

## RESEARCH

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# The impact of the COVID-19 Pandemic on Hip and Knee Arthroplasty: A Systematic Review

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## ABSTRACT

**Background:** In order to ameliorate the burden the coronavirus disease 2019 (COVID-19) pandemic had on the medical resources, and to ensure the safety of orthopaedic patients and medical personnel, some hip and knee arthroplasties, as forms of elective surgeries, were suggested to be canceled or postponed. This review aims to analyze the available literature on the impact of COVID-19 pandemic on all areas surrounding hip and knee arthroplasty service.

**Materials and Methods:** A systematic literature search was conducted in five databases from July 5<sup>th</sup> to 10<sup>th</sup>, 2020. We included studies that assessed any impacts the COVID-19 pandemic had on the patients who require hip or knee arthroplasty, hip and knee surgeons, and any other areas that are related to hip and knee arthroplasty service. We excluded studies that do not report complete clinical results, reviews, editorials, and letters.

**Results:** After the screening, a total of nine articles were selected. Two studies evaluated the impact of COVID-19 on the hip and knee arthroplasty patients, one study on public interest in hip and knee arthroplasty, three studies on the hip and knee arthroplasty surgeons, two studies on surgical volume, and one study on industry partners. Of 360 surveyed patients, 60% felt anxious about the uncertainty of the rescheduled arthroplasty. Of 1770 surveyed surgeons, 61.9%, 54.7%, and 20.9% of them reported canceled elective inpatient procedures, outpatient procedures, and all types of surgeries, respectively.

**Conclusion:** COVID-19 pandemic had some impacts on the patients, public interest, surgeons, industry partners, and hip and knee arthroplasty volume.

**Keywords:** COVID-19; Hip arthroplasty; Knee arthroplasty; Surgeons; Impact

**Level of Evidence:** I



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## Introduction

At the end of 2019, we faced a new variant of the coronavirus that can cause pneumonia and acute respiratory distress syndrome-like symptoms. It started in Wuhan, Hubei Province, China, and spread quickly to the whole world.<sup>1</sup> This new virus is called Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and can manifest as a disease called coronavirus disease 2019 (COVID-19). On March 13<sup>th</sup>, 2020 World Health Organization (WHO) declared COVID-19 as a global pandemic, and it had been claiming hundreds of thousands of lives since then.<sup>2</sup>

The impact that this new disease has given has affected medical aspects, including orthopaedic surgery services. One that is affected is the hip and knee department. In order to alleviate the burden on the medical resources and ensure the safety of orthopaedic patients, surgeons, and other medical personnel, the American College of Surgeons (ACS) and American Academy of Orthopaedic Surgeons (AAOS) have recommended minimizing, postponing, or canceling all elective operations<sup>3,4</sup> Elective surgery is intended at patients with chronic diseases which by postponing the surgery will not cause any significant harm to the patients. It includes some types of hip and knee arthroplasty.<sup>4</sup> Consequently, curtailing or canceling hip and knee arthroplasty, as one of the most frequent elective surgery, inevitably will affect the health care system.<sup>5</sup> Although it is crucial to abide by this recommendation to help in preventing the spread of SARS-CoV-2, little is known about the impact of it on the patients, surgeons, and other areas. This review aims to analyze the available literature on the impact of COVID-19 pandemic on all areas surrounding hip and knee arthroplasty service, including but not limited to the patients, the hip and knee surgeons, and the health care system.

## Methods

This systematic review was written according to the guidelines for Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA).<sup>6</sup>

## 2.1 Eligibility criteria

### 2.1.1 Study characteristics

The population of the review is patients who require hip or knee arthroplasty, hip and knee surgeons, and any other areas that are related to hip and knee arthroplasty service. The intervention is COVID-19. The outcomes include any impacts the COVID-19 pandemic had on the population.

### 2.1.2 Report characteristics

All study designs in English, including clinical, prospective, retrospective, case series, and case reports were included in the study. No time limitations applied. Studies that do not report complete clinical results, review articles, editorials, and letters were excluded.

## 2.2 Search strategy and study selection

A literature search was conducted from July 5<sup>th</sup> to 10<sup>th</sup>, 2020, in 5 databases (*PubMed, Science Direct, ProQuest, The Cochrane Library, and Wiley Online Library*). Search keywords used across all databases using Boolean logic were: covid AND (hip OR knee) AND arthroplasty. Any duplicate studies were first excluded, and study titles and abstracts were then screened. Full-text analysis of selected articles was subsequently done based on previously set eligibility criteria. Additionally, the bibliographies of extracted full-text articles were further analyzed to identify other studies that could be included. Two independent researchers performed article screening and data analysis.

## 2.3 Data Extraction

Relevant data pooled from each study article were: study characteristics and design, population characteristics, and outcome measures, which include any impacts COVID-19 pandemic had on the population.

## 2.4 Critical Appraisal

The quality of included studies was critically appraised using CEBM Harm/Etiology/Risk Critical Appraisal Worksheet, and Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence.

## Results

## 3.1 Literature search

A total of 408 publications were initially retrieved (Figure 1). Out of them, 375 were excluded after title/abstract screening, and 24 were excluded after the full-text screening, leaving nine articles included for review.

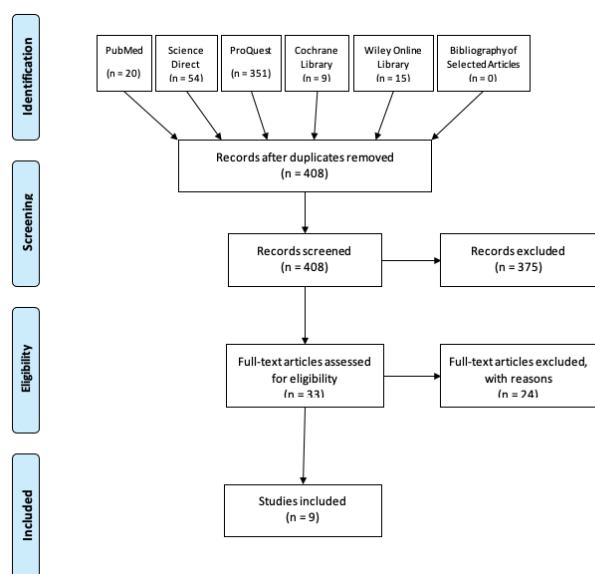


Figure 1. Literature searching process

## 3.2 Study characteristics

Of the nine articles, eight of them are cross-sectional studies, and one of them is a prospective cohort. Therefore, only one study included a follow-up. Subjects ranged from 10 to 1399. Three studies did not use any subjects in their study. Jella et al.<sup>7</sup> calculated the public interest in hip and knee arthroplasty using Google Search Volume Index (GSVI). Meanwhile, D'Apolito et al.<sup>8</sup> computed the hip and knee arthroplasties volume based on their institution's database, and Bedard et al.<sup>9</sup> estimated the hip and knee arthroplasties volume based on previously published studies. Six studies used a survey for conducting the study. The more detailed characteristics of the studies are listed in Table I.

Table I. Characteristics of the included studies

Author(s)	Year	Country(s)	Study Design	Evidence level	Subjects	Mean Age	Male: Female	Mean follow up duration (weeks)
Brown et al. <sup>10</sup>	2020	USA	Cross-sectional	IV	360	65	152:208	N/A
Endstrasser et al. <sup>11</sup>	2020	Austria	Prospective cohort	III	63	62.4	28:35	8
Jella et al. <sup>7</sup>	2020	USA	Cross-sectional	IV	N/A	N/A	N/A	N/A
Thaler et al. <sup>12</sup>	2020	Austria, Switzerland, Netherlands, Italy, & France	Cross-sectional	IV	272	N/A	N/A	N/A
Athey et al. <sup>13</sup>	2020	USA, China, Japan, Italy, & Germany	Cross-sectional	IV	99	N/A	N/A	N/A
Liebensteiner et al. <sup>14</sup>	2020	Austria & Switzerland	Cross-sectional	IV	1399	N/A	N/A	N/A
D'Apolito et al. <sup>8</sup>	2020	Italy	Cross-sectional	IV	N/A	N/A	N/A	N/A
Bedard et al. <sup>9</sup>	2020	USA	Cross-sectional	IV	N/A	N/A	N/A	N/A
Warth et al. <sup>15</sup>	2020	USA	Cross-sectional	IV	10	N/A	N/A	N/A

Abbreviation: N/A, not applicable

## 3.3 Impact of the arthroplasty rescheduling or cancellation due to COVID-19

Two studies evaluated the impact of COVID-19 on the hip and knee arthroplasty patients (423 subjects), one study on public interest in hip and knee arthroplasty, three studies on the hip and knee arthroplasty surgeons (1770 subjects), two studies on surgical volume, and one study on industry partners (10 subjects).

Studies with the same affected subject and outcome measure are grouped, and the results are quantified. A total of 1770 surgeons were surveyed regarding their canceled procedure. Sixty-one-point nine percent, 54.7%, and 20.9% of them reported canceled elective inpatient procedures, outpatient procedures, and all types of surgeries, respectively.

Regarding the type of canceled arthroplasties, 82.1% of 1770 surgeons reported that they did not perform all primary total joint arthroplasty (TJA) anymore, while 72.9% answered that all aseptic TJA revisions were canceled. However, 75.1% and 59% of 1770 surgeons stated that they still performed surgeries for periprosthetic fracture and first-stage explantations for periprosthetic joint infection (PJI), respectively.

It was found that 89.8% of 1671 surgeons from two studies described a drastically reduced surgical volume. Moreover, 43.6%, 41.5%, and 23.3% of 1770 surgeons reported disrupted teaching activities, more administrative work, and non-orthopaedic duties, respectively.

Fifty-pointfour percent of 371 surgeons stated that they were effectively not working anymore. Furthermore, 63.9% and 56.6% of 371

surgeons experienced supply and staff disruptions, respectively.

Regarding surgeons' personal and social life, 11% of 1671 surgeons avoided physical contact with their families, 14.5% applied some forms of social distancing with their families, and 4.8% lived in separate rooms. Moreover, 2.9% not even go home anymore. A more detailed review of the studies is presented in Table II.

Table II. Impact of arthroplasty rescheduling or cancellation

Author(s)	Area affected	Impact
Brown et al. <sup>10</sup>	Patient's well-being	<p>Anxiety:</p> <ul style="list-style-type: none"> <li>- Not knowing when the canceled arthroplasty will be rescheduled as the highest source of anxiety (60%)</li> <li>- Younger subjects were significantly more anxious about finances (<math>P &lt; .001</math>) &amp; job insecurity (<math>P &lt; .001</math>) than older subjects</li> </ul> <p>Pain: Increased hip/knee arthritis pain since cancellation (54%)</p> <p>Plan:</p> <ul style="list-style-type: none"> <li>- Will still reschedule surgery in the near future (88%)</li> <li>- Wished to delay further for fear of COVID-19 (6%)</li> </ul>
Endrasser et al. <sup>11</sup>	Patients well being	<p>VAS: The mean scores increased significantly at follow-ups (<math>P = .009</math> &amp; <math>P = .029</math>)</p> <p>WOMAC: The mean scores increased significantly at follow-ups (<math>P = .004</math> &amp; <math>P &lt; .001</math>)</p> <p>SF-12 PCS: The mean scores decreased significantly between the 1st and the last interview (<math>P = .026</math>)</p> <p>Plan:</p> <ul style="list-style-type: none"> <li>- Want to do the surgery as soon as possible (79%)</li> <li>- Wished to delay further for fear of COVID-19 (21%)</li> </ul>
Jella et al. <sup>7</sup>	Public interest	<p>GSVI:</p> <ul style="list-style-type: none"> <li>- Between March 1<sup>st</sup>, 2020, and March 29<sup>th</sup>, 2020, the relative popularity of searches for "knee replacement," "hip replacement," and "orthopedic surgeon" declined by 62.1%, 52.1%, and 44.3%, respectively</li> <li>- A drastic increase in the relative popularity of search for "elective surgery cancellation" on March 15<sup>th</sup>, 2020</li> </ul>
Thaler et al. <sup>12</sup>	Surgeon's services & well-being	<p>Cancellation:</p> <ul style="list-style-type: none"> <li>- Elective inpatient procedure (68.4%)</li> <li>- All outpatient procedures (68%)</li> <li>- All type of surgeries (25.7%)</li> </ul> <p>Canceled surgeries:</p> <ul style="list-style-type: none"> <li>- Aseptic TJA revisions (94.7%)</li> <li>- Primary TJA (92.6%)</li> <li>- TJA for rapid progressive osteoarthritis (86.2%)</li> </ul> <p>Still performed surgeries:</p> <ul style="list-style-type: none"> <li>- Periprosthetic fracture (87.2%)</li> <li>- THA/hemiarthroplasty for femoral neck fractures (84.8%)</li> <li>- First-stage explantations for PJI (75.6%)</li> </ul> <p>Work:</p> <ul style="list-style-type: none"> <li>- Drastically reduced surgical volume (82.6%)</li> <li>- Effectively not working due to institutional or self-</li> </ul> <p>Hospital resources:</p> <ul style="list-style-type: none"> <li>- Supply disruptions (63.5%)</li> <li>- Staff disruptions (62%)</li> </ul> <p>Personal life:</p> <ul style="list-style-type: none"> <li>- Avoided physical contact with their families (22.6%)</li> <li>- Keep a distance to their families (21.3%)</li> <li>- Lived in separate rooms at home (5.5%)</li> <li>- Not even go home anymore (2.9%)</li> </ul>
Atthey et al. <sup>13</sup>	Surgeon's services & well-being	<p>imposed deferral of elective surgery (53%)</p> <ul style="list-style-type: none"> <li>- Disrupted teaching (52.2%)</li> <li>- More administrative work (46.7%)</li> <li>- Non-orthopaedic duties (39.3%)</li> </ul> <p>Cancellation:</p> <ul style="list-style-type: none"> <li>- Elective inpatient procedure (71%)</li> <li>- Elective outpatient procedures (41%)</li> <li>- All type of surgeries (14%)</li> </ul> <p>Canceled surgeries:</p> <ul style="list-style-type: none"> <li>- Aseptic TJA revisions (91%)</li> <li>- Primary TJA (87%)</li> <li>- Second-stage reimplantations for PJI (85%)</li> </ul> <p>Still performed surgeries:</p> <ul style="list-style-type: none"> <li>- Periprosthetic fracture (83%)</li> <li>- Massively failed TJA (43%)</li> <li>- First-stage explantations for PJI (35%)</li> </ul> <p>Work:</p> <ul style="list-style-type: none"> <li>- Reduced clinical volume (69%)</li> <li>- Disrupted teaching (44%)</li> <li>- Effectively not working due to institutional or self-imposed deferral of elective surgery (42%)</li> <li>- More administrative work (26%)</li> <li>- Non-orthopaedic duties (10%)</li> </ul> <p>Hospital resources:</p> <ul style="list-style-type: none"> <li>- Supply disruptions (64%)</li> <li>- Staff disruptions (41%)</li> </ul> <p>Telemedicine:</p> <ul style="list-style-type: none"> <li>- Telephone (including apps, such as WhatsApp) (72%)</li> <li>- Zoom video conference (40%)</li> <li>- FaceTime/Google Chat (18%)</li> </ul> <p>Finance:</p> <ul style="list-style-type: none"> <li>- Governmental assistance (8%)</li> <li>- Private assistance (9%)</li> <li>- No assistance (82%)</li> <li>- Forego compensation (44%)</li> <li>- Close practice (37%)</li> <li>- Furlough/layoff employees (22%)</li> <li>- Under financial stress (19%)</li> </ul> <p>Personal life:</p> <ul style="list-style-type: none"> <li>- Adapting successfully (49%)</li> <li>- Concern about putting the family at risk (21%)</li> <li>- Under mental/emotional stress (8%)</li> </ul>
Liebensteiner et al. <sup>14</sup>	Surgeons services & well-being	<p>Cancellation:</p> <ul style="list-style-type: none"> <li>- Elective inpatient procedure (59.9%)</li> <li>- All outpatient procedures (53%)</li> <li>- All type of surgeries (20.4%)</li> </ul> <p>Canceled surgeries:</p> <ul style="list-style-type: none"> <li>- Primary TJA (79.7%)</li> <li>- Aseptic TJA revisions (67.3%)</li> <li>- Massively failed TJA (39.5%)</li> </ul> <p>Still performed surgeries:</p> <ul style="list-style-type: none"> <li>- Periprosthetic fracture (72%)</li> <li>- THA/hemi-arthroplasty in femoral neck fractures (65.3%)</li> <li>- First-stage explantations for PJI (57.4%)</li> </ul> <p>Work:</p> <ul style="list-style-type: none"> <li>- Drastically reduced surgical volume (91.1%)</li> <li>- Disrupted teaching (41.8%)</li> <li>- More administrative work (41.5%)</li> <li>- Non-orthopaedic duties (21.1%)</li> </ul> <p>Personal life:</p> <ul style="list-style-type: none"> <li>- Avoided physical contact with their families (8.6%)</li> <li>- Keep a distance to their families (13.2%)</li> <li>- Lived in separate rooms at home (4.7%)</li> <li>- Not even go home anymore (2.8%)</li> </ul>

D'Apolito et al. <sup>8</sup>	Surgical volume	Hip and knee arthroplasties performed in 7 weeks period: - 706 in 2019 to 166 in 2020 (76.5% decrease) - Mean: 101 per week in 2019 to 24 per week in 2020 - Mortality rate: 0% in 2019 to 1.2% in 2020
Bedard et al. <sup>9</sup>	Estimated surgical volume	The number of procedures canceled in 100% cancellation scenario: - Primary THA: 9265 - Primary TKA: 20738 - Revision THA: 977 - Revision TKA: 1893
Warth et al. <sup>15</sup>	Industry partners	Decreased resources for orthopaedic meetings: - Regional meetings (67%) - Other national meetings (55%) - AAHKS spring meeting (40%) - AAHKS annual meeting (30%) Decreased resources for education: - Hands-on cadaveric (40%) - Resident (20%) - Fellow (20%) - Surgeon (20%) Increased resources for web-based education: - Recorded video education (100%) - Live video education (100%) Decreased resources for strategic points of emphasis: - Marketing (60%) - Technology (22%) - Product R&D (10%) Increased resources for strategic points of emphasis: - COVID-19 related operative safety measures (90%) - Outpatient joint arthroplasty (70%)

Abbreviation: VAS: Visual Analog Scale, WOMAC: Western Ontario And McMaster Universities Osteoarthritis Index, SF-12: Short-form health survey, PCS: Physical Component Summary, GSVI: Google Search Volume Index, TJA: Total Joint Arthroplasty, THA: Total Hip Arthroplasty, PJI: Periprosthetic Joint Infection, TKA: Total Knee Arthroplasty, AAHKS: American Association of Hip and Knee Surgeons, R&D: Research and Development.

## Discussion

Annually, hip and knee arthroplasty accounted for around 1.5 million elective procedure in the United States and around 5.6 million elective procedure in Europe, making them one of the most frequent elective procedure.<sup>5,16,17</sup> The recommendation declared by ACS and AAOS to limit the elective procedures, including hip and knee arthroplasty, was estimated to have a significant impact on many sectors around the hip and knee arthroplasty service. This review evaluated every available literature and found five areas that are affected by COVID-19, including patient's general well-being, public interest on hip and knee arthroplasty, surgeon's services and well-being, industry partners, and hip and knee arthroplasty overall volume.

WOMAC questionnaire was developed to evaluate the clinical status of patients with hip and knee osteoarthritis and reported to be clinically useful.<sup>18</sup> It consists of 3 subscales, including pain, stiffness, and physical function. It was observed that the patients' WOMAC scores increased

significantly between pre, during, and post-lockdown period. It was supported by the significant increase in the mean VAS scores between all periods and the significant decrease in SF-12 PCS mean scores between pre- and post-lockdown period. It may be explained by the lower level of physical activity the overall patients had during the lockdown period. Kraus et al.<sup>19</sup> and Morcos et al.<sup>20</sup> reported the association between low physical activity level and deterioration of hip and knee osteoarthritis. Thus, it is recommended to maintain an active lifestyle at home even during the lockdown period.

Moreover, it was discovered that the delay in receiving arthroplasty affected the patients not only physically, but also mentally. The highest source of anxiety for the patients was found to be not knowing when their arthroplasty will be rescheduled. However, younger patients have significantly more anxiety due to their financial condition and job insecurity than older patients. Ahmed et al.<sup>21</sup> evaluated the effect COVID-19 pose on the patient's psychological status and reported that social isolation during the lockdown period was correlated with several psychological problems. Furthermore, during this pandemic, the level of economic crisis experienced by each country depends on the availability of health insurance provided by the government. In countries where there is a lack of national health insurance, there will be an increased amount of unemployment that results in the loss of commercial health insurance. Consequently, there will be many citizens that cannot afford surgery although they actually need it.<sup>22,23</sup> It may be reflected by the drop of public interest in hip arthroplasty (52.1%) and knee arthroplasty (62.1%) between March 1<sup>st</sup> and March 29<sup>th</sup>, 2020. It will eventually pose emotional stress on the patients, especially the younger ones. Nevertheless, a total of 366 (86.5%) patients from two studies stated that they were still eager to do the arthroplasty as soon as possible raising a concern on a potential surge of arthroplasty demand after the pandemic subsides.

Of 1770 surgeons surveyed from three studies, 61.9% declared that elective inpatient surgeries were canceled, while 54.7% and 20.9% responded



that they no longer performed outpatient surgeries and all kind of surgeries, respectively. Regarding the type of surgery, 82.1% reported that they abandoned all primary TJA, while 72.9% answered that all aseptic TJA revisions were no longer being performed. These numbers represent a considerable reduction in elective arthroplasty practice. Meanwhile, 3.1 million THA and 2.5 million TKA were annually conducted in Europe, and around 1.4 million TJA was estimated to occur in 2020.<sup>5,17</sup> It would be translated to high values of costs that in turn will be allocated for developing the health care system. Thus, this massive cutback will eventually encumber the government generally and health care system specifically. In countries without national health insurance, the result will be a vicious cycle in which a high amount of unemployment will occur, resulting in the inability of patients to afford the needed arthroplasty and the reduced interest in seeking care for their pathologic condition, and finally even lower demand for hip and knee arthroplasty. Conversely, in countries with proper national health insurance, the pent-up schedule for the hip and knee arthroplasties may result in the spike of demand once the elective surgery restriction is lifted.

In this review, 89.8% of 1671 surgeons from two studies described a drastically reduced surgical volume. It is supported by the result of a study that found 76.5% decrease in the total number of hip and knee arthroplasties performed in seven weeks period and decreased mean hip and knee arthroplasties performed each week. One study estimated 9265 and 20738 canceled primary THA and primary TKA, respectively. Other literature in different fields of surgery discovered a similar outcome. Angelico et al.<sup>24</sup> found a 25% decrease in major organ transplantation volume due to limited availability of intensive care unit beds for both donors and recipients. Meanwhile, Connor et al.<sup>25</sup> and Lisi et al.<sup>26</sup> showed decreased urology and colorectal surgical volume, respectively. Moreover, 43.6% of 1770 surgeons reported that all student, resident, and fellow teaching activity was stopped. Forty-one-point five percent have to allocate their time for more administrative work and even non-orthopaedic

duties (23.3%). Surprisingly, 50.4% of 371 surgeons stated that they were effectively not working anymore due to self-imposed or institutional moratorium of elective surgery. This phenomenon will significantly cause some financial burden not only for the surgeons, but the entire health care system provided by the local government, hospital, private orthopaedic practices, and their employees. Forty-four percent of 99 surgeons had to forego their compensation in order to help relieve hospital's financial burden. Furthermore, 22% surgeons had to furlough their employees and 37% even closed their practice altogether. It is concerning that 19% of them were under financial stress.

One of the solutions to help with this burden is governmental aid. The United States government have passed the Coronavirus Aid, Relief, and Economic Security (CARES) Act to help individuals, businesses, and state and local government to maintain public services in the form of \$2 trillion funds. In addition, there are \$350 billion in additional loans for small business, including private orthopaedic practices.<sup>27</sup> However, from this review, it was discovered that only 8% of 99 surgeons that received governmental aid, while 82% of them received no financial assistance at all. The difference in governmental aid policy in every surgeon's country of origin may elucidate this result.

In addition to the surgeon's finance, the COVID-19 pandemic also affected the surgeon's personal and social life. Orthopaedic surgeons are at risk of contracting COVID-19 from their workplace. Guo et al.<sup>28</sup> found 26 orthopaedic surgeons that were infected by COVID-19 from December 31<sup>st</sup>, 2019 to February 24<sup>th</sup>, 2020 in Wuhan, China. They found that the incidence of the infected orthopaedic surgeons in each hospital is 1.5-20.7%. Therefore, at home, 11% of 1671 surgeons avoided physical contact with their families, 14.5% applied some forms of social distancing with their families, and 4.8% lived in separate rooms. Moreover, 2.9% not even go home anymore lest spreading the virus to their family members.

Not only the patients, hospitals, surgeons, and employees of the hospital and private practice, this pandemic also had some impacts on

arthroplasty industry partners. With massive financial burden suffered from this pandemic, the resources allocated for arthroplasty meetings has also been reduced. Thirty to 67% of surveyed companies responded that there had been a drop in resources for meetings, including regional, national, AAHKS spring, and AAHKS annual meetings. Resources allocated for the educational purpose has also been decreased with 20% of responding companies reported decreased educational resources for residents, fellows, and surgeons, and 40% of responding companies anticipated reduced resources for hands-on cadaveric training. At the same time, all companies (100%) agreed to allocate more resources on recorded and live video education. As the pandemic put a massive financial burden on the companies, every department in the companies has to make several compensation measures to balance the load. Twenty percent and 10% of surveyed companies had to furlough the production and marketing employees, respectively, while 10% of surveyed companies had to cut the wages of employees in the sales representative, R&D, and marketing departments. Ten percent of responding companies answered that they even had to let go of some of the employees in their R&D and marketing departments.

As we mentioned before, in countries with adequate national health insurance, the pent-up number of hip and knee arthroplasties is predicted to cause a surge of elective arthroplasty volume after the pandemic starts to resolve. For a countermeasure, 60% and 40% of the industry partners planned to increase the implant production and instrumentation number of sets, respectively. Besides, 90% of responding partners stated that there would be no change in their sales workforce once the pandemic subsides.

In the near future, the main goal of a surgeon will be how to maintain contact with patients for whom surgery was deemed elective until the rescheduled surgery is performed. In this case, the trend is moving toward the utility of social media and digital platform for medical counselling purpose. In this review, 72% of 99 surgeons used conventional telephone and also

calling application, such as Whatsapp for providing care to their patients. Moreover, 40% and 18% of the surveyed surgeons admitted using a video call-based application, such as Zoom and FaceTime, respectively, for keeping in contact with their patients during the pandemic. Centers for Medicare & Medicaid Services (CMS) recommended a tiered framework to prioritize services and care for the patients and suggested that for patients whom the surgeon classified as Tier 1 or patients that need low acuity treatment or service, the surgeon should consider postponing the surgery and follow up the patients using telemedicine.<sup>29</sup> The trend of utilizing internet and digital platform may also spread to education in medicine. Face to face teaching between surgeons and fellows, residents, or medical students may be limited, and some of it would be replaced by web-based video education. There are several limitations to this review. First, there is a limited number of studies that evaluate the impact of COVID-19 on hip and knee arthroplasty. Moreover, most of the available studies had different outcome measures and analyzed different outcomes, making it difficult for us to group them and quantify the results as one conclusive outcome. Furthermore, the available studies are mostly cross-sectional, resulting in a lower level of evidence. Nevertheless, COVID-19 is a new and immediate emerging disease that has been around for a short period, and it is difficult to predict how long it will last. Consequently, to conduct a long prospective study about the impact of COVID-19 and to write a systematic review with a more significant number of studies seems infeasible. Considering the unpredictable course of this pandemic and the ever-changing policy from both international and national policymakers in facing this pandemic may justify these limitations. However, we agreed that further studies evaluating the impact of this pandemic on various aspects in orthopaedic and traumatology generally and hip and knee arthroplasty specifically are needed.

## Conclusions

COVID-19 pandemic had some impacts on the patients, public interest, surgeons, industry

partners, and hip and knee arthroplasty volume. It affected the patients, surgeons, and industry partners not only behaviorally, but also physically, mentally, financially, and socially.

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