

Research Article

How have the Volume and Backlog of Total Shoulder Arthroplasty Cases Changed during the COVID-19 Pandemic?

Zachary C. Pearson^{1a}, Amil R. Agarwal^{2b}, R. Timothy Kreulen^{2c}, Mark Haft^{1d}, Alex Gu, MD^{3e}, Matthew J. Best, MD^{2f}, Uma Srikumaran, MD, MBA, MPH^{2g}

a Zachary Pearson is a 4th year medical student pursuing a residency in orthopedic surgery who just completed a year as a research fellow in the Department of Orthopaedic Surgery at the Johns Hopkins University School of Medicine under Dr. Uma Srikumaran.

[Connect with Zachary Pearson on LinkedIn](#)

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b Amil Agarwal is a 4th year Medical Student at the George Washington University School of Medicine and Health Sciences.

[Connect with Amil Agarwal on LinkedIn](#)

[Conflicts of Interest Statement for Amil Agarwal](#)

c Dr. Kreulen is a current chief resident at Johns Hopkins Hospital pursuing fellowship in orthopaedic sports medicine.

[Connect with Dr. Kreulen on LinkedIn](#)

[Conflicts of Interest Statement for Dr. Kreulen](#)

d Mark Haft is a 4th year medical student at the West Virginia School of Osteopathic Medicine. He is currently working as an orthopedic research fellow for Dr. Uma Srikumaran at Johns Hopkins University and will be applying for an orthopedic surgery residency position in the upcoming match cycle.

[Connect with Mark Haft on LinkedIn](#)

[Conflicts of Interest Statement for Mark Haft](#)

e Alex Gu is a current orthopedic surgery resident at George Washington University.

[Visit Dr. Gu's Website](#)

[Connect with Dr. Gu on LinkedIn](#)

[Conflicts of Interest Statement for Dr. Gu](#)

f Matthew Best, M.D., is an orthopaedic surgeon with advanced specialty training in sports medicine and sports-related injuries. Dr. Best has experience caring for athletes at all levels and has served as an assistant team physician for numerous professional and collegiate sports teams, including the New England Patriots, the New England Revolution, Harvard University Athletics and now works as a Team Physician with the Johns Hopkins University Athletic Department. He specializes in conditions such as rotator cuff tears, shoulder instability or labral tears, cartilage injuries of the knee, ACL tears, meniscus tears, UCL injuries of the elbow (Tommy John surgery) and shoulder arthritis.

Dr. Best completed his fellowship in sports medicine at Massachusetts General Hospital/Harvard Medical School, where he was selected for the Frisbie Family Endowed Fellow Award. He completed his orthopaedic surgery training at The Johns Hopkins Hospital, and was awarded the Frank L. Coulson Award for Clinical Excellence and the Paul S. Lietman Global Health Scholarship for his outreach work in Kumasi, Ghana. Dr. Best graduated from medical school at the University of Miami, where he was elected to the Alpha Omega Alpha Honor Society and was awarded the Benton-Stockman Medical Scholarship and the Dean's Fund scholarship.

In addition to his clinical practice, Dr. Best serves as the sports medicine division director of research, with a focus on improving patient outcomes, reducing complications and enhancing value-based health care delivery. He has over 100 scientific publications, book chapters and presentations at national and international meetings.

[Visit Dr. Best's Website](#)

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g Dr. Umasuthan Srikumaran is an associate professor of orthopaedic surgery at the Johns Hopkins School of Medicine and chair of the Department of Orthopaedics at Howard County General Hospital. Specializing in shoulder surgery, Dr. Srikumaran treats patients with shoulder pain, rotator cuff disease, traumatic injuries, instability or dislocations, fractures, osteoarthritis or other sports related injuries.

His surgical expertise includes fracture fixation, rotator cuff repair, shoulder stability procedures, revision shoulder surgery, as well as total shoulder replacements and reverse shoulder replacements.

Dr. Srikumaran earned his M.D. from the Johns Hopkins School of Medicine and completed his residency in orthopaedic surgery at The Johns Hopkins Hospital. He performed a fellowship in shoulder and elbow surgery at Harvard at Massachusetts General Hospital and Brigham and Women's Hospital in Boston, MA. Dr. Srikumaran joined the Johns Hopkins faculty in 2011.

[Visit Dr. Srikumaran's Website](#)

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¹ Orthopaedic Surgery, Johns Hopkins Medicine, ² Department of Orthopaedic Surgery, Johns Hopkins Medicine, ³ Department of Orthopaedic Surgery, George Washington University

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BACKGROUND

As COVID-19 rapidly propagated, many institutions were forced to respond with suspension in all elective surgical procedures, including primary and revision Total Shoulder Arthroplasty (TSA). In 2021, the Centers of Medicare & Medicaid Services (CMS) removed primary and revision TSA from the Inpatient-Only-List (IPO). These rapid changes created uncertainty surrounding the potential backlog of patients that healthcare systems could face. The purpose of this study is to observe the change in volume as well as proportion of TSA performed in the outpatient setting.

METHODS

Patients who underwent primary and revision elective TSA from January 2018 to April 2021 were identified using the Pearldiver database. Descriptive analysis was utilized to report the monthly changes in elective TSA volume and the proportion of the volume performed in the outpatient setting. A linear forecast analysis using historical data was utilized to determine the expected volume and proportion of TSA cases performed on an outpatient basis during the pandemic period. This was compared to the observed case volume and setting.

RESULTS

Within 3 months following suspension, the total volume had returned to expected for both primary and revision TSA. Those performed in the outpatient setting significantly increased throughout the pandemic, with the largest peak following January 2020. By April 2021, four months after the CMS removal of TSA from the IPO list, the backlog of primary TSA volume had decreased by 30.8% with respect that in December 2020. For revision TSA, the backlog was entirely overcome by April 2021 as there was an observed decrease of 131% with respect that in December 2020.

CONCLUSION

The backlog for both primary and revision TSA from the beginning of the pandemic has decreased. The observed decrease did not seem to start until January 2021 following CMS' removal of TSA from the IPO list. Therefore, the reduction in the backlog may be associated with the increased utilization of outpatient primary and revision TSA.

INTRODUCTION

As the prevalence of arthritis and patient's life expectancy are projected to increase, primary Total Shoulder Arthroplasty (TSA) volume is predicted to increase as well. This increase in TSA volume presents an inevitable increase in the volume and burden of revision TSA (Best et al. 2021, 2023; Wagner et al. 2020). However, following the American College of Surgeons, the Surgeon General, and Centers for Medicare and Medicaid Services recommendation to suspend elective surgical procedures in response to the World Health Organization (WHO)'s announcement of the novel coronavirus (COVID-19) as a global pandemic, elective orthopedic procedures, including elective primary and revision TSA, were temporarily held (Cucinotta and Vanelli 2020; for Medicare, Centers, and Medicaid Services, n.d.; Ganesh Kumar and Drolet 2020).

Following these recommendations, TSA volume decreased by 54.6% in the second quarter of 2020 (Gordon et al. 2022). This backlog in cases has led to consequences to patients, surgeons, and healthcare systems. For patients, studies have shown that the initial delay led to prolonged reported pain, with a longer reliance on opioids (Farrow et al. 2021). Hospitals and surgeons suffered financially, with estimates suggesting a loss of \$4-5.4 billion per month in net income for US hospital systems (Best et al. 2020). Due to these consequences, there was a push to resume elective surgery (Attia, Omar, and Kaliya-Perumal 2020). However, there was still significant anxiety surrounding the resumption of elective surgery out of fear of unnecessary exposure to COVID-19 (Moverman et al. 2021).

Outpatient surgery seemed to provide a solution to mitigate much of this anxiety. Most of the current literature focused on the benefits of outpatient arthroplasty for hip

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and knee (Meneghini et al. 2018; Rozell et al. 2021). The literature on TSA has suggested that outpatient surgery is safe, with similar outcomes and complications compared to inpatient surgery (Kramer et al. 2020; Erickson et al. 2020; Brolin et al. 2017). During the pandemic, early published studies have shown an increase in the proportion of TSA's performed in the outpatient setting without an increase in complications (Gordon et al. 2022; Seetharam et al. 2022). Outpatient arthroplasty presented a solution to address the backlog of primary and revision TSA. However, current published studies are limited in their ability to represent the evolving nationwide impact of the pandemic due to their small sample size and utilization of data only until the end of 2020. In 2021, CMS removed primary and revision TSA from the inpatient-only list, permitting more surgeries to be performed in the outpatient setting ("CY 2022 Medicare Hospital Outpatient Prospective Payment System and Ambulatory Surgical Center Payment System Final Rule (CMS-1753FC) | CMS," n.d.). This presents a new opportunity to address the backlog of cases. To our knowledge, no current studies have observed the changes in primary and revision TSA volume following the CMS changes.

Therefore, the purpose of this study was to observe, from the beginning of the pandemic to April 2021, 1) the changes in monthly elective primary and revision TSA volume, 2) the percentage of the backlog that currently remains, and 3) the changes in monthly proportion of that volume performed. We hypothesized that, following the suspension, there would be a rapid surge in primary and revision TSA volume to normal pre-pandemic volume. We also hypothesized that following the CMS removal of primary and revision TSA from the inpatient-only list there will not only be an increase in procedures performed in the outpatient setting but also an expedited reduction in the backlog of cases.

METHODS

DATABASE

The Pearldiver (Mariner Dataset) Database (10435 Marble Creek Circle Colorado Springs, CO 80908) was utilized for this retrospective analysis. The Mariner dataset of the database contains all-payers claims information of more than 150 million patients from January 2010 to April 2021. Patients can be identified in the database using Current Procedure Terminology (CPT) and International Classification of Diseases (ICD) billing codes. The database only contains

de-identified patient information, deeming this study exempt from Institutional Review Board review.

PATIENT SELECTION: INCLUSION/EXCLUSION

Patients who underwent primary TSA were identified in our database using the CPT code 23472 and those who underwent revision TSA were identified in our database using the CPT codes 23473 and 23474. Only elective cases were observed since the suspension only impacted these types of cases. Therefore, non-elective indications for these procedures were excluded using International Classifications of Diseases (ICD) codes. For TSA, proximal humeral fractures indications were excluded. For revision TSA, periprosthetic joint infections and periprosthetic fracture indications were excluded. Next, we only included patients who underwent surgery between January 2018 and April 2021. Following this criteria, 67,258 patients who underwent primary elective TSA and 5,244 patients who underwent revision elective TSA were included in this study.

OBSERVED AND EXPECTED VOLUME

Monthly elective primary and revision TSA volume was observed from January 2018 to April 2021. The monthly proportion of these performed in the outpatient setting was calculated by dividing the number of cases with a length of stay of zero days by the total number of cases that month. To observe the change in monthly pandemic volume and proportion of primary and revision TSA performed in the outpatient setting, a linear forecasted analysis of the historical data from January 2018 to February 2020 was conducted to predict the expected volume and proportion from March 2020 to April 2021. 95% Confidence intervals were recorded with the expected volume and proportion projections. If the observed volume or proportion did not fall within the 95% confidence interval, it was determinant that there was a statistically significant difference in the observed and expected volume for that month. Adjusted R^2 's were used to evaluate the performance of the linear forecasting models.

The observed and expected volume was also utilized to determine the change in backlog of cases throughout the pandemic. The initial backlog was identified as the difference in the number of primary and revision TSA cases observed and expected from March 2020 to May 2020 (Gomez et al. 2022; Jin et al. 2022; Wang et al. 2020). The percent change in volume was recorded in December 2020 (before



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CMS-changes) and April 2021 (after CMS-changes). All statistical analysis was performed on Microsoft Excel 2018 (Microsoft Corporation, Redmond, Washington).

SOURCE OF FUNDING

No funding was received for the production of this study

RESULTS

PRE-PANDEMIC: VOLUME AND CHANGE IN OUTPATIENT PROPORTION

Between January 2018 to February 2020, the volume of elective primary TSA increased by 23.1% from 1,553 in January 2018 to 9,398 in February 2020 (**Figure 1, Table 1**). Within the same period, the volume of elective revision TSA increased by 33.3% from 111 in January 2018 to 148 in February 2020 (**Figure 2, Table 2**). The percentage of elective primary TSA volume performed in the outpatient setting increased by 31.6% from 5.7% in January 2018 to 7.5% in December 2020 (**Figure 2**). The percentage of elective revision TSA volume performed in the outpatient setting increased by 28.0% from 15.3% in January 2018 to 19.6% in December 2020 (**Figure 2**).

PANDEMIC: TSA VOLUME

A linear projection model using historical primary TSA volume from January 2018 to February 2020 was created. The adjusted R^2 for the model was 0.826. Between March 2020 to May 2020 (first wave of COVID-19 and surgeon general recommendation), there was a significant decrease in primary TSA volume (**Figure 1, Table 1**) from what was expected. By June 2020, total primary TSA volume reached the expected number based on the linear regression model (Observed: 1,889; Expected: 1,963 (95% CI: 1,629-2,296; **Figure 1, Table 1**). The observed volume never dropped below the expected volume. From March 2021 to April 2021, there was a significant increase in primary TSA volume from what was expected (**Figure 1, Table 1**).

A linear projection model using historical revision TSA volume from January 2018 to February 2020 was created. The adjusted R^2 for the model was 0.769. Between March 2020 to May 2020 (first wave of COVID-19 and surgeon general recommendation), there was a significant decrease in revision TSA volume (**Figure 2, Table 2**) from what was expected. By June 2020, total revision TSA volume reached

the expected number based on the linear regression model (Observed: 135; Expected: 144 (95% CI: 117-170); **Figure 2, Table 2**). The observed volume never dropped below the expected volume. From March 2021 to April 2021, there was a significant increase in revision TSA volume from what was expected (**Figure 2, Table 2**).

PANDEMIC: CHANGE IN OUTPATIENT PROPORTION

A linear projection model using historical proportions of primary TSA volume performed in the outpatient setting from January 2018 to February 2020 was created. The adjusted R^2 for the model was 0.654. There was a significantly increased proportion of primary TSA performed in the outpatient setting following October 2020. By December 2020, the proportion of primary TSA performed in the outpatient setting increased by 116.67% (March 2020: 7.8 vs December 2020: 16.9%; **Figure 3, Table 3**) when compared to the proportion in March of 2020. By April 2021, the proportion had increased even more by 199.4% (December 2020: 16.9% vs. 50.6%; **Figure 3, Table 3**).

A linear projection model using historical proportions of revision TSA volume performed in the outpatient setting from January 2018 to February 2020 was created. The adjusted R^2 for the model was 0.514. There was a significantly increased proportion of revision TSA performed in the outpatient setting following December 2020. By December 2020, the proportion of revision TSA performed in the outpatient setting increased by 48.17% (March 2020: 19.6% vs December 2020: 28.3%; **Figure 4, Table 4**) when compared to the proportion in March of 2020. By April 2021, the proportion had increased even more by 110.95% (December 2020: 28.3% vs. 59.7%; **Figure 4, Table 4**).

CHANGE IN BACKLOG THROUGHOUT THE PANDEMIC

The estimated backlog of primary TSA volume from March to May 2020 was 3,608 cases. By December 2020, it had increased by 26.69% (-4,571 total cases). By April 2021, it had decreased by 30.82% (-3,162 total cases) with respect to the backlog in December 2020. For revision TSA, the estimated backlog from March to May 2020 was 197 cases. By December 2020, it slightly decreased by 3.55% (-190 total cases). By April 2021, it had decreased by 130.96% (+61 total cases) with respect to the backlog in December 2020.



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DISCUSSION

The results of this study demonstrated that primary and revision TSA volume returned to the expected pre-pandemic volume by June 2020, with no significant dip in volume since. Our study also found a progressive increase in the proportion of primary and revision TSA performed in the outpatient setting. This proportion was found to increase by 199% and 111% for primary and revision TSA respectively following CMS changes. With respect to the backlog of primary TSA cases, there was an increase in the backlog of primary cases until December 2020, with a reduction in the estimated backlog by 31% by April 2021 when compared to December 2020. For revision TSA, the backlog stayed around the same until December 2020, with a decrease in the backlog by 131% by April 2021 when compared to December 2020.

The significant reduction in volume following suspension of elective cases, return to expected volume in June 2020, and no change in volume until December are all congruent with Gordon et al's published study (Gordon et al. 2022). They observed patients who underwent elective primary TSA in the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database from January 2019 to December 2020. They divided each year into quarters (labeled Q1-Q4), and found no changes in volume from 2019 Q1 through 2020 Q2. However, elective TSA volume decreased by 54.6% in 2020 Q2, which coincides with the start of the COVID-19 pandemic. Elective TSA volume reached prior levels in Q3 and Q4 of 2020. Thus, our volume analysis before 2021 is congruent with other national databases.

The increased utilization of outpatient TSA throughout the pandemic is also consistent with published literature. Gordon et al's study also observed an increase in the per-

centage of patients undergoing outpatient TSA from 13.9% in 2019 to 20.6% in 2020 ($p < 0.001$) (Gordon et al. 2022). Seetharam and Menendez examined 567 and 508 consecutive patients at their respective institutions (Menendez et al. 2021; Seetharam et al. 2022). Patients were grouped into cohorts based on whether their surgery was pre-Covid-19 (before March 2020) or after Covid-19 (March 2020 or later). Seetharam found an increase in the proportion of cases being performed outpatient in the COVID-19 era (31.9% versus 6.1%), with the average length of stay decreasing from 1.4 to 0.8 days ($p < 0.0001$) (Seetharam et al. 2022). Menendez also found a significant decrease in length of stay from 16 to 12 hours ($p = 0.017$) and an increase in outpatient surgeries from 79.1% to 87.3% ($p = 0.013$) (Menendez et al. 2021).

The COVID-19 pandemic placed an increased burden on inpatient hospital capacity. This heavy increase in inpatient burden combined with the already high interest in outpatient TSA permitted the pandemic to serve as a catalyst in the transition to outpatient arthroplasty. The rapid resurgence in volume following the suspension of elective surgeries during the pandemic may be associated with the increased utilization of outpatient primary and revision shoulder arthroplasty. Although the volume had returned to around pre-pandemic levels, the backlog of cases was still not addressed. By December 2020, our study found that estimated backlog for primary TSA had increased since the beginning of the pandemic, with no change in that for revision TSA.

January 2021 led to major changes following CMS' announcement to remove TSA from the IPO list. This change in policy was attributed to literature highlighting the safety of outpatient TSA. Brolin et al were on the forefront of outpatient TSA in 2016 when they published a matched cohort analysis comparing 30 TSA patients at both an outpatient surgery and an inpatient surgery center. They demon-

strated no difference in 90-day complication rates (Brolin et al. 2017). Their data has been further validated in more highly powered studies. Erikson et al performed a matched cohort of 94 outpatient and 77 inpatient surgeries, finding no difference in clinical outcome scores or complications (Erikson et al. 2020). Analysis of national databases, including the Kaiser and NSQIP databases have also shown no difference in complication rates (Kramer et al. 2020; Leroux et al. 2016). In a small retrospective cohort analysis, even non-elective outpatient TSA performed in the setting of proximal humerus fractures were shown to have no increase in 30-day readmission rates or ED visits (Dillon et al. 2021). Our study is currently the first to observe the changes in outpatient volume following the CMS changes.

Interestingly, when observing the period following the CMS changes, the volume in primary and revision TSA significantly increased with respect to what was expected. With respect to backlog, within four months, that of elective revision TSA had been eliminated. For primary TSA, although not eliminated, within four months, the backlog had reduced by over 30%. With no other major changes at this time, this increase in volume and reduction in backlog may be associated with the 2021 CMS changes.

However, there are other factors that can be contributing. By December 2020, studies had reported reductions in hospitalizations for COVID-19 and its direct and indirect complications. Therefore, the increased outpatient arthroplasty could also be complemented with an increase in free hospital beds for patients who require inpatient services for TSA. Other explanations can be attributed to adaptations made by hospitals during the pandemic by expanding operating room hours and scheduling elective surgeries on weekends (Billig and Sears 2020; Anastasio et al. 2021; Matava et al. 2022). Multiple systemic reviews and meta-analyses have been published that report on the safety, cost-effectiveness, and high patient satisfaction with outpatient TSA which could also contribute to the growing number of outpatient TSA's performed (Allahabadi et al. 2021; Puzzitiello et al. 2022).

Valuable information may be elucidated from the removal of total knee arthroplasty (TKA) and total hip arthroplasty (THA) off of the CMS IPO list in 2018 and 2020, respectively. In 2018, one year after its removal from the IPO list, outpatient TKA rates jumped from 0.2% to 35% (Abdel, Meneghini, and Berry 2021; Barnes et al. 2020; Haas et al. 2020). There have been several factors attributing to the increase in outpatient procedures in the TKA population. Firstly, hospitals have been shown to be reimbursed an average of 30% lower from Medicare for outpatient TKA cases (Yates et al. 2018; Rankin et al. 2021). This financial incentive for insurance carriers to push for outpatient surgery has increased the number of procedures that are being approved only as outpatient procedures. In addition, there is still much confusion among providers on which patients should be treated inpatient versus outpatient. Krueger et al. surveyed 419 members of the American Association of Hip and Knee Surgeons and found that nearly 35% of respondents said that all TKA patients were scheduled as an outpatient procedure unless the hospital deemed it neces-

sary to be performed in the inpatient setting (Krueger et al. 2020). To our knowledge, no similar studies exist examining the specific CMS-related changes and its effect on total shoulder arthroplasty, although it is possible that there are similar factors at play.

Our study has several strengths. Unlike other published works, we observe the difference in volume using a national database, increasing external validity of our study with respect to the single institutional studies. Additionally, this study analyzes the most recent national data available and is the first study to examine the volume and backlog of cases following the IPO list changes. In terms of limitations, retrospective analyses, like this study, are unable to determine causation. Although we found a rapid surge in volume and reduction in backlog following January 2021. We cannot confirm that this was caused by the CMS changes. Other limitations of this study are inherent to the utilization of national insurance claim databases. First, Pearldiver relies on the accurate coding of its billing codes. There is always the chance that there are discrepancies in the utilization of these codes. Additionally, although PearlDiver is a large database containing outpatient and inpatient claims information of over 150 million patients, it does not include all United States hospitals. Therefore, it may not be generalizable to all national institutions. Our analysis lacks information on COVID-19 related factors including staffing shortages and the conversion of operating rooms to ICU's which could decrease the number of inpatient surgeries being performed. Lastly, our data analysis did not include information on regional COVID-19 case numbers or testing requirements. This prevents us from making correlations between case numbers and the severity of COVID-19 in particular regions. Nonetheless, we believe this study provides novel information about TSA epidemiology following the COVID-19 pandemic.

CONCLUSION

This study found that the backlog for both primary and revision TSA from the beginning of the pandemic was reduced. The observed decrease in backlog does not seem to start until January 2021 following CMS' removal of TSA from the IPO list. Therefore, the reduction in the backlog may be associated with the increased utilization of outpatient primary and revision TSA. Future works can observe to see if the heightened volume returns to the expected volume before the pandemic after the backlog of cases are addressed.

ETHICAL APPROVAL

This study was not subject to Institutional Review Board approval.

CONSENT FOR PUBLICATION

Not applicable.

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AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available from PearlDiver but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of PearlDiver.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no competing interests.

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AUTHORS' CONTRIBUTIONS

ZP- conception, design, data acquisition and analysis, interpretation of data, drafting original manuscript, revising manuscript; AA- conception, design, interpretation of data, drafting original manuscript, revising manuscript; RK- interpretation of data, drafting original manuscript, revising manuscript; MH- interpretation of data, revising manuscript; AG- conception, drafting original manuscript; MB- conception, design, interpretation of data, revising manuscript US- conception, design, interpretation of data, revising manuscript

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REFERENCES

- Abdel, Matthew P., R. Michael Meneghini, and Daniel J. Berry. 2021. "Current Practice Trends in Primary Hip and Knee Arthroplasties Among Members of the American Association of Hip and Knee Surgeons: An Update During the COVID-19 Pandemic." *The Journal of Arthroplasty* 36 (7): S40-S44.e3. <https://doi.org/10.1016/j.arth.2021.01.080>.
- Allahabadi, Sachin, Edward C Cheung, Jonathan D Hodax, Brian T Feeley, Chunbong B Ma, and Drew A Lansdown. 2021. "Outpatient Shoulder Arthroplasty—A Systematic Review." *Journal of Shoulder and Elbow Arthroplasty* 5 (January): 247154922110280. <https://doi.org/10.1177/24715492211028025>.
- Anastasio, Albert T., Preet Shailesh Patel, Joseph Fernandez-Moure, and Mark J. Gage. 2021. "A Solution to After-Hours Fatigue and Surgical Backlog." *Geriatric Orthopaedic Surgery & Rehabilitation* 12 (January):215145932198952. <https://doi.org/10.1177/2151459321989523>.
- Attia, A.K., U.F. Omar, and A.K. Kaliya-Perumal. 2020. "A Review of Guidelines to Resuming Elective Orthopaedic Surgeries amid Covid-19 Pandemic: Deriving a Simple Traffic Light Model." *Malaysian Orthopaedic Journal* 14 (3): 10–15. <https://doi.org/10.5704/moj.2011.003>.
- Barnes, C. Lowry, Richard Iorio, Xiaoran Zhang, and Derek A. Haas. 2020. "An Examination of the Adoption of Outpatient Total Knee Arthroplasty Since 2018." *The Journal of Arthroplasty* 35 (6): S24–27. <https://doi.org/10.1016/j.arth.2020.01.073>.
- Best, Matthew J., Keith T. Aziz, John H. Wilckens, Edward G. McFarland, and Uma Srikumaran. 2021. "Increasing Incidence of Primary Reverse and Anatomic Total Shoulder Arthroplasty in the United States." *Journal of Shoulder and Elbow Surgery* 30 (5): 1159–66. <https://doi.org/10.1016/j.jse.2020.08.010>.
- Best, Matthew J., Edward G. McFarland, Gerard F. Anderson, and Uma Srikumaran. 2020. "The Likely Economic Impact of Fewer Elective Surgical Procedures on US Hospitals during the COVID-19 Pandemic." *Surgery* 168 (5): 962–67. <https://doi.org/10.1016/j.surg.2020.07.014>.
- Best, Matthew J., Kevin Y. Wang, Suresh K. Nayar, Amil R. Agarwal, Edward G. McFarland, and Uma Srikumaran. 2023. "Epidemiology of Revision Shoulder Arthroplasty in the United States: Incidence, Demographics, and Projected Volume from 2018 to 2030." *Seminars in Arthroplasty: JSES* 33 (1): 53–58. <https://doi.org/10.1053/j.sart.2022.07.020>.
- Billig, Jessica I., and Erika D. Sears. 2020. "The Compounding Access Problem for Surgical Care: Innovations in the Post-COVID Era." *Annals of Surgery* 272 (2): e47–48. <https://doi.org/10.1097/sla.0000000000004085>.
- Brolin, Tyler J., Ryan P. Mulligan, Frederick M. Azar, and Thomas W. Throckmorton. 2017. "Neer Award 2016: Outpatient Total Shoulder Arthroplasty in an Ambulatory Surgery Center Is a Safe Alternative to Inpatient Total Shoulder Arthroplasty in a Hospital: A Matched Cohort Study." *Journal of Shoulder and Elbow Surgery* 26 (2): 204–8. <https://doi.org/10.1016/j.jse.2016.07.011>.
- Cucinotta, Domenico, and Maurizio Vanelli. 2020. "WHO Declares COVID-19 a Pandemic." *Acta Biomedica* 91 (1): 157–60. <https://doi.org/10.23750/abm.v91i1.9397>.
- "CY 2022 Medicare Hospital Outpatient Prospective Payment System and Ambulatory Surgical Center Payment System Final Rule (CMS-1753FC) | CMS." n.d. Accessed February 21, 2023. <https://www.cms.gov/newsroom/fact-sheets/cy-2022-medicare-hospital-outpatient-prospective-payment-system-and-ambulatory-surgical-center-0>.
- Dillon, Mark T., Priscilla H. Chan, Heather A. Prentice, Kathryn E. Royse, Elizabeth W. Paxton, Kanu Okike, Monti Khatod, and Ronald A. Navarro. 2021. "The Effect of a Statewide COVID-19 Shelter-in-Place Order on Shoulder Arthroplasty for Proximal Humerus Fracture Volume and Length of Stay." *Seminars in Arthroplasty: JSES* 31 (2): 339–45. <https://doi.org/10.1053/j.sart.2021.01.010>.
- Erickson, Brandon J., Yousef Shishani, Stacy Jones, Tia Sinclair, Meghan E. Bishop, Anthony A. Romeo, and Reuben Gobeze. 2020. "Outpatient versus Inpatient Anatomic Total Shoulder Arthroplasty: Outcomes and Complications." *JSES International* 4 (4): 919–22. <https://doi.org/10.1016/j.jseint.2020.07.003>.
- Farrow, Luke, William T Gardner, Chee Chee Tang, Rachel Low, Patrice Forget, and George Patrick Ashcroft. 2021. "Impact of COVID-19 on Opioid Use in Those Awaiting Hip and Knee Arthroplasty: A Retrospective Cohort Study." *BMJ Quality & Safety*, September, bmjqs-2021-013450. <https://doi.org/10.1136/bmjqs-2021-013450>.
- for Medicare, Centers, and Medicaid Services. n.d. "Non-Emergent, Elective Medical Services, and Treatment Recommendations." Accessed February 21, 2023. <https://www.cdc.gov/coronavirus/2019-ncov/healthcare-facilities/index.html>.
- Ganesh Kumar, Nishant, and Brian C. Drolet. 2020. "COVID-19 - Implications on and of Surgical Practices: Where Do We Draw the Line?" *Annals of Surgery* 272 (2): e45–46. <https://doi.org/10.1097/sla.0000000000004009>.
- Gomez, David, Jordan Nantais, Teagan Telesnicki, Charles de Mestral, Andrew S. Wilton, Therese A. Stukel, David R. Urbach, and Nancy N. Baxter. 2022. "A Population-Based Analysis of the COVID-19 Generated Surgical Backlog and Associated Emergency Department Presentations for Inguinal Hernias and Gallstone Disease." *Annals of Surgery* 275 (5): 836–41. <https://doi.org/10.1097/sla.0000000000005403>.

- Gordon, Adam M., Bhavya Sheth, Charles Conway, Matthew Magruder, Ramin Sadeghpour, and Jack Choueka. 2022. "The Resiliency of Elective Total Shoulder Arthroplasty Case Volumes in the United States during the COVID-19 Pandemic: A Nationwide Temporal Trends Analysis." *Journal of Shoulder and Elbow Surgery* 31 (10): e507–17. <https://doi.org/10.1016/j.jse.2022.02.045>.
- Haas, Derek A., Xiaoran Zhang, Charles M. Davis III, Richard Iorio, and C. Lowry Barnes. 2020. "The Financial Implications of the Removal of Total Knee Arthroplasty From the Medicare Inpatient-Only List." *The Journal of Arthroplasty* 35 (6): S33–36. <https://doi.org/10.1016/j.arth.2020.01.074>.
- Jin, Ya Ping, Mayilee Canizares, Sherif El-Defrawy, and Yvonne M. Buys. 2022. "Backlog in Ophthalmic Surgeries Associated with the COVID-19 Pandemic in Ontario 2020." *Canadian Journal of Ophthalmology*, July. <https://doi.org/10.1016/j.cjco.2022.06.020>.
- Kramer, Jonathan D., Priscilla H. Chan, Heather A. Prentice, Joshua Hatch, Mark T. Dillon, and Ronald A. Navarro. 2020. "Same-Day Discharge Is Not Inferior to Longer Length of in-Hospital Stay for 90-Day Readmissions Following Shoulder Arthroplasty." *Journal of Shoulder and Elbow Surgery* 29 (5): 898–905. <https://doi.org/10.1016/j.jse.2019.09.037>.
- Krueger, Chad A., Joshua M. Kerr, Michael P. Bolognesi, P. Maxwell Courtney, and James I. Huddleston III. 2020. "The Removal of Total Hip and Total Knee Arthroplasty From the Inpatient-Only List Increases the Administrative Burden of Surgeons and Continues to Cause Confusion." *Journal of Arthroplasty* 35 (10): 2772–78. <https://doi.org/10.1016/j.arth.2020.04.079>.
- Leroux, Timothy S., Bryce A. Basques, Rachel M. Frank, Justin W. Griffin, Gregory P. Nicholson, Brian J. Cole, Anthony A. Romeo, and Nikhil N. Verma. 2016. "Outpatient Total Shoulder Arthroplasty: A Population-Based Study Comparing Adverse Event and Readmission Rates to Inpatient Total Shoulder Arthroplasty." *Journal of Shoulder and Elbow Surgery* 25 (11): 1780–86. <https://doi.org/10.1016/j.jse.2016.04.006>.
- Matava, Clyde, Jeannette So, RJ Williams, and Simon Kelley. 2022. "A Canadian Weekend Elective Pediatric Surgery Program to Reduce the COVID-19–Related Backlog: Operating Room Ramp-Up After COVID-19 Lockdown Ends—Extra Lists (ORRACLE-Xtra) Implementation Study." *JMIR Perioperative Medicine* 5 (1): e35584. <https://doi.org/10.2196/35584>.
- Meneghini, R., Wilford Gibson, David Halsey, Douglas Padgett, Keith Berend, and Craig J. Della Valle. 2018. "The American Association of Hip and Knee Surgeons, Hip Society, Knee Society, and American Academy of Orthopaedic Surgeons Position Statement on Outpatient Joint Replacement." *Journal of Arthroplasty* 33 (12): 3599–3601. <https://doi.org/10.1016/j.arth.2018.10.029>.
- Menendez, Mariano E., Noah Keegan, Brian C. Werner, and Patrick J. Denard. 2021. "COVID-19 as a Catalyst for Same-Day Discharge Total Shoulder Arthroplasty." *Journal of Clinical Medicine* 10 (24): 5908. <https://doi.org/10.3390/jcm10245908>.
- Moverman, Michael A., Richard N. Puzitiello, Nicholas R. Pagani, C. Lowry Barnes, Andrew Jawa, and Mariano E. Menendez. 2021. "Public Perceptions of Resuming Elective Surgery During the COVID-19 Pandemic." *Journal of Arthroplasty* 36 (2): 397–402.e2. <https://doi.org/10.1016/j.arth.2020.07.037>.
- Puzitiello, Richard N., Michael A. Moverman, Nicholas R. Pagani, Mariano E. Menendez, and Matthew J. Salzler. 2022. "Current Status Regarding the Safety of Inpatient Versus Outpatient Total Shoulder Arthroplasty: A Systematic Review." *HSS Journal* 18 (3): 428–38. <https://doi.org/10.1177/15563316211019398>.
- Rankin, Kelsey A., Isaac G. Freedman, Lee E. Rubin, and Jonathan N. Grauer. 2021. "Centers for Medicare & Medicaid Services' 2018 Removal of Total Knee Arthroplasty From the Inpatient-Only List Led to Broad Changes in Hospital Length of Stays." *Journal of the American Academy of Orthopaedic Surgeons* 29 (24): 1061–67. <https://doi.org/10.5435/jaaos-d-20-01228>.
- Rozell, Joshua C., Michael P. Ast, William A. Jiranek, Raymond H. Kim, and Craig J. Della Valle. 2021. "Outpatient Total Joint Arthroplasty: The New Reality." *Journal of Arthroplasty* 36 (7): S33–39. <https://doi.org/10.1016/j.arth.2021.02.030>.
- Seetharam, Abhijit, Priyanka Ghosh, Ruben Prado, and Brian L. Badman. 2022. "Trends in Outpatient Shoulder Arthroplasty during the COVID-19 (Coronavirus Disease 2019) Era: Increased Proportion of Outpatient Cases with Decrease in 90-Day Readmissions." *Journal of Shoulder and Elbow Surgery* 31 (7): 1409–15. <https://doi.org/10.1016/j.jse.2021.12.031>.
- Wagner, Eric R., Kevin X. Farley, Ixavier Higgins, Jacob M. Wilson, Charles A. Daly, and Michael B. Gottschalk. 2020. "The Incidence of Shoulder Arthroplasty: Rise and Future Projections Compared with Hip and Knee Arthroplasty." *Journal of Shoulder and Elbow Surgery* 29 (12): 2601–9. <https://doi.org/10.1016/j.jse.2020.03.049>.
- Wang, Jonathan, Saba Vahid, Maria Eberg, Shannon Milroy, John Milkovich, Frances C. Wright, Amber Hunter, et al. 2020. "Clearing the Surgical Backlog Caused by COVID-19 in Ontario: A Time Series Modelling Study." *Canadian Medical Association Journal* 192 (44): E1347–56. <https://doi.org/10.1503/cmaj.201521>.
- Yates, Adolph J., Joshua M. Kerr, Mark I. Froimson, Craig J. Della Valle, and James I. Huddleston. 2018. "The Unintended Impact of the Removal of Total Knee Arthroplasty From the Center for Medicare and Medicaid Services Inpatient-Only List." *The Journal of Arthroplasty* 33 (12): 3602–6. <https://doi.org/10.1016/j.arth.2018.09.043>.