0.177, Table 1). Weeks 13–17 (April) of 2020 showed an 88.2% decrease in VREs compared with 2016–2019 (P = 0.007, Table 1).

Severity Analysis

Weeks 9–17 (March and April) of 2020 showed 58.8% (P = 0.013), 36.0% (P = 0.005), and 74.3% (P = 0.0004) decreases in HWF, LWF, and LOF, respectively, compared with 2016–2019 (Table 1 and see **Table**, **Supplemental Digital Content 3**, http://links.lww.com/JOT/B113). When LWF and LOF were combined, there was a 42.9% (P = 0.0003, Table 1 and see **Table**, **Supplemental Digital Content 3**, http://links.lww.com/JOT/B113) decrease compared with 2016–2019. A χ^2 test comparing HWF with combined LWF and LOF showed no difference in the proportion comparing 2016 with 2020 (P = 0.805), 2017 with 2020 (P = 0.138), 2018 with 2020 (P = 0.740), and 2019 with 2020 (P = 0.660).

Traffic Data

March 2020 traffic counts decreased beginning the day school closure was announced (March 12, 2020) and continued to decrease until the shelter-in-place order became effective (March 24, 2020). After the order, traffic counts

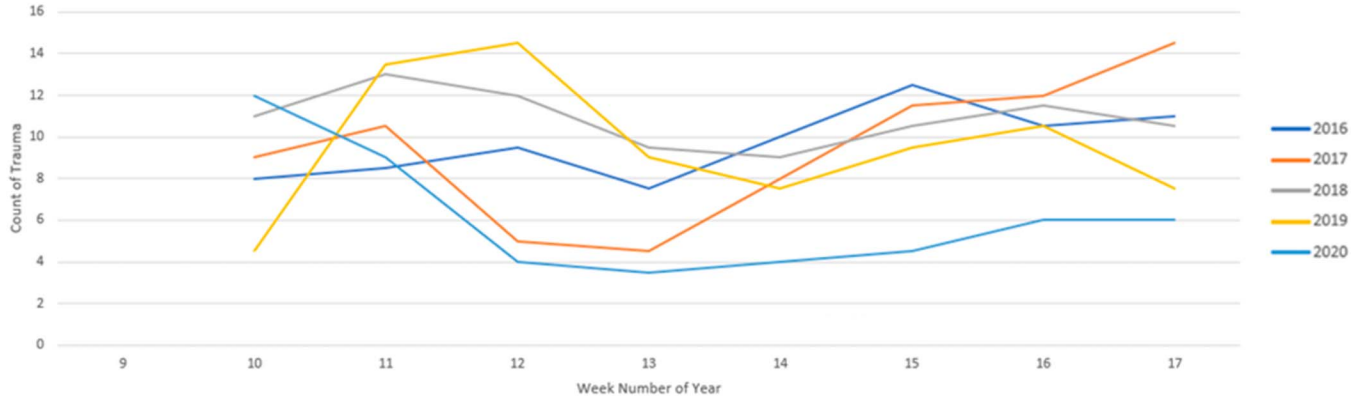

FIGURE 3. Moving average of OTEs March and April 2016–2020.

plateaued near the MOH to 68.3% lower than the max earlier in March (Fig. 2). Traffic counts plateaued for 3.5 weeks (Fig. 2) after the shelter-in-place order. The third week in April, the traffic counts began to rise until they were 28.2% higher than the minimum. Year-over-year traffic data show no long-term large changes in traffic patterns until the start of the COVID-19 pandemic and subsequent shelter-in-place order.

MSP MVC Data

March 2020 traffic MVCs in Oakland county dropped 45.6% from 2891 to 1573 compared with March of 2019.

TSA Data

There was a 96.2% decrease in checkpoint travel counts from the March 1, 2020, maximum of 2,280,522 to the April 14, 2020, minimum of 87,534.

DISCUSSION

A 45.1% decrease ($P = 0.0005$) in OTEs at the MOH was observed during March and April 2020 compared with 2016–2019. This decrease, however, began around March 12, 2020, and continued until the shelter-in-place order (Fig. 4). The decrease is likely due to changes in human behavior surrounding the COVID-19 pandemic (starting to telecommute, childcare with schools closed, etc.). Although OTEs had already plateaued by the time the shelter-in-place order was effective, it likely contributed to OTEs remaining low for a time afterward. There was also a 48.5% drop ($P = 0.0007$) in OTEs in April 2020 compared with April 2016–2019. Future studies would be beneficial to monitor the change in OTEs when the order is lifted and schools reopen.

A 38.6% decrease in OTEs at the MOH was observed in March 2020 compared with 2016–2019 ($P = 0.051$). This analysis is likely insignificant because of the first 2 weeks of March being typical in human behavior as manifest in OTE counts and traffic volume during that period. The last 2 weeks of March, people drastically changed their behavior (Figs. 2, 4).

Traffic volume decreased by 68.3% surrounding the MOH during March 2020. The change started just before the announcement of school closures and plateaued 13 days later, after the shelter-in-place order was enacted (Fig. 2). There was a drop in OTEs during the same timeframe (Fig. 4). Both traffic volumes and OTEs plateaued until there was a noticeable increase in both (Figs. 2, 4) 2 weeks and 3 weeks, respectively, into the shelter-in-place order. These changes could be related to lockdown fatigue as people begin to defy orders and engage in more activity. This potential fatigue and its relation to capacity modeling in future quarantine situations should be studied because past pandemics have affected populations in multiple waves where peaks in incidence and mortality showed a separation of multiple months.[22]

Of further note, MVCs for Oakland county dropped by 45.6% in March 2020 versus 2019, which is notable given that there was a near typical traffic volume on March 1–12, 2020. It can be concluded that the COVID-19 pandemic and shelter-in-place order led to a decrease in traffic volume, traffic accidents, and deaths, which is related to the decrease in OTEs. A 67.2% drop ($P = 0.021$) in VREs occurred during March and April 2020 (Table 1). As previously mentioned, these data suggest that human behavior likely changed in response to the COVID-19 pandemic and government intervention. Future studies should investigate the severity of injuries that occur as a result of VREs in low traffic density situations such as those that occur during a shelter-in-place order.

The severity of OTEs significantly affects patient morbidity and mortality as well as the quantity of resources (eg, personnel, personal protective equipment, etc) needed to properly treat the injury. Therefore, it is appropriate to include injury severity in the context of this study. Although there are several validated trauma severity classifications, a literature review did not return any validated classifications focused specifically on orthopaedic trauma severity; therefore, the algorithm was created (Fig. 1).

HWF, LWF, and LOF trauma all decreased significantly in March and April of 2020 compared with 2016–2019. The hypothesized change in the proportion of HWF to combined LWF and LOF injuries was not demonstrated. Although analysis showed a decrease in VREs and traffic volume, results of this analysis indicate that other high severity injuries due to mechanisms other than VREs must

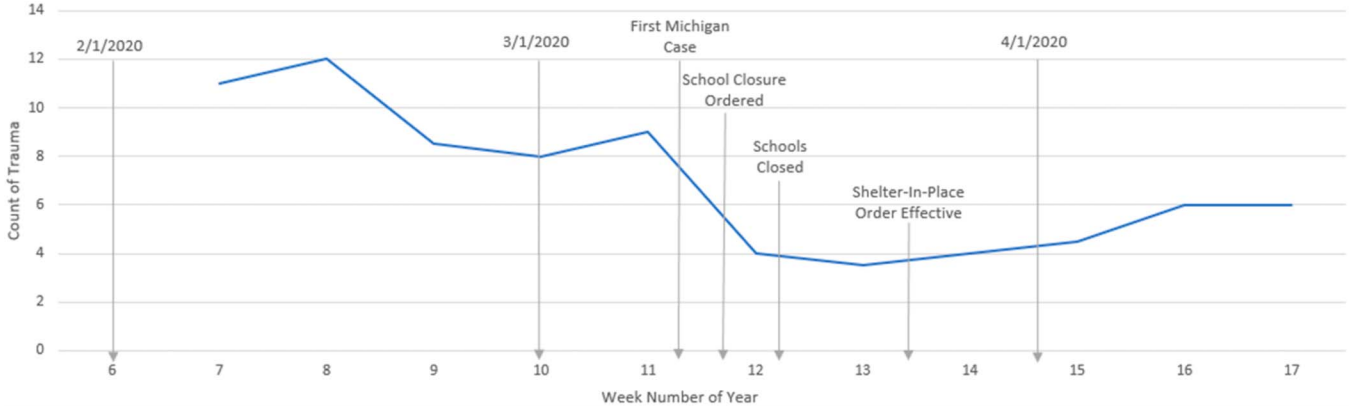

FIGURE 4. Moving average of OTEs February, March, and April 2020.

have become more prevalent, possibly because of people being more active in and around their homes.

The decrease in overall OTEs due to COVID-19 has changed the way orthopaedic surgeons and their teams approach day-to-day operations. Reduction in overall OTEs has reduced the need for orthopaedic staff to be present at the hospital. This can potentially free up staff and resources, through effective capacity modeling, to focus on treating acute illness and screening burden caused by COVID-19. Many institutions have gone to virtual sign-out/handoff sessions and have designed new "shift" schedules or teams with a limited number of individuals,[10,11,23] maximizing the time between potential exposure events without sacrificing patient safety and satisfaction. Utilization of telehealth has become more common to limit exposure of patients and is generally well received.[24]

Hospitals nationwide are feeling the financial toll of significantly limiting elective orthopaedic procedures as recommended by the American College of Surgeons[25,26] and Centers for Medicare and Medicaid Services.[27] Up to 47% of orthopaedic expenditures come from elective procedures.[28] Coupling this with an even further decrease in overall OTEs leading to orthopaedic procedures could be a costly combination for hospitals and orthopaedic practices. A report highlighting multiple surveys completed by AAOS members in April 2020 indicated that 48% of respondents reported financial challenges, 81% were not covering expenses, and more than 50% instituted salary cuts. According to these surveys, financial changes were more likely to occur in group practice.[29] Although trauma is deemed essential, it is likely that most orthopaedic surgeons who treat trauma in the United States have not covered overhead during the pandemic because of the significant drop in OTEs and surgical procedures.

Considering data were compiled from 1 hospital, results may not be generalizable to all institutions, especially those with different patient demographics. Further multicenter studies would increase the applicability of these results. In addition, external factors not considered for this study coinciding with COVID-19, such as weather, may have influenced the frequency of trauma presentations. Finally, the lack of a validated severity scoring system specifically for OTE is itself a limitation.

Overall, a 45.1% decrease in OTEs at the MOH was caused by the COVID-19 pandemic and shelter-in-place order. This decrease was similar to the decrease in traffic counts (68.3%) and MVCs (45.6%). A large decrease occurred in both high severity OTEs and low severity OTEs, although the proportion between them did not change. The data suggest that changes in OTEs and traffic volume began approximately 12 days before the shelter-in-place order. This could be attributed to changes in human behavior related to the COVID-19 pandemic. The shelter-in-place order may also have played a role in decreasing OTEs and maintaining the decreased levels for a period of time afterward. It is important that the orthopaedic community continues to study the effects of the COVID-19 pandemic on orthopaedics so that methods to safely and effectively care for patients can be created and implemented.

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