

Original article

Changes in Orthopaedic diagnoses during the COVID-19 pandemic

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ABSTRACT

Background: The coronavirus disease 2019 (COVID-19) pandemic has been accompanied by significant reductions in patient volumes for non-COVID-19-related conditions ranging from acute coronary syndrome to ischemic strokes to acute trauma. However, the impact of the COVID-19 pandemic on patient volumes for a broad range of orthopedic conditions remains unknown. The purpose of this study was to investigate the association of the COVID-19 pandemic with changes in patient volumes of 35 emergent (e.g. dislocations, open fractures), urgent (e.g. fractures), and nonurgent orthopedic conditions (e.g. osteoarthritis, sprains).

Methods: A retrospective interrupted time-series analysis of patient volumes was conducted for 35 orthopedic conditions based on ICD-10 diagnosis codes. Patient hospitalizations and new problem visits were aggregated across two institutions in New York state, including one urban tertiary care orthopedic hospital, one urban academic medical center, and all state outpatient facilities affiliated with the orthopedic institution. Patient volumes in the COVID-19 peak period (03/2020–05/2020) and COVID-19 recovery period (06/2020–10/2020) were compared against pre-COVID-19 vol (01/2018–02/2020).

Results: Overall, 169,047 cases were included in the analysis across 35 conditions with 3775 emergent cases, 6376 urgent cases, and 158,896 nonurgent cases. During the COVID-19 peak period, patient caseloads for 1 out of 7 emergent conditions ($p = 0.02$) and 26 out of 28 urgent and nonurgent conditions ($p < 0.05$) were significantly reduced compared to the pre-COVID-19 period. During the COVID-19 recovery period, patient volumes in 3 out of 13 emergent and urgent conditions ($p < 0.03$) and 11 out of 22 nonurgent conditions ($p < 0.04$) were decreased compared to pre-COVID-19 vol.

Conclusions: This study found that the pandemic was associated with considerable changes in patient patterns for non-COVID-19 orthopedic conditions. The long-term effects of patient volume reductions on both patient outcomes and orthopedic health systems remain to be seen.

Level of evidence: Cohort study; level of evidence IV.

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1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic in the United States has resulted in over 15 million infections and 300,000 deaths.¹ Understanding the overall impact of the pandemic, however, requires an assessment of the pandemic's association with

changes in patient volumes for non-COVID-19-related conditions. Within emergent medical conditions, patient volumes of acute coronary syndrome,^{2–4} ischemic stroke,^{4,5} and acute asthma⁶ decreased following the onset of the COVID-19 pandemic. Within orthopedics, previous reports identified reductions in presentations for acute trauma,^{7–10} motor vehicle collisions,^{8,10} pediatric fractures,¹¹ and emergency department visits.¹² Notably, though volumes for emergent conditions have demonstrated gradual returns to pre-COVID-19 levels, many of the volumes for chronic diseases (e.g. heart failure, chronic obstructive pulmonary disease [COPD]) generally have not.⁴

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Still, the impact of the COVID-19 pandemic on patient volumes for a broad range of common non-trauma orthopedic conditions remains unknown. The purpose of this study was to investigate the association of the COVID-19 pandemic on patient volumes of emergent, urgent, and nonurgent orthopedic conditions by assessing the incidence of 35 orthopedic conditions. We hypothesized that the multifactorial combination of social distancing, stay-at-home orders, fear of exposure to COVID-19, lost health insurance, and widespread closure of parks, gyms, schools, and large-group activities would lead to substantial reductions in patient volumes for orthopedic conditions during the COVID-19 pandemic.

2. Methods

2.1. Patient population

A retrospective analysis of patient volumes was performed at two urban New York tertiary care centers between January 1, 2018 and August 31, 2020 using International Classification of Disease (ICD)-10 diagnosis codes for 35 orthopedic conditions (Supplemental Table 1). Conditions with too few pre-COVID-19 cases such as compartment syndrome were not included. For each condition, patient hospitalizations and new problem visits—including both in-person clinic visits and telemedicine encounters—were aggregated across an urban tertiary care orthopedic hospital, an urban tertiary care academic medical center, and all state urban and suburban outpatient facilities affiliated with the orthopedic institution. Based on the case report trends for COVID-19 in New York state, daily case volumes were compared across three time periods: 1) pre-COVID-19 (01/2018–02/2020), 2) COVID-19 peak (03/2020–05/2020), and 3) COVID-19 recovery (06/2020–10/2020). Conditions were classified into emergent, urgent, and nonurgent conditions through assessment and review by five authors. Classification was based on established designations¹³ as well as the potential mortality and morbidity associated with deferring or delaying care for each condition.

2.2. Statistical analysis

Interrupted time-series analysis was conducted using segmented Quasi-Poisson regression models to analyze trends between periods and approximate an effect size with the pre-COVID-19 period as the baseline.¹⁴ Case volumes during the two COVID-19 periods were compared to pre-COVID-19 volumes. Results were expressed as relative risk of patient presentation compared to pre-COVID-19 incidence. Seasonality was factored in for all conditions using Fourier terms given the link between the incidence of orthopedic conditions and seasonality.^{15,16} The COVID-19 peak period was selected as March 1, 2020, corresponding to the first observed case in the city. The recovery period was selected as June 1, 2020, following the decrease in COVID-19 cases in New York. Data analysis was conducted using R v4.0.0 (R Foundation for Statistical Computing).

This study was deemed exempt by the Institutional Review Boards at both tertiary care centers as no identifiable patient data was used.

3. Results

3.1. Patient volume of total, pre-COVID-19, COVID-19 peak, and COVID-19 recovery cases

A total 169,047 cases (163.3 total cases per day) were included in the analysis across 35 conditions. Table 1 delineates the breakdown of total, emergent, urgent, and nonurgent cases by each period.

3.2. Patient volumes during the COVID-19 peak period compared to pre-COVID-19

During the COVID-19 peak period, patient caseloads for 27 out of 35 conditions were significantly reduced compared to the pre-COVID-19 period ($p < 0.05$) (Table 1). Within emergent conditions during the COVID-19 peak, patient volumes for septic arthritis (RR 0.59, 95% CI 0.38–0.92, $p = 0.02$) were significantly reduced compared to pre-COVID-19 vol (Fig. 1). Though there were decreases in patient volumes for total dislocations (shoulder, hip, ankle, knee, sternoclavicular joint) (RR 0.70, 95% CI 0.47–1.06, $p = 0.09$) and cauda equina syndrome (RR 0.65, 95% CI 0.40–1.07, $p = 0.09$), there was no significant difference in either condition compared to pre-COVID-19 volumes. There was no significant difference in open fractures (femur, lumbar spine and pelvis, wrist and hand, lower leg and ankle, foot and toe, shoulder and upper arm, forearm) (RR 1.31, 95% CI 0.68–2.51, $p = 0.42$) during the peak period in comparison to pre-COVID-19 volumes. Within urgent conditions, there was a significant decrease in COVID-19 peak period patient cases compared to pre-COVID-19 vol for distal radius fractures (RR 0.45, 95% CI 0.32–0.65, $p < 0.001$), proximal humerus fractures (RR 0.67, 95% CI 0.46–1.00, $p = 0.05$), tibia fractures (RR 0.50, 95% CI 0.31–0.81, $p = 0.005$), and periprosthetic hip fractures (RR 0.43, 95% CI 0.24–0.76, $p = 0.004$) (Fig. 2). Within nonurgent conditions, there was a significant fall in patient volumes for all 22 nonurgent conditions including knee osteoarthritis (RR 0.28, 95% CI 0.19–0.40, $p < 0.001$), hip osteoarthritis (RR 0.34, 95% CI 0.25–0.46, $p < 0.001$), and total sprains (knee, ankle, hip, and shoulder) (RR 0.34, 95% CI 0.24–0.49, $p < 0.001$) (Fig. 3). There were no conditions with significant increases in patient volume during the COVID-19 peak period compared to pre-COVID-19 ($p > 0.93$).

3.3. Patient volumes during the COVID-19 recovery period

During the COVID-19 recovery period, caseloads for 14 out of the 35 conditions were significantly reduced compared to the pre-COVID-19 period ($p < 0.04$). Of the 27 conditions with decreased patient volumes during the COVID-19 peak period, 15 of these conditions returned to pre-COVID-19 levels with 12 conditions remaining significantly decreased. Two emergent conditions—shoulder dislocation and femur fracture—were not significantly reduced during the COVID-19 peak period but were significantly decreased during the COVID-19 recovery period. Within emergent conditions, cases of shoulder dislocation (RR 0.63, 95% CI 0.42–0.96, $p = 0.03$), femur fracture (RR 0.67, 95% CI 0.50–0.89, $p = 0.006$), and septic arthritis (RR 0.64, 95% CI 0.46–0.87, $p = 0.005$) were lower than pre-COVID-19 case numbers (Table 2). Within urgent conditions, the four conditions that were decreased during the COVID-19 peak period including distal radius fractures, proximal humerus fractures, tibia fractures, and periprosthetic hip fractures returned to pre-COVID-19 levels (Table 2). However, femur fractures were significantly reduced (RR 0.67, 95% CI 0.50–0.89, $p = 0.006$). Patient volumes for 11 of the 22 nonurgent conditions returned to pre-COVID-19 levels in the COVID-19 recovery period (Table 3). The 11 nonurgent conditions with a sustained decrease in volume included knee osteoarthritis (RR 0.82, 95% CI 0.71–0.94, $p = 0.004$), knee sprains including ligament tears (RR 0.59, 95% CI 0.49–0.72, $p < 0.001$), meniscus tears (RR 0.75, 95% CI 0.65–0.87, $p < 0.001$), post-traumatic knee osteoarthritis (RR 0.82, 95% CI 0.68–0.98, $p = 0.03$), and Achilles tendon injuries including tears (RR 0.55, 95% CI 0.40–0.76, $p < 0.001$). There were no conditions with significant increases in patient volume during the COVID-19 recovery period compared to pre-COVID-19 ($p > 0.12$).

Table 1
Total orthopedic cases during pre-COVID-19, COVID-19 peak, and COVID-19 recovery.

Category		Total	Pre-COVID-19	COVID-19 Peak	COVID-19 Recovery
Total	Number of Cases	169,047	137,226	6496	25,325
	Cases per Day	163.3	173.7	70.6	165.5
Emergent	Number of Cases	3775	3062	241	472
	Cases per Day	3.6	3.9	2.6	3.1
Urgent	Number of Cases	6376	5073	391	912
	Cases per Day	6.2	6.4	4.3	6.0
Nonurgent	Number of Cases	158,896	129,091	5864	23,941
	Cases per Day	153.5	163.4	63.7	156.5

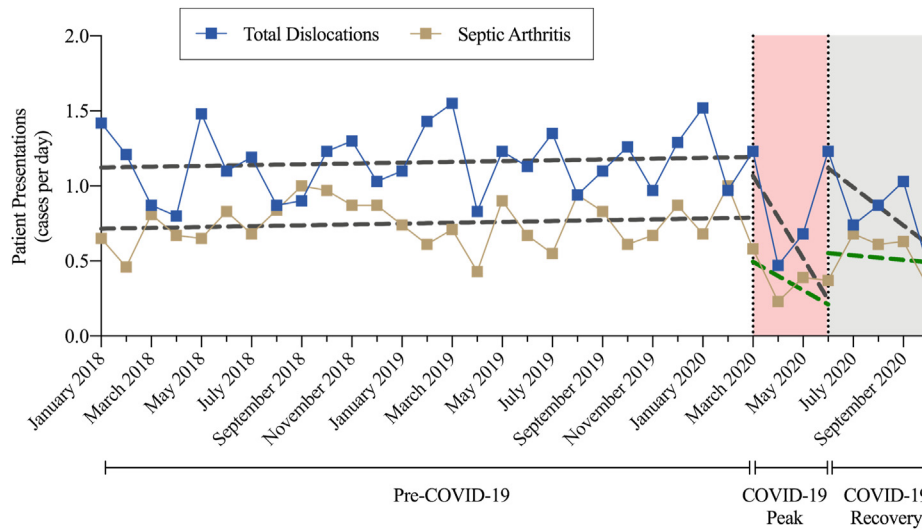


Fig. 1. Association of the COVID-19 Pandemic with the Daily Caseload of 2 Emergent Orthopedic Conditions. Trends in patient cases of dislocations (knee, shoulder, hip, ankle, and sternoclavicular joint) and septic arthritis. Trendlines highlighted in green represent a p-value < 0.05. Trendlines in the figure are shown linearly though the seasonality-adjusted Quasi-Poisson models compare non-linear trendlines with Fourier terms as part of the interrupted time-series analysis.

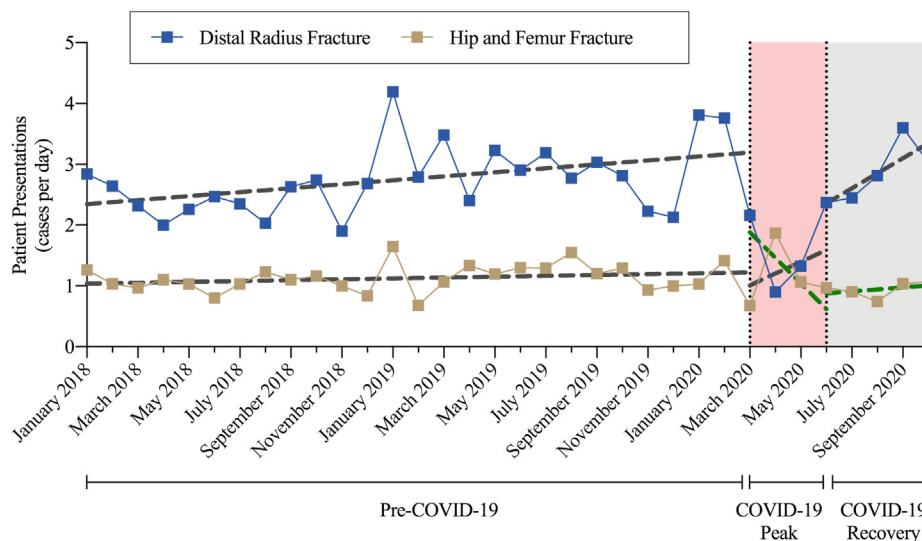


Fig. 2. Association of the COVID-19 Pandemic with the Daily Caseload of 2 Urgent Orthopedic Conditions. Trends in patient cases of distal radius fractures and proximal humerus fractures. Trendlines highlighted in green represent a p-value < 0.05. Trendlines in the figure are shown linearly though the seasonality-adjusted Quasi-Poisson models compare non-linear trendlines with Fourier terms as part of the interrupted time-series analysis.

4. Discussion

This is one of the first studies to quantify the impact of the

COVID-19 pandemic on patient volumes for a broad range of common non-trauma orthopedic conditions. Overall, after adjusting for seasonality, there were significant decreases in patient

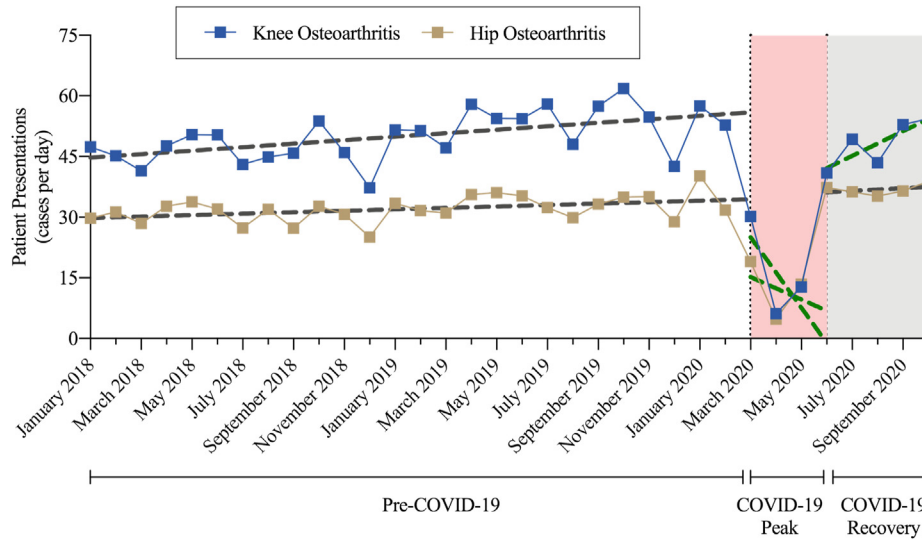


Fig. 3. Association of the COVID-19 Pandemic with the Daily Caseload of 2 Nonurgent Orthopedic Conditions. Trends in patient cases of knee osteoarthritis and hip osteoarthritis. Trendlines highlighted in green represent a p-value < 0.05. Trendlines in the figure are shown linearly though the seasonality-adjusted Quasi-Poisson models compare non-linear trendlines with Fourier terms as part of the interrupted time-series analysis.

Table 2
Trends in cases of emergent and urgent orthopedic conditions during the COVID-19 pandemic.

Condition	Mean Daily Count			Time Series Analysis: COVID-19 Peak Period		Time Series Analysis: COVID-19 Recovery Period	
	Pre-COVID-19	COVID-19 Peak	COVID-19 Recovery	Relative Risk (95% CI)	P value	Relative Risk (95% CI)	P value
Emergent	Total Dislocations ⁱ	1.16	0.79	0.70 (0.47–1.06)	0.09	0.76 (0.56–1.03)	0.08
	Shoulder Dislocation	0.74	0.53	0.74 (0.42–1.30)	0.30	0.63 (0.42–0.96)	0.03
	Hip Dislocation	0.22	0.15	0.63 (0.36–1.13)	0.12	1.06 (0.67–1.67)	0.81
	Ankle Dislocation	0.09	0.09	1.03 (0.35–3.02)	0.95	0.78 (0.31–1.95)	0.59
	Septic Arthritis	0.75	0.40	0.59 (0.38–0.92)	0.02	0.64 (0.46–0.87)	0.005
	Cauda Equina Syndrome	0.64	0.37	0.65 (0.40–1.07)	0.09	1.07 (0.73–1.55)	0.74
	Open Fracture ⁱⁱ	0.27	0.28	1.31 (0.68–2.51)	0.42	1.09 (0.66–1.81)	0.74
Urgent	Distal Radius Fracture	2.75	1.47	0.45 (0.32–0.65)	<0.001	0.89 (0.71–1.12)	0.34
	Proximal Humerus Fracture	1.14	0.74	0.67 (0.46–1.00)	0.05	0.97 (0.74–1.27)	0.83
	Tibia Fracture	1.05	0.62	0.50 (0.31–0.81)	0.005	0.84 (0.58–1.22)	0.37
	Femur Fracture	0.89	1.09	1.02 (0.66–1.58)	0.93	0.67 (0.50–0.89)	0.006
	Periprosthetic Hip Fracture	0.34	0.23	0.43 (0.24–0.76)	0.004	0.73 (0.47–1.13)	0.16
	Hip Fracture	0.25	0.11	0.48 (0.20–1.16)	0.10	0.83 (0.50–1.39)	0.49

Abbreviations: COVID-19, coronavirus disease 2019.

ⁱ Total dislocations includes knee, shoulder, hip, ankle, and sternoclavicular joint dislocations.

ⁱⁱ Open fractures includes femur, lumbar spine and pelvis, wrist and hand, lower leg and ankle, foot and toe, shoulder and upper arm, and forearm open fractures.

volumes for 1 out of 7 emergent orthopedic conditions, 4 out of 6 urgent conditions, and 22 out of 22 nonurgent conditions during the COVID-19 peak period (March 2020 to May 2020) compared to pre-COVID-19 levels (January 2018 to February 2020). Septic arthritis was the only emergent condition with a significant patient volume reduction during the COVID-19 peak period. Though previous studies identified substantial reductions in emergent conditions such as acute coronary syndrome^{2–4} and ischemic stroke^{4,5} during the COVID-19 peak period, there was no significant difference in patient volumes during the COVID-19 peak period for emergent orthopedic conditions including joint dislocations, cauda equina syndrome, and open fractures. This may be due to a combination of factors, including more obvious clinical presentations for emergent orthopedic conditions such as distinct limb and joint deformities in dislocations and open fractures in comparison to emergent medical conditions such as chest pain in acute coronary syndrome and weakness in stroke. For urgent conditions, the majority of diagnoses were decreased during the COVID-19 peak period including distal radius fractures, proximal humerus

fractures, and tibia fractures. There were no decreases in hip and femur fractures during the COVID-19 peak period. Among non-urgent conditions, all 22 conditions including osteoarthritis, joint sprains, and shoulder and knee ligament tears were substantially reduced during the COVID-19 peak period.

During the COVID-19 recovery period (June 2020 to August 2020), of the 27 conditions with decreased patient volumes during the COVID-19 peak period, 15 of these conditions returned to pre-COVID-19 baseline levels. Among emergent conditions, 2 out of 7 conditions including shoulder dislocations and septic arthritis were decreased during the recovery period. Among urgent conditions, 1 out of 6 conditions including femur fractures were decreased during the recovery period. Among nonurgent conditions, 11 out of 22 conditions remained significantly decreased during the recovery period. The sustained reduction in knee osteoarthritis, the diagnosis with the greatest patient volume among analyzed conditions, echoes previous findings demonstrating sustained decreases volumes of chronic diseases.⁴

Though this study is not able to identify causal factors for the

Table 3
Trends in cases of nonurgent orthopedic conditions during the COVID-19 pandemic.

Condition	Mean Daily Count			Time Series Analysis: COVID-19 Peak Period		Time Series Analysis: COVID-19 Recovery Period	
	Pre-COVID-19	COVID-19 Peak	COVID-19 Recovery	Relative Risk (95% CI)	P value	Relative Risk (95% CI)	P value
Nonurgent							
Knee Osteoarthritis	50.09	16.47	48.19	0.28 (0.19–0.40)	<0.001	0.82 (0.71–0.94)	0.004
Hip Osteoarthritis	32.02	12.50	36.82	0.34 (0.25–0.46)	<0.001	1.05 (0.95–1.17)	0.35
Total Sprains ⁱ	18.21	8.87	13.90	0.34 (0.24–0.49)	<0.001	0.66 (0.57–0.77)	<0.001
Knee Sprain ⁱⁱ	11.10	5.35	6.62	0.33 (0.22–0.50)	<0.001	0.59 (0.49–0.72)	<0.001
Ankle Sprain	3.69	1.71	2.85	0.34 (0.24–0.48)	<0.001	0.56 (0.47–0.67)	<0.001
Hip Sprain	1.98	1.21	2.63	0.34 (0.22–0.53)	<0.001	0.76 (0.60–0.97)	0.03
Shoulder Sprain	1.44	0.61	1.79	0.40 (0.25–0.65)	<0.001	1.11 (0.90–1.36)	0.32
Meniscus Tear	15.06	5.54	14.14	0.28 (0.19–0.41)	<0.001	0.75 (0.65–0.87)	<0.001
Rotator Cuff Tear	9.98	3.67	10.40	0.27 (0.20–0.38)	<0.001	0.86 (0.74–1.00)	0.05
Carpal Tunnel Syndrome	3.89	1.85	4.51	0.45 (0.33–0.6)	<0.001	1.09 (0.98–1.21)	0.12
Aseptic Osteonecrosis	2.62	1.21	2.48	0.44 (0.32–0.61)	<0.001	0.96 (0.82–1.13)	0.62
Lateral Epicondylitis	2.04	0.75	2.20	0.31 (0.23–0.42)	<0.001	0.92 (0.79–1.07)	0.29
Plantar Fasciitis	2.06	0.68	1.60	0.26 (0.17–0.39)	<0.001	0.68 (0.55–0.83)	<0.001
Post-Traumatic Knee Osteoarthritis	2.00	0.68	2.08	0.28 (0.19–0.40)	<0.001	0.82 (0.68–0.98)	0.03
Post-Traumatic Hip Osteoarthritis	1.29	0.48	1.64	0.35 (0.22–0.55)	<0.001	1.21 (0.94–1.55)	0.14
Achilles Tendon Injury ⁱⁱⁱ	1.26	0.53	1.07	0.30 (0.17–0.55)	<0.001	0.55 (0.40–0.76)	<0.001
Concussion	1.06	0.45	0.59	0.39 (0.19–0.82)	0.01	0.58 (0.36–0.93)	0.02
Muscle Strain ^{iv}	0.89	0.27	0.66	0.32 (0.19–0.55)	<0.001	0.8 (0.57–1.12)	0.19
Medial Epicondylitis	0.81	0.25	0.83	0.29 (0.15–0.54)	<0.001	0.92 (0.69–1.23)	0.59
Quadriceps and/or Patellar Injury	0.75	0.26	0.67	0.27 (0.16–0.45)	<0.001	0.73 (0.55–0.99)	0.04
Juvenile Arthritis	0.64	0.23	0.44	0.39 (0.21–0.72)	0.002	0.88 (0.58–1.32)	0.53
Acute Osteomyelitis	0.54	0.17	0.37	0.31 (0.19–0.53)	<0.001	0.72 (0.51–1.02)	0.07

Abbreviations: COVID-19, coronavirus disease 2019.

ⁱ Total sprains includes knee, ankle, hip, and shoulder sprain.

ⁱⁱ Knee sprain includes ligament tears of the knee.

ⁱⁱⁱ Achilles tendon injury includes tears.

^{iv} Muscle strains include head, abdomen, neck, and lower back.

observed trends, given the range of orthopedic diagnoses affected, the underlying trigger for the decrease in patient volumes, especially among nonurgent conditions, is likely multifactorial. First, the unprecedented implementation of social distancing measures, “stay-at-home” orders, and widespread closures of parks, gyms, schools, and other large-group activities may have decreased overall risk exposure to injury and disease, including trauma. A recent meta-analysis demonstrated reductions in trauma ranging from 20% to 85%, with decreases in road traffic collisions and trauma occurring outdoors.¹⁰ For sports-related injuries, the suspension of organized sports may help explain the significant, sustained decrease in patient volumes for soft tissue injuries such as knee sprains (including ligament tears) and Achilles tendon injuries across both the COVID-19 peak and recovery periods. Similarly, social distancing and stricter infection control may be accompanied by decreased exposure to community-acquired infections, such as *Staph Aureus*. This in turn may lead to decreased risk of seeding joints, thus helping to explain the significant reduction in patient volumes of septic arthritis across both the COVID-19 peak and recovery periods. These findings are echoed by reports showing significantly reduced emergency department admissions during the COVID-19 pandemic for non-COVID-19 air communicable diseases in comparison to other diagnoses.¹⁷

Second, CDC recommendations¹⁸ during the pandemic have encouraged limiting in-person visits for urgent conditions while delaying elective care to mitigate the spread of COVID-19. Musculoskeletal injuries were classified as “less likely” to result in patient harm if care was deferred. At the tertiary care orthopedic institution, in-person patient visits during late March and April were restricted to emergent and urgent conditions only. Though this restriction was lifted by May and the use telemedicine has burgeoned during the pandemic,¹⁹ this study still found significant decreases in patient volume across numerous orthopedic conditions during the COVID-19 recovery period, even after accounting for telemedicine visits. Third, the unprecedented surge in

unemployment in the US may account for an overall decrease in patient volumes due directly to lost health insurance.²⁰ Finally, patient behavior may be influencing the change in patient volumes during the pandemic. Patients may be delaying or declining care due to wariness of exposure to COVID-19, especially within healthcare settings. Furthermore, patients may be adapting their own self-management and lifestyle decisions in the context of social distancing.

The substantial reduction in orthopedic patient volumes during the COVID-19 pandemic, paired with the deferral of elective surgeries during the COVID-19 peak, has created a significant backlog of future orthopedic patients. A recent simulation-based study found that the US may be facing a backlog of more than 1 million total joint and spine surgery cases by 2022.²¹ With 21 out of 35 conditions reaching pre-COVID-19 levels in the COVID-19 recovery period in comparison to 8 out of 35 conditions reaching pre-COVID-19 levels in the COVID-19 peak period, the current study provides evidence for a rebound in orthopedic patient volumes. However, the sustained decrease in patient volumes of conditions such as knee osteoarthritis, joint sprains, and other soft tissue injuries may persist as long as social distancing measures are in place.

This study should be considered in the context of its limitations. First, the study’s results may not be generalizable to other settings, especially for non-academic, rural centers. Second, given the study design with no use of identifiable patient data, there was no adjustment for age, sex, race/ethnicity, comorbidities, and socioeconomic factors. Third, a potential limitation of interrupted time series analysis is the possibility that other events may occur simultaneously leading to distorted estimates of the intervention effect size. Fourth, though this study reveals a definitive reduction in hospital volumes for orthopedic conditions during the pandemic, the exact causes are still uncertain. Finally, a final limitation is our reliance upon the accurate coding of diagnoses via ICD codes.

5. Conclusion

This study identified significant reductions in the patient volumes of volumes for 1 out of 7 emergent orthopedic conditions, 4 out of 6 urgent orthopedic conditions, and 22 out of 22 urgent and nonurgent orthopedic conditions during the COVID-19 peak. In the COVID-19 recovery period, patient volumes in 2 out of 7 emergent conditions, 1 out of 6 urgent conditions, and 11 out of 22 nonurgent conditions were decreased compared to pre-COVID-19 volumes. Amid the combination of social distancing, fear of exposure to COVID-19, loss of health insurance, and widespread closures of parks, gyms, schools, and large-group activities, this study found that the pandemic was associated with considerable changes in patient patterns for non-COVID-19 orthopedic conditions. The long-term effects of patient volume reductions on both patient outcomes and orthopedic health systems remain to be seen.

Author contributions

Study concept and design: Yu, Ricci. Acquisition, analysis, or interpretation of data: All authors. Drafting of the manuscript: Yu. Critical revision of the manuscript for important intellectual content: All authors. Administrative, technical, or material support: Ricci, Dines, Carr. Study supervision: Ricci.

Ethics approval

This study was deemed exempt by the Institutional Review Boards at both Hospital for Special Surgery and Weill Cornell Medicine.

Declaration of competing interest

The authors have no conflicts of interest to declare. No author has any relevant financial interests, activities, relationships, and/or affiliations.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jcot.2021.101603>.

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