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The Initial Impact of COVID-19 on Total Hip and Knee Arthroplasty

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ABSTRACT

Background: The SARS-CoV-2 (COVID-19) pandemic caused a massive disruption in elective arthroplasty practice in the United States that to date has not been quantified. We sought to determine the impact of COVID-19 on arthroplasty volumes in the United States, how this varied across the country, and the resultant financial implications.

Methods: We conducted a retrospective analysis of Medicare fee-for-service beneficiaries undergoing primary and revision total knee arthroplasty (TKA) and total hip arthroplasty (THA) from January 1st through March 31st, 2020 with 74,080 TKAs and 54,975 THAs identified. We calculated the percent drop in average daily cases from before and after March 18, 2020. We then examined variation across states in arthroplasty case volumes as it related to reported COVID-19 cases, the impact of COVID-19 on length of stay and percentage of patients discharged home. Finally, we calculated the revenue impact on hospitals and surgeons.

Results: There was a steep decline in TKA and THA volumes in mid-March of 94% and 92%, respectively. There was a significant variation for arthroplasty case volumes across states. We found minimal change in length of stay except for primary THAs with fracture going from 5 + days to 4 days. We saw an increasing trend in discharge to home with the greatest effect in primary THAs with fracture. The total daily hospital Medicare revenue for arthroplasty declined by 87% and surgeon revenue decreased by 85%.

Conclusion: The beginning of the COVID-19 pandemic caused a significant decrease in arthroplasty volumes in the Medicare population with a resultant substantial revenue loss for hospitals and surgeons.

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The SARS-CoV-2 (COVID-19) pandemic started at the end of 2019 in Wuhan, China [1]. The first reported case in the United States of human-to-human transmission was identified on January 30th [2]. Response varied across the United States in the timing and severity of public health measures implemented to contain the disease spread. Major turning points in the practice of arthroplasty occurred when the World Health Organization declared COVID-19 a worldwide pandemic on March 10, 2020 rapidly followed by the Surgeon General recommending cancellation of all elective surgery in the United States on March 14, 2020, and then the Centers for

Medicare & Medicaid Services (CMS) recommending the same on March 18, 2020 [3,4]. There was subsequently significant variation in regard to state recommendations for halting elective procedures [5].

Cancellation of elective surgeries to control the COVID-19 pandemic had significant effects on hip and knee arthroplasty volume in the United States. It was initially estimated that up to 33,000 revision and primary hip and knee arthroplasty procedures would be canceled on a weekly basis [6]. However, these estimates were based on American Joint Replacement Registry data that only provide a small sample of US arthroplasty volume with no current way to accurately obtain national arthroplasty case volume. Despite these limitations to date in directly measuring the effects of COVID-19 on arthroplasty volumes, the consequences of surgery cancellations have had significant lasting negative ramifications for patients, surgeons, and the health care system [7,8].

This study used national Medicare claims data to better understand the effect of COVID-19 on elective total hip arthroplasty (THA) and total knee arthroplasty (TKA). We sought to determine the

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impact at the start of the pandemic in the United States and how this response varied across the country. Our goals were also to determine the effect on surgeries provided during this time on hospital length of stay (LOS), inpatient versus outpatient status, and discharge location (home versus facility). Finally, we sought to determine the financial implications for hospitals and surgeons.

Materials and Methods

We conducted a retrospective, national, population-based analysis of Medicare fee-for-service beneficiaries undergoing primary and revision TKAs and THAs at hospitals. We used 100% Medicare part A fee-for-service claims data for arthroplasty surgeries from January 1st through March 31st, 2020. There were 74,080 primary and revision TKAs and 54,975 primary and revision THAs during this time period. We identified procedures that matched one of the following 3 inclusion criteria: (1) MS-DRG of 466–468 (revision procedures), (2) MS-DRG of 469–470 and an ICD-10-PCS code that started with 0SRC, 0SRD, 0SR9, and 0SRB for inpatient primary procedure, or (3) a primary CPT code of 27447 or 27130 for a primary outpatient procedure.

We first examined the daily trend in the case volume during the first calendar quarter of 2020. We excluded weekend days because almost all arthroplasties were performed Monday–Friday. We examined the national daily trend in number of surgeries of the following 5 categories of procedures: (1) primary TKAs, (2) revision TKAs, (3) primary THAs where the principal diagnosis was not a fracture, (4) primary THAs where the primary diagnosis was a fracture, and (5) revision THAs. Because there was a strong day of the week effect, we then calculated the five-day moving average of number of cases of each type to more easily examine any potential time trend during the quarter.

Second, we calculated the percent drop in average daily cases for each of the primary types of cases (TKA, THA with fracture, and THA without fracture) from the period January 1, 2020 through March 18, 2020 compared with the period from March 19, 2020 through March 31, 2020. March 18th was chosen as the cutoff date because that is when CMS announced its recommendation to defer all elective procedures [4]. We then compared these percentage decreases with other types of common surgeries in the Medicare population. The other types of surgeries we examined included spinal fusions (cervical and noncervical), hip and femur procedures excluding major joint arthroplasties, coronary artery bypass grafts (CABGs), major bowel procedures, and percutaneous coronary interventions. We hypothesized that the nonfracture arthroplasty procedures experienced the largest percentage decline in volumes of all procedure types.

Third, we examined variation across states in their percent decrease in average daily number of arthroplasty cases as it related to the number of COVID-19 cases per 1 million people in their state. The percentage decreases in each state were for primary TKAs and THAs using the timeframes in the preceding paragraph, and the number of COVID cases per million people was determined by dividing the number of COVID-19 cases in the state on March 25th, as measured by the Centers for Disease Control and Prevention [8], by the state population based on the 2019 census estimate [9]. We then plotted each state on a graph of percentage decrease in arthroplasty cases relative to COVID-19 cases per million people and fitted a trend line on the scatterplot. We hypothesized that there was a positive relationship between per capita COVID-19 case rates and the percentage decline in arthroplasty cases across states.

Fourth, we examined the impact of COVID-19 on LOS for primary arthroplasty cases. We plotted average LOS by day of surgery for primary TKAs, primary THAs without fractures, and primary THAs with fractures. Because we only had claims data available through

March 31, 2020, we only examined LOS for fracture cases through a date of surgery of March 25th and nonfracture cases through March 27th to minimize the potential for LOS to be biased due to the exclusion of cases that were discharged after March 31st. We hypothesized that average LOS decreased across case types after March 18th to enable hospitals to make capacity available for COVID-19 cases.

Fifth, we assessed for primary arthroplasty cases whether COVID-19 influenced the percentage coded as outpatient versus inpatient. For each of the 3 types of primary arthroplasty cases, we plotted the percentage coded as outpatient on a daily basis from January 1st through March 27th. We hypothesized that the percentage of nonfracture arthroplasty cases coded as outpatient increased after March 18th in line with our hypothesis for a lower average LOS.

Sixth, we examined whether COVID-19 impacted the percentage of primary arthroplasty cases that were discharged home. For each of the 3 types of primary arthroplasty cases, we plotted the percentage discharged directly to home (as opposed to a postacute care provider) from January 1st to March 27th. We hypothesized that COVID-19 led to an increase in discharge home rates because of a fear of the increased transmission rates of COVID-19 in an institutional setting compared with at home.

Finally, we calculated the revenue impact on hospitals and surgeons by comparing their average total daily revenue from Medicare arthroplasty cases in the first quarter up through March 18th as compared with in the remainder of the quarter after that date.

Results

First, we examined the weekday daily trend in the case volume between January 1st and March 31st, 2020. As seen in [Figure 1](#), primary TKAs and primary THAs saw a decreasing trend by about 20% from the beginning of January through the first 2 weeks of March. A much steeper decline came after the Surgeon General's recommendation to cancel elective surgeries on March 14th and the CMS recommendation on March 18th. This trend is clearest in the five-day moving average view in the bottom of [Figure 1](#) where the day of the week effect was smoothed out.

To examine the percentage drop in case volume for primary TKA and THAs, we then compared the average daily volume of January 1st through March 18th, 2020 with that of March 19th through March 31st, 2020 ([Table 1](#)). Primary TKAs and primary THAs without fracture saw a decrease in case volume of 94% and 92%, respectively. The percentage drop for primary THAs with fracture was 43%, smaller than the previous 2 types of cases, but still pronounced. Primary TKAs and THAs without fracture had the largest percentage decline of all the procedure types we examined. There was a 77% decrease in case volume for spinal fusions, 66% for CABGs, 65% for major bowel procedures, 65% for percutaneous coronary interventions, and 44% for hip and femur procedures.

Third, we examined the variation in case volume percentage drop for primary TKAs and THAs across states. [Figure 2](#) is a scatter plot showing on the Y-axis the percentage drop in cases across states and on the X-axis, the number of COVID-19 cases per 1 million people in the state as of March 25, 2020. States with fewer than 10 combined primary TKA and THA cases per day before March 18th were excluded from the plot to avoid the potential effect of outliers due to small sample sizes. A trend line was added to more clearly display the correlation. As seen in [Figure 2](#), the percentage drop in primary TKAs and THAs varied from 72% to 94% among eligible states. As the trend line indicates, a higher number of COVID-19 case rates were correlated with a higher percentage drop in primary TKAs and THAs. However, the COVID-19 case rate

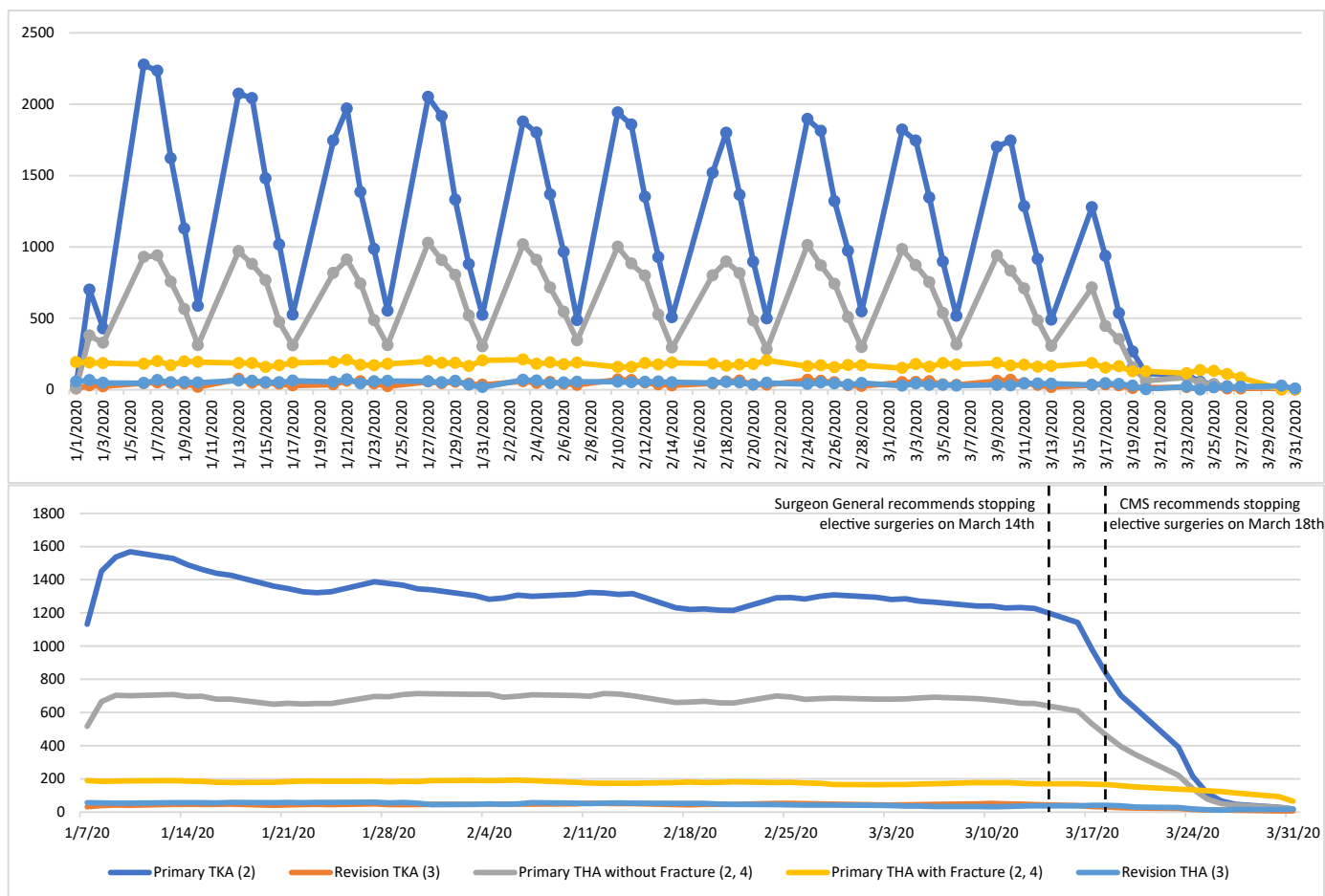


Fig. 1. Weekday daily volume (1) and five-day moving average from January 1st to March 31st, 2020. Weekends were excluded from the plot because of the fact that almost all arthroplasties were performed Monday-Friday. (1) Primary TKA and THA procedures were identified using MS-DRG 469–470 and an ICD-10-PCS code that started with 0SRC, OSRD, OSR9, or OSRB for inpatient cases and CPT 27447 or 27,130 for outpatient cases. (2) Revision TKA and THA procedures were identified using MS-DRG 466–468. (3) Hip fracture cases were identified using ICD-10-CM codes of the primary diagnosis within primary THA procedures.

was loosely associated with the decline, explaining only 10% of the state level variation.

We then examined the impact of COVID-19 on the LOS during the index stay (the initial hospital visit where the arthroplasty was performed), percentage of cases coded as outpatient versus inpatient, and percentage of cases being discharged home for primary TKAs and THAs. We plotted a five-day moving average time trend of these 3 metrics (Figs. 3–5). For primary TKAs and THAs without fracture, we saw a slight decrease in LOS from 1.7 days to 1.5 days after March 18th. For primary THAs with fracture, however, the

decrease was much more significant, going from 5 + days to 4 days. For percentage of cases being coded as outpatient, we saw a slight increasing trend before March 18th. After March 18th, the trend reversed back down for primary nonfracture THAs (there was an increase from 30% to 45% coded as outpatient up to March 18th and after then it decreased back to 30% of cases coded as outpatient). Almost no primary THAs with fracture were coded as outpatient throughout the first quarter of 2020. For percentage of cases being discharged home, all primary TKAs and THAs saw an increasing trend toward the end of March, with the magnitude of increase

Table 1
Percentage Change in Average Daily Case Volume Before and After March 18th for TKA and THA Arthroplasties and Other Common Surgeries.

Arthroplasty		Average Daily Volume Between January 1 st and March 18 th , 2020	Average Daily Volume Between March 19 th and March 31 st , 2020	% Change in Case Volume
Arthroplasty	Primary TKA	907.4	53.3	–94%
	Primary THA without fracture	476.5	38.6	–92%
	Primary THA with fracture	172.2	97.8	–43%
Other types of surgery	Spinal fusion	331.8	75.5	–77%
	Coronary artery bypass graft	133.4	45.8	–66%
	Major bowel procedure	281.7	97.6	–65%
	Percutaneous coronary intervention	458.0	181.8	–60%
	Hip and femur procedures excl. major joint	329.2	185.4	–44%

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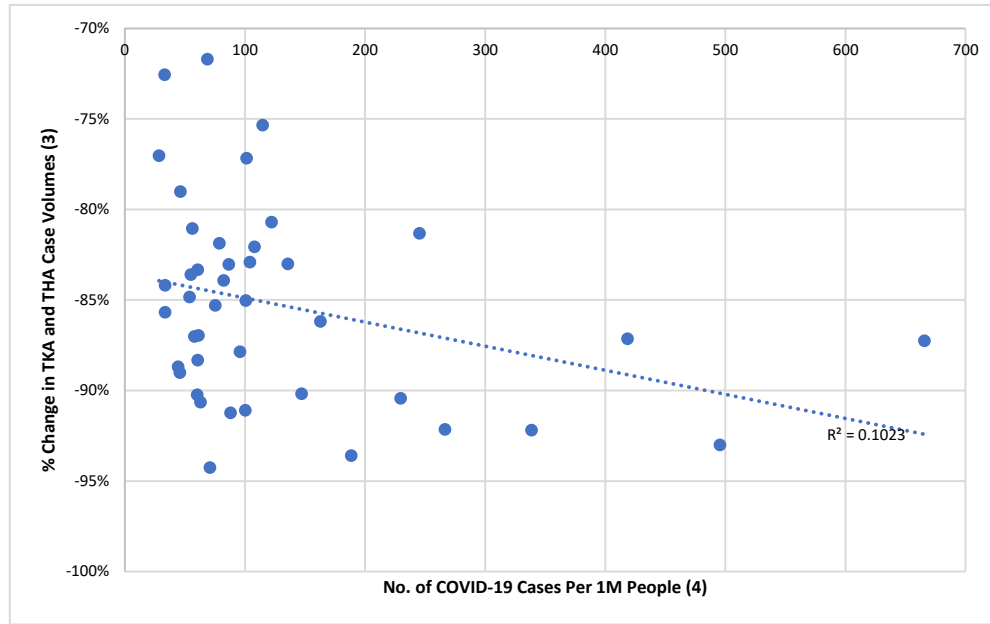


Fig. 2. Scatterplot (1) of decrease in TKA and THA case volumes and No. of COVID-19 cases of U.S. states (2). (1) A trend line with an R square was added to the scatterplot to display the correlation. (2) States with an average daily volume smaller than 10 before March 18th were excluded from the scatterplot. (3) Percentage change in TKA and THA volumes was calculated by comparing the average daily volume before and after March 18th for each state. (4) No. of COVID-19 cases per 1M people was calculated using CDC measurements on March 25th and 2019 census population estimate for each state.

being much larger for primary THAs with fracture (20% to 50%) compared with the other 2 arthroplasties (80% to 90%). It is worth noting that the increasing trend of being discharged home for primary THAs with fracture began at the end of February, a few weeks before the increase began for primary TKAs and THAs without fracture.

Finally, we calculated the revenue impact of COVID-19 on hospitals and surgeons. The total daily Medicare revenue for hospitals for knee and hip arthroplasty declined by 87% from \$21.0 million before March 18th and \$2.8 million afterward. For surgeons, the total daily revenue decreased from \$1.6 million to \$0.2 million, or by 85%.

Discussion

The impact of COVID-19 on elective total joint arthroplasty case volumes in the United States was swift and dramatic as the Surgeon General, and subsequently CMS, recommended halting elective procedures. We found an overall 94% daily decrease in primary TKA volume and 92% decrease in THA volume in the last 2 weeks of March 2020 in comparison with before then in the first quarter of 2020. We also found surgical volume decreases in essential orthopedic surgeries, such as THA for femoral neck fracture, and nonorthopaedic surgeries, such as CABG and major bowel procedures, but none as severe as primary total joint arthroplasty. This led

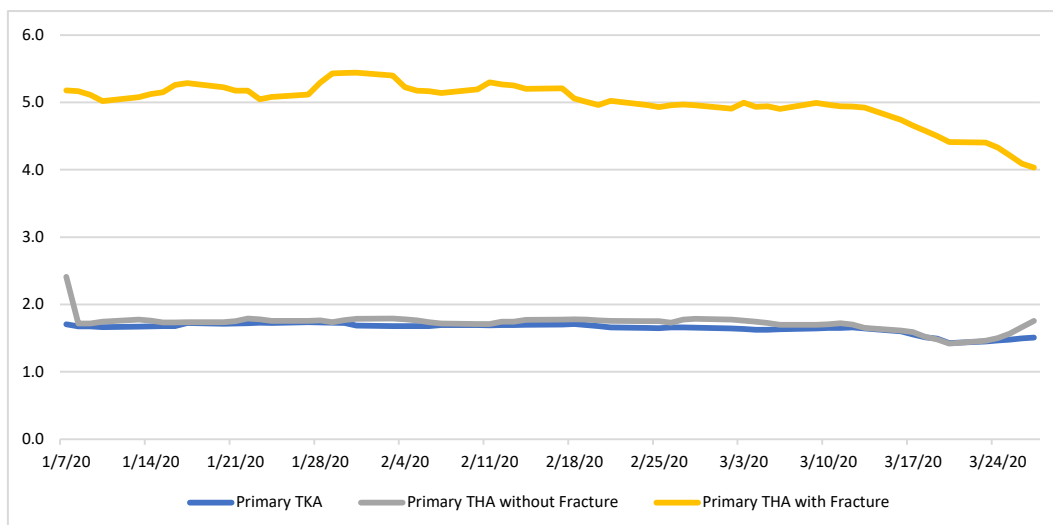


Fig. 3. Five-day moving average of weekday daily average LOS from January 1st to March 31st, 2020.

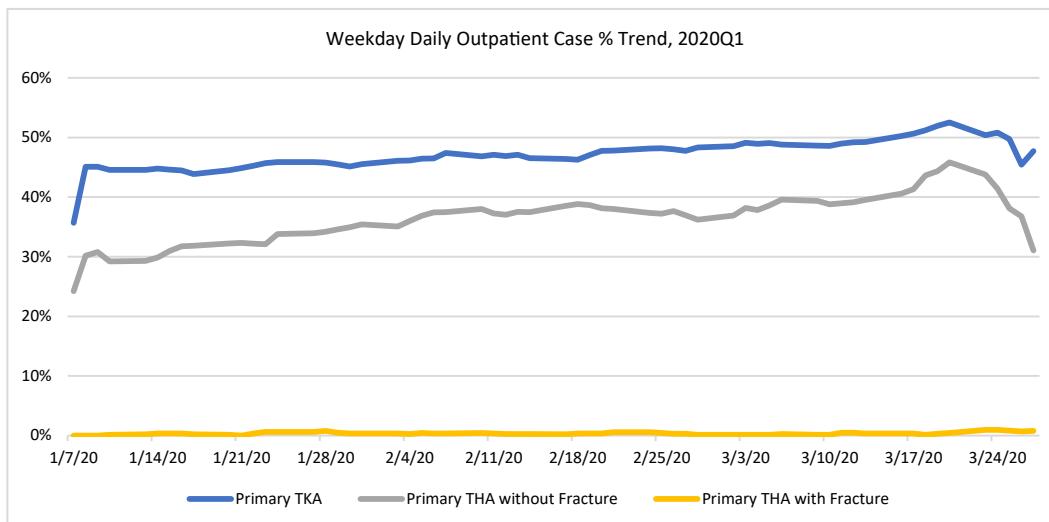


Fig. 4. Five-day moving average of weekday daily average percentage of outpatient cases from January 1st to March 31st, 2020.

to a significant backlog of arthroplasty procedures that needed to be performed and has had lasting effects on the practice of arthroplasty [10,11]. We did not see a similar dramatic decrease in revision arthroplasty volume. We suspect this is due to many of these surgeries being justifiably deemed essential, such as prosthetic joint infection or recurrent hip dislocation, with further delay placing the patient at risk for increased morbidity.

There have been recent dramatic changes in the field of arthroplasty before COVID-19 in regard to reimbursement and clinical care. This has included the removal of TKA from the CMS inpatient-only list and subsequent approval as an ambulatory surgery center-qualified procedure [12,13]. CMS also removed THA from the inpatient-only list in January, 2020, 3 months before pandemic [14]. There continued to be a shift toward short stay and outpatient total joint arthroplasty, which previously has been driven by economics, and is now potentially being further accelerated because of the pandemic. We saw a decrease in LOS during our study timeframe for primary procedures. The onset of COVID also reversed what had been a trend toward more primary non-fracture cases being performed on a hospital outpatient basis.

There was a shift in the arthroplasty community away from the use of postdischarge rehab facilities and skilled nursing facilities before

the advent of the COVID-19 pandemic [15]. We found an acceleration of this process in the Medicare population during our study period with a significant shift toward a discharge to home. This was most dramatic in the hip fracture population. We speculate this is likely due to a desire to avoid skilled nursing facilities during the COVID-19 pandemic to prevent viral exposure. This demonstrates that many of the patients who have previously been sent to these facilities before the pandemic can likely be discharged to home if appropriate care can be provided, but further analysis of readmissions and complications in this population needs to be undertaken to better understand the consequences of this change in practice.

Arthroplasty has occupied a unique space during the COVID-19 pandemic as it accounts for a significant amount of revenue for the health care system but also is viewed as a nonessential procedure that was rapidly curtailed. The economic ramifications in the United States due to the halting of arthroplasty procedures were severe and mirror the dramatic case volume decrease seen. Medicare payments for TKA and THA to hospitals were decreased 87% and to surgeons were decreased 85% during the last 2 weeks of March 2020. This translates into an approximately \$236 million loss to hospitals and \$18 million loss to surgeons just from Medicare for primary hip and knee arthroplasty during these 2 weeks and does

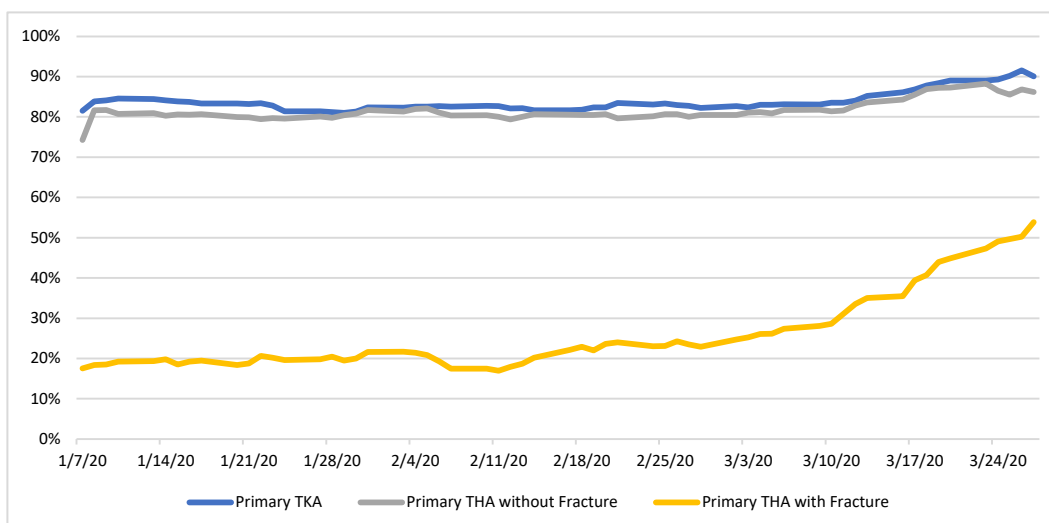


Fig. 5. Five-day moving average of weekday daily average percentage of discharged home cases from January 1st to March 31st, 2020.

not account for the losses from privately insured patients. The overall monthly revenue losses to hospitals in the United States from decreased arthroplasty cases during the COVID-19 pandemic have been estimated at 1.3–1.8 billion dollars [16]. Federal relief has been provided to both hospitals and surgeons that has partially offset some of these losses. A high volume, revenue generating procedure that has been deemed nonessential has created a financial crisis in health care that is unprecedented and will likely have long-lasting negative effects for the health care system.

There are several limitations to the present study. The first limitation is the use of the Medicare claims database to represent national trends in arthroplasty. There currently is no unified database to capture all arthroplasty procedures being performed in the United States. The American Joint Replacement Registry continues to develop but currently only represents a small subset of arthroplasty procedures being performed in the United States by sites willing to submit data. We used the Medicare claims database in an effort to provide the most comprehensive perspective of arthroplasty volume in the United States, but this excludes privately insured, state Medicaid, and uninsured patients receiving arthroplasty care. The Medicare claims database provides a limited subset of data, but is useful for determining trends in practice. The second limitation is the assumption that the effects seen were related directly to COVID-19 when there are confounding factors to changes in clinical practice during this time to include the shift toward outpatient status and the ambulatory surgery center for arthroplasty that are unrelated to the pandemic.

In conclusion, our analysis of the Medicare claims database found that after March 18, 2020, there were dramatic decreases in arthroplasty surgical case volumes and Medicare payments to hospitals and surgeons. After March 18th, we also found shorter LOS, more patients being discharged home, and a reversal of the trend toward more cases being performed outpatient. We anticipate long-lasting clinical and financial effects from the decreased surgical arthroplasty volumes related to the COVID-19 pandemic.

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