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Rapid Decline in Online Search Queries for Hip and Knee Arthroplasties Concurrent With the COVID-19 Pandemic



Tarun K. Jella, MPH, Linsen T. Samuel, MD, MBA, Alexander J. Acuña, BS, Ahmed K. Emara, MD, Atul F. Kamath, MD*

Department of Orthopaedic Surgery, Cleveland Clinic Foundation, Cleveland, OH

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ABSTRACT

Background: In response to the coronavirus disease 2019 (COVID-19) pandemic, US hospitals have canceled elective surgeries. This decline in total joint arthroplasty (TJA) revenue may place financial strain on hospitals. Our goal was to quantify the impact of COVID-19 on the public interest in elective TJA. **Methods:** The Google Search Volume Index (GSVI) identified the terms “knee replacement,” “hip replacement,” and “orthopedic surgeon” as the most common to describe TJA. The term “elective surgery cancellation” was also analyzed. Weekly GSVI data were extracted between 04-01-2015 and 04-04-2020. Time series analysis was conducted and state GSVI values were compared with COVID-19 prevalence and unemployment claims.

Results: The relative public interest in elective TJA has sharply declined since the WHO declaration of COVID-19 as a global pandemic. Between 03-01-2020 and 03-29-2020, the popularity of searches for “knee replacement,” “hip replacement,” and “orthopedic surgeon” dropped by 62.1%, 52.1%, and 44.3%, respectively. A concurrent spike was observed for the term “elective surgery cancellation.” California, New Hampshire, Maine, and Nevada showed a low relative rate for TJA searches, and the highest increase in unemployment claims.

Conclusion: The onset of COVID-19 correlates with declining relative popularity of searches related to elective TJA. Higher volume of COVID-19 cases in certain states may correspond with lower relative search popularity, although this correlation remains unclear. These results portend the possibility of a decline in elective TJA case volume, further straining hospitals. Further research is required to inform stakeholders how best to proceed and determine any sustained effects from the current diminished relative interest in TJA.

Level of Evidence: Level III.

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The coronavirus disease 2019 (COVID-19) continues to spread, with almost 2.5 million confirmed cases and over 169,000 deaths attributed to the disease as of April 20, 2020 [1,2]. On March 11, 2020, the World Health Organization issued a statement

characterizing COVID-19 as a worldwide pandemic and warning governments to take expedient action [3]. This global health crisis has already disrupted all aspects of society, with safety and economic concerns radiating across the world. As part of the international collaboration to flatten the number of emerging cases, multiple organizations have released guidelines related to the cessation of elective surgical procedures [4–7]. In light of the increased utilization of health care associated with the disease, these guidelines have left providers and stakeholders increasingly concerned regarding the true financial impact COVID-19 will have on the health care systems [8,9].

In response to this growing financial strain, the American Medical Association, American Hospital Association, and the American Nurses Association wrote a unified message to Congress requesting \$100 billion to help cover the excessive costs associated

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* Reprint requests: Atul F. Kamath, MD, Center for Hip Preservation Orthopaedic and Rheumatologic Institute Cleveland Clinic Foundation, 9500 Euclid Avenue, Mailcode A40 Cleveland, OH, 44195.

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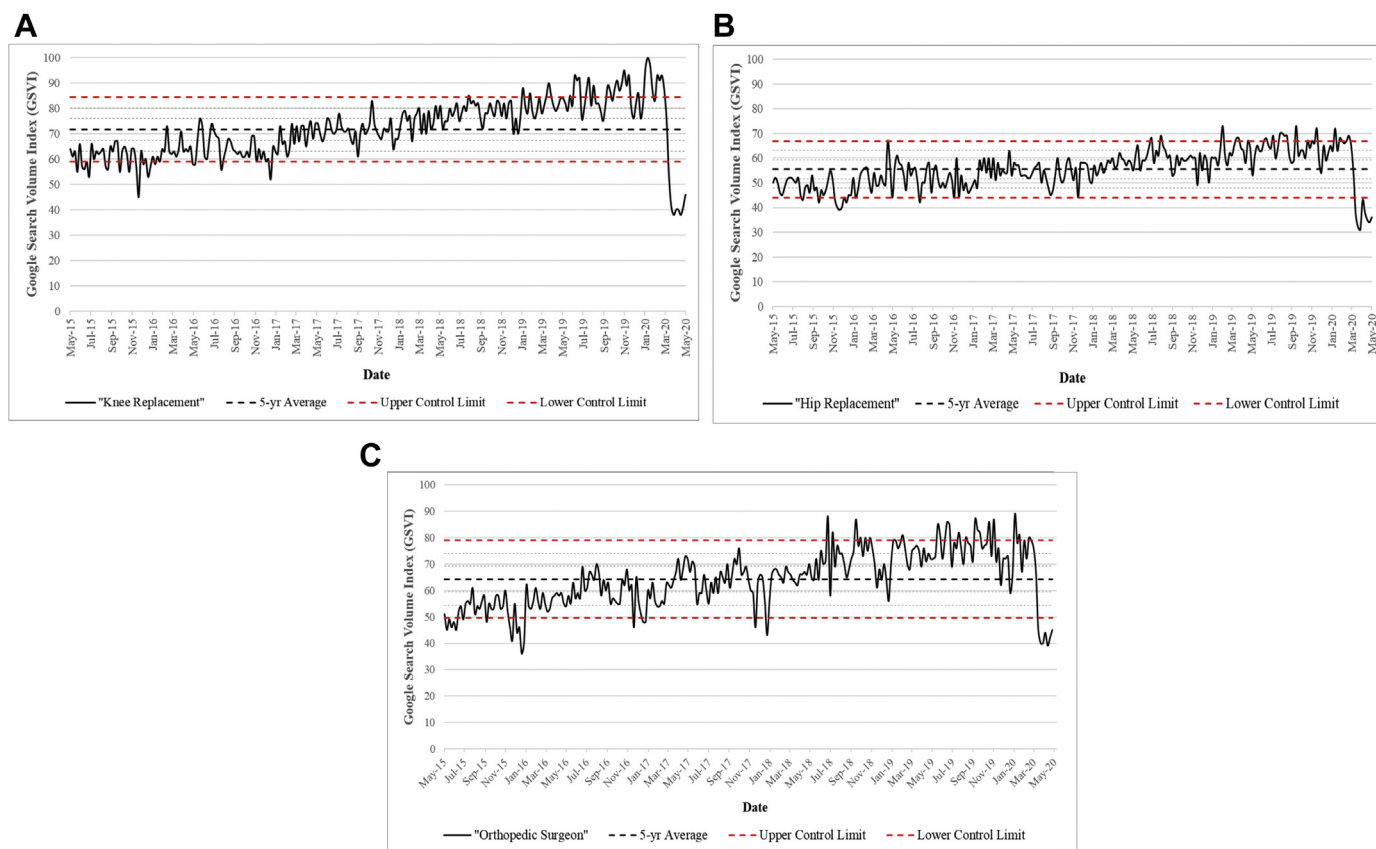


Fig. 1. Google Search Volume Index (GSVI)* values for total joint arthroplasty–related keywords in the United States from May 2015 to May 2020. (A). Knee replacement; (B). hip replacement; (C). orthopedic surgeon. *The Google Search Volume Index (GSVI) is calculated by Google Trends by normalizing the volume of a search term against the total volume of searches within a specific period and region. (1-100 = low to high popularity).

with COVID-19 treatment, as well as the lost revenue caused by the suspension of elective surgical procedures [10,11]. Although the Coronavirus Aid, Relief, and Economic Security (CARES) Act provided these funds to hospitals and health care providers [12,13], the rapid decrease in elective surgical procedures will undoubtedly continue to economically impact health care systems that previously relied on these stable sources of revenue. In addition, hospitals must prepare for the surge in procedural demand expected to follow the current pandemic. While there is limited information available for providers and governing bodies at this time, understanding how public interest for elective procedures has changed during the recent crisis can help policy makers understand these potential future financial losses and surges in health care demand. Given that total joint arthroplasty (TJA) remains one of the most commonly performed elective procedures in the United States [14], interest in TJA likely serves as an appropriate model to obtain this information.

A rapid decline in elective TJA and other stable revenue sources during the current crisis could place enormous financial strain on hospitals faced with a surge of COVID-19 cases. In times of urgency or crisis, primary data sources are often unavailable. A successful tool, however, to study the epidemiology of disease outbreaks and public consciousness alike has been the Google Trends analytics platform [15–18]. Regarding the present pandemic, the tool is already being utilized to map the prevalence of symptoms related to COVID-19 and predict hotspot regions before they overtly emerge [19–21]. The purpose of this study was to use the Google Trends analytics platform to quantify the impact of COVID-19 on the relative public interest in elective TJA.

Methods

The Google Trends analytics platform was utilized to determine the Google Search Volume Index (GSVI) values for key search terms related to TJA. The platform is useful for describing both geographic and temporal patterns in the popularity search terms. The GSVI is a normalized index, relating the volume of searches within a given region or time against the total volume of Google searches within the same setting. GSVI values are scaled from 1 to 100, with a value of 50 representing half the search popularity as a value of 100. This service has previously been used to analyze public interest in orthopedic surgery, elective surgical procedures in other surgical subspecialties [22–24], and a variety of other clinical services [25–30]. The terms “knee replacement,” “hip replacement,” and

Table 1
 Google Search Volume Index (GSVI)^a Values for Total Joint Arthroplasty–Related Searches (2015-2020).

Search Term	Google Search Volume Index (GSVI) Values						5-y Average
	April 2015	April 2016	April 2017	April 2018	April 2019	April 2020	
“Knee replacement”	68	72	75	84	86	42	71.47
“Hip replacement”	50	61	63	66	69	39	55.38
“Orthopedic surgeon”	54	59	72	70	81	48	64.02

^a The Google Search Volume Index (GSVI) is calculated by Google Trends by normalizing the volume of a search term against the total volume of searches within a specific period and region. (1-100 = low to high popularity).

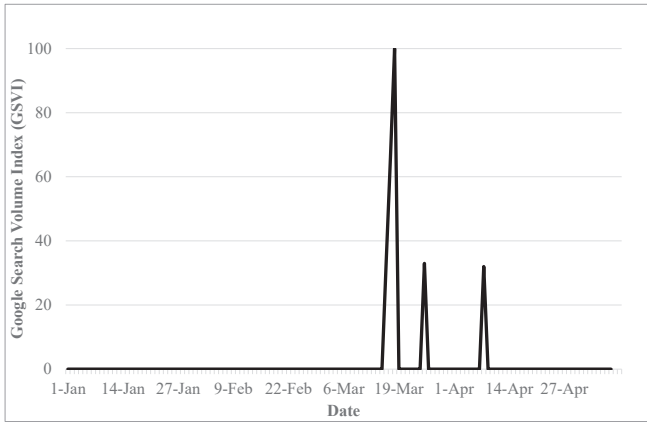


Fig. 2. Google Search Volume Index (GSVI)* values for the keyword “elective surgery cancellation” in the United States from January 1, 2020, to May 9, 2020. *The Google Search Volume Index (GSVI) is calculated by Google Trends by normalizing the volume of a search term against the total volume of searches within a specific period and region. (1-100 = low to high popularity).

“orthopedic surgeon” were determined to be the most searched and, therefore, were included in our analysis. Among the general public, these keywords were discovered to have a much higher usage than terms such as “arthroplasty” or “total joint replacement.” We implemented searches for both **“orthopaedic”** and **“orthopedic”** to expand the scope of our analysis but determined

the latter keyword to have an over 16-fold higher utilization in the United States. To account for the current shift of elective surgeries, the string “elective surgery cancellation” was analyzed.

For each search term, weekly GSVI data were extracted for all 50 states and the District of Columbia between April 1, 2015, and April 4, 2020. Time series analysis was conducted using validated statistical process control (SPC) methodology. An average moving range was calculated across the entirety of the study period. This value was used to construct control limits, which closely approximate three standard deviations above and below the mean. The purpose of these limits is to differentiate between random and special cause variation, the former being defined as fluctuation within the upper and lower boundaries. These methods are commonly used to track the stability of large data sets across many industries [30–36].

In addition to the SPC analysis, individual states were compared to determine those with the lowest interest in TJA during the first four months of 2020. The states identified to have the lowest GSVI values were compared against states with the highest number of COVID-19 cases and against the states experiencing the greatest increase in new unemployment claims filed [37,38]. States were then stratified by the severity of the public health policies adopted by local governments as well as by US Census regions to assess for regional variation [39,40]. Changes in GSVI values assessed for states that issued a statewide shelter-in-place warning during the month of April were compared with those that did not. Similarly, changes in GSVI values were compared between states that were either in the process of reopening or remaining closed as of May 9, 2020 [41]. A

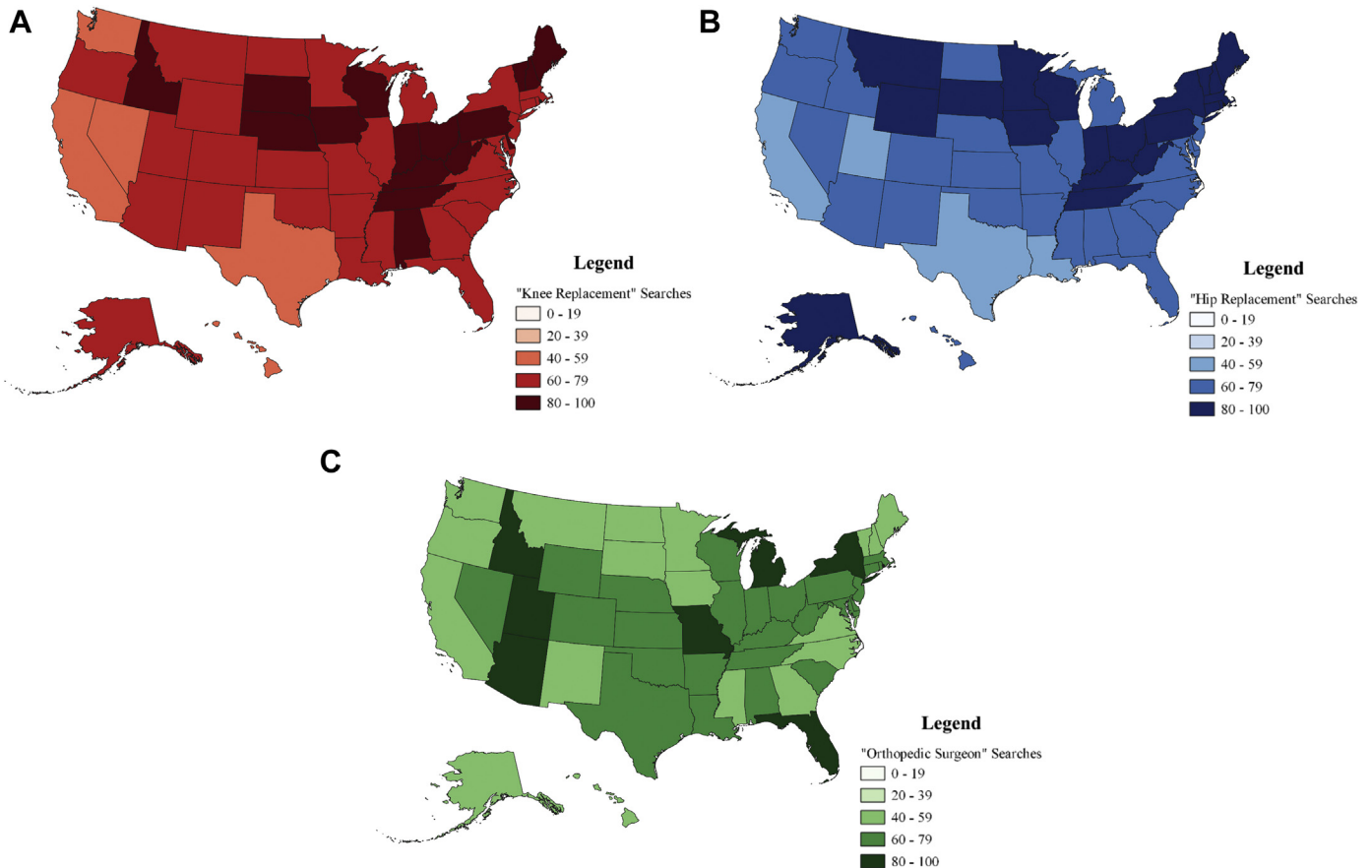


Fig. 3. US state analysis of Google Search Volume Index (GSVI)* values for total joint arthroplasty–related search terms from January 1, 2020, to May 9, 2020. (A). Knee replacement; (B). hip replacement; C. orthopedic surgeon. *The Google Search Volume Index (GSVI) is calculated by Google Trends by normalizing the volume of a search term against the total volume of searches within a specific period and region. (1-100 = low to high popularity).

Table 2
Comparison of US States With the Lowest Google Search Volume Index (GSVI)^a Values for Total Joint Arthroplasty–Related Keywords, COVID-19 Cases^b, and Recently Filed Unemployment Claims^c.

State Rank	“Knee Replacement”	“Hip Replacement”	“Orthopedic Surgeon”	Confirmed COVID-19 Cases (#)	Average Weekly Unemployment Claims Filed, % Increase From 2019 to 2020
1	District of Columbia (42)	District of Columbia (50)	North Dakota (44)	New York (340,792)	New Hampshire (1783.8%)
2	California (44)	Texas (52)	Oregon (47)	New Jersey (138,532)	Georgia (1466.4%)
3	Hawaii (45)	Utah (56)	North Carolina (50)	Massachusetts (76,743)	Louisiana (1459.4%)
4	Nevada (46)	California (57)	Maine (51)	Illinois (76,008)	Florida (1448.3%)
5	Texas (53)	Louisiana (59)	Minnesota (51)	California (67,165)	North Carolina (1347.5%)

^a The Google Search Volume Index (GSVI) is calculated by Google Trends by normalizing the volume of a search term against the total volume of searches within a specific period and region. (1–100 = low to high popularity).

^b COVID-19 Case data taken from Lancet [36]. Current as of May 10, 2020.

^c Unemployment Claims data taken from the US Department of Labor [34]. Average weekly unemployment claims were calculated from January 1 to December 31 for the year 2019, and from January 1 to April 25 for the year 2020.

two-tailed Student’s *t*-test was used to compare changes in GSVI values across groups of states with the threshold for significance set to $P = .05$. Variation in GSVI values by census region was assessed using a one-way ANOVA test with a significance threshold also of $P = .05$. All statistical analyses were conducted using RStudio version 3.6.2 (RStudio, Incorporated, Boston, MA).

Results

Across the United States, relative public interest in elective TJA has sharply declined since the World Health Organization declaration identifying COVID-19 as a global pandemic on March 11, 2020 [3]. Specifically, between March 1, 2020, and March 29, 2020, the relative popularity of searches for “knee replacement,” “hip replacement,” and “orthopedic surgeon” declined by 62.1%, 52.1%, and 44.3%, respectively (Fig. 1A–C). The 5-year average GSVI values for these search terms were 72.1, 55.2, and 63.7, respectively. To account for seasonal variation, GSVI values for April of each year between 2015 and 2020 were assessed as well (Table 1). For each search term, the drop in GSVI values observed during March of 2020 breached the lower control limit, approximating three standard deviations below the five-year mean. According to standard SPC methodology, this drop signifies a nonrandom variation in the GSVI data. The decline was the most significant for “knee replacement” searches, followed by “hip replacement” and “orthopedic surgeon” searches. A concurrent spike was apparent in March 2020 for the search term “elective surgery cancellation,” with an observable peak on March 15, 2020 (Fig. 2).

States with the lowest GSVI values for “knee replacement,” “hip replacement,” and “orthopedic surgeon” were the District of Columbia, District of Columbia, and North Dakota, respectively. Meanwhile, the states with the highest number of confirmed COVID-19 cases (as of April, 2020) were determined to be New York, New Jersey, Massachusetts, Illinois, and California. California was identified among the bottom 5 states for search popularity of knee and hip arthroplasties, while also being in the top 5 states for the number of COVID-19 cases (Fig. 3A–C; Table 2). Interestingly, Louisiana and North Carolina were observed among the bottom five states for TJA-related searches, while also experiencing the greatest increases in average weekly unemployment claims (Table 2). An analysis of US Census regions revealed slight geographic variations, although none determined to be statistically significant (Fig. 4).

Current public health policies in response to the pandemic are demonstrated in Figure 5. These responses varied across states and range from no social distancing mandate (“limited action”) to mandatory quarantine alongside the complete suspension of all nonessential activities (“stay at home order”). A comparison of states issuing mandatory shelter-in-place orders against states that did not showed the former group to have greater decreases in GSVI

values for TJA-related searches (Table 3). Notably, GSVI values for “orthopedic surgeon” searches decreased on average by -4.49 (15.17) in shelter-in-place states compared with an average increase of $+11.50$ (24.18) in non-shelter-in-place states. Similarly, for “knee replacement” searches, average GSVI values decreased by -7.67 (19.31) in shelter-in-place states, while increasing by $+0.50$ (19.12) in non-shelter-in-place states. However, neither of these differences was determined to be statistically significant ($P = .19865$ and $P = .28619$, respectively). An additional analysis comparing states by reopening status as of May 9, 2020, revealed states in the process of reopening to have slightly smaller decreases in GSVI values compared with states remaining closed for the time being (Table 4). However, these findings similarly did not reach the level of statistical significance.

Discussion

The onset of the global COVID-19 pandemic has been correlated with a sharp decline in the popularity of online searches related to elective TJA both in the United States and worldwide. Specific regions experiencing a high volume of COVID-19 cases may coincide with regions where the relative public interest in elective TJA is lowest, although this pattern remains unclear. In addition, the recent rise of unemployment, concurrent with the closure of many nonessential businesses may be useful in explaining declining interest in elective TJA. Employer-based insurance remains the

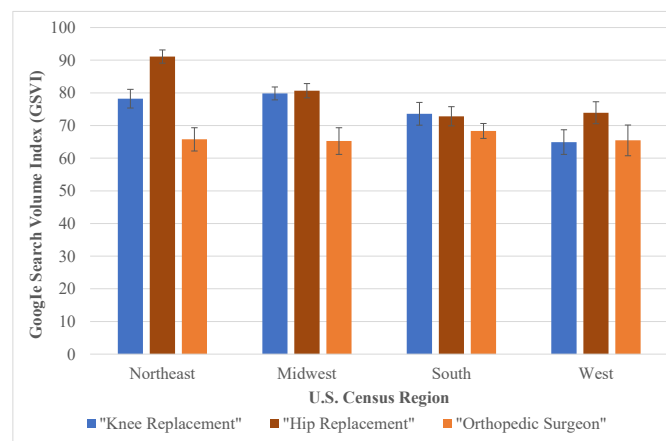


Fig. 4. US Census regional analysis of Google Search Volume Index (GSVI)* values for total joint arthroplasty–related search terms from January 1, 2020, to May 9, 2020. *The Google Search Volume Index (GSVI) is calculated by Google Trends by normalizing the volume of a search term against the total volume of searches within a specific period and region. (1–100 = low to high popularity).

Table 3
Change in Google Search Volume Index (GSVI)^a Values for Total Joint Arthroplasty–Related Search Terms, by April State Policy Response^b.

Search Term	Change in GSVI Values Between Two Periods (January 1 – March 14; March 15 – May 9)			P-value
	All States (SD)	Statewide Shelter-in-Place (SD)	No Statewide Shelter-In-Place (SD)	
“Knee replacement”	–6.39 (19.50)	–7.67 (19.31)	+0.50 (19.12)	.285619
“Hip replacement”	–5.65 (14.01)	–5.93 (14.62)	–4.13 (9.97)	.744039
“Orthopedic surgeon”	–1.98 (17.88)	–4.49 (15.17)	+11.50 (24.18)	.19865

^a The Google Search Volume Index (GSVI) is calculated by Google Trends by normalizing the volume of a search term against the total volume of searches within a specific period and region. (1–100 = low to high popularity).

^b State policy response defined as presence of a shelter-in-place warning in the month of April [41]. States with no statewide shelter-in-place orders include Iowa, North Dakota, South Dakota, Nebraska, Arkansas, Oklahoma, Wyoming, and South Carolina.

primary means with which patients under the age of 65 years access important health care services. A wave of unemployment could potentially be accompanied by a wave of un/underinsurance, making it difficult for patients to seek necessary medical and surgical care. Conversely, a lowered interest in hip and knee arthroplasties might be reflective at the system level, considering the possibility that patients with nonemergent health care needs are truly deferring care-seeking behavior to adhere to with social distancing protocols. Irrespective of the reason, these results represent a decline in elective TJA case volume and subsequent financial strain on many hospitals, particularly those serving critical-access functions.

Our study is most clearly limited by the use of GSVI values as a proxy for public interest in elective TJA and as a predictor for distal health care economic trends. In addition, our analysis included a relatively short time frame and did not, therefore, account for longer term trends in the online search queries of potential patients. However, given the rapid progression of COVID-19, we would suggest that real-time data regarding its impact on current and future elective surgery remain crucial. The degree to which Google Trends data such as the GSVI truly represents current consumer behavior and sentiment around elective TJA is uncertain. Notably, we were unable to capture queries related to additional

search engines and could not control for the possibility of patients seeking TJA information elsewhere. Furthermore, although elderly patients are more likely to seek surgical management for osteoarthritis, it is possible that this patient population may be less accustomed to using technological services [42]. Granted that Google receives over 2 trillion queries a year [43], however, our study population likely serves as an adequate sample of those seeking health information on the internet [44].

One growing concern across the orthopedic community is the potential surge in TJA demand expected after the resolution of the coronavirus crisis. According to the model by Sloan et al., approximately 1.4 million TJA procedures were projected in 2020 [14]. These numbers translated to billions of US dollars in expected costs for the Centers for Medicare and Medicaid, as well as for hospital systems nationwide. However, now that there has been a delay in care for months, the pent-up demand for TJA will result in a greater burden on the health care systems with subsequent delays in care, as providers attempt to catch up with this increased need. Several prior studies have examined the impact of delays in care-seeking behavior from a variety of angles. Utilizing National Readmission Database, Schwartz et al. found that TJA incidence sharply declined at age 63 years, with an abrupt increase demonstrated at between ages 64 and 65 years (total hip arthroplasty: 30; 4%; total knee

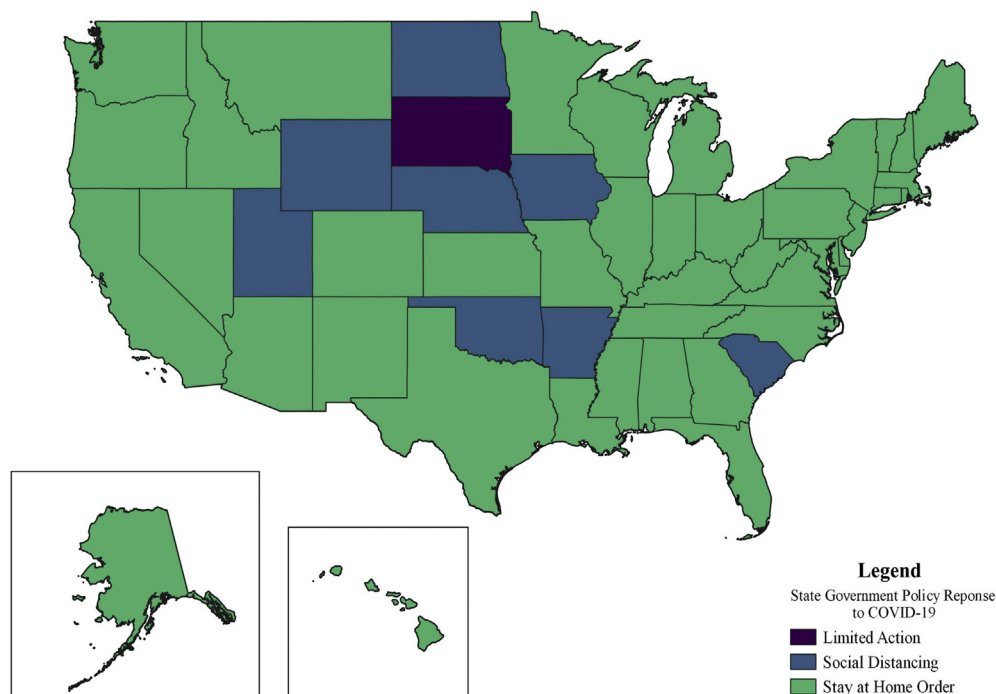


Fig. 5. Map of United States stratified by public health policies in effect as of April 7, 2020 [36]. *Policy data accurate as of April 7, 2020. “Limited action” refers to public advocacy around social distancing and hygiene measures, without mandatory restrictions. “Social distancing” refers to voluntary quarantine directives with the closure of schools, bars, and restaurants. “Stay at Home Order” refers to mandatory quarantine and suspension of all nonessential business and activities.

Table 4
Change in Google Search Volume Index (GSVI)^a Values for Total Joint Arthroplasty–Related Search Terms, by State Closure Status^b.

Search Term	Change in GSVI Values Between Two Periods (March 1 – April 14; April 15 – May 9)			P-value
	All States (SD)	Closed States (SD)	Reopening States (SD)	
“Orthopedic surgeon”	–3.88 (27.13)	–9.24 (25.18)	–0.13 (27.81)	.246847
“Knee replacement”	–23.20 (18.63)	–23.62 (12.50)	–22.83 (21.91)	.885036
“Hip replacement”	–20.30 (21.47)	–22.83 (21.91)	–19.38 (10.67)	.800122

^a The Google Search Volume Index (GSVI) is calculated by Google Trends by normalizing the volume of a search term against the total volume of searches within a specific period and region. (1–100 = low to high popularity).

^b State closure status is reported as of May 9, 2020 [41].

arthroplasty: 24.7%). This translated to an estimated excess cost of \$55 million (range: \$33–\$70 million) for 4616 pent-up TJA procedures [45]. When these findings are considered with respect to the likely decreased demand for TJA during the present pandemic, the possibility of overwhelming future costs becomes clear. Therefore, our study should encourage policy makers and providers to fashion contingency planning to mitigate potentially pent-up demand.

Further research is warranted to evaluate the impact of COVID-19 and elective surgery postponement on health care utilization and economic trends across orthopedic practices. Specifically, future analyses should incorporate primary data regarding procedural volumes, costs, and additional financial metrics wherever possible. Strategies for resiliency and possible avenues for continued, although modified, patient care should also be investigated. In terms of maintaining patient access in the setting of mandatory social distancing, the implementation of telemedicine has become a viable option [46]. Given the consistent financial benefits that these platforms have demonstrated [47–51], their utilization may serve to partially reduce the lost elective revenue that health care systems are likely experiencing. However, a lack of nationwide parity laws related to their coverage among insurance providers has significantly been shown to limit their use [52,53]. Multiple states have already passed laws regarding expanding telehealth services for their constituents [54], and Congress recently mandated \$500 million for the implementation of telehealth in Medicare patients through the Coronavirus Preparedness and Response Supplemental Appropriations Act [55]. Nevertheless, a continued and swift push for parity laws to ensure the wide telehealth services may very well be warranted.

The present study provides a unique evaluation of online search queries related to TJA and demonstrates their rapid decline during the COVID-19 pandemic. We have found a drastic decrease in the relative popularity of google searches for hip and knee arthroplasties both nationally and worldwide. Granted that patients suffering from osteoarthritis will continue to need care after the current crisis is controlled, the possible pent-up demand could result in a greater volume and economic burden that our present health care systems may be able to withstand. This, in turn, could translate to a bottleneck of care for many orthopedic patients. Public interest in TJA should continue to be followed in real time, nationally and globally, as the pandemic progresses. Further research is required to inform physicians, patients, the government, insurers, and other key stakeholders on how best to proceed through the COVID-19 pandemic. Focus should be on maintaining patient and physician safety, ensuring continued access, and analyzing preparedness for sudden fluctuations in both the supply and demand of care.

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