



Quantifying the Backlog of Total Hip and Knee Arthroplasty Cases: Predicting the Impact of COVID-19

Jacob M. Wilson, MD · Andrew M. Schwartz, MD · Kevin X. Farley, BS · James R. Roberson, MD · Thomas L. Bradbury, MD · George N. Guild III, MD

Received: 12 June 2020/Accepted: 13 September 2020 / Published online: 4 November 2020
© Hospital for Special Surgery 2020

Abstract *Background:* Total hip arthroplasty (THA) and total knee arthroplasty (TKA) are two high-volume procedures that were delayed due to COVID-19. *Questions/Purposes:* To help strategize an effective return to elective orthopedic surgery, we aimed to quantify the volume of THA and TKA cases delayed across the USA and estimate the time required to care for these patients when non-urgent surgery resumes. *Methods:* Population-level data was used to estimate monthly THA and TKA procedural volume from 2011 to 2017. Using linear regression, we used this data to project monthly procedural volumes for 2020 to 2023. Nine different permutations were modeled to account for variations in case delay rates (50%, 75%, 100%) and in resumption of non-urgent procedure timing. Two recovery pathways using the highest volume month as a surrogate for maximum operative capacity, and a second using the highest month + 20% were used to simulate a theoretical expansion of current capacity. *Results:* The projected national volume of delayed cases was 155,293 (mid-March through April; 95% CI 142,004 to 168,580), 260,806 (through May; 95% CI 238,658 to 282,952), and 372,706

(through June; 95% CI 341,699 to 403,709). The best- and worst-case scenarios for delayed cases were 77,646 (95% CI 71,002 to 84,290) and 372,706 (95% CI 341,699 to 403,709), respectively. The projected catch-up time varied between 9 and nearly 35 months for the best- and worst-case scenarios. The addition of 20% increased productivity decreased this time to between 3.21 and 11.59 months. *Conclusion:* The COVID-19 pandemic has generated a significant backlog of THA and TKA procedures. Surgeons, administrators, and policymakers should account for these modeled estimates of case volume delays and projected demands.

Keywords coronavirus · COVID-19 · total hip arthroplasty · total knee arthroplasty · volume

Introduction

The COVID-19 pandemic has caused unprecedented interruption in the delivery of healthcare [25]. The first case of COVID-19 in the USA was reported in late January 2020 and infection spread quickly [25]. Viral dissemination has had far-reaching implications. By mid-March 2020, it was recommended that elective procedures in the USA be postponed and rescheduled [4, 26]. The American Academy of Orthopaedic Surgeons supported the government's guidance [14], and non-urgent cases such as total hip arthroplasty (THA) and total knee arthroplasty (TKA) were postponed indefinitely. A recent survey by the American Academy of Hip and Knee Surgeons found that 92% of hospitals initially ceased elective inpatient surgical procedures [1].

THA and TKA are two of the most commonly performed surgical procedures in medicine [21, 32]. While performed for a number of indications, primary total hip and knee arthroplasty are typically non-urgent procedures aimed at improving pain and function [20]. As such, these procedures were among the first to be postponed. The intent of

Level of Evidence: Level III, Economic Study.

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s11420-020-09806-z>) contains supplementary material, which is available to authorized users.

J. M. Wilson, MD · A. M. Schwartz, MD · K. X. Farley, BS ·
J. R. Roberson, MD · T. L. Bradbury, MD · G. N. Guild, III, MD
Emory University School of Medicine,
201 Dowman Dr.,
Atlanta, GA 30322, USA

J. M. Wilson, MD (✉) · A. M. Schwartz, MD ·
J. R. Roberson, MD · T. L. Bradbury, MD · G. N. Guild, III, MD
Emory University Orthopaedics and Spine Hospital,
1455 Montreal Rd. E.,
Tucker, GA 30084, USA
e-mail: jacobmwilson12@gmail.com

postponement was to mitigate risk to provider and patient, conserve personal protective equipment, the supply of which quickly became strained [5, 16, 17], and remain cautious given the uncertain trajectory of COVID-19 spread. These actions especially affected hospital-based procedures, given the rapid transition in institutional focus and resource reallocation to COVID-19 care.

The COVID-19 pandemic and cessation of non-urgent surgery has caused a backlog of hip and knee arthroplasty in the USA. Understanding the volume of unmet demand is important when planning for the return to non-urgent surgery and to mitigate decreased patient access to care. The purpose of this study is to estimate the volume of delayed THA and TKA procedures resulting from COVID-19 related bans on elective surgery and to project the time it will require to catch up on care for delayed patients as hospitals resume elective procedures. We hypothesize that the number of delayed patients will be significant and that it will take over 1 year for surgeons to treat this group of patients.

Methods

This is a retrospective observational study using the National Inpatient Sample (NIS) to estimate population-level procedural volume of hospital-based primary THA and TKA in the USA. The NIS, a part of the Healthcare Cost and Utilization Project overseen by the Agency for Healthcare Research and Quality, is a publicly available, de-identified, all-payer sample of hospital discharges from participating state-wide databases that allows for weighted estimation of national volumes.

Patients undergoing primary THA and TKA were identified from the database using International Classification of Diseases 9th revision (ICD-9) and 10th revision (ICD-10) procedural codes. As we were interested only in non-urgent arthroplasty cases, ICD diagnosis codes were used to exclude patients undergoing arthroplasty for fracture or infection. Other non-elective indications were excluded using a variable provided by the NIS. Monthly procedural volumes were recorded from January 2011 to December 2017 (the most recent year data was available). ICD-9 procedure codes were used for data from 2011 to September 31, 2015. Beginning October 1, 2015—when the transition from ICD-9 to ICD-10 took place—ICD-10 diagnosis and procedure codes were used. National THA and TKA volume estimates were created from 2011 to 2017 using the complex samples function of IBM SPSS (Version 25.0, IBM Corp., Armonk, NY, USA) accounting for discharge weights and the complex survey design of the NIS.

A linear regression model was then used, based on data from 2011 to 2017, to project monthly procedural volumes through 2023, to allot for potential time required for completion of backlogged cases. The linear model was chosen as contemporary TKA and THA procedural volume growth has been linear, and more complex Poisson regression models now approximate a linear model, unlike past exponential expansion [30, 32]. Three linear models were created. Two were made to estimate monthly procedural volume for THA

and TKA through 2023, employing 2-way interaction terms between month and year. Another estimated the overall THA and TKA monthly procedural volume by US census region. For the purposes of these projections, it was assumed that future demand for THA and TKA would not change in the post-COVID-19 era.

To account for both the inability to quantify the percent compliance with elective case cessation and assumed regional variations, we chose to estimate the volume of delayed cases using 9 distinct permutations. These scenarios are dual-faceted and contain hypothetical percentages of case cancellations and possibilities for the resumption of non-urgent arthroplasty (i.e., return to work dates). For the percentage of cases canceled in the non-urgent surgery ban period, we included 3 assumptions: (1) 100% of cases canceled; (2) 75% of cases canceled; (3) 50% of cases canceled. For duration of non-urgent surgery ban, 3 estimations of the commencement of non-urgent THA and TKA were included: (1) end of April (cases resume May 1, 2020); (2) end of May (cases resume June 1, 2020); (3) end of June (cases resume July 1, 2020). These choices were then merged to create 9 possible sequences (Table 1). All projective scenarios began in mid-March as elective case postponement was initially recommended at this time.

After estimation of the delayed procedural volume created by the COVID-19 elective surgery ban, we estimated the time needed to perform this backlog of procedures (i.e., the catch-up time). This was defined as number of months needed to surgically manage patients who had surgery delayed by COVID-19, in addition to the baseline procedural volume that would have been expected without the occurrence of the pandemic. To do this, we used two different models. First, we used the highest volume month of the current projected year as an estimate of maximum monthly output for that year. This number was used as a surrogate for institutional and physician volume maxima. Second, we began with the same maximum number but increased the volume by 20% to simulate accommodative measures, such as the addition of hospital operating room (OR) days (i.e., elective weekend blocks) or the expansion of existing block time capacity. We then calculated the difference between projected volume for each month and projected capacities and summed the monthly differential. When the total differential was equivalent to the number of patients delayed in each specific scenario, this time point was defined as the “catch-up time.” Statistical analysis in this study was performed using IBM SPSS and Microsoft Excel 2016 (Microsoft, Redmond, WA, USA).

Results

In 2017, there were a total of 729,039 (95% CI 698,986 to 759,093) of TKA and 396,460 (95% CI 375,654 to 417,266) THA cases performed in the USA. In 2020, a projected 820,514 (95% CI 752,498 to 888,529) TKA and 476,730 (438,438 to 515,016) THA cases would have been performed in the USA. During the months of interest (March, April, May, June) in 2020 a projected 267,345 TKA and

Table 1 Projected scenarios of COVID-19 related TKA and THA delayed surgical volume

Scenario*		Hip and knee arthroplasty	Knee arthroplasty	Hip arthroplasty
% case loss	End date	Volume loss	Volume loss	Volume loss
100%	Through April	155,293 (142,004–168,580)	97,160 (88,658–105,662)	58,133 (53,347–62,919)
	Through May	260,806 (238,658–282,952)	163,025 (148,855–177,195)	97,781 (89,804–105,758)
	Through June	372,706 (341,699–403,709)	233,833 (213,995–253,670)	138,873 (127,705–150,040)
75%	Through April	131,999 (120,703–143,293)	72,870 (75,359–89,812)	49,413 (45,345–53,481)
	Through May	221,685 (202,859–240,509)	122,268 (126,526–150,615)	83,114 (76,333–89,894)
	Through June	316,800 (290,444–343,153)	175,374 (181,895–215,619)	118,042 (108,549–127,534)
50%	Through April	77,646 (71,002–84,290)	48,580 (44,329–52,831)	29,067 (26,673–31,459)
	Through May	130,403 (119,329–141,476)	81,512 (74,427–88,597)	48,891 (44,902–52,879)
	Through June	186,353 (170,850–201,855)	116,916 (106,997–126,835)	69,437 (63,852–75,020)

*Scenarios depicting 100%, 75%, or 50% loss of elective surgical volume starting in mid-march through the end of April, May, or June

159,132 THA cases would have been performed. (Table 2, Fig. 1).

Estimations of deferred surgery began in mid-March as previously mentioned. If 100% loss of non-urgent case volume is assumed nationally, with a return to work date of the end of April, May, or June, a projected delayed national volume of 155,293 (95% CI 142,004 to 168,580), 260,806 (95% CI 238,658 to 282,952), and 372,706 (95% CI 341,699 to 403,709) were calculated, respectively. The 372,706 cases projected by a 100% case ban that lasts through the end of June represent the worst-case scenario. To the contrary, with a 50%

reduction in non-urgent case volume from mid-March through the end of April, 77,646 (95% CI 71,002–84,290) cases would be delayed. This is our best-case scenario (Table 1). Regional variations can be seen in Table 3.

Projections of catch-up time ranged from 9.09 months (best-case scenario) to 34.75 months (worst-case scenario) when using the highest monthly volume as the maximum national case output. When projecting using highest volume plus 20% increased capacity, the catch-up time ranged from 3.21 months to 11.59 months for best- and worst-case scenario, respectively (Table 4. Fig. 2).

Table 2 Actual and projected volume of elective hip and knee arthroplasty in the USA, 2017 and 2020

Month and year		Total knee arthroplasty Volume (95% CI)	Total hip arthroplasty Volume (95% CI)
2017 (actual)	January	65,535 (62,812–68,258)	33,265 (31,557–34,973)
	February	58,900 (56,511–61,289)	32,360 (30,613–34,107)
	March	61,505 (58,967–64,043)	33,820 (32,033–35,607)
	April	55,360 (53,069–57,651)	30,715 (29,071–32,359)
	May	62,150 (59,578–64,721)	34,370 (32,585–36,155)
	June	61,725 (59,156–64,294)	33,495 (31,664–35,326)
	July	52,815 (50,646–54,984)	29,695 (28,088–31,302)
	August	59,725 (57,282–62,168)	34,495 (32,713–36,277)
	September	55,970 (53,599–58,341)	28,910 (27,358–30,462)
	October	70,660 (67,821–73,499)	36,960 (35,075–38,845)
	November	66,320 (63,652–68,988)	35,490 (33,674–37,306)
	December	58,375 (55,894–60,856)	32,885 (31,224–34,546)
	Total	729,039 (698,986–759,093)	396,460 (375,654–417,266)
2020 (projected)**	January	68,655 (62,987–74,323)	36,732 (33,541–39,923)
	February	68,513 (62,845–74,181)	39,981 (36,790–43,172)
	March	67,025 (61,357–72,693)	40,518 (37,327–43,709)
	April	63,647 (57,979–69,315)	37,874 (34,683–41,064)
	May	65,865 (60,197–71,533)	39,648 (36,457–42,839)
	June	70,808 (65,140–76,475)	41,092 (37,901–44,282)
	July	59,815 (54,147–65,483)	36,188 (32,997–39,378)
	August	66,334 (60,666–72,002)	41,385 (38,194–44,575)
	September	66,486 (60,818–72,154)	36,634 (33,443–39,824)
	October	76,270 (70,602–81,938)	42,566 (39,375–45,756)
	November	75,611 (69,943–81,279)	42,129 (38,938–45,320)
	December	71,485 (65,817–77,153)	41,983 (38,792–45,174)
	Total	820,514 (752,498–888,529)	476,730 (438,438–515,016)

*95% confidence intervals in parentheses

**Represents volume projections in absence of COVID-19 pandemic

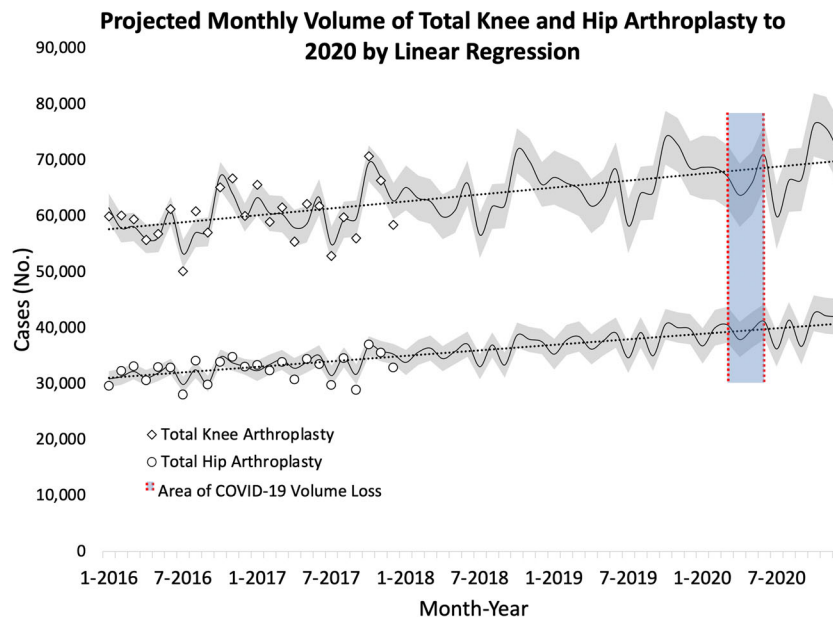


Fig. 1. Actual (1-2016 through 12-2017) and projected (1-2018 through 12-2020) national monthly volumes, TKA and THA, by linear regression. Volumes represent projected volumes in absence of COVID-19 pandemic.

Discussion

THA and TKA remain two of the most successful and common surgical procedures performed in medicine [21, 30, 32]. Procedural volumes continue to reach record highs [30], and the unprecedented elective surgery cessation caused by the COVID-19 pandemic will inevitably lead to a rapid accrual of patients waiting for surgery. In this study we aimed to quantify the volume of delayed THA and TKA procedures and project the time it would take to care for these delayed patients. The results of our projections indicate that a substantial number of patients have had surgery delayed and it could take considerable time for surgeons to catch up and restore optimal patient access to care.

There are several limitations to the current study. First, assumptions were required to project the delayed case volume. Given this, we created 9 different scenarios that could represent best- and worst-case scenarios and variations in regional adherence to elective delay recommendations. Additionally, we did not directly analyze and account for

potential differences in incidence based on patient age or sex, nor did we account for potential population changes using census data. We also assumed that capacity would return to 100% upon resumption of orthopedic care. The reality is that there is likely to be a slower return to full capacity as there may be a relative shortage of OR capacity as multiple specialties attempt to catch up with patient care. We also presupposed that there would be no further delays in non-urgent orthopedic care. This may be true for most of the nation but it is not likely to be true for all regions given the unpredictable future course and duration of the viral pandemic. Non-elective arthroplasty (i.e., arthroplasty for tumor or fracture) care has proceeded, and therefore we excluded these patients in our analysis. Similarly, because COVID-19 is unpredictable, the ability for healthcare systems to accommodate an increase in elective surgery volume will vary by region, institutional capacity, and resource availability. It remains to be seen to what extent patients will be willing to undergo elective surgery once restrictions are lifted, as decisions may be influenced by concerns over

Table 3 Projected scenarios of COVID-19 related loss of surgical volume by U.S. Census Region

Scenarios*	Northeast	Midwest	South	West	
100%	Through April	29,106	39,983	55,326	30,878
	Through May	49,272	67,242	92,414	51,878
	Through June	70,304	96,402	132,089	73,909
75%	Through April	21,830	33,986	41,494	26,246
	Through May	36,954	57,156	69,310	44,096
	Through June	52,728	81,942	99,066	62,823
50%	Through April	14,553	19,992	27,663	15,439
	Through May	24,636	33,621	46,207	25,939
	Through June	35,152	48,201	66,044	36,955

*Scenarios depicting 100%, 75%, or 50% loss of elective surgical volume starting in mid-March through the end of May, June, or July

Table 4 Projected scenarios of COVID-19 recovery

Scenarios*		THA and TKA, monthly max	THA and TKA, max + 20%
100%	Through April	15.24	5.15
	Through May	24.99	8.80
	Through June	34.75	11.59
75%	Through April	13.18	4.50
	Through May	22.41	7.73
	Through June	30.67	10.21
50%	Through April	9.09	3.21
	Through May	13.13	4.46
	Through June	19.11	6.58

viral contraction and/or they may be experiencing financial difficulties. Along the same lines, demand may be reduced as COVID-19 related deaths have affected patients with similar demographics to many arthroplasty patients. We did not account for this influence, although it is anticipated to be small. It should also be noted that the NIS contains information on surgeries performed at centers with inpatient capacity. Therefore, our results could underestimate the true procedural backlog as primary THA and TKA are increasingly being performed at ambulatory centers, although this is a minority of patients on a national scale [8, 9, 23]. Finally, despite these weaknesses, the use of population-level data is a strength of this study. It allowed us to examine and project volume on a monthly basis and to approximate the backlog of cases that may be created by the COVID-19 pandemic. There is no other database, to our knowledge, that would allow these estimates [10].

The pandemic-driven surgical delays in THA and TKA are unprecedented and pose significant threat to patient access to orthopedic care [11]. While delays in non-urgent

THA and TKA are known to exist in some countries [31], traditionally this has not been an issue in the USA [11, 31]. This is a concern, as surgical delays are known to have potential deleterious effects [2, 3, 12, 13, 15, 28, 29]. Prior work has demonstrated that disease progression occurs in patients waiting for surgery, who experience concomitant declines in physical function and increased psychological distress while waiting [2, 3, 12, 13, 15]. It has also been demonstrated that 19% of THA patients and 12% of TKA patients report a health state “worse than death” while waiting for arthroplasty [29]. This has led some authors to support more active non-operative management for patients waiting for total joint arthroplasty [15]. It is crucial to consider the patient’s perception of delays when accounting for the inevitable scheduling congestion generated by COVID-19 [27].

Our results suggest that COVID-19 elective surgery cessation will lead to between 77,000 (best-case scenario) and 372,000 (worst-case scenario) primary THA and TKA cases that require rescheduling. This workload will likely take

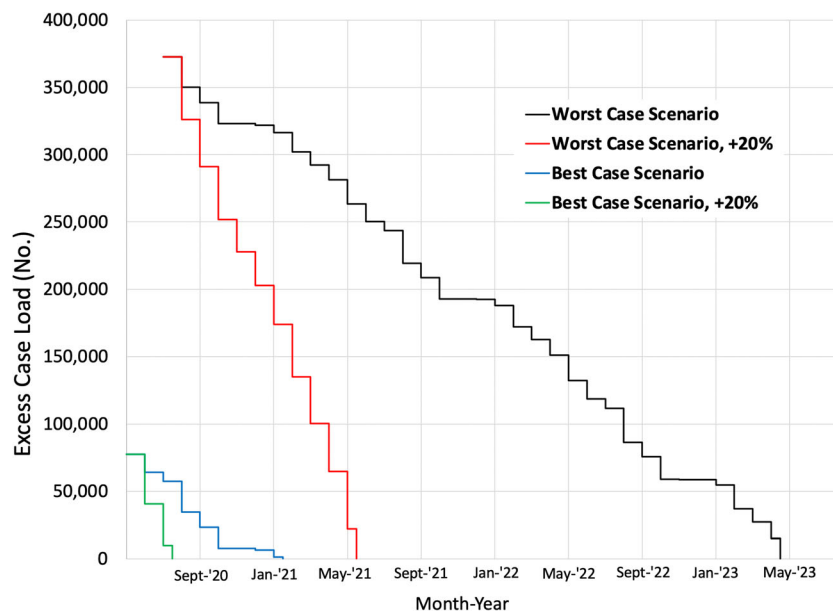


Fig. 2. Projected recovery models following COVID-19 related elective surgery bans. Best-case scenario represents a starting case excess created by 50% of cases being canceled and a return to work date of May 1, 2020. Worst-case scenario is a 100% ban with a return to work date of July 1, 2020. + 20% reflects an increase in operative capacity of 20% over the highest volume month (other projections are performed using the highest volume month as the operative output during each month).

between 9 months (best-case scenario) and 35 months (worst-case scenario) to be managed without expanding operative volume beyond our defined maximum. Regional differences were also observed, with the Southern USA facing the largest volume of delayed cases, but we are not able to reliably account for regional heterogeneity in COVID-19 burden.

While we anticipate that reality lies somewhere between our best- and worst-case scenarios, this data provides multiple actionable items. First, surgeons can use these concrete numbers to present to patients as procedures are rescheduled. Second, surgeons should take an active role in multimodal non-operative management of their patients who are waiting for surgery. Some patients may feel that, while waiting, they are in a health state “worse than death” [29]. That toll should not be trivialized [24], and substitution of opioid analgesics for surgery should be avoided [6, 7, 18, 33]. Third, surgeons may need to increase surgical capacity to care for more patients expeditiously and to mitigate practice attrition [22]. Policymakers and hospital administrators need to preemptively anticipate excess volume and make provisions to quickly and safely accommodate patients forced to delay their care. We anticipate that this may include expanding operative days or hours and, for this reason, we modeled a 20% increase in output. This would approximate the influence of adding 20% in volume or another full operative day (such as Saturday or Sunday). To this end, our data show that these provisions could significantly decrease patient waiting time. Lastly, this data offers surgeons and healthcare professionals up-to-date projections that may aid in adapting the delivery of care to meet unmet demand. This includes increasing patient access to both surgical intervention and non-operative management options while waiting for surgery.

As anticipated [19], the surplus of volume following the COVID-19 pandemic elective case ban will be substantial. Our multi-scenario, adaptable model offers projections of the non-urgent THA and TKA surgical volume postponed due to the COVID-19 pandemic. We confirm that this volume is significant and that it may take 1 year or longer to catch up with demand. However, we hope that our recovery models demonstrate the importance of anticipatory planning to mitigate the impact of the pandemic. This information is useful to surgeons, administrators, and healthcare systems preparing for return to non-urgent surgery and attempting to maximize patient access to care. In the interim, surgeons should take an active role in temporizing nonsurgical arthritis care, anticipatory guidance, and practice adaptations in order to serve patients and protect against practice erosion. Future research should examine which institutional changes are effective in accommodating this increased demand.

Compliance with Ethical Standards

Conflict of Interest: The authors declare that they have no conflicts of interest.

Human/Animal Rights: All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2013.

Informed Consent: Informed consent was waived from all patients for being included in this study.

Required Author Forms Disclosure forms provided by the authors are available with the online version of this article.

References

1. AAHKS Surveys Members on COVID-19 Impact. 2020. Available at: <http://www.aahks.org/aahks-surveys-members-on-covid-19-impact/>. Accessed 4/16/20.
2. Ackerman IN, Bennell KL, Osborne RH: Decline in Health-Related Quality of Life reported by more than half of those waiting for joint replacement surgery: a prospective cohort study. *BMC Musculoskelet Disord*. 2011;12:108.
3. Ackerman IN, Graves SE, Wicks IP, Bennell KL, Osborne RH: Severely Compromised Quality of Life in Women and Those of Lower Socioeconomic Status Waiting for Joint Replacement Surgery. *Arthritis Rheum*. 2005;53:653-658.
4. American College of Surgeons A. COVID-19: Recommendations for Management of Elective Surgical Procedures. <https://www.facs.org/covid-19/clinical-guidance/elective-surgery>. Accessed 4/10/2020.
5. Bauchner H, Fontanarosa PB, Livingston EH: Conserving Supply of Personal Protective Equipment—A Call for Ideas. *JAMA*. 2020;323(19):1911.
6. Bedard NA, DeMik DE, Dowdle SB, Owens JM, Liu SS, Callaghan JJ: Does Preoperative Opioid Use Increase the Risk of Early Revision Total Hip Arthroplasty? *J. Arthroplasty*. 2018;33:S154-s156.
7. Bedard NA, DeMik DE, Dowdle SB, Owens JM, Liu SS, Callaghan JJ: Preoperative Opioid Use and Its Association With Early Revision of Total Knee Arthroplasty. *J. Arthroplasty*. 2018;33:3520-3523.
8. Berend KR, Lombardi AV, Jr., Berend ME, Adams JB, Morris MJ: The outpatient total hip arthroplasty: a paradigm change. *Bone Joint J*. 2018;100-B:31-35.
9. Berend ME, Lackey WG, Carter JL: Outpatient-Focused Joint Arthroplasty Is the Future: The Midwest Center for Joint Replacement Experience. *J Arthroplasty*. 2018;33:1647-1648.
10. Bohl DD, Singh K, Grauer JN: Nationwide Databases in Orthopaedic Surgery Research. *J Am Acad Orthop Surg*. 2016;24(10):673-682. <https://doi.org/10.5435/JAAOS-D-15-00217>.
11. Centers for Disease Control and Prevention. Coronavirus Disease 2019 (COVID-19): Healthcare Facility Guidance. 2020. https://www.cdc.gov/coronavirus/2019-ncov/hcp/guidance-hcf.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fhealthcare-facilities%2Fguidance-hcf.html. Accessed 4/10/2020.
12. Coyte PC, Wright JG, Hawker GA, Bombardier C, Dittus RS, Paul JE, Freund DA, Ho E: Waiting times for knee-replacement surgery in the United States and Ontario. *N Engl J Med*. 1994;331:1068-1071.
13. Desmeules F, Dionne CE, Belzile E, Bourbonnais R, Fremont P: Waiting for total knee replacement surgery: factors associated with pain, stiffness, function and quality of life. *BMC Musculoskelet Disord*. 2009;10:52.
14. Featherall J, Brigati DP, Faour M, Messner W, Higuera CA: Implementation of a Total Hip Arthroplasty Care Pathway at a High-Volume Health System: Effect on Length of Stay, Discharge Disposition, and 90-Day Complications. *J. Arthroplasty*. 2018;33:1675-1680.
15. Guy DK BJ, Savoie FH: AAOS Guidelines for Elective Surgery During the COVID-19 Pandemic. 2020. <https://www.aaos.org/>

- [about/covid-19-information-for-our-members/aaos-guidelines-for-elective-surgery/](#). Accessed 4/10/2020.
16. Ho KW, Pong G, Poon WC, Chung KY, Kwok Y-Y, Chiu KH: Progression of health-related quality of life of patients waiting for total knee arthroplasty. *J Eval Clin Pract.* 2020;1–6. <https://doi.org/10.1111/jep.13388>.
 17. Iacobucci G: Covid-19: Doctors still at “considerable risk” from lack of PPE, BMA warns. *BMJ.* 2020;368:m1316.
 18. Iacobucci G: Covid-19: Lack of PPE in care homes is risking spread of virus, leaders warn. *BMJ.* 2020;368:m1280.
 19. Jain N, Brock JL, Malik AT, Phillips FM, Khan SN: Prediction of Complications, Readmission, and Revision Surgery Based on Duration of Preoperative Opioid Use: Analysis of Major Joint Replacement and Lumbar Fusion. *J Bone Joint Surg Am.* 2019;101:384-391.
 20. Koenig L, Zhang Q, Austin MS, Demiralp B, Fehring TK, Feng C, Mather RC 3rd, Nguyen JT, Saavoss A, Springer BD, Yates AJ Jr. Estimating the Societal Benefits of THA After Accounting for Work Status and Productivity: A Markov Model Approach. *Clin. Orthop. Relat. Res.* 2016;474:2645-2654.
 21. Learmonth ID, Young C, Rorabeck C. The operation of the century: total hip replacement. *Lancet.* 2007;370:1508-1519.
 22. Marshall DA, Deal K, Conner-Spady B, Bohm E, Hawker G, Loucks L, MacDonald KV, Noseworthy T. How do patients trade-off surgeon choice and waiting times for total joint replacement: a discrete choice experiment. *Osteoarthritis Cartilage.* 2018;26:522-530.
 23. Meneghini R, Gibson W, Halsey D, Padgett D, Berend K, Della Valle CJ: The American Association of Hip and Knee Surgeons, Hip Society, Knee Society, and American Academy of Orthopaedic Surgeons Position Statement on Outpatient Joint Replacement. *J Arthroplasty.* 2018;33:3599-3601.
 24. Mistry JB, Gwam CU, Chughtai M, Khlopas A, Ramkumar P, Piuze NS, Muschler G, Harwin SF, Mont MA, Delanois RE: Factors Influencing Patients’ Hospital Rating After Total Joint Arthroplasty. *Orthopedics.* 2017;40:377-380.
 25. Omer SB, Malani P, Del Rio C: The COVID-19 Pandemic in the US: A Clinical Update. *JAMA.* 2020;323(18):1767-1768.
 26. Rat AC, Guillemain F, Osnowycz G, Delagoutte JP, Cuny C, Mainard D, Baumann C: Total hip or knee replacement for osteoarthritis: mid- and long-term quality of life. *Arthritis Care Res. (Hoboken).* 2010;62:54-62.
 27. Regenbogen SE, Cain-Nielsen AH, Norton EC, Chen LM, Birkmeyer JD, Skinner JS. Costs and Consequences of Early Hospital Discharge After Major Inpatient Surgery in Older Adults. *JAMA surgery.* 2017;152:e170123.
 28. Scott CEH, MacDonald DJ, Howie CR: ‘Worse than death’ and waiting for a joint arthroplasty. *Bone Joint J.* 2019;101-B:941-950.
 29. Sloan M, Premkumar A, Sheth NP: Projected Volume of Primary Total Joint Arthroplasty in the U.S., 2014 to 2030. *J Bone Joint Surg Am.* 2018;100:1455-1460.
 30. Snider MG, MacDonald SJ, Pototschnik R: Waiting times and patient perspectives for total hip and knee arthroplasty in rural and urban Ontario. *Can J Surg.* 2005;48:355-360.
 31. Wagner ER, Farley KX, Wilson JM, Higgins I, Daly C, Gottschalk MB: The Incidence of Shoulder Arthroplasty: Rise and Future Projections Compared to Hip and Knee Arthroplasty. *J Shoulder Elbow Surg.* 2020; <https://doi.org/10.1016/j.jse.2020.03.049>.
 32. Weber KL: Re: Pandemic COVID-19. <https://www.aaos.org/globalassets/about/covid-19/aaos-letter-to-vp-pence.pdf>. Accessed 4/10/2020.
 33. Weick J, Bawa H, Dirschl DR, Luu HH: Preoperative Opioid Use Is Associated with Higher Readmission and Revision Rates in Total Knee and Total Hip Arthroplasty. *J Bone Joint Surg Am.* 2018;100:1171-1176.