Volatility of Public Interest in Orthopaedics during the COVID-19 Pandemic

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Abstract

Background

Several studies have demonstrated the decrease of public interest in elective orthopaedic surgeries throughout the beginning and middle of the COVID-19 pandemic, but none have assessed the return, if any, of public interest as the pandemic has progressed.

Questions/Purpose

Apply a user-friendly tool and replicable methodology to (1) determine differential impacts of COVID-19 on search frequencies for exploratory and interventional search terms; (2) evaluate if public interest towards some common orthopaedic symptoms and their respective elective procedures have returned to pre-pandemic baseline.

Method

Google search frequencies for common orthopaedic procedures and symptoms were extracted from Google Extended Trends for Health (GETH) between January 7th, 2018, and January 15th, 2022, using the Google Trends Information Extraction Tool. Queried terms were split into two categories: exploratory and interventional. Control limit analysis was performed for each search term to determine special cause variations and assess any recovery.

Results

All search terms saw significant decreases the week of March 15th, 2020, and five of the six saw at least one more drop during the 2020 holiday season. Search volumes for exploratory terms initially fell less and recovered nearly four times faster compared to search volumes for interventional terms, but volatility of public interest was seen until the end of the study window.

Conclusions

Public interest in elective orthopaedic procedures continues to be chaotic during this pandemic. This study is the first to assess the initial recovery of public interest in elective orthopaedic procedures in the COVID-19 era using a novel application of the Google Trends Information Extraction Tool and provides a timely update on changes in public perception as the pandemic has progressed. These results can be used to better understand, quantify, and potentially anticipate the interests of the national patient population and tailor care, public outreach programs, or policy based on real-time search trends.

Level of Evidence: V

Introduction

An estimated 41% of U.S. adults have delayed accessing healthcare during the COVID-19 pandemic [10]. Early in the pandemic, orthopaedics was predicted to have a total surgical backlog of greater than one million cases two years after elective surgeries had been hypothesized to have resumed [13]. This prediction is likely dramatically underestimating the effects of the pandemic as elective surgeries in many regions have continued to be put on hold secondary to staffing shortages from COVID-19 outbreaks of new variants in January 2022.

Given this backlog, orthopaedic surgeons, hospital systems, and policymakers would benefit from gaining an accurate understanding of the public interest towards orthopaedics to better prepare for their forthcoming needs. One patient survey of 360 total joint arthroplasties canceled due to COVID-19 showed that 90% of patients desired surgery as soon as possible, although they did express significant anxiety regarding COVID-19 transmission when seeking care [7]. Waiting for a surgical procedure is associated with decreased quality of life, with 12% of patients waiting for a knee replacement and 19% of patients waiting for a hip replacement describing themselves in a state "worse than death" [23]. While these studies demonstrate that there is a significant proportion of patients who would benefit from orthopaedic intervention as soon as possible, they fail to assess timely and regional changes in public interest towards orthopaedics, a gap for which the application of Google search volumes has become highly efficacious.

Google search volumes allow researchers to gauge public interest in almost any subject across the United States. These search volumes can be accessed via the open access platform Google Trends or via the platform designed specifically for healthcare researchers, Google Extended Trends API for Health (GETH), which gives increased data granularity and accuracy. These platforms allow users to query Google search data within a window of time and specific region, and their use in research has increased 20-fold from 2009 to 2018 [2]. Besides being used to track elective procedures across various specialties, Google search volumes has also been used to track public interest in cancer, suicide, vaccinations, and more [2, 5, 24, 27]. Considering this increasing momentum, using Google data to support major decision making and research may be commonplace in the near future, especially when paired with machine learning algorithms. For example, Poirier *et al.* were able to detect influenza outbreaks faster than the Center for Disease Control (CDC) [20]. Prior to the release of the Google Trends Extraction Tool in December 2020, data from GETH was only able to be extracted using coding languages such as Python, and the data and extraction methodology have been critiqued on their accuracy and reproducibility [18, 21]. Google Trends studies in orthopaedics after the COVID-19 pandemic have neither used the Google Trends Extraction tool nor assessed the recovery, if any, of public interest in elective orthopaedic procedures [14, 15, 24, 26]. However, increased public interest in orthopaedic symptomatology and procedures, measured via Google Trends, has been positively correlated to claims data and surgical procedures performed, making this work highly relevant to orthopaedic stakeholders [3, 9, 22, 27].

This study aims to utilize this user-friendly Google Trends Extraction tool and demonstrate a replicable methodology to (1) determine differential impacts of COVID-19 on search rates of exploratory and interventional terms; (2) evaluate if public interest towards some common orthopaedic symptoms and their respective elective procedures have returned to baseline. Given the proven relationship between public interest and surgical procedures, the results of this investigation will allow orthopaedic surgeons, hospital systems, and policymakers to better understand the effect that COVID-19 had on their patients and better anticipate the resurgent caseload.

Methods

Institutional Board Review approval was not required for this study. An API key was applied for and received from Google. Popular elective rather than urgent or emergent orthopaedic procedures was the focus of this study. Knee, hip, and shoulder symptoms and interventions were the focus of this study given the high frequency of these orthopaedic complaints and procedures. Google search frequency for orthopaedic symptoms and their respective elective procedures was extracted from GETH between January 7th, 2018, and January 15th, 2022, using the Google Trends Extraction Tool [21]. Data was collected from only within the United States using 200 samples. Sampling frequency was selected to increase data accuracy as noted by Raubenheimer *et al.* and in the Google Trends Extraction Tool help file [21].

Paired query terms were split into two categories: exploratory and interventional. The exact terms were selected by using the "Top Topics" and "Top Queries" features of the Google Trends Extraction Tool. This feature returns the search terms of the highest frequency or on relevant topics to the original search term, allowing users to fine-tune the search criteria for more accurate data collection. "Pain" was the most common exploratory term, and it was paired to anatomical regions (i.e., "hip pain") to specify searches for hip-related issues from more general searches relating to pain. This resulted in an exploratory category including "hip pain", "knee pain", and "shoulder pain". The interventional category included "hip surgery + hip replacement + total hip arthroplasty + arthroscopic hip surgery + hip labrum surgery", "knee surgery + knee replacement + meniscus surgery + acl surgery + arthroscopic knee surgery + total knee arthroplasty", "shoulder surgery + shoulder replacement + rotator cuff surgery + shoulder labrum surgery + shoulder tear surgery + arthroscopic shoulder surgery".

Statistical Analysis

Search frequencies for all terms were reported as weekly searches per 10 million Google searches. Control limit charts, based on time-series statistical process control (SPC) analysis, were created for each search term by finding a pre-pandemic mean search frequency, defined as January 1st, 2018, through January 1st, 2020. The upper and lower control limits (UCL/LCL) were defined as three standard deviations (SD) above and below the pre-pandemic mean search frequency. Using these control limits captures 99.7% of all normal search activity in a pre-COVID-19 era. Special cause variation or "out of control events" were defined as points falling outside control limits and events that tested positive on statistical control charts tests as defined by Benneyan and colleagues [4].

Descriptive statistics were reported as mean and standard deviation (SD) for search frequencies. Time to recovery, defined as the length of time measured in weeks that search frequencies were below the LCL on control limit analysis, was calculated. Differences in time to recovery were analyzed using non-paired *Student* t-tests. Statistical analyses were performed using Microsoft Excel Version 2013. Significance was set at 0.05.

Results

Search frequencies for all queried terms were found between January 1st, 2018, and January 15th, 2022 (**Figure 1**). The "pre-pandemic" time was defined as up to March 1st, 2020, as this was the week before the CDC announced COVID-19 as a pandemic on Wednesday March 11th, 2020. All time afterwards was considered within the pandemic. The mean pre-pandemic search frequencies, mean pandemic frequencies, and percent drop from the lowest point seen initially following the outbreak of the pandemic compared to the pre-pandemic mean are seen in **Table 1**. All control limit analyses can be seen in **Figures 2-7**. Search frequencies returned to at least above the LCL, on average, after 3.0 weeks for exploratory terms and 9.7 weeks for interventional terms (p= 0.013) (**Table 2**).
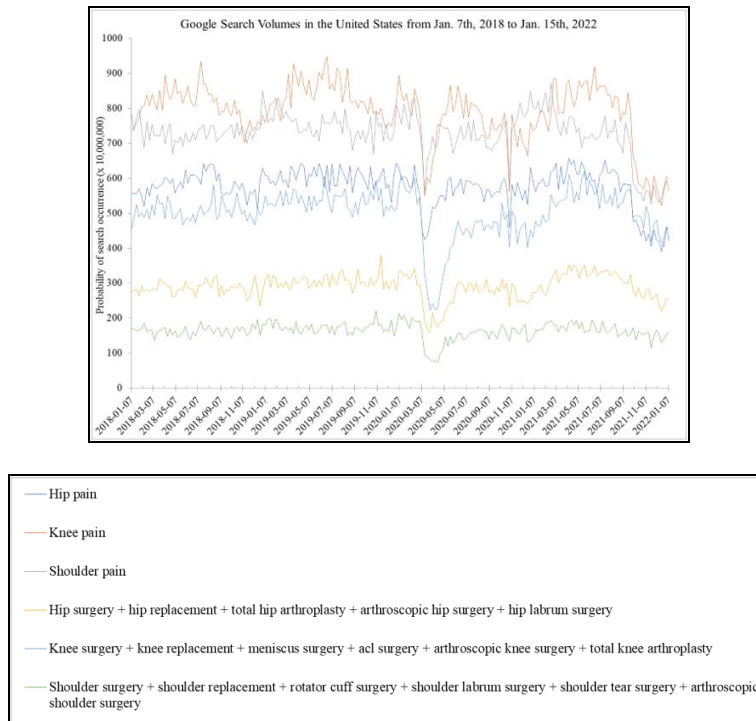

Figure 1: Google search frequencies from January 2018 through January 2022, divided in weekly intervals. Search frequencies for exploratory terms decreased comparatively less and recovered to pre-pandemic volumes faster than searches for interventional terms initially, but thisrelationship reversed as the pandemic went into the year 2022.
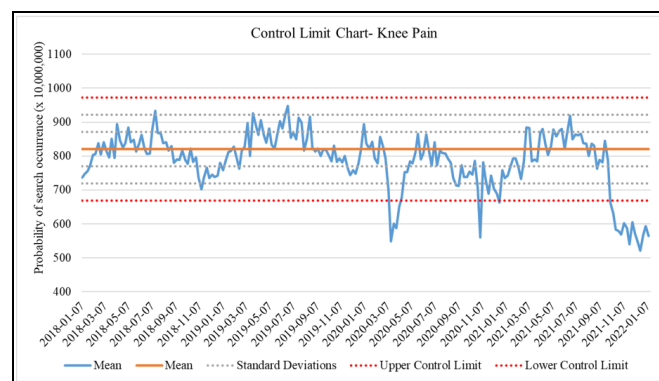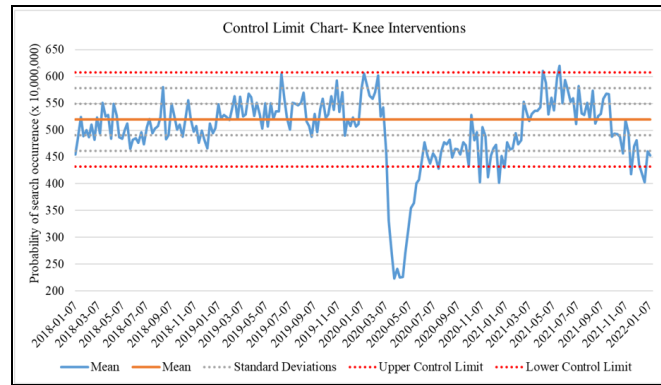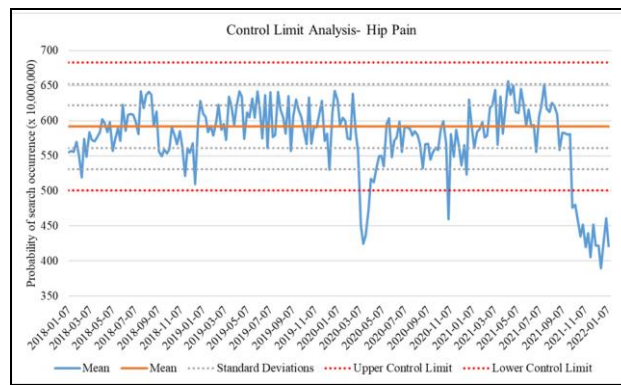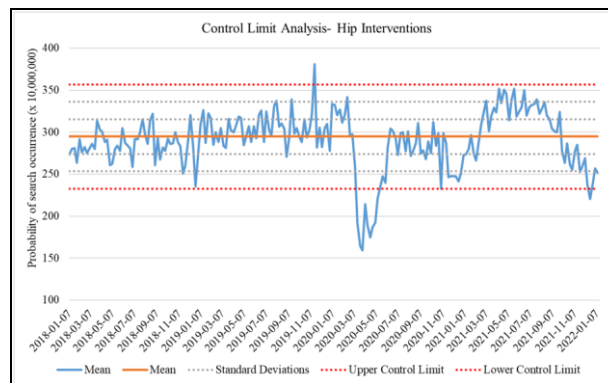

Figure 2: Control limit analysis for "knee pain" demonstrating the first significant decrease insearch volumes in March 2020 and subsequent out of control events. Pre-pandemic mean is defined as the mean search frequency from January 7th, 2018, to March 1st, 2019. UCL (uppercontrol limit) and LCL (lower control limit) represent three standard deviations from the pre-pandemic mean search frequency.

Figure 3: Control limit analysis for "knee interventions" demonstrating the first significant decrease in search volumes in March 2020 and subsequent out of control events. Pre-pandemic mean is defined as the mean search frequency from January 7th, 2018, to March 1st, 2019. UCL(upper control limit) and LCL (lower control limit) represent three standard deviations from the pre-pandemic mean search frequency.

Figure 4: Control limit analysis for "hip pain" demonstrating the first significant decrease in search volumes in March 2020 and subsequent out of control events. Pre-pandemic mean is defined as the mean search frequency from January 7th, 2018, to March 1st, 2019. UCL (uppercontrol limit) and LCL (lower control limit) represent three standard deviations from the pre-pandemic mean search frequency.
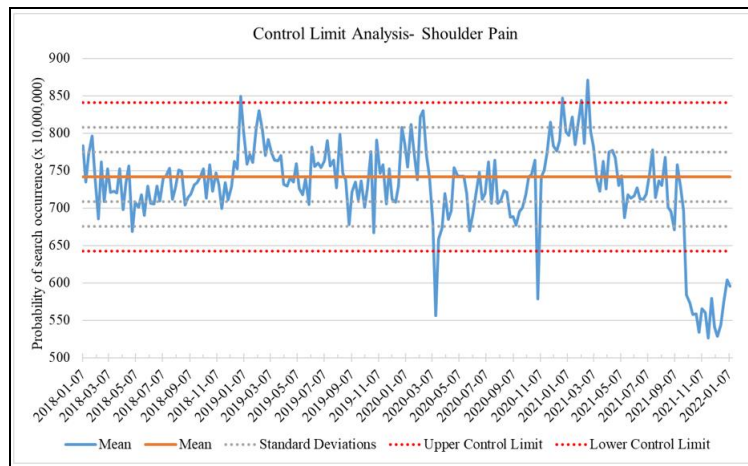

Figure 5: Control limit analysis for "hip interventions" demonstrating the first significant decrease in search volumes in March 2020 and subsequent out of control events. Pre-pandemic mean is defined as the mean search frequency from January 7th, 2018, to March 1st, 2019. UCL(upper control limit) and LCL (lower control limit) represent three standard deviations from the pre-pandemic mean search frequency.
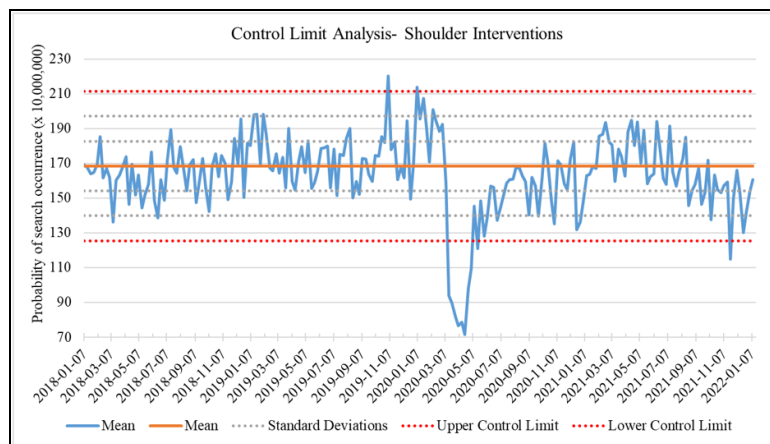
Figure 6: Control limit analysis for "shoulder pain" demonstrating the first significant decreasein search volumes in March 2020 and subsequent out of control events. Pre-pandemic mean is defined as the mean search frequency from January 7th, 2018, to March 1st, 2019. UCL (uppercontrol limit) and LCL (lower control limit) represent three standard deviations from the pre-pandemic mean search frequency.

Figure 7: Control limit analysis for "shoulder interventions" demonstrating the first significant decrease in search volumes in March 2020 and subsequent out of control events. Pre-pandemic mean is defined as the mean search frequency from January 7th, 2018, to March 1st, 2019. UCL(upper control limit) and LCL (lower control limit) represent three standard deviations from the pre-pandemic mean search frequency.

Query Term	Pre-PandemicMean*	PandemicMean*	Pandemic Search Drop[+]
Exploratory Terms			
Hip Pain	592 +/- 30	556 +/- 67	28%
Knee Pain	821 +/- 50	750 +/- 100	33%
Shoulder Pain	745 +/ 35	708 +/- 79	25%
Interventional Terms			
Hip Interventions	297 +/- 21	282 +/- 44	46%
Knee Interventions	523 +/- 32	473 +/ 83	57%
Shoulder Interventions	171 +/ 16	155 +/- 26	58%
*Search probability is reported as number of Google searches per 10^7 searches [+]Percentage change between pre-pandemic mean and lowest search frequency during initial dropin March 2020.			

Table 1: Variation in Google Search Frequency Between Pre-Pandemic and Pandemic Periods.

Time to Recovery (Weeks)		Average Recovery (Weeks)	P-value*
Exploratory Terms			
Hip Pain	4	3.0	
Knee Pain	4		
Shoulder Pain	1		**0.013**
Interventional Terms			
Hip Interventions	9	9.7	
Knee Interventions	12		
Shoulder Interventions	8		
Student's t-test			

Table 2: Time Required for Google Search Frequencies to Return above the LCL in March 2020.

There were subsequent out of control events for both exploratory and interventional search terms during the 2020 holiday season before a period of increased interest and special cause variations in April, May, and June 2021for all search terms except knee exploratory and shoulder interventional terms. After July 2021, search frequencies for exploratory terms trended down to an all-time low, while search frequencies for interventional terms did not show such a dramatic drop. Interventional terms did still demonstrate special cause variations and search frequencies below the LCL until the end of the search window.

Discussion

This study aimed to gain insight into public interest for common orthopaedic symptoms and their respective elective orthopaedic procedures as the COVID-19 pandemic has progressed. Our results showed that public interest declined sharply in 2020, once in March and again during the winter holiday season. Public interest in orthopaedics seemed to be recovering in the spring and summer of 2021 but was then found to fall again after the introduction of new variants of COVID-19. As of January 2022, the public interest in many orthopaedic conditions remains significantly depressed compared to before the pandemic. The search frequencies of exploratory terms were less influenced by the COVID-19 pandemic initially and recovered faster than those of interventional terms. As the pandemic progressed, search frequencies for interventional terms showed comparative resilience to resurgent caseloads in the final months of 2021 and beginning of 2022. Most significantly, search frequencies for all terms demonstrated volatility until the end of study period.

These findings and the method in which they were reached are both important additions to the literature as exploring the recovery of interest in orthopaedic procedures allows physicians, healthcare systems, and policymakers to better understand and anticipate the needs of their patient populations. By analyzing the public's response to real-world events, stakeholders can interpret their real-time reactions and respond to them. Using the COVID-19 pandemic as an example of a disturbance to the supply and demand of orthopaedic procedures allows researchers to see both the effect of this disturbance and the timeline until which equilibrium is restored. This study showed that the public initially did lose interest in elective orthopaedic procedures during the same week as the surgeon general announced a halt to these operations [1, 25]. The public interest in interventional terms dropped more significantly than the exploratory terms prior to June 2020. However, as the COVID-19 pandemic progressed, the data no longer demonstrated this relationship between interest in orthopaedic symptomology and procedures. In fact, the opposite was found. Even with the January 2022 COVID-19 caseload nearly four times higher than previously seen, elective surgeries canceled once again, and hospitals lacking adequate staffing, the public interest in elective orthopaedic procedures is higher than it was during the 2020 holidays [8]. This disassociation may reflect the public fatigue regarding COVID-19 or the quality-of-life challenges faced by patients during this time, leading them to grow restless to receive their procedures. Studies have shown that patients during the pandemic have suffered from increased rates of weight gain, drug abuse, and psychological disease, and these factors may be compounded in patients dealing with chronic pain, an area of further research [6, 16, 17].

Compared to similar studies, this study expanded on the symptoms, procedures, and window of time evaluated, as well as utilized a more accurate and reliable data extraction tool [15]. Combining these GETH data findings with the known surgical case backlog suggests a potential application of Google Trends for identifying bottlenecks in the healthcare process from symptom onset to treatment to recovery. Hospital systems and policymakers could leverage the methodology used in this study to identify bottlenecks in other aspects of patient care, such as examining interest in rehabilitation centers for chronic pain or postoperative care. They could then tailor patient outreach and distribute healthcare resources proportionally based on a timely assessment of community interest. The Google Trends Extraction tool also allows for the collection of data by state. This increased granularity could be used to analyze how individual states have been affected by COVID-19. Additionally, the recovery of interest in elective orthopaedic procedures could drive policy changes or scheduling flexibility in the clinic or operating room, tailored to the needs of their patient population. Studies have demonstrated the seasonality of interest and concurrent increase in surgical demand during those times, and further studies should explore the efficacy of applying this seasonality to staffing or supply chains [3].

This study should be viewed within the scope of its limitations. The monthly unemployment rate rose from 4% in March 2020 to

15% in April 2020 [**11**]. Patients' loss of health insurance through their employer may have contributed to decreased search frequency but not decreased interest in elective procedures. Additionally, there is also no way to discern the demographics of who is searching on Google, and this is a limitation in all Google Trends/ GETH studies. Some subgroups who do not search online or in English are likely left out from this data collection, however the majority of the United States is both digitally and English literate, so these limitations do not invalidate these results [**12, 19**]. The exact search terms used in this study only capture one specific symptom, pain, thus underestimating the true interest for orthopaedic complaints. Finally, the COVID-19 pandemic is actively evolving, so this study is limited by the most current data available. Despite these limitations, this study can be used to better understand, quantify, and potentially anticipate the interests of the national patient population and tailor care, public outreach programs, or policy based on timely search trends.

Conclusion

Our study has demonstrated a novel use of GETH data to measure public interest in orthopaedics since the beginning of the COVID-19 pandemic by applying the Google Trends Extraction Tool and utilizing control limit analysis. Analyzing special cause variations within those search windows, a marked decrease in public interest for orthopaedics occurred in March 2020, followed by an initial recovery but then subsequent volatility until the end of the study period. By the end of the study period, full recovery of public interest in elective orthopaedic procedures to baseline pre-pandemic levels had not yet been reached. With the application of the Google Trends Extraction Tool, our study is the first to record any resurgence in public interest in elective orthopaedics as the COVID-19 pandemic has progressed and provides a timely update to the literature as new variants continue develop. With GETH and the Google Trends Extraction tool, orthopaedic surgeons, hospital systems, and other stakeholders can easily and accurately gauge public interest in several common orthopaedic symptoms and procedures and utilize those data to make better-informed decisions about patient care, preventative action, or policy changes.

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