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ARTHROPLASTY

National operating volume for primary hip and knee arthroplasty in the COVID-19 era: a study utilizing the Scottish arthroplasty project dataset

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Aims

The COVID-19 pandemic led to a national suspension of "non-urgent" elective hip and knee arthroplasty. The study aims to measure the effect of the COVID-19 pandemic on total hip arthroplasty (THA) and total knee arthroplasty (TKA) volume in Scotland. Secondary objectives are to measure the success of restarting elective services and model the time required to bridge the gap left by the first period of suspension.

Methods

A retrospective observational study using the Scottish Arthroplasty Project dataset. All patients undergoing elective THAs and TKAs during the period 1 January 2008 to 31 December 2020 were included. A negative binomial regression model using historical case-volume and mid-year population estimates was built to project the future case-volume of THA and TKA in Scotland. The median monthly case volume was calculated for the period 2008 to 2019 (baseline) and compared to the actual monthly case volume for 2020. The time taken to eliminate the deficit was calculated based upon the projected monthly workload and with a potential workload between 100% to 120% of baseline.

Results

Compared to the period 2008 to 2019, primary TKA and THA volume fell by 61.1% and 53.6%, respectively. Since restarting elective services, Scottish hospitals have achieved approximately 40% to 50% of baseline monthly activity. With no changes in current workload, by 2021 there would be a reduction of 9,180 and 10,170 for THA and TKA, respectively. Conversely, working at 120% baseline monthly output, it would take over four years to eliminate the deficit for both TKA and THA.

Conclusion

This national study demonstrates the significant impact that COVID-19 pandemic has had on overall THA and TKA volume. In the six months after resuming elective services, Scottish hospitals averaged less than 50% normal monthly output. Loss of operating capacity will increase treatment delays and likely worsen overall morbidity.

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Keywords: Arthroplasty, COVID-19, Elective Operating

Introduction

On 11 March 2020, the World Health Organization (WHO) defined the SARS-CoV-19 infection outbreak as a global pandemic.[1] In the UK, an exponential rise in cases and associated increases in hospital admissions provoked fears that the health service would quickly be overwhelmed. By 17 March 2020, the Scottish Government decided to suspend all "non-urgent" elective surgery as part of a rapid reconfiguration of hospitals to double critical care capacity and substantially increase overall bed numbers.[2] On 19 June 2020 (94 days later), Scottish hospitals began a phased resumption of elective operating based upon the "Re-Mobilize, Recover, Redesign" strategy for exiting lockdown.[3]

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Table I. Total hip arthroplasty and total knee arthroplasty volume in Scotland in 2008 to 2019 versus 2020.

Volume	2008 to 2019, median (IQR)	2020, median (IQR)
THA annual	7,679 (7182 to 7,788)	3,566
THA monthly	623.5 (581 to 667)	301 (129 to 438)
TKA annual	7,242 (6,808 to 7,576)	2,820
TKA monthly	601 (554 to 653)	188 (44 to 370)

IQR, interquartile range; THA, total hip arthroplasty; TKA, total knee arthroplasty.

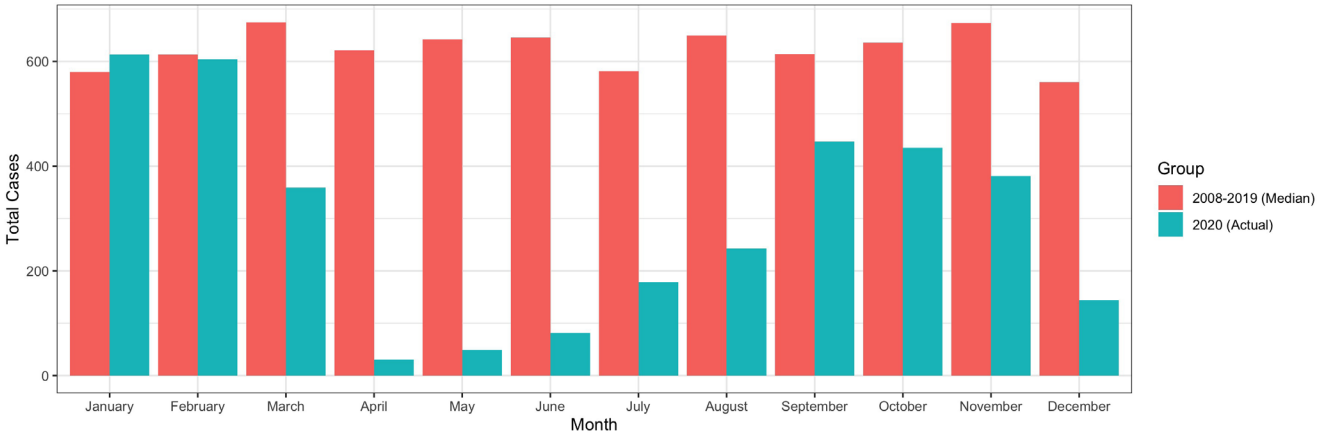

Fig. 1
Monthly total hip arthroplasty volume.

The Scottish Government defined "non-urgent" elective activity as procedures for non-life-threatening conditions and whose cancellation would have "negative clinical impact".[4] Using this definition, non-trauma orthopaedic surgery, including primary hip and knee arthroplasty, were considered to be "non-urgent" elective procedures.

A second wave of the COVID-19 pandemic[5,6] during the winter of 2020, a period which traditionally has high levels of bed occupancy,[7] has placed significant pressures on healthcare services. Many health boards have taken the difficult decision to further suspend non-urgent elective surgeries, leading to increased waiting times and prolonging patient suffering.[8]

The primary aim of this study is to the measure the effect of the COVID-19 pandemic on THA and TKA volume in Scotland. Secondary objectives are to measure the success of restarting elective services and model the time required to bridge the gap left by the suspension of elective orthopaedic operating.

Methods

This study utilized the Scottish Arthroplasty Project (SAP) dataset to determine the effect of COVID-19 pandemic on primary hip and knee arthroplasty volume. The SAP is a national audit which monitors the outcome of all arthroplasty procedures undertaken in all NHS and independent-sector hospitals. The SAP's process of continuous audit, quality improvement, and identification of outliers has been previously described.[9] Access to the SAP dataset for this study was approved by the SAP Steering Committee.

The SAP receives data from two routinely-collected administrative datasets - the Scottish Morbidity Record (SMR) 01 and the National Records of Scotland NHS Central Register of Deaths. SMR01 data is collected by local coding teams and submitted to the Information Services Division (ISD) of NHS Public Health Scotland. Data linkage is performed via a unique identifier given to every person living in Scotland – the community health index (CHI).

The SAP dataset was used to identify the number of primary TKA and THA procedures undertaken in Scotland during the period 2008 to 2019. We did not include THA cases undertaken for neck of femur fractures. The median monthly case volume from this period was used as a benchmark and compared against real-time monthly data for 2020 up to the last extract (31 December 2020). The total deficit and percentage total deficit for the two time periods was calculated.

The change in operating volume was used as an indirect measure of increasing waiting list size, with the assumption that case numbers would continue to grow. A negative binomial regression model was developed using historical case volume (including patient age and sex) and mid-year population estimates for Scotland (historical and projected).[10] A separate model was created for THA and TKA, with case-volume estimates (with 95% confidence intervals (CIs)) projected

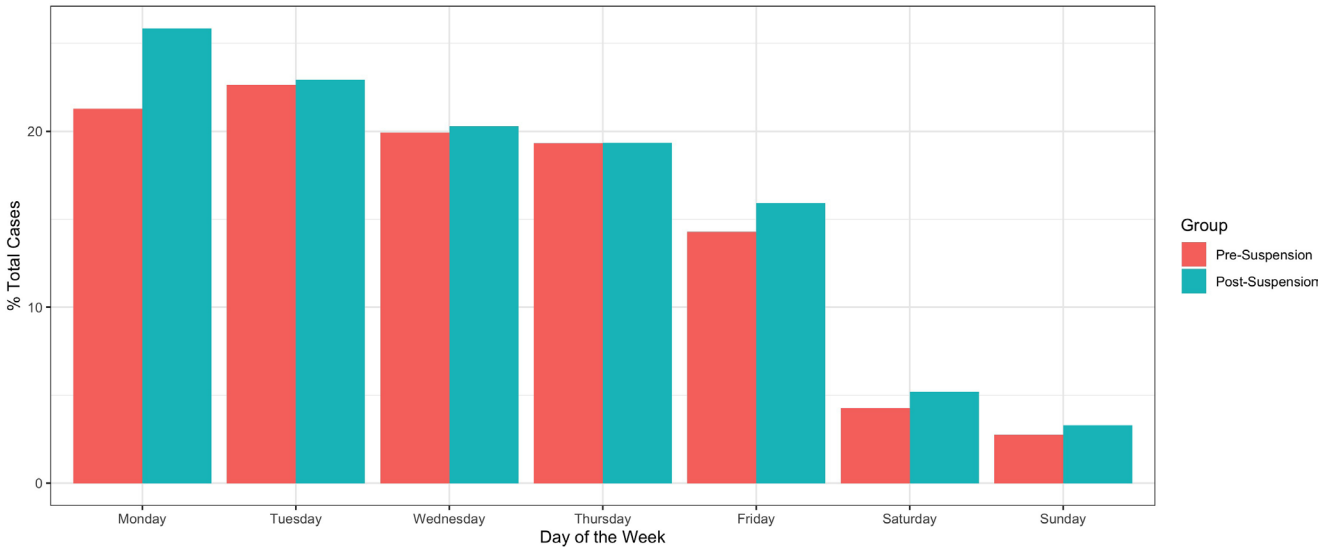

Fig. 2

Comparison of total hip arthroplasty volume by day of the week.

Table II. Total hip arthroplasty and total knee arthroplasty patient demographics in Scotland (pre- and post-suspension (first save).

Variable	Pre-suspension, n (%)	Post-suspension, n (%)	p-value
THA			
Sex			
Female	932 (60.2)	423 (61.5)	0.589*
Male	617 (39.8)	265 (38.5)	
Median (IQR)	68 (60 to 75)	67 (59 to 75)	0.323†
Age, yrs			
< 50	112 (7.2)	61 (8.9)	0.072*
50 to 59	302 (19.5)	135 (19.5)	
60 to 69	496 (32.0)	227 (33.0)	
70 to 79	487 (31.4)	181 (26.3)	
> 80	152 (9.8)	84 (12.2)	
TKA			
Sex			
Female	866 (54.2)	164 (54.2)	0.817*
Male	733 (45.8)	144 (46.8)	
Median (IQR)	69 (62 to 75)	67 (61 to 73)	0.001†
Age, yrs			
< 50	46 (2.9)	17 (5.5)	0.010*
50 to 59	242 (15.1)	50 (16.2)	
60 to 69	595 (37.2)	131 (42.5)	
70 to 79	563 (35.2)	91 (29.5)	
> 80	153 (9.6)	19 (6.2)	

*Chi-squared test.
†Mann-Whitney U test.

up to 2030. The effect of reduced and increased workloads was then modelled to project the time required to clear the estimated deficit of cases.

The Scottish government is currently aiming to have vaccinated all priority patients identified by the Joint Committee on Vaccination and Immunisation (JCVI) by May 2021, and to have offered vaccination to the entire adult population by autumn 2021.[11] Therefore, we estimated that a return to full national operating volume would not be achievable until August 2021. The estimated loss in operating volume was therefore based on the assumption that national arthroplasty output would remain consistent with the current level of post-pandemic recovery from 1 January 2021 to 31 July 2021. After 1 August 2021, we then hypothesized that the projected monthly case volume would increase to 100% to 120% of 'normal' workload.

All data was analyzed in R Studio (version 1.3.959, Integrated Development for R Studio, USA) using the Tidyverse[12] suite of packages. Depending on the distribution of data, descriptive statistics are reported as the mean (with standard deviation (SD) or median (with interquartile range (IQR)). Differences between continuous variables were measured using the Student's *t*-test or Mann-Whitney U test. Categorical variables were assessed using the chi squared test. A p-value < 0.05 was considered statistically significant.

Results

Primary total hip arthroplasty. From 2008 to 2019, 90,017 primary THA procedures were performed in Scotland, and the annual number of primary THA increased by 17.9% (6,770 in 2008 vs 7,982 in 2019). Comparing the period 2008 to 2019 to 2020, the median monthly volume of THA fell by 51.7% (624 (IQR 581 to 667)) in 2008 to 2019 vs 301 (IQR 129 to 438) in 2030 (p < 0.001, Mann-Whitney U test) (Table I and Figure 1). The majority of cases (> 90%) were performed Monday to Friday, with no change in distribution once services restarted (Figure 2). There were no differences in the

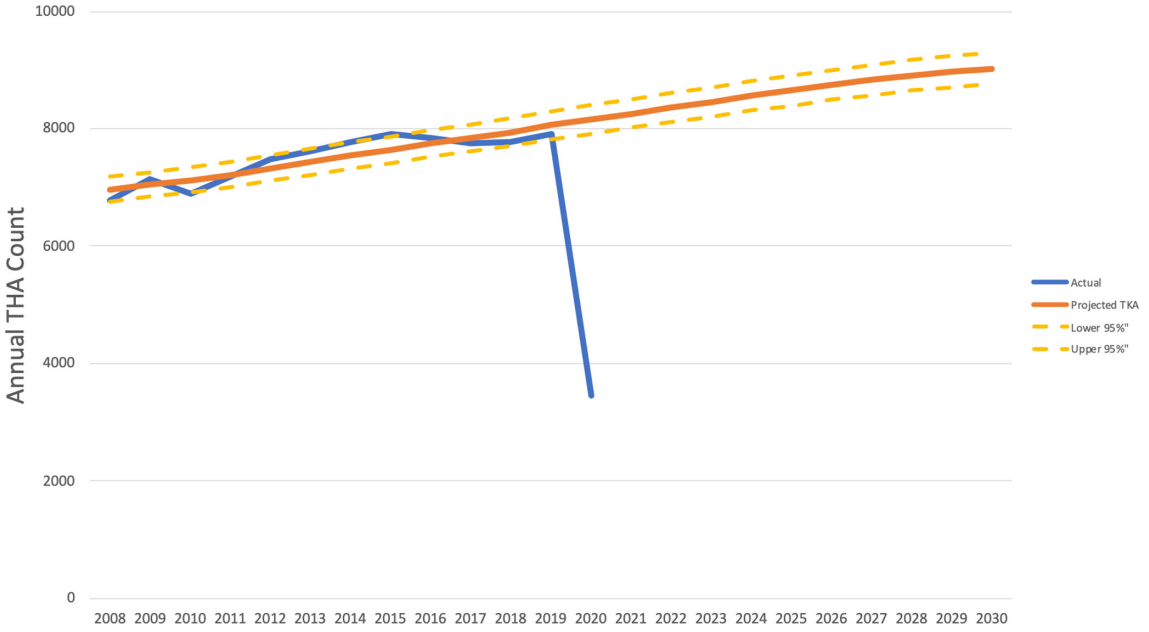

Fig. 3

Projected versus actual annual total hip arthroplatst volume in Scotland from 2008 to 2030.

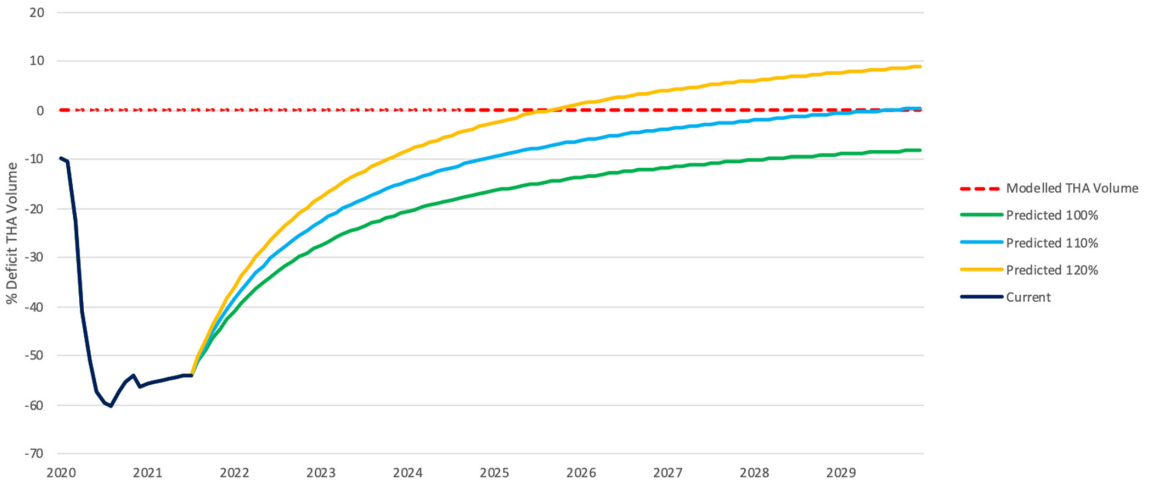

Fig. 4

Percentage deficit of total hip arthroplasty volume from January 2020 to January 2030.

age or sex distributions of patients treated after the first wave of COVID-19 (Table II).

The model projected that annual volume of primary THA would rise by 10.7% over the period 2020 to 2030 (8,156 (95% CI 7,919 to 8,401) in 2020 vs 9,027 (95% CI 8,764 to 9,298) in 2030) (Figure 3). Assuming no change in the current levels of activity, the net loss in overall productivity for primary THA was projected to be 9,180 (-55.9%) by the end of 2021. Conversely, if Scottish hospitals were able to increase their overall elective THA output to 120% of 'normal' activity, it would take over four years (55 months) to achieve parity with the pre-COVID-19 era (Figure 4). For every extra month working at the current level, it would take an additional three to four months working at 120% to reduce the deficit.

Primary total knee arthroplasty. From 2008 to 2019, 86,357 primary TKA procedures were performed in Scotland and the annual volume increased by 23.6% (6,254 in 2008 vs 7,733 in 2019). Comparing the period 2008 to 2019 to 2020, the median monthly volume of TKA fell by 68.8% (601 (IQR 554 to 653) in 2008 to 2019 vs 188 (IQR 44 to 370) in 2020 ($p < 0.001$, Mann-Whitney U test) (Table I) (Figure 5). The majority of cases (> 90%) were performed Monday to Friday, with no change in distribution once services restarted (Figure 6). Patients treated after the first wave of

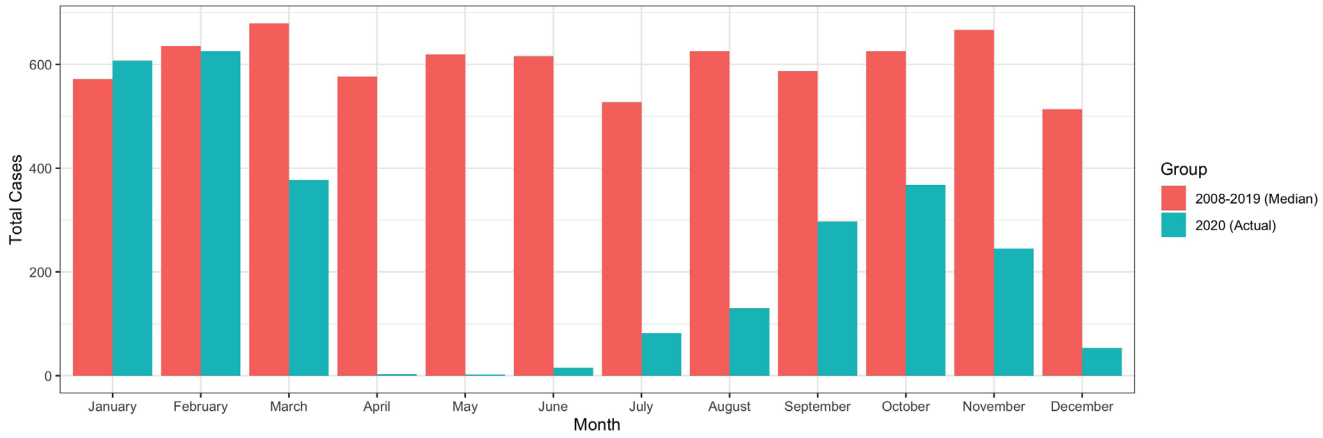

Fig. 5

Monthly total knee arthroplasty volume.

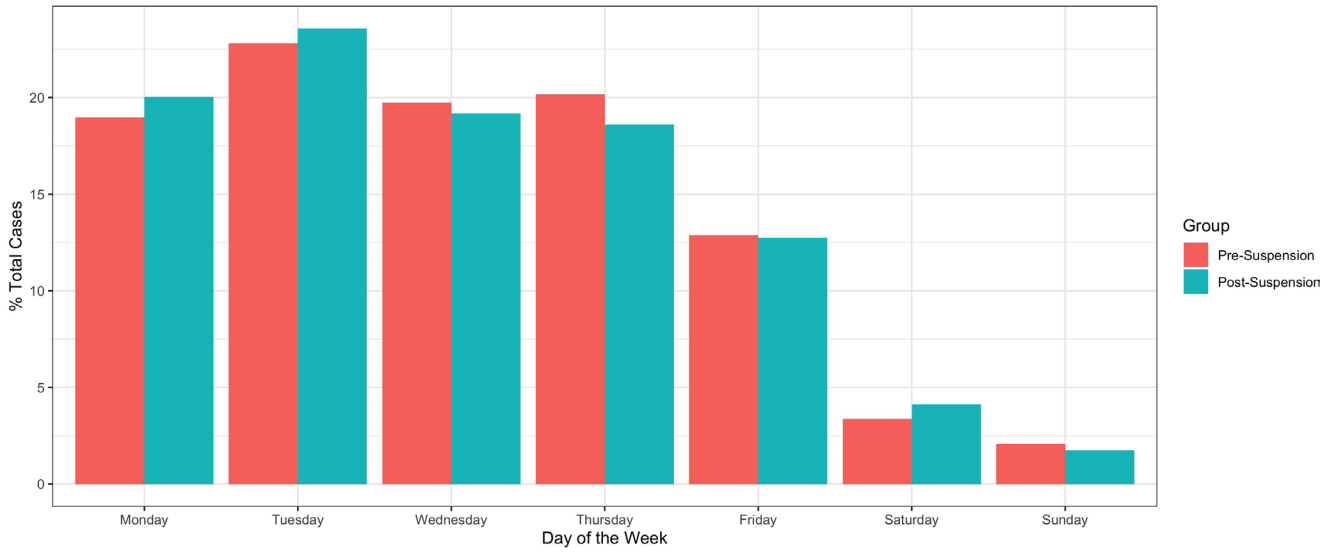

Fig. 6

Comparison of total knee arthroplasty volume by day of the week.

COVID-19 were younger, but there were no sex differences noted (Table II).

The model projected that annual volume of primary TKA would rise by 11.4% over the period 2020 to 2030 (7,905 (95% CI 7,609 to 8,214) in 2020 vs 8,806 (95% CI 8,476 to 9,150) in 2030) (Figure 7). Assuming the current level of elective TKA activity is maintained, the net loss in overall volume of primary TKA was projected to be 10,170 (-63.9%) by the end of 2021. However, if Scottish hospitals were able to increase their overall elective TKA output to 120% of 'normal' activity, it would take until December 2025 (60 months) to get back to baseline (Figure 8). For every extra month working at the current level, it would take an additional four to five months working at 120% to reduce the deficit.

Discussion

As expected, the national suspension of elective operating in Scotland during the COVID-19 pandemic significantly reduced the overall number of procedures performed in 2020 by 53.6% for hip arthroplasty; and by 61.1% for knee arthroplasty (Table I). However, it is concerning that national hip and knee arthroplasty volume has only averaged around 40% to 50% of normal since services restarted. While these numbers are not a direct reflection of patients awaiting surgery, reduced operating capacity will result in delays to treatment.

End-stage symptomatic arthritis is not a benign condition.[13] Patients can suffer mentally, physically, and may struggle to return to work.[14] Under normal circumstances, 12% to 19% of patients awaiting THA

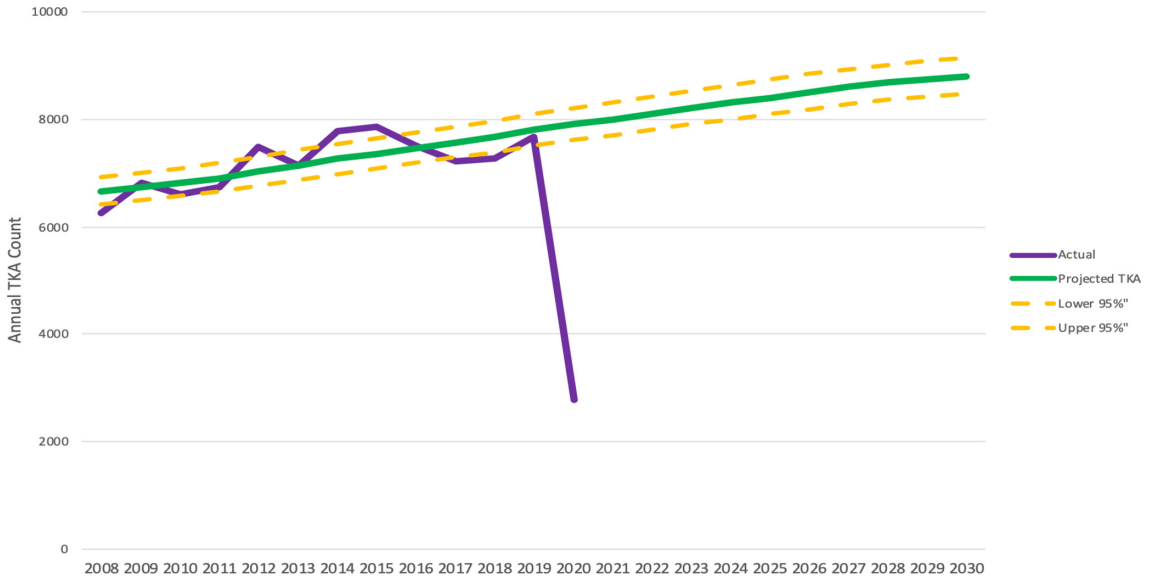

Fig. 7

Projected versus actual annual total knee arthroplasty volume in Scotland from 2008 to 2030.

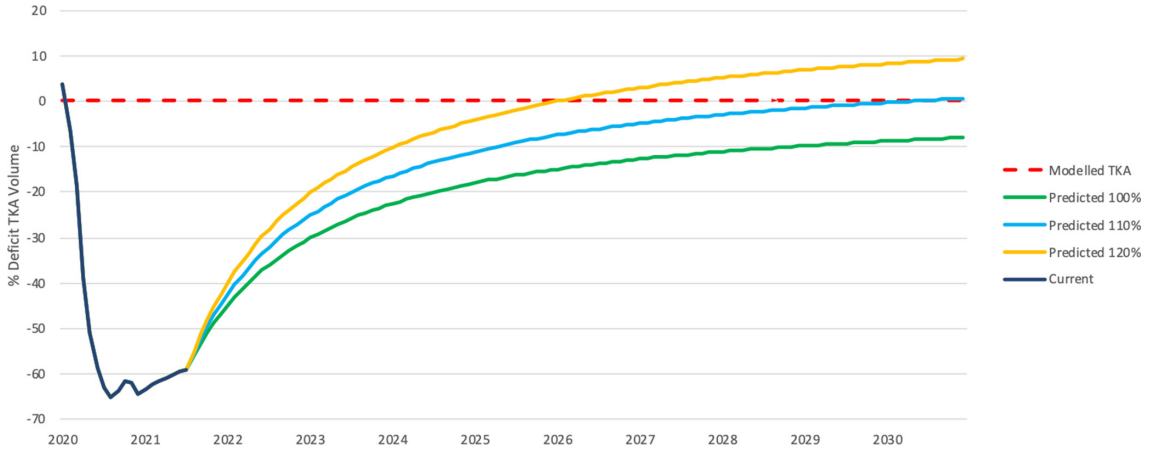

Fig. 8

Percentage deficit of total knee arthroplasty volume from 2020 to 2030.

and TKA, are defined as living in a health state "worse than death" according to the EuroQol five-level dimension (EQ-5D).[15] During the pandemic this has doubled and currently 35% of patients awaiting THA and 22% awaiting knee arthroplasty are in a "worse than death" health state.[16] Suspending all elective operating risks harm to a large group of patients who are already suffering and should only be used as a last resort.

The current study projected several scenarios regarding national elective operating, including the possibility of no improvement in the current level of capacity. Our estimates are deliberately simplistic and may be too pessimistic or optimistic, depending on changes to workforce planning and the availability of a working vaccine. In the best-case scenario, it would take over four years to break even and would require Scottish hospitals to work at 120% of normal activity levels from first August 2021. Given that the average hospital bed occupancy for Trauma and Orthopaedics in Scotland was 85.2% during the period 2018 to 2019 (62.4 to 100),[17] this is unlikely to be feasible without significant investment.

Positive COVID-19 status is associated with significantly increased complications, longer duration of hospital stay, and greater risk of perioperative mortality.[18,19] In frail and elderly patients with multiple comorbidities, COVID-19 infection conveys a significantly higher risk of perioperative mortality following orthopaedic surgery.[20-22] However, during the first wave of the pandemic in the UK and prior to preoperative patient screening or precautions, the overall rate of postoperative COVID-19 infection following elective

hip and knee arthroplasty was 0.5%.[23] Adopting a 'COVID-19-free' or 'green' pathway has since shown promise in providing elective services in a safe and efficient manner.[24-26]

Since restarting "elective" surgeries, the working patterns for hospitals undertaking THA and TKA appear relatively unchanged. The majority of THA and TKA cases are performed Monday to Friday, suggesting potential utilization of weekend operating lists. However, COVID-19-free sites and changes to weekly working patterns require workforce planning, reorganization of theatre resources, and ultimately, significant financial investment.

A recent study using data from the National Joint Registry estimated that the waiting list in England had increased by three times the pre-COVID-19 average and would cost approximately £198,811,335 to clear.[27] It was not possible to correlate the loss in operating volume to the number of patients currently on the waiting list for THA or TKA in Scotland. It has been hypothesized that patients may choose to delay, or even permanently postpone, elective arthroplasty during a global pandemic. However, Clement et al[28] demonstrated that by September 2020, the majority of patients wished to proceed with their elective orthopaedic surgery. Uncertainty regarding the numbers of patients waiting for surgery may underestimate the true scale of the problem facing elective orthopaedics in Scotland.

A limitation of the current study is that we did not evaluate whether the comorbidity profile of patients undergoing arthroplasty differed pre- and post-pandemic. While we identified no differences in the age and sex distribution in patients undergoing THA, there was a trend towards treating younger patients in the TKA cohort. It was not possible to conclusively identify the reasons for this difference. This may simply reflect the increasing number of young patients undergoing TKA surgery in Scotland or could potentially relate to selection issues related to risks of the procedure. Although this trend should be interpreted with caution, this is clearly an area that requires ongoing monitoring. National registries will be well placed to assess the patient, surgeon, and system factors likely to influence elective arthroplasty output in the COVID-19 era.[29]

This national study demonstrates the effect of the COVID-19 pandemic on THA and TKA volume in Scotland. We believe these findings provide a realistic overview of how successful Scotland has been in restarting elective orthopaedic activity during the first and second waves. Since restarting, monthly operating volume for THA and TKA was close to 40% to 50% of normal. If it is possible to increase operating volume to 120% of normal, it would still take over four years to return to pre-pandemic levels. Further suspensions of elective operating should only be considered as a last resort.

Take home message

- The COVID-19 pandemic has led to a significant reduction in annual total hip arthroplasty (THA) and total knee arthroplasty (TKA) volume in Scotland.
- Since restarting elective operating, median monthly volume for THA and TKA was reduced by 40% to 50%, respectively.
- If hospitals could increase the monthly operating volume to 120% of normal, it would still take over four years to reduce the deficit in national operating volume.

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Author contributions:
- L. Z/ Yapp: Conceptualized and designed the study, Undertook data analysis and interpretation, Prepared and revised the manuscript.
- J. V. Clarke: Interpreted the data, Reviewed and revised the manuscript.
- M. Moran: Concept, Data interpretation, Manuscript review and revision.
- A. H. R. W. Simpson: Interpreted the data, Reviewed and revised the manuscript.
- C. E. H. Scott: Conceptualized and designed the study, Undertook data analysis and interpretation, Reviewed and revised the manuscript.

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