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Citation: Oussedik, Sam, MacIntyre, Sam, Gray, Joanne, McMeekin, Peter, Clement, Nick D. and Deehan, David J. (2021) Elective orthopaedic cancellations due to the COVID-19 pandemic: where are we now, and where are we heading? Bone & Joint Open, 2 (2). pp. 103-110. ISSN 2633-1462

Published by: British Editorial Society of Bone and Joint Surgery

URL: <https://doi.org/10.1302/2633-1462.22.bjo-2020-0161...> <<https://doi.org/10.1302/2633-1462.22.bjo-2020-0161.r1>>

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■ GENERAL ORTHOPAEDICS

Elective orthopaedic cancellations due to the COVID-19 pandemic: where are we now, and where are we heading?

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Aims

The primary aim is to estimate the current and potential number of patients on NHS England orthopaedic elective waiting lists by November 2020. The secondary aims are to model recovery strategies; review the deficit of hip and knee arthroplasty from National Joint Registry (NJR) data; and assess the cost of returning to pre-COVID-19 waiting list numbers.

Methods

A model of referral, waiting list, and eventual surgery was created and calibrated using historical data from NHS England (April 2017 to March 2020) and was used to investigate the possible consequences of unmet demand resulting from fewer patients entering the treatment pathway and recovery strategies. NJR data were used to estimate the deficit of hip and knee arthroplasty by August 2020 and NHS tariff costs were used to calculate the financial burden.

Results

By November 2020, the elective waiting list in England is predicted to be between 885,286 and 1,028,733. If reduced hospital capacity is factored into the model, returning to full capacity by November, the waiting list could be as large as 1.4 million. With a 30% increase in productivity, it would take 20 months if there was no hidden burden of unreferred patients, and 48 months if there was a hidden burden, to return to pre-COVID-19 waiting list numbers. By August 2020, the estimated deficits of hip and knee arthroplasties from NJR data were 18,298 (44.8%) and 16,567 (38.6%), respectively, compared to the same time period in 2019. The cost to clear this black log would be £198,811,335.

Conclusion

There will be up to 1.4 million patients on elective orthopaedic waiting lists in England by November 2020, approximate three-times the pre-COVID-19 average. There are various strategies for recovery to return to pre-COVID-19 waiting list numbers reliant on increasing capacity, but these have substantial cost implications.

Cite this article: *Bone Jt Open* 2021;2-2:103–110.

Keywords: COVID-19, arthroplasty, economics, health policy

Introduction

The reorganization of hospital facilities to meet the COVID-19 challenge has necessitated the cessation of routine elective orthopaedic surgery as resources are diverted to the frontline response.^{1,2} This mobilization of healthcare professionals and equipment avoided the dreaded scenario of the NHS becoming overwhelmed by COVID-19 cases, but this came at a cost borne by patients whose routine, yet necessary, elective procedures were deferred.³ In addition to those

already on waiting lists seeing their admission date put back, an increasing number of patients were failing to clear the first hurdle towards receiving definitive care by the reduction in access to primary care physicians. This 'silent' waiting list of patients awaits a resumption of normal referral pathways before being entered or considered eligible to be placed onto elective waiting lists.

There has been a gradual return of elective orthopaedic services as the peak of

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doi: 10.1302/2633-1462.22.BJO-
2020-0161.R1

Bone Jt Open 2021;2-2:103–110.

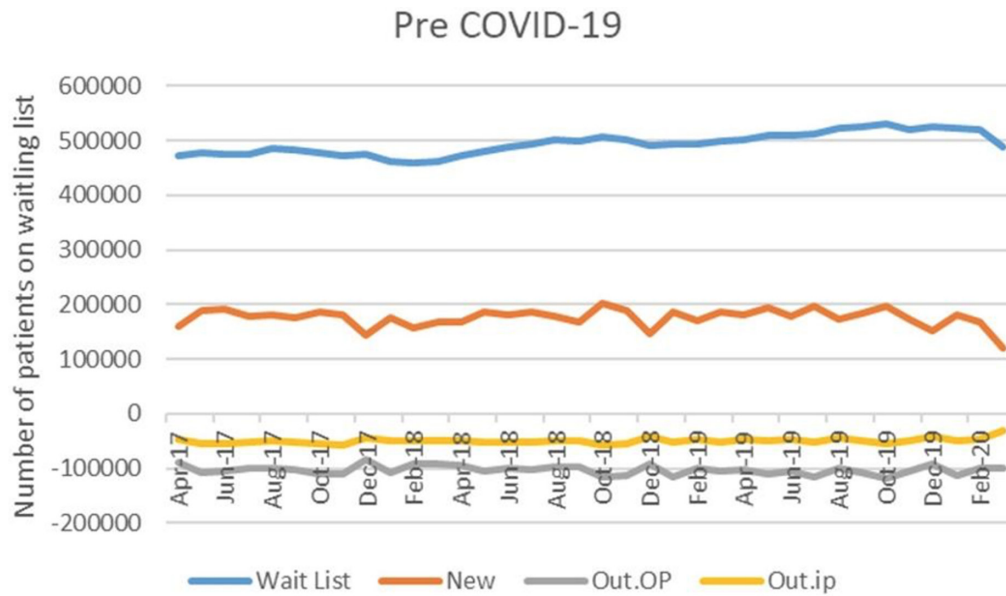


Fig. 1

Number of patients on elective trauma and orthopaedic waiting lists due to prior to the COVID-19 pandemic (March 2019).

Table I. The predicted and actual number of patients on trauma and orthopaedic elective waiting lists according to the month. The difference related to that predicted by the model and the actual number of patients on the waiting list.

Number of patients on waiting list	May 2020, n	June 2020, n	July 2020, n	August 2020, n
Predicted	475,610	481,064	488,368	513,633
Actual	460,595	456,108	473,996	521,400
Difference	15,015	24,956	14,372	7,767

COVID-19 pandemic has begun to fall.^{4,5} There is guidance for which patients should go forward with surgery (i.e. those with the least potential risk of dying from COVID-19 should they contract it postoperatively), and measures that should be in place to reduce the risk of contracting COVID-19 in hospital.⁶ There are specific patient screening pathways to be followed.⁷ However, the capacity to deliver elective procedures continues to be constrained by the precautions necessary to do so in a safe setting.^{8,9}

Planning elective surgery for the COVID-19 era requires a detailed appraisal of the amount of work waiting to be done; the likely rate of increase in the number of patients requiring surgery as services unlock; the increase in waiting times during the period of reduced activity; the resources necessary to bring waiting times back in line with the pre-COVID-19 performance. Previous work conducted by the COVIDSurg group estimated an 82% global cancellation rate during the peak 12 weeks of the COVID-19 pandemic.³ The cost of clearing this backlog in the UK was estimated at £2 billion, although this may underestimate the rate of cancellation in the UK where

Table II. Predicted number of patients on trauma and orthopaedic elective waiting lists according to the scenario and month.

Month (2020)	Waiting list scenario, n (95% confidence interval)		
	Hidden demand occurred	Hidden demand occurred with decreased capacity	Hidden demand occurred at 70%
August	700,646 (664,002 to 737,288)	750,431 (703,076 to 797,786)	689,876 (654,430 to 725,321)
	824,706 (782,569 to 866,842)	892,595 (839,169 to 946,023)	791,067 (752,420 to 830,713)
September	951,973 (905,841 to 998,104)	1,028,733 (973,502 to 1,084,864)	885,286 (844,233 to 926,338)
October			

a complete shutdown was seen in many hospitals.³ Furthermore, the COVIDSurg group assumed immediate return to 100% capacity after the 12-week period, which is currently not the case in elective orthopaedics.³

Knowledge of the current and accumulating backlog of elective hip and knee arthroplasty is an essential part of planning the recovery of services and return to pre-COVID-19 waiting times.² These questions will be of relevance to all surgical specialities. Hip and knee arthroplasty procedures have previously shown stable levels of demand with predictable rates of increase.¹⁰ As such, and as the data for these common procedures are readily available in a reliable form, they were selected to model the work necessary to bring the provision of elective surgery back in line with pre-COVID-19 performance.

The primary aim of this study was to estimate the current and potential number of patients on trauma and

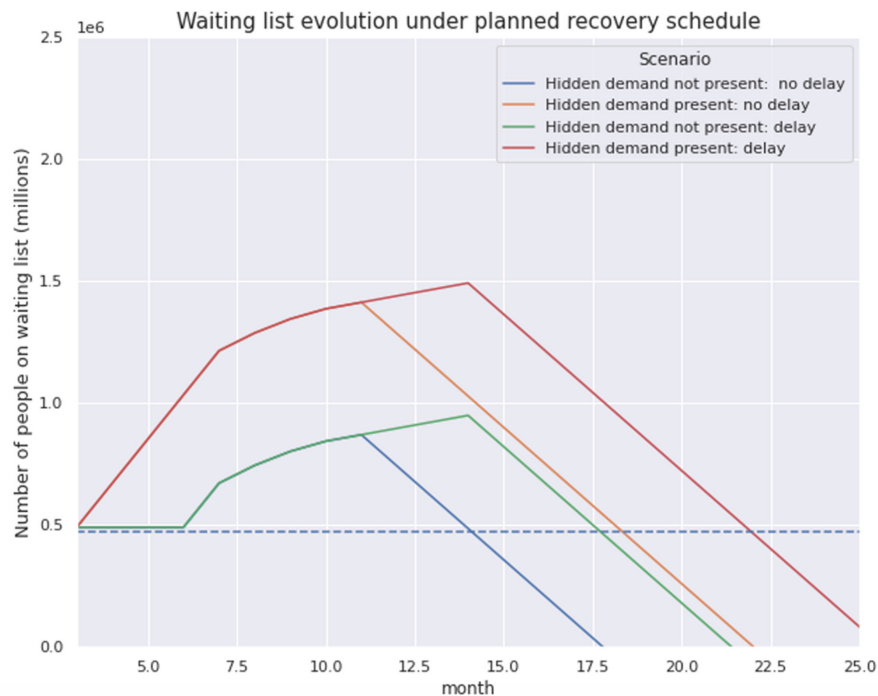


Fig. 2

Number of patients on elective trauma and orthopaedic waiting lists accounting for decreased capacity (August 70%, September 80%, October 90%) and return to full capacity by November 2020 (month 11: peak of the blue lines). The effect of the potential hidden demand (orange line) is also illustrated, and if there was a three-month delay in returning to 100% capacity (green and red lines) were also assessed.

orthopaedic elective waiting lists by November 2020. The secondary aims were to model recovery strategies, review the deficit of hip and knee arthroplasty, and assess the associated financial costs of recovery.

Methods

A model of the non-emergency orthopaedic trauma pathway was developed using the Python programming language to estimate the consequences of COVID-19 on patients referred for, or requiring, knee and hip arthroplasty. The model represents the pathway as a dynamic system, where patients are referred for treatment and spend time on a waiting list before being treated if they require surgery. The model allowed changes in either inflow (referrals) or outflow (eventual treatments) to be represented as effects on waiting list sizes and/or times while holding the proportion of patients referred who are suitable for surgery constant. The model incorporated seasonal differences in referrals and procedures:

$$B_{t+1} = B_t + \left(\frac{A_t}{\partial't} - \frac{O_t}{\partial''t} \right)$$

where B_t is the waiting list at time t , A_t are referrals at time t , O_t are procedures carried out at time t , and $\partial't$ and $\partial''t$ are constants that vary seasonally, taking 2019 values are best estimates of pre-COVID-19 seasonal variation.

In order to facilitate comparisons with previous time periods, the productivity coefficient (PC) was incorporated into the model: A PC of one represents a system in a

state where patients progress along the pathway at historically average rates, assuming a constant rate of referrals and treatment capacity. A PC of 0.5 represents a doubling of the time on the waiting list, and a PC coefficient of 2 represents a halving of time on the list; assuming inflows and treatment capacity are comparable. The model was calibrated using referrals to treatment (RTT) historic NHS waiting list data from England for 2019, matched by month and numbers of procedures in 2019 were used as a measure of treatment capacity.¹¹

In order to model the unrealized/hidden demand's effect of waiting lists, 2019 figures for May, June, and July were added to the April 2020 list and to the overall list estimated for December 2020. To model the implications of the plans to return to a normal PC by November, the increased size of the waiting list in December 2020 was estimated based on the waiting list at April 2020. Finally, to estimate the resources, in terms of PC, required to return the waiting list to the levels expected pre-COVID-19 we estimated the months required to return to trend on varying PCs.

The model was developed using data from April 2017 to March 2020 (separated into three time periods), using the number of new referrals, and number of in and outpatient treatments (Figure 1), which demonstrated high reliability with a R^2 of 0.977. The model was a good fit with minimal over projection (1.5%) for August 2020 (Table I).

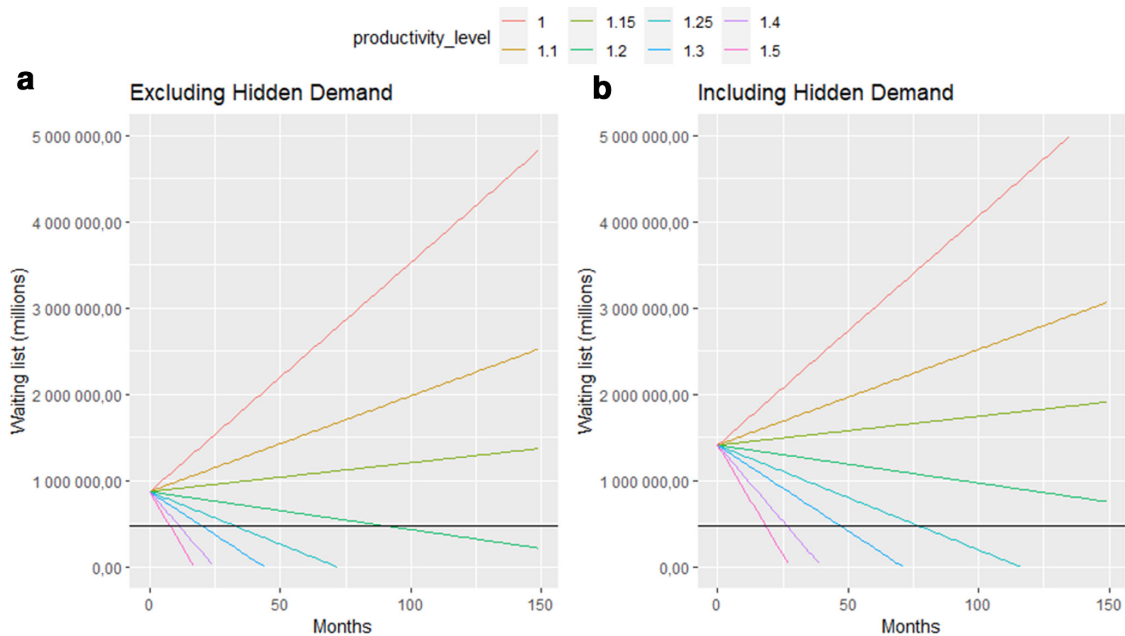


Fig. 3

Number of patients on elective trauma and orthopaedic (T&O) waiting lists according to level of productivity and time for no hidden demand (a) and a hidden demand (b). The baseline waiting list number at time zero was taken from the estimated burden of patients by November 2020 excluding hidden demand (0.8 million) and including hidden demand (1.4 million).

The number of elective total hip and knee arthroplasties performed for 2019 and 2020, up to August) were obtained from the National Joint Registry (NJR) of England, Wales, and Northern Ireland.¹² This enabled a comparison of the number of arthroplasties that were performed in 2019 and 2020, to allow the deficit of procedures due to diminished capacity due to the COVID-19 pandemic. The National NHS tariff costs for hip (HB12B and HB12C) and knee (HB21B and HB21C) arthroplasty were used assign the cost for the estimated deficit in these procedures compared to same time period the year previously (January to August 2019) and the cost of increasing productivity to facilitate return to pre-COVID-19 waiting list numbers.¹³ The cost for total hip arthroplasty was defined as £5,517, and £5,907 for total knee arthroplasty, which assumed 50% of the patients had a comorbidity that inflated the cost from baseline.

Results

Primary aim: predicted T&O waiting listing burden by November 2020. By November 2020, the orthopaedic elective waiting list in England was predicted to be at least 885,286 and at most 1,028,733, which was dependant on the case scenario of the hidden demand of patients that may present after the first wave of the COVID-19 pandemic (Table II). Whatever scenario was used it remained approximately double the size of the pre-COVID-19 waiting list. If reduced hospital capacity was also factored into the model for August (70%), September (80%), October (90%) with

return to full capacity (100%) by November, the number of patients on the waiting list could range from 0.8 million, if there was no hidden burden, to 1.4 million if there was a hidden burden (Figure 2). However, if there was a delay in returning to full capacity (to meet the demand) the number of patients waiting will increase and recovery to pre-COVID-19 waiting list numbers will take longer (Figure 2). If a delay in returning to full capacity of three months was modelled, from November 2020 to February 2020, this resulted in a four-month delay in return to pre-COVID-19 waiting list numbers, due to the accrued increase in patients during those three months (Figure 2).

Secondary aims: recovery strategies. Time to recovery was directly proportional to the level of productivity and the number of patients on the waiting list, which was also dependent upon whether the hidden burden was accounted for or not (Figure 3). If the level of productivity were increased by 30%, it would take 20 months and 48 months to return to pre-COVID-19 waiting list numbers if there was no hidden burden and with a hidden burden of patients, respectively.

Secondary aims: deficit of hip and knee arthroplasty and the associated financial costs of recovery. By August 2020, the estimated deficits in hip and knee arthroplasties performed in 2020 compared to those performed January to August 2019 were 18,298 and 16,567, respectively. This represented a 44.8% fall in hip arthroplasty and 38.6% fall in knee arthroplasty compared to that same time period in 2019 (Figure 4).

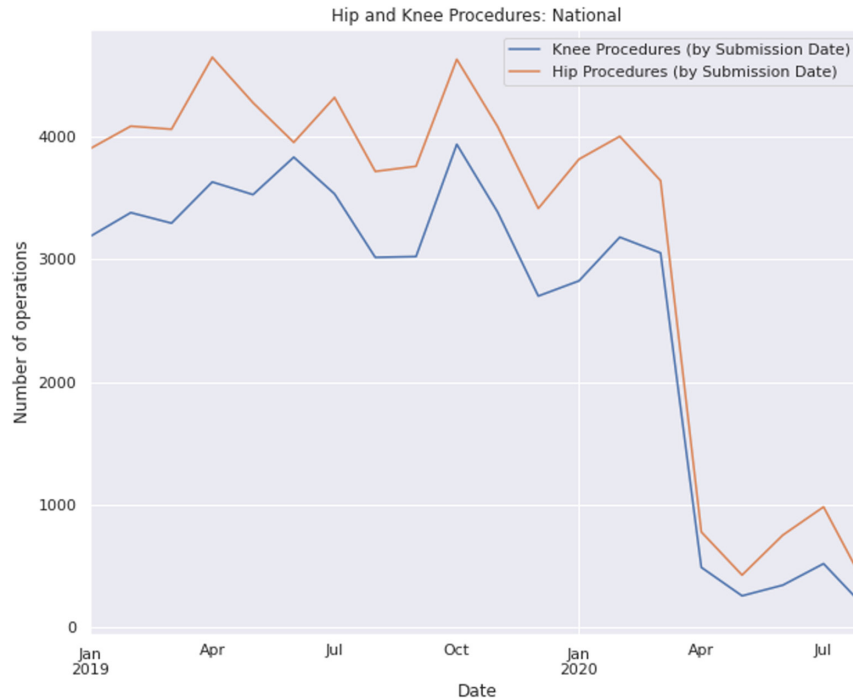


Fig. 4

Number of hip and knee arthroplasty performed per month registered on the National Joint Registry.

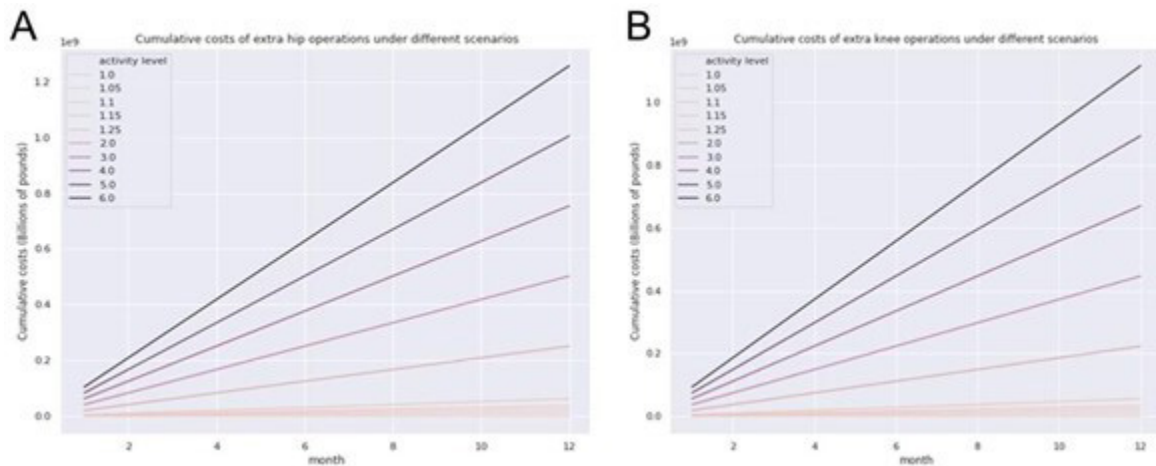


Fig. 5

Cumulative costs of increasing the capacity of hip (A) and knee (B) arthroplasty according to the required level of activity and time using tariff data without any capital expenditure.

Using the NHS tariff cost for hip and knee arthroplasty, the cost to clear this black log alone would be £100,950,066 and £97,861,269, respectively. However, the cost may be far greater if capacity remained reduced and the number of patients waiting for their hip and knee arthroplasty increased. Increasing the productivity level to address this backlog is directly proportional to the incurred costs to undertake this (Figure 5). For example, working at an increase capacity of 30% compared to normal would cost approximately £200,000,000 to

perform these additional hip and knee arthroplasties per year or £16,000,000 per month.

Discussion

This study has demonstrated that by November 2020 the orthopaedic elective waiting list in England was predicted to be at least 885,286 and at most 1,028,733. If reduced hospital capacity were also factored into the model, with return to full capacity by November, the number of patients on the waiting list would be as high

as 1.4 million. If the level of productivity were increased by 30% compared to normal it would take 20 months if there was no hidden burden, and 46 months if there was, to return to pre-COVID-19 waiting list numbers. By August 2020, the estimated deficits in hip and knee arthroplasties in England, Wales, Northern Ireland, the Isle of Man, and the Channel Islands from NJR data were 18,298 (44.8%) and 16,567 (38.6%), respectively. The cost to clear this black log alone would be £100,950,066 and £97,861,269, respectively, but this does not account for the decreased capacity from August to November. Increasing the productivity level of hip and knee arthroplasty by 30% compared to normal would cost the NHS approximately £16,000,000 per month.

The major limitations of the current study are the assumptions made in predicting the burden of patients on the waiting list and for those waiting for a hip or knee arthroplasty. There will be a proportion of patients who will die while waiting or may choose to opt for private treatment due to the prolonged waiting times which would decrease the estimated burden of patients waiting presented in the current study. In contrast, there are factors that may result in an increased number of patients on the waiting list that were not included such as winter bed pressures, further waves of COVID-19 with cessation of elective services, and prolonged (beyond November 2020) reduced hospital capacity due to adherence to the new patient pathways.⁴ A further limitation of the current study is that only the backlog of hip and knee arthroplasty procedures and cost of addressing this were assessed. These procedures were chosen as they were thought to be representative, common elective orthopaedic procedures.¹⁰ These data also cover a different, larger geographical territory to the NHS England figures used for the activity modelling.

There is a further assumption that the proportion of referred patients who go on to receive surgery will remain constant, at around 50%. It is possible that the extra delay in referral, induced by difficulties in accessing hospital care during the pandemic, may lead to worse disease states by the time patients are assessed, with a greater proportion requiring surgical intervention.

This study offers the best available estimate of the current waiting list burden for elective orthopaedics in England and the potential backlog of hip and knee arthroplasty from the NJR. The COVIDSurg group estimate of cancellations was not based on real data but on the estimated cancellation rate of the included experts across the globe at the end of March 2020.³ The prevalence of COVID-19 across the globe at that time varied and this estimated rate may not have been representative of the UK at that time.¹⁴ The current study has used real waiting list and NJR data gathered throughout the COVID-19 pandemic to estimate the number of patients

and hip and knee arthroplasties that would have been observed compared to previous years.¹² Furthermore, the COVIDSurg group assumed a 100% return to capacity after the pandemic (after 12 weeks),³ which is not the case currently due the restriction of new patient pathways and capacity of NHS healthcare facilities to deliver this, with most units working at 70% to 80% currently.^{4,8,15}

The current study modelled this decreased capacity in the recovery phase from August 2020 to November 2020 when capacity was assumed to return to 100%. However, these models did not account for a second wave with impact upon service capacity and winter bed pressures that may be greater this year because of COVID-19.

The delay to hip and knee arthroplasty may have an impact on the patient's quality of life. Approximately 12% and 19% of patients waiting for hip and knee arthroplasty, respectively, are in a perceived "state worse than death" due to the functional deficit and pain from their joint disease.¹⁶ Scott et al¹⁶ highlighted that such patients are often prioritised by clinicians and undergo their surgery as soon as possible. However, these patients may have had their surgery delayed because of the COVID-19 pandemic and may not actually be offered surgery due to the criteria when restarting elective orthopaedic services, as frailer patients may be deemed too high of a mortality risk should they contract COVID-19 postoperatively and therefore may not be offered surgery.^{4,5}

Several studies have shown that delaying hip and knee arthroplasty results in a worse preoperative functional score which is subsequently associated with a worse postoperative health state¹⁷ and lower rate of patient satisfaction.¹⁸⁻²⁰ The effect of the COVID-19 pandemic on patient outcome will likely be difficult to quantify in the future, with patients living for longer with their disability and potentially having a worse outcome due to their delayed surgery.^{17,21} This should be assessed in future studies. Alternatively, some patients may not wish to go forward with their surgery when considering their increased mortality risk should they contract COVID-19 in the postoperative period.²² At the height of the pandemic, the rate of cancellation was greater than 50%,²² but this has gradually declined to less than 5%,²³ which may be related to the patients perceived risk of COVID-19 as the prevalence decreases.

The structure of the NHS elective service will likely be changed forever after this COVID-19 pandemic.^{4,6} Measures that have been implemented to protect patients, such as social distancing within the hospital setting, will result in diminished capacity with the same amount of resources, such as ward capacity, relative to pre-COVID-19 levels. Actions to try and counteract this negative effect will need to be considered.^{4,6} A move

towards day case hip and knee arthroplasty may be one such action.^{24,25} It may be that the current facilities will not allow the NHS to regain the same capacity levels as pre-COVID-19 despite such interventions and more resources may need to be invested.

In addition to the cost of clearing the backlog, new costs may accrue associated with restructuring services and maintaining capacity while adhering to new standards. Returning to full capacity as soon as is safely possible must remain a priority: delaying this for three months results in a further delay of five months in returning to pre-COVID-19 waiting list numbers, as demonstrated by the current study.

It is not clear how the NHS protects elective orthopaedic service capacity in the coming months and years from further waves of COVID-19 infections and admissions to acute hospital sites with the associated bed pressures. Separating elective and acute services on different sites may be a way forward to ensuring continued capacity but this would come with a significant financial cost to the NHS.

There will be up to 1.4 million patients on elective orthopaedic waiting lists in England by November 2020. There are various options of recovery by increasing capacity to return to pre-COVID-19 waiting list numbers, but these have substantial cost implications on the NHS.



Take home message

- Healthcare resources have been redirected from elective care towards dealing with the COVID-19 pandemic.
- This redirection has resulted in a significant increase in the number of patients waiting for surgery.
- Returning to pre-COVID-19 performance will require time and an increase in elective capacity.

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Author contributions:

- S. Oussedik: Undertook data analysis strategy, Wrote the manuscript.
- S. MacIntyre: Analyzed the data.
- J. Gray: Undertook data analysis strategy, Reviewed the manuscript.
- P. McMeekin: Undertook data analysis strategy, Reviewed the manuscript.
- N. D. Clement: Analyzed the data, Wrote the manuscript.
- D. J. Deehan: Undertook data analysis strategy, Reviewed the manuscript.

Funding statement:

- No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

ICMJE COI statement:

- S. Oussedik reports consultancy and payment for lectures from Stryker, grants/grants pending from Digital Surgery, and payment for the development of educational

presentations from AO, all of which are unrelated to this article.

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