

COVID-19 orthopaedic trauma volumes: a Canadian experience during lockdown and staged reopening

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Abstract

Objectives: The aim of this study is to report the impact of public health measures (PHM), including their relaxation, on surgical orthopaedic trauma volumes. We hypothesize an initial reduction in orthopaedic trauma volumes during lockdown followed by a surge as Stages 1 and 2 of reopening progressed in Summer 2020.

Methods: All unscheduled surgical orthopaedic trauma cases from March through August were retrospectively reviewed in Calgary, Alberta, Canada, from 2008 to 2020. Trauma volumes from 2008 to 2019 were used to model expected 2020 volumes, and multivariable Poisson regression was used to determine the effect of PHM on orthopaedic trauma volumes.

Results: A total of 22,331 trauma orthopaedic surgeries were included. During lockdown, there was a significant decrease in trauma volume compared with expected (-14.2% , -25.7 to -10.5% , $P < .001$) and there were significantly fewer ankle fractures (-17.8% , -30.9 to -2.2% , $P = .027$). During reopening Stage 2, there was a significant increase in trauma volume ($+8.9\%$, $+2.2$ to $+16.1\%$, $P = .009$). There was no change in the incidence of polytrauma, hip fracture, or wrist fracture during the pandemic.

Conclusions: This study provides the first report of a surge in trauma volumes as PHM are relaxed during the COVID-19 pandemic. The ability to predict decreases in trauma volumes with strict PHM and subsequent surges with reopening can help inform operating room time management and staffing in future waves of COVID-19 or infectious disease pandemics.

Level of Evidence: Prognostic – Level III

Keywords: COVID-19, orthopaedic, public health measures, surgical wait times, trauma volumes

1. Introduction

Severe acute respiratory syndrome coronavirus 2 and the public health measures (PHM) used to control the spread of the coronavirus disease 2019 (COVID-19) pandemic have unprecedented impacts on lives and health care systems worldwide.^[1] On March 17, 2020, a State of Public Health Emergency was declared in the province of Alberta, Canada. Staying home whenever possible was recommended. A staged relaunch strategy was initiated on May 25, 2020 in Calgary. A summary of PHM in

effect during each stage of relaunch is provided in Table 1.^[2,3] At the time of writing Alberta has reimplemented enhanced PHM (beginning November 24, 2020) to slow the spread of the second wave of COVID-19 in the province.

These PHM have had a significant, complicated impact on population activity levels. Overall decreases in physical activity due to COVID-19 confinement have been demonstrated based on international survey data in April 2020.^[4] Canadian survey data from April to May, 2020 demonstrated a differential effect of public health measures, with active individuals becoming more active and inactive individuals becoming less active.^[5] Furthermore, there have been several studies worldwide consistently discussing the reduction in orthopaedic trauma volumes during this time period, with reductions of 10% to 78% observed.^[6–13] However, frequency of hip fracture presentation remained consistent in several jurisdictions.^[8,12,14] As staged reopening occurred in Calgary, reports suggested increased outdoor physical activity. This included surges in bike sales,^[15] provincial camping reservations,^[16] and more people requiring search and rescue services from more severe situations throughout summer 2020.^[17] The effects of eased restrictions on trauma volumes are unreported to date. The effect of COVID-19 PHM on wait times for orthopaedic trauma surgery has been reported only during lockdown in 1 previous study, with no change observed.^[7] While orthopaedic guidelines for use of personal protective equipment (PPE) and operating room protocols have been created,^[18] it is also unknown how increased time to don/doff PPE and safely clean ORs for COVID-19 positive or suspected positive may impact surgical wait times.

To the best of our knowledge, the effect of COVID-19 PHM on orthopaedic trauma volumes and surgical wait times in Canada

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Table 1**Summary table of COVID-19 public health measures in Alberta (2,3)**

Stage	Lockdown	Stage 1	Stage 2
Dates	March 17 to May 24, 2020	May 25 to June 11, 2020	June 12 to Nov 24, 2020
Public health measures	Maintain 2 m physical distancing wear a mask when unable to physically distance <ul style="list-style-type: none"> • Max. gathering size 15 (indoor and outdoor) • Non-essential businesses closed • Schools closed • Elective surgical procedures postponed 	<ul style="list-style-type: none"> • Max. gathering size 15 indoor/50 outdoor • Some businesses/ facilities re-open • Schools remain closed • Some elective surgeries resume 	<ul style="list-style-type: none"> • Max. gathering size 50 indoor/100 outdoor • Additional businesses/facilities reopen • Schools open for exams/summer school • In person school (K-12) resumes Sept 2020 • Additional scheduled elective surgeries

has not been reported. We hypothesize initial reduction in orthopaedic trauma volumes during lockdown will be followed by a surge in trauma volumes during reopening in Summer 2020. We further hypothesize that surgical wait times will increase in all stages of COVID-19 due to the increased use of PPE and other protocols implemented to keep the surgical team safe.

2. Methods

The study was approved by the local university research ethics board (REB18-0777). All orthopaedic trauma cases presenting to the 4 adult hospitals (1 level 1 trauma center, 3 level 2 trauma centers) between January 1, 2008 and August 31, 2020 in Calgary, Alberta, Canada were included. Subjects with an injury to the appendicular skeleton and/or associated girdles were selected from the Operating Room Informatics System. Surgery to the skull, thorax, and/or vertebral column was excluded. Nontraumatic operations (i.e., incision and drainage for infection, revision arthroplasty) were also excluded. The dataset was further narrowed to March 1 to August 31 of each year to reflect the presence of COVID-19 in 2020. Census data from Calgary Economic Development from 2008 to 2019, including forecast predictions for 2020, were gathered to account for population changes.^[19]

Cases satisfying inclusion were crossmatched to the National Ambulatory Care Reporting System to extract ICD-10 Codes for primary diagnosis; these codes were used to divide the cohort into groups for comparison. The data extractions from Operating Room Informatics System and National Ambulatory Care Reporting System included the following parameters: age, gender, injury diagnosis, and date and time values for surgical booking and start of procedure. Polytrauma cases were identified when a subject had 2 or more orthopaedic injuries receiving operative intervention under the same anesthetic; operative interventions by other providers such as general surgery teams were not captured. Polytrauma was used as a surrogate for high-energy trauma mechanisms, as mechanism of injury was not available in the dataset.

2.1. Statistical analysis

All descriptive statistics, multivariable Poisson and linear regression models were performed using SAS v9.4 (SAS Institute, Cary, North Carolina). Multivariable Poisson regression models were used to determine the influence of PHM on trauma volumes during individual months and staged reopening (Lockdown: March 17 to May 24, 2020; Stage 1: May 25 to June 11, 2020; Stage 2: June 12 to August 31, 2020). To account for increases in trauma volumes due to population growth, trauma volumes per 100,000 people were calculated and used for analysis. Expected trauma per 100,000 people based on 2008 to 2019 data was used to model expected 2020 volumes. Data from 2020 were used to calculate the

difference between actual and expected trauma volumes during affected months and staged reopening periods—which is presented as a percentage comparison ($\% \pm 95\%$ CI). Analysis of specific injuries was also performed, with hip fractures further stratified into those older and younger than 75 years old to better isolate the geriatric population experiencing low-energy hip fracture from younger patients with traumatic hip fracture. Several re-parameterized tests were done to ensure the accuracy of these regression models. Multiple linear regression models were used to investigate PHM effects on surgical wait-times (difference between date and time data for booking and start of procedure).

3. Results

The final dataset consisted of 22,331 trauma orthopaedic surgeries occurring from March through August of each year. Overall trauma volumes per month have increased over time since 2008 (Fig. 1). When normalized to cases per 100,000 people, trauma volumes did not increase over time. Hip (22.5%), ankle (20.2%), and wrist (8.9%) fractures accounted for 54.5% of the dataset, and thus were chosen as the focus for analysis and discussion. Demographics for these injuries are shown in Table 2.

3.1. Overall trauma volumes

A comparison of the trauma volumes during the COVID-19 pandemic to expected trauma volumes is shown in Figure 2. There was an initial decrease in trauma volumes in March (-8% , -17% to $+2\%$, $P=.123$), April (-11% , -21% to $+1\%$, $P=.062$), and May (-8% , -18% to $+3\%$, $P=.158$), though the decreases were not statistically significantly different from expected. June trauma volumes were similar to previous years (-3% , -14% to $+8\%$, $P=.565$). Trauma volumes increased in July ($+10\%$, -1% to $+22\%$, $P=.071$) and statistically significantly in August ($+17\%$, $+5\%$ to $+29\%$, $P=.003$).

Trauma volumes during lockdown, Stage 1 and Stage 2 of reopening compared with expected trauma volumes are shown in Figure 3. During lockdown, there was a significant decrease in trauma volume (-14.2% , -20.7 to -7.1% , $P<.001$). During Stage 1, the total number of orthopaedic trauma cases did not differ significantly from expected (-5.7% , -8.2% to $+21.6\%$, $P=.443$). In Stage 2 there was a significant increase in trauma volume ($+8.9\%$, $+2.1$ to $+16.1\%$, $P=.009$).

3.2. Specific injuries

Effects of COVID-19 by month on trauma volumes for specific injuries are shown in Table 3. Excluding hip fractures, the volume of all trauma cases decreased significantly in March (-14.7% , $P=.013$) and April (-18.4% , $P=.005$) and increased significantly in August ($+19\%$, $P=.003$). There was no change in the incidence

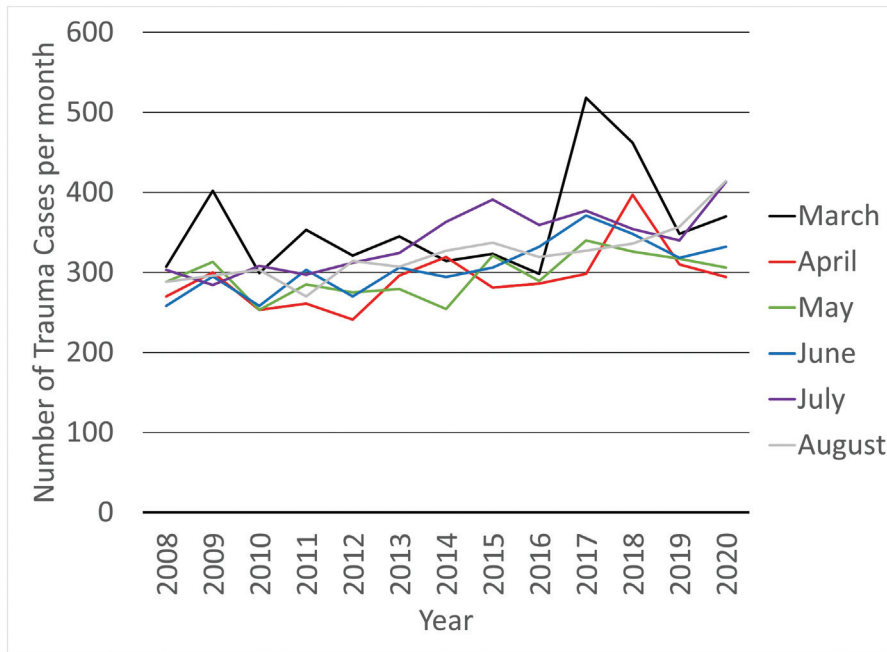


Figure 1. Number of orthopaedic trauma cases per month (2008–2020).

Table 2

Demographic information for dataset and most common injuries

Injury type	Diagnostic ICD-10 code	Number of patients (% of dataset)	Age ±SD	Percent female
All injuries		24,331 (100%)	54.7 ± 22.0	49.7%
Ankle fracture	S823	4501 (20.2%)	44.3 ± 17.1	48.3%
Hip fracture	S720, S721	5705 (25.5%)	78.1 ± 14.4	68.5%
Wrist fracture	S525	1986 (8.9%)	49.4 ± 17.2	60.3%

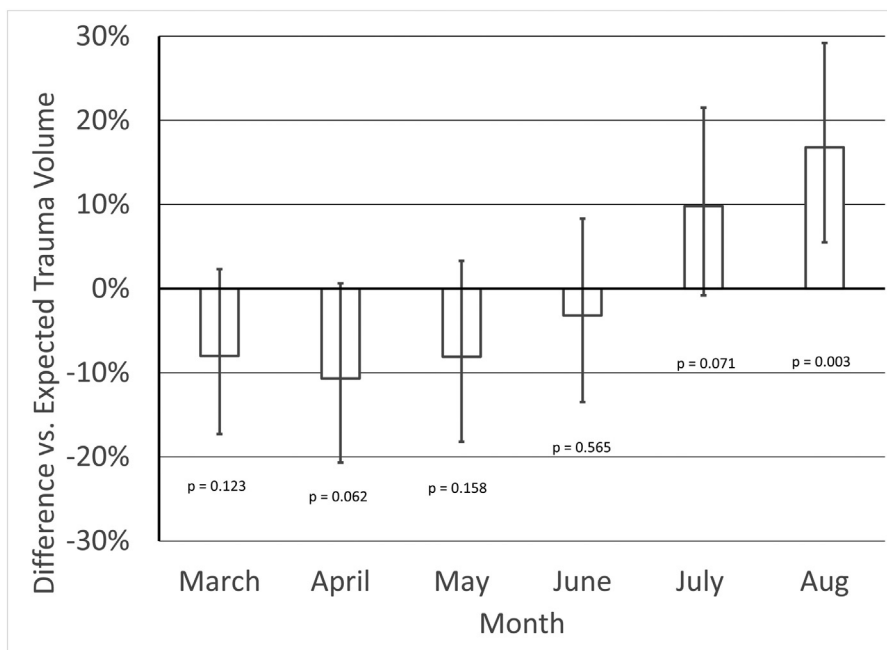


Figure 2. Change in orthopaedic trauma volumes as a percentage of expected by month (% ± 95% CI).

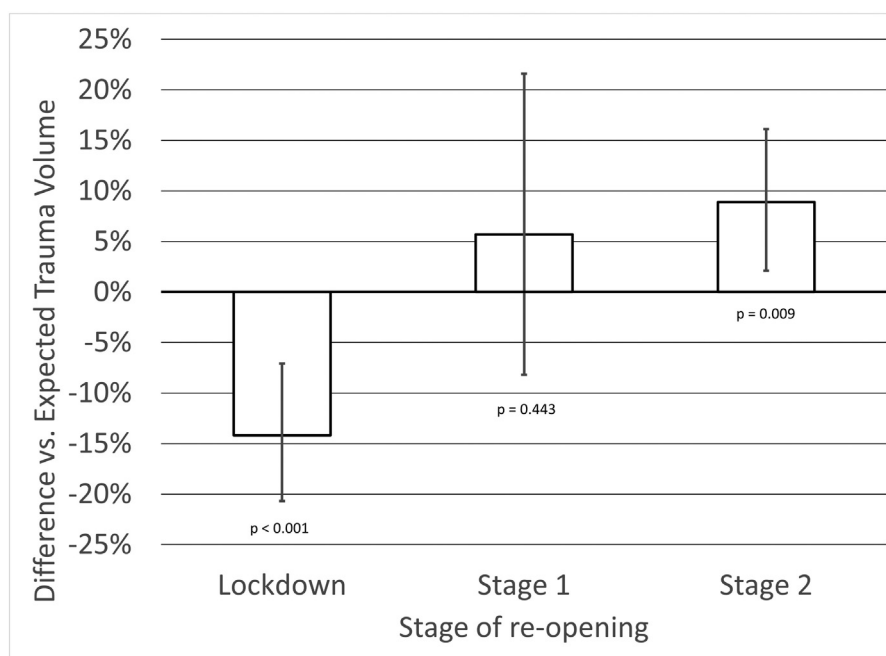


Figure 3. Change in orthopaedic trauma volumes as a percentage of expected by Stage (Lockdown: March 17 to May 24, 2020; Stage 1: May 25 to June 11, 2020; Stage 2: June 12 to August 31, 2020) (% ± 95% CI).

of polytrauma. Ankle fractures were significantly lower in March (-23.7%, $P=.013$). There were no significant changes in the incidence of hip or wrist fractures at any time. When hip fractures were stratified by those over age 75 and those under 75, there was no change in trauma volumes in any month.

Effects of stage of reopening on trauma volumes for specific injuries are shown in Table 4. Excluding hip fractures, there was a significant decrease in orthopaedic trauma volumes during lockdown (-18.5%, $P<.001$). There was a significant increase in non-hip fracture trauma during Stage 2 of reopening (+9.2%, $P=.020$). There was no change in the incidence of polytrauma.

There were significantly fewer ankle fractures during the lockdown stage (-17.8%, $P=.027$). There was no change in the incidence of hip or wrist fractures. When hip fractures were stratified by those age >75 and those < 75, there was similarly no change in trauma volumes in any stage.

3.3. Wait times

Wait times for all injuries decreased significantly in May (-3.22 hours, -6.1 to -0.3 hours, $P<.032$), and increased significantly in July (+6.7 hours, +3.8 hours to +9.6 hours, $P<.001$) and

Table 3

Percentage difference in orthopaedic trauma volume compared with expected by month of 2020

Month	% change in cases compared with expected	95% CI (lower)	95% CI (upper)	Cases/100,000 people/day	P value
All injuries excluding hip fracture					
March	-14.7%	-24.9%	-3.3%	0.514	.013
April	-18.4%	-29.3%	-5.9%	0.412	.005
May	-9.7%	-21.2%	3.5%	0.444	.141
June	-9.4%	-20.8%	3.5%	0.477	.146
July	9.8%	-2.4%	23.5%	0.602	.121
August	19.0%	5.9%	33.8%	0.618	.003
Ankle fracture					
March	-23.7%	-38.4%	-5.6%	0.185	.013
April	-12.9%	-32.8%	13.0%	0.140	.299
May	-5.1%	-28.4%	25.8%	0.144	.716
June	-13.2%	-33.0%	12.5%	0.141	.286
July	3.0%	-19.0%	30.9%	0.172	.808
August	0.8%	-20.2%	27.3%	0.159	.948
Hip fracture					
March	-8.5%	-10.9%	32.0%	0.225	.418
April	13.5%	-8.5%	40.7%	0.209	.249
May	-5.8%	-24.9%	18.3%	0.177	.607
June	8.5%	-11.9%	33.6%	0.214	.442
July	5.1%	-13.8%	28.2%	0.220	.62
August	5.5%	-14.0%	29.5%	0.206	.607

Table 4
Percentage difference in orthopaedic trauma volume compared with expected for lockdown and stages of reopening

Stage	% change in cases compared with expected	95% CI (lower)	95% CI (upper)	Cases/100,000 people/day	P value
All injuries excluding hip fracture					
Lockdown	-18.5%	-25.7%	-10.5%	0.419	<.001
Stage 1	-3.8%	-18.7%	13.9%	0.503	.653
Stage 2	9.2%	1.4%	17.6%	0.581	.02
Ankle fracture					
Lockdown	-17.8%	-30.9%	-2.2%	0.142	.027
Stage 1	6.6%	-32.4%	48.1%	0.171	.705
Stage 2	-3.1%	-16.5%	12.5%	0.156	.678
Hip fracture					
Lockdown	-3.0%	-14.0%	15.6%	0.188	.968
Stage 1	21.6%	-5.9%	56.9%	0.237	.134
Stage 2	2.7%	-9.5%	16.6%	0.207	.676

August (+7.4 hours, +4.5 to +10.3 hours, $P < .001$). Wait times for hip fractures decreased significantly in March (-4.6 hours, -9.2 to 0.0 hours, $P = 0.048$) and May (-5.2 hours, -9.9 to -0.5 hours, $P = .031$). Wait times for ankle fractures increased significantly in July (+6.5 hours, +1.2 to +11.8 hours, $P = .016$), and wait times for wrist fractures increased significantly in August (+15.2 hours, +7.9 to +22.6 hours, $P < .001$). There were no significant changes in wait times for polytrauma.

The effects of Stage of reopening on wait times are shown in Table 5. There was a significant decrease in surgical wait time during the lockdown stage (-3.4 hours, $P < .001$). Surgical wait times did not differ from expected in Stage 1 of reopening. Wait times increased significantly during Stage 2 of reopening (+4.9 hours, $P < .001$). Notably, wait times for hip fractures did not increase in Stage 2, whereas wait times for ankle and wrist fractures increased significantly. There were no significant changes in wait times for polytrauma.

4. Discussion

This study provides insight into how the PHM used to limit the spread of COVID-19 affect population behaviors and subsequent

orthopaedic surgery trauma volumes in Calgary, Alberta, Canada. During the lockdown stage (March 17-May 25, 2020), there was a 14% decrease in orthopaedic trauma volumes, indicating that staying at home decreased the burden of orthopaedic trauma. When hip fractures are excluded, this decrease is more pronounced at 18.5%. Decreased trauma volumes during lockdown are ideal given the risk to our health care systems being overwhelmed with patients infected by COVID-19. As restrictions were initially eased there were no significant changes compared with expected trauma volumes. However, when restrictions were further eased, there was a 9% increase in orthopaedic trauma. Even more striking is the increase of 17% observed in August 2020.

Previous studies have demonstrated decreases in orthopaedic trauma volumes during COVID-19, which this study supports. Reports of trauma volume decreases have varied widely from 10% to 78%.^[6-13] Reports likely vary due to diversity of timelines compared, baseline used, populations and health systems studied. Weather may also account for variations in reported trauma volumes; the lockdown stage in Calgary occurred during winter and spring months. Trauma occurring due to exposure to snow and ice while performing essential

Table 5
Change in wait times compared with expected for lockdown and Stages of reopening

Stage	Change in wait time compared with expected (hours)	95% CI (lower, hours)	95% CI (upper, hours)	Wait time (hours)	P value
All injuries					
Lockdown	-3.4	-5.4	-1.4	16.6	<.001
Stage 1	-3.5	-7.3	0.4	17.4	.082
Stage 2	4.9	3.1	6.7	27.5	<.001
All injuries excluding hip fracture					
Lockdown	-2.9	-5.2	-0.5	17.0	.017
Stage 1	-3.7	-8.4	0.9	18.0	.114
Stage 2	6.4	4.2	8.6	29.2	<.001
Ankle fracture					
Lockdown	-3.7	-7.2	-0.1	15.4	.043
Stage 1	-1.1	-8.4	6.3	19.0	.779
Stage 2	3.9	0.7	7.1	25.4	.016
Hip fracture					
Lockdown	-4.5	-7.7	-1.4	15.0	.005
Stage 1	-4.4	-10.5	1.6	15.1	.15
Stage 2	-0.2	-3.1	2.6	21.4	.862
Wrist fracture					
Lockdown	0.6	-4.9	6.1	19.3	.834
Stage 1	-6.0	-16.0	4.1	14.8	.246
Stage 2	6.9	2.3	11.5	29.4	.003

activities may have blunted the impact of PHM in this study. The 14% decrease in trauma volumes observed in this study provides information regarding effects of PHM in a Northern climate for a relatively young population.^[19]

The incidence of specific injuries observed in this study is also in line with previous reports. Ankle, hip, and wrist fractures made up 54.5% of all injuries, and these injuries were selected for further analysis as their management consumes considerable operating room resources. The incidence of polytrauma consistently appears unchanged in lockdown.^[8,9,11] The incidence of hip fractures through lockdown was reported to be unchanged in several studies.^[8-10,14] Although there are several reports of decreased incidence of hip fractures,^[7,14] the unchanged incidence observed in this study is consistent with the fact that most geriatric hip fractures happen in the home.^[20] We speculate that the activity levels of this large cohort of dependent patients did not change with public health restrictions as much as the younger trauma patients included in this dataset. The analysis performed in this study to exclude the hip fracture population may be a more realistic reflection of the effects of PHM on the nongeriatric population. Similarly, the fact that no change in trauma volumes was seen when hip fractures were grouped by age less than 75 and those over 75 strengthens the conclusion that there was no change in the incidence of geriatric hip fractures; this population over the age of 75 makes up 85% of hip fractures in Canada.^[21] No reports of changes in incidence of ankle or wrist fractures are available for comparison. The majority of wrist fractures sustained by older individuals occur due to low-energy falls, while younger individuals sustain these injuries through sports/activities.^[22] The population with operatively treated wrist fractures in this study (60% women, average age 49 years) is more likely to have sustained a low-energy fall, and thus any changes in operative wrist fracture incidence due to high-energy mechanisms are eclipsed by the higher proportion of older patients. The 18% decrease in ankle fractures during lockdown observed here may reflect cancellation of organized sporting activities during lockdown; 21% of ankle fractures have been reported to occur during sports.^[23] Effects of relaxation of PHM on orthopaedic trauma volumes have not previously been reported. The novel finding of this study, whereby trauma volumes increased as restrictions were eased, is important for predicting and managing the burden of orthopaedic trauma on the health care system as subsequent waves of COVID-19 trigger fluctuations in PHM.

The increase in trauma volumes with easing of restrictions is consistent with the previously cited reports in the media of increased recreational activities locally. People who may normally travel internationally or by airline may be exploring activities closer to home, including hiking and other experiences in the nearby Rocky Mountains. It has also previously been shown that weather and orthopaedic trauma volumes are correlated, with warmer weather being correlated with increased trauma.^[24-27] The relaxation of PHM in Alberta coincided with late spring and summer weather, and this together with increased opportunity for recreational activity while working from home may have affected trauma volumes. Despite the benefit of outdoor physical activity for mental and physical health, lack of experience and/or proper equipment may put people at risk of injury while taking up new activities. This surge in injuries with reopening presents opportunity for injury prevention, emphasizing the importance of safety and proper footwear for personal wellbeing and to minimize burden on the health care system.

The previous report of wait times during the COVID-19 pandemic is from a large retrospective study of public hospitals in

Hong Kong.^[7] Wait times for emergency orthopaedic operations did not change in January 25 to March 27, 2020 compared with the 4 previous years and averaged 2.25 hours. Spine pathology, infection, and malignancy made up a small proportion of this large cohort; their inclusion may contribute to differences in wait times observed in this study (as these conditions were excluded in this study). The pre-COVID-19 average surgical wait time of 2.25 hours is much lower than the 20 to 22.5 hours in this study, reflecting differences in health care systems. Contrary to our hypothesis, the significant decrease in wait time observed during the lockdown stage likely reflects lower trauma volumes and possibly increased operating room availability due to postponement of elective surgical procedures. As reopening progressed, wait times for all injuries except hip fractures increased. This is likely multifactorial, considering increased trauma volumes, resumption of elective surgical procedures, and possibly increased time required for operating room staff to properly don PPE. Consistent wait times for hip fractures are a testament to achievement of the national standard of hip fracture surgery within 48 hours to prevent increased mortality.

The major strength of this study is the robust nature of this dataset. Previous studies have used a maximum of 4 years of historical data for comparisons. Using data from 2008 to 2019 allows for reliable historical averages and expected trauma volumes for 2020 to be calculated, and will help ameliorate any variations in trauma volumes in a given year (due to events, inclement/excellent weather, etc). Comparison of actual 2020 trauma volumes compared with predicted 2020 trauma volumes (based on historical 2008-2019 data) allows for isolation, as much as possible, of the effects of public health measures. This study has considerably expanded the scope of the existing literature, as at the time of writing, there have been no reports on the effects of reopening strategies on orthopaedic trauma volumes or surgical wait times during the COVID-19 pandemic.

Though the dataset used here is large and robust, there are several features that are not included, such as mechanism of injury. Also, this dataset includes only trauma requiring operative intervention. This, combined with exclusion of surgical axial skeleton and thoracic/abdominal injuries, means that the number of polytrauma patients captured here is lower than in reality. Furthermore, although total trauma volumes increased over time in this study, deeper investigation of the constant orthopaedic trauma volumes per 100,000 people observed over the time period in this study is required. Any possible delay to presentation (due to fear of going to hospital because of COVID-19, etc) is not captured by this dataset as the wait time calculation is from surgical booking time to the time the patient arrives in the OR. This and previous studies have used solely the PHM in effect to look at trauma volumes during COVID-19. The behavior of a population is dependent on many factors besides public health guidance, including weather, which are not accounted for in these studies.

The COVID-19 pandemic presents continually evolving challenges to health care system management. Surges and lulls in orthopaedic trauma volumes in, for example, times of war or mass casualty incidents differ from the current situation in that COVID-19 does not increase requirements for surgical care. In fact, surgical resources (ventilators, staff, operating rooms, etc) may be diverted for critical care. The first step in being able to devise efficient ways of planning and staffing operating rooms is acquisition of data regarding demand, or trauma volumes in the case of orthopaedics. If volumes of orthopaedic trauma can be roughly estimated based on PHM, strategies to manage workforces can be better informed. Such strategies have included

centralization of surgical services to “clean” institutions, redeployment of staff to critical care capacities, as well as managing restaffing when personnel need to quarantine.^[28] This study does show that it will be important to ensure appropriate operating room time is allocated for orthopaedic trauma, while the enormous backlog of elective procedures that have been cancelled is addressed.

Given the novelty of the COVID-19 pandemic, it is difficult to make specific recommendations for orthopaedic trauma resource planning. However, this and previous studies support that surgical resources need to remain available for orthopaedic trauma patients during all the stages of the COVID-19 pandemic. While trauma volumes may decrease with restrictive PHM, injuries still occur and require urgent treatment. This study demonstrates that our city has continued to meet the national standard of treatment of geriatric hip fractures within 48 hours; achievement of this standard to prevent mortality of this population already disproportionately affected by COVID-19 must continue. The novel finding of this study, whereby trauma volumes and wait times increased as restrictions were eased, helps identify a potential target for population-based injury prevention strategies. It also provides evidence that maintenance of orthopaedic trauma surgical resources will be important to manage the burden of orthopaedic trauma on the health care system. Minimizing hospitalization and wait times with expedient surgery for trauma patients will help preserve hospital capacity for patients undergoing delayed surgical procedures.

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