Chapter

Impact of the COVID-19 Pandemic on the Field of Orthopedics

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Abstract

During the COVID-19 pandemic, countries all over the world suffered from different kinds of service disruption or reduction in the field of orthopedics with or without lockdowns. The consequences include no restriction, partial disruption, overburden of medical services and complete shutdown of clinical practices. This chapter systematically reviews the current published literature on the global impact of COVID-19 on the field of orthopedics through multiple aspects, including educational impact, service volume impact, workload impact, personal practice change, psychological impact, and impact on orthopedic research. The rates of all surgeries and elective surgeries decreased by 15.6%–49.4% and 43.5–100%, respectively. The overall impact was attributable to the staff redeployment in response to the pandemic. Therefore, it is important to maintain a flexible allocation of manpower and more sufficient and reservable staffing measures in case of emergency staff shortages. Orthopedic surgeons are suggested to prepare proper preventive strategies and set up special equipment and places for regular telemedicine for virtual consultations or virtual teaching. It can be expected that the integration of the different experiences of global countries from the impact of COVID-19 may help us to face possible similar impacts in the future.

Keywords: COVID-19, pandemic, impact, lockdown, restriction, orthopedics, education, orthopedic service, clinical practice, workload, psychological effect

1. Introduction

The World Health Organization declared the 2019 coronavirus disease (COVID-19) as a worldwide pandemic on March 12, 2020. COVID-19 cases were first found in Wuhan, China, in December 2019 [1], possibly owing to the purchase, slaughtering, and consumption of exotic live animals in the Huanan seafood and animal market. COVID-19 is an infectious disease that can cause pneumonia. It has spread rapidly and has infected numerous individuals globally. A cumulative millions of cases have been confirmed, and thousands to millions of people have died of this disease, seriously impacting the global economy. Under this pandemic situation, the global orthopedics field was of course inevitably impacted and the impact was comprehensive.

The COVID-19 pandemic and related lockdowns or restrictions have greatly changed the daily lives of populations worldwide. It forced the healthcare system to undergo dramatic changes in response. A large number of COVID-19 cases in some regions have forced hospitals to reorganize their departments to have the capacity to treat infected patients. Certain administrative or preventive epidemic strategies

have caused many restrictions, such as separation of employees, reduction in the number of outpatient clinics, delayed or suspension of elective surgeries, and cancelation of non-emergency consultations or referrals to reduce the infection risk among patients and orthopedic staff.

In this chapter, the relevant publications from various countries in the world were sorted out and extracted their important research results based on different aspects, and provided readers with a comprehensive understanding of the impact of the pandemic. Because of the different infection situations in different countries, with different early responses, different infection control measures and different administrative management strategies, many of the results may not be suitable for a direct comparison. Therefore, this article mostly presented the results in an itemized, organized and narrative manner, avoiding unfair rankings among countries. All publications presenting comparable data, including reduction percentage of all surgeries and reduction percentage of elective surgery, were compared.

2. Global research trend of COVID-19 impact on the field of orthopedics

A comprehensive literature search was conducted covering a period from January 1, 2020, to September 1, 2021, to include all possible matching articles since the appearance of the new coronavirus. PubMed served as the database for the literature search. If all the subspecialties of orthopedics were included, the number of searched publications will be too large, so we limit the search to the title that contains "orthopedic" or "orthopedic". The search was performed using the following search items for the title: "impact" AND "COVID-19" AND "orthopedic" (20 search results) plus "impact" AND "COVID-19" AND "orthopedic" (38 search results). One search result was excluded because it was a letter to the editor. In total, 57 studies were identified (**Table 1**). In terms of the regions of these publications, the most are in Europe, followed by Asia and North America.

3. Various aspects affected in the field of Orthopedics

Research on the impact in the field of orthopedics can be subdivided into education, clinical service volume, changes in clinical practice, workload, psychological factors, research work, etc. The essence of each peer-reviewed publication was listed in a sorted manner. The remaining few studies, focused on a single or some specific index of orthopedics for analysis, were not discussed in this article.

4. Educational impact

Most research on the impact of education comes from the United States, which may also reveal that the pandemic has disrupted their education system to a greater extent. Routine orthopedic education and training are still more or less affected or even suspended in most countries. The source of the impact may come from the interference of lockdowns or restrictions and various infection prevention measures including social distancing.

4.1 Impact on application

A perspective/narrative study in the United States discussed and provided potential strategies to understand the impact of COVID-19 on the orthopedic

No	Year	Study	Country	Region	Focus	Study method
1	2020	Aiyer *et al*. [2]	USA	North America	Education/Residency Application	Perspective/Narrative
2	2020	Alyami *et al*. [3]	Saudi Arabia	Middle East	Service/Education	Perspective/Narrative
3	2020	Andreozzi *et al*. [4]	Italy	Europe	Service/Orthopedic Trauma	Retrospective
4	2020	Bernstein *et al*. [5]	USA	North America	Education/ Intern, resident training	Perspective/reflection
5	2020	Chang *et al.* [6]	South Korea	Asia	Education/Residency	Questionnaire survey
6	2020	Clement *et al*. [7]	UK	Europe	Surgical Risk Assessment	Multicenter, retrospective
7	2020	Costa *et al*. [8]	Italy	Europe	Prevention measures	Retrospective
8	2020	Danford, *et al*. [9]	USA	North America	Education/Residency Application	Questionnaire survey
9	2020	Dattani *et al*. [10]	UK	Europe	Education/Trainees	Perspective/Narrative
10	2020	Elhalawany *et al*. [11]	UK	Europe	Service/Orthopedic emergency	Retrospective
11	2020	Ghermandi *et al*. [12]	Italy	Europe	Service/Orthopedic oncology and spine	Retrospective
12	2020	Gonzi *et al*. [13]	UK	Europe	Education/Trainees	Four-nation questionnaire survey
13	2020	Haffer *et al*. [14]	Germany	Europe	Service/Orthopedic and Trauma Surgery	Nationwide questionnaire survey
14	2020	Mackay *et al*. [15]	UK	Europe	Surgical Risk Assessment	Retrospective cohort
15	2020	Maniscalco *et al*. [16]	Italy	Europe	Service/Emergency Room and Orthopedics	Retrospective
16	2020	Maryada *et al*. [17]	India	Asia	Service/Orthopedic Trauma	Multi-centre retrospective
17	2020	Megaloikonomos *et al*. [18]	Europe	Europe	Education/Trainees	23 European countries questionnaire
18	2020	Murphy *et al*. [19]	UK	Europe	Workload / Orthopedic	Retrospective
19	2020	Ong *et al*. [20]	Hong Kong	Asia	Service/Education/Research	Perspective/Experience
20	2020	Park *et al*. [21]	UK	Europe	Workload / Orthopedic trauma	Retrospective
21	2020	Phillips *et al*. [22]	N/A	N/A	Orthopedic care	Review
22	2020	Richardson *et al*. [23]	USA	North America	Education / medical student	Perspectives

No	Year	Study	Country	Region	Focus	Study method
23	2020	Sahu *et al*. [24]	India	Asia	Psychological /orthopedic surgeon	Questionnaire survey
24	2020	Sheridan *et al*. [25]	Ireland	Europe	Education / Trainees	Questionnaire
25	2020	Sugand *et al*. [26]	UK	Europe	Workload / Pediatric orthopedic trauma	Multi-centre retrospective
26	2020	Teo *et al*. [27]	Malaysia	Asia	Practice Change/Surgeon	Nationwide questionnaire survey
27	2020	Upadhyaya *et al*. [28]	India	Asia	Education/Trainees	Questionnaire survey
28	2020	Wallace *et al.* [29]	UK	Europe	Trauma and orthopedic surgery	Perspectives
29	2020	Wong *et al*. [30]	Hong Kong	Asia	Service / Orthopedic and Trauma	Retrospective cohort
30	2020	Wong *et al*. [31]	Singapore	Asia	Psychological/orthopedic outpatient setting	Questionnaire survey
31	2021	Barahona *et al*. [32]	Chile	South America	Service/Orthopedic surgery	Retrospective
32	2021	Blum *et al*. [33]	N/A	N/A	Service/Orthopedic and Trauma Surgery	Review
33	2021	Chatterji *et al*. [34]	N/A	N/A	Miscellaneous	Rapid Review
34	2021	Garcia *et al*. [35]	Spain	Europe	Personal Practice Change/ Orthopedic Surgeon	Questionnaire survey
35	2021	Gibbard *et al*. [36]	N/A	N/A	Personal Practice Change/Pediatric Orthopedic Surgeon	Global (45 countries) questionnaire survey
36	2021	Giordano *et al*. [37]	N/A	N/A	Financial, Psychosocial/Orthopedic Trauma surgeon	14 Latin American countries questionnaire survey
37	2021	Green *et al.* [38]	UK	Europe	Length of stay/total hip and knee arthroplasty	Retrospective cohort
38	2021	Heaps *et al*. [39]	USA	North America	Service/multi-subspecialty	Retrospective cohort
39	2021	Howles *et al*. [40]	UK	Europe	Service/One-stop minor injuries unit	Retrospective cohort
40	2021	Jain *et al*. [41]	India	Asia	Personal Practice Change/Orthopedic Surgeon	Nationwide questionnaire
41	2021	Khan *et al*. [42]	UK	Europe	Personal Practice Change/Orthopedic Surgeon	Nationwide questionnaire
42	2021	Ma et al. [43]	Taiwan	Asia	Screening/trauma at emergency department	Retrospective cohort
43	2021	Maleitzke *et al*. [44]	Germany	Europe	Service/Orthopedic trauma	Retrospective cohort

No	Year	Study	Country	Region	Focus	Study method
44	2021	Moretti *et al*. [45]	Italy	Europe	Psychological/gender-specific	Nationwide Questionnaire
45	2021	Oguzkaya *et al*. [46]	Turkey	Asia and Europe	Orthopedic fracture characteristics	Multi-center retrospective
46	2021	Paul *et al*. [47]	USA	North America	Practice Change/Elective procedures, telehealth and income	Nationwide Questionnaire
47	2021	Peebles *et al*. [48]	USA	North America	Education/Sports Fellowship Application	Perspective/Narrative Review
48	2021	Probert *et al*. [49]	Australia	Australia	Service/Orthopedic trauma	Retrospective
49	2021	Qian *et al*. [50]	China	Asia	Service/Orthopedic trauma	Retrospective
50	2021	Rachuene *et al*. [51]	South Africa	Africa	Service/Orthopedic trauma	Multicenter retrospective
51	2021	Ribau *et al.* [52]	Portugal	Europe	Service /Orthopedic trauma	Retrospective
52	2021	Shah *et al*. [53]	Canada	North America	Education/Residency application	Perspectives/Narrative Review
53	2021	Sharma *et al*. [54]	India	Asia	Psychological/Practice Change	Questionnaire
54	2021	Shih *et al*. [55]	Taiwan	Asia	Psychological/Service	Retrospective
55	2021	Unterfrauner *et al.* [56]	Switzerland	Europe	Complications/deep surgical site infections	Retrospective
56	2021	Van Heest *et al*. [57]	USA	North America	Education/Orthopedic Graduate Medical Education	Review / Symposium summary
57	2021	Vasiliadis *et al*. [58]	Greece	Europe	Service	Retrospective

Table 1.
Characteristics of relevant publications.

residency application process. Because COVID-19 may have an impact on the matching of residents, there is a great demand for insights into the inevitable changes in the application process and how medical students can adapt. In addition, the procedure is likely to ask the applicants how they spent the time they were not in the hospital due to COVID-19, and the applicants should be prepared to provide meaningful answers [2]. A questionnaire survey was conducted in the United States for medical students. Women stated that they are "unlikely" to apply for orthopedic residents due to the pandemic (14.9% vs. 5.5% for men, $P < 0.001$). Students identified as black/African American stated that they were "unlikely" to apply (16.9% compared with 8.8% of non-Hispanic whites, $P < 0.001$). The students stated that they had "slightly fewer" or "much less" opportunities to fully engage in orthopedic surgery training to make professional application choices (88.9% of students) [9].

4.2 Impact on training

A perspective study in the United States shared the thoughts of 3 orthopedic interns in different levels of a single training program. Although they are all trainees, the difference in training years is crucial to clarify different sources of professional stress. Everyone has their own sources of stress and response to ongoing crises [5].

A questionnaire survey was performed in South Korea for orthopedic residents. The average working time of 72.7 hours/week before the pandemic was reduced to 65.6 hours/week during the pandemic ($p < 0.001$). During the pandemic, educational time for lectures and clinical case discussions were reduced (both, $p < 0.001$). While reducing the use of traditional teaching methods, the use of online teaching methods has been increased ($p < 0.001$). However, compared with traditional teaching methods, the satisfaction of online teaching methods is significantly lower. The average quality of life score before the pandemic was 68.9 out of 100, which dropped to 61.7 during the pandemic ($p < 0.001$). The most stressful factor for orthopedic residents during the pandemic is family/relative health, followed by their own health and residency plan [6].

A perspective/narrative study in UK described the reductions in trainees' surgical exposure, cancelation of exams and courses, and revisions to professional recruitment and annual evaluations. This group of trainees is witnessing new methods of providing orthopedic services [10]. A four-nation questionnaire survey of orthopedic trainees was conducted in UK. 23.1% (23/101) of the trainees were redeployed to non-surgical positions. A total of 42.9% (42/101)% of the trainees did not have the fracture clinic training on the schedule, 53% (53/101) of the trainees had assigned operating theater training once per week, and 63.8% (64/101) of the trainees did not feel that sufficient experience has been gained in the affiliated subspecialties and preferred repeating training [13].

A questionnaire survey of orthopedic trainees was conducted in 23 European countries. Most trainees retained their usual clinical roles (59.8%), but quite a few were redeployed to COVID-19 units (20.9%). 52.1% stated that teacher-led education was restricted, 46.3% pursued self-directed learning, and 58.6% stated that surgical training was severely impaired. 58.2% of participants expressed concern about achieving the annual training goals, while 25.0% of participants expected an additional year of training [18].

A perspective study in the USA believe that the following suggestions may be helpful to students seeking alternative supplementary learning methods: [1] read major orthopedic journals, [2] contact orthopedic surgeons in the field of interest, [3] contact program coordinators or directors to have the opportunity to participate

in their education courses in a virtual way, [4] attend online lectures, and [5] use practice kits to practice suture techniques [23].

A questionnaire survey in Ireland found the average total number of operations per trainee in 2019 was 40.6, and reduced to 18.3 during the 2020 pandemic ($p = 0.043$). Moreover, 7.69% ($n = 3$) of the trainees were infected with COVID-19 [25].

A questionnaire survey in India revealed that 65.1% of the post-graduate trainees stated that no clinical courses are currently offered. Most (94%) confirmed that COVID-19 has affected their surgical and clinical training. A large number (71.6%) encountered problems when completing the thesis, and 96% were worried about their mental health [28].

5. Global service impact

Through major publications in different regions, we can understand the real impact of COVID-19 on the volume of clinical services. Generally, the service volume was inevitably reduced in all aspects, except for a few specific items. Even in a country where there was no lockdowns or restrictions, there was still a small reduction, which may also be influenced by psychological factors.

5.1 Europe

A study in Italy during lockdown revealed the average age of the COVID-19 group is 51.9 +/− 24.8 years, which is significantly higher than the pre-COVID-19 group (41.4 +/− 25.7) ($p < 0.0001$). The most common injury was fracture (45.1% in 2019; 62.7% in 2020) ($p < 0.0001$). The most severely injured anatomical location during COVID-19 lockdown was the hand (14.2%), while in the pre-COVID-19 group, the most common type of injury was multiple injuries (22.8%) [4]. Another study in Italy focused on orthopedic oncology and spine had a unique result. During the lockdown period, by managing urgent and non-delayable spinal diseases with a low COVID-19 infection rate (3.9%), surgical activities have increased instead [12]. The other study in Italy showed a reduction of emergency room visits (−18.0%). The increase in the number of deaths in the emergency room was equal to +220%. The orthopedic pathway dropped by −26.8%. Trauma at home increased (+19.1%) [16].

A nationwide questionnaire survey in Germany showed only 7 respondents (13.7%) fully agreed or quite agreed with the authorities' support for orthopedics and trauma surgery. Major financial and personnel changes had taken place, resulting in an average reduction in operating room capacity of 49.4% and an estimated loss of income of 29.3%. In addition, 14.7% of doctors were redistributed [14]. Another study in Germany focused on emergency departments during the 35-day lockdown. The daily total number of patient cases (lockdown and control, 106.94 and 167.54) and orthopedic trauma cases (lockdown and control, 30.91 and 52.06) declined with an increase in the incidence of home injuries, bicycle accidents, domestic violence, and acute/conventional drug abuse [44].

A study in the UK focused on orthopedic emergencies, during lockdown, showed that patient visits had a decrease of 58.6%. The orthopedic presentations in 2020 and 2019 were 736 (37.2%) and 1729 (36.2%), a decrease of 57.4% [11]. An orthopedic team in the UK set up a 7-day "One-Stop" clinic for minor injuries/ambulatory patients. Approximately 700 patients who were supposed to be treated in the emergency room changed to minor injuries unit, reducing the pressure on the emergency room. Seventy-one percent of patients were discharged after the

initial appointment, and only 9 patients (1%) needed to make an appointment for a fracture clinic within 72 hours. A total of 15 patients (2%) revisited the clinic with concern, and only 4 of them required additional intervention [40].

5.2 Asia

A multi-center study in India revealed that the total number of traumas during lockdown period was significantly reduced by 1266 cases, a reduction of 62.7% ($p < 0.01$). Road traffic accident is the main cause of trauma in all age groups except the elderly, and a 77.9% reduction in cases was found during the lockdown period ($n = 1343$ vs. $n = 298$) [17].

A study in Hong Kong showed orthopedic surgery decreased by 44.2%, from a weekly average of 795 ± 115.1 to 443.6 ± 25.8 ($p < 0.001$), and the ratio of emergency surgery to elective surgery increased from 1.27:1 to 3.78:1. Surgery for treatment of upper and lower limb fractures was reduced by 23% (from 98.5 ± 14 to 75.9 ± 15.2 per week; $p < 0.001$) and 20% (from 210.6 ± 29.5 to 168.4 ± 16.9 per week) 16.9 times; $p < 0.001$), while elective joint replacement and ligament reconstruction surgery decreased by 74–84% ($p < 0.001$). The number of hospitalizations decreased by 41.2% (from 2365 ± 243 to 1391 ± 53 per week; $p < 0.001$), while the number of clinical outpatient visits decreased by 29.4% (from 11,693 ± 2240 to 8261 ± 1104 per week; $p < 0.001$, 30).

A study in Taiwan showed that the COVID-19 pandemic resulted in a 22%–29% and 20%–26% reduction in outpatients, 22%–27% and 25%–37% reduction in inpatients, and 26%–35% and 18%–34% reduction in orthopedic operations [55]. Taiwan successfully prevented the spread of COVID-19 without lockdown and adopted many prevention strategies effectively, such as the use of masks in the public [59].

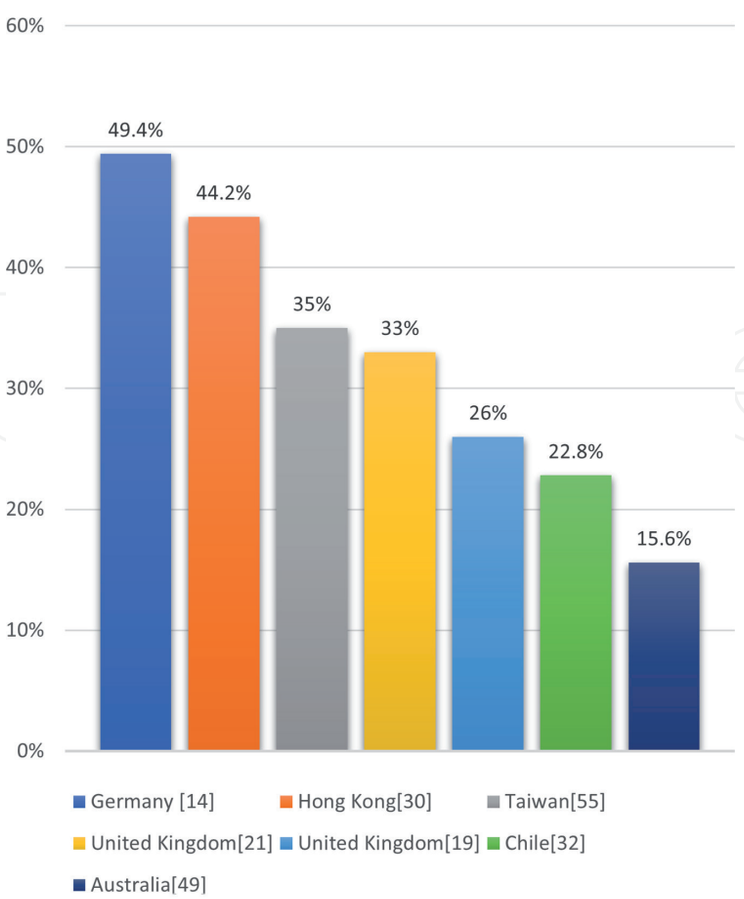

Figure 1.
Reduction percentage of all surgeries.

5.3 North and South America

A study focused on multi-subspecialty in the United States analyzed a total of 2830 (1917 pre-COVID-19 and 913 post-COVID-19) cases. A significant increase in the percentage of hip procedures performed (+3.5 ± 1.1%, p = 0.002), a significant decrease in the percentage of wrist procedures performed (−2.6 ± 0.8%, p = 0.002), and a significant decrease in the percentage of hand procedures performed (−2.1 ± 1.0%, p = 0.027). Foot, ankle, knee, shoulder, elbow, and back procedures showed no significant change [39].

A study in Chile revealed that the number of orthopedic surgeries fell by 22.8%. All surgical procedures were adversely affected, with fracture/traumatic surgery being the least affected. Knee replacement (−64%) had the greatest adverse impact, followed by hip replacement (−41%) and knee ligament reconstruction (−44%). The number of orthopedic surgeries was slightly correlated with the number of COVID-19 cases per month (p = 0.08) and strongly correlated with the country's mobility (p = 0.0001) [32].

5.4 Australia

A study in Australia during lockdown revealed the total number of emergency operations performed decreased by 15.6% compared to the same period in 2019. The number of orthopedic hospitalizations decreased by 30.8%. Road trauma accounts for a similar proportion of overall cases; however, bicycle-related

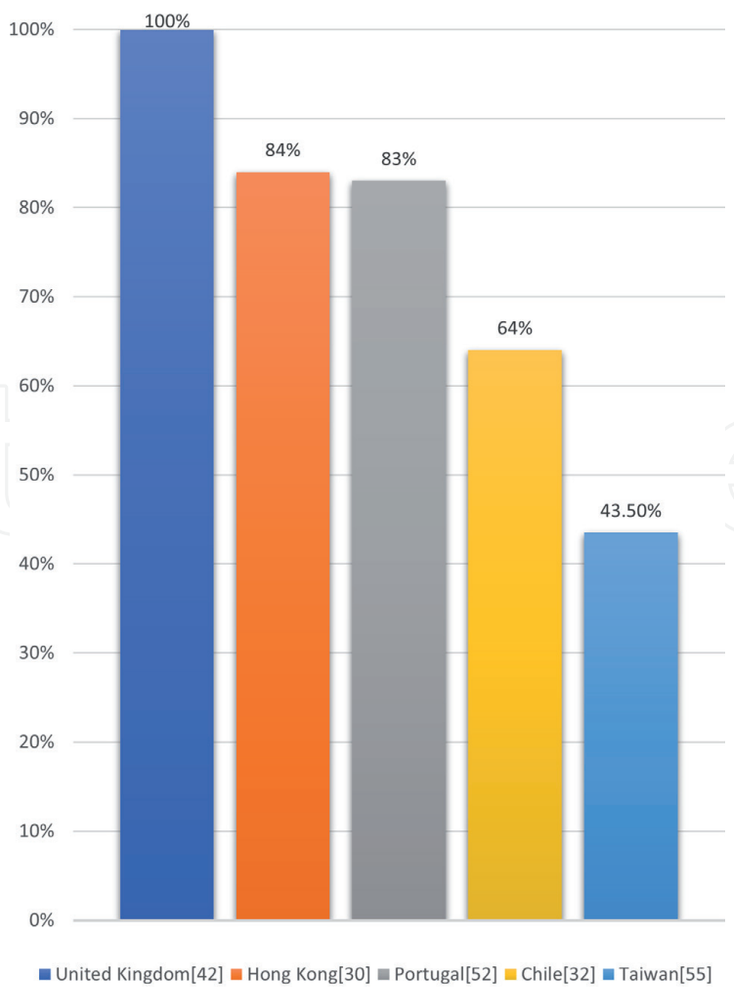

Figure 2.
Maximal reduction percentage of the elective surgeries.

accidents have increased significantly, accounting for 11% of presentations. During the pandemic, sports injuries, work-related injuries, and multiple injuries have decreased [49].

5.5 Comparable reduction percentage of all surgeries and elective surgeries

The reduction percentage in various countries was one of the few parameters that can be compared. However, the data may not be available from some countries. The reduction percentage of the volume of all surgeries was 49.4% in Germany [14], 44.2% in Hong Kong [30], 35% in Taiwan [55], 33% and 26% in the United Kingdom [19, 21], 22.8% in Chile [32], and 15.6% in Australia (**Figure 1**, [49]). Surprisingly, even though there were few COVID-19 cases in the first wave and no serious lockdowns or restrictions in Hong Kong and Taiwan, they still experienced a substantial impact on the number of surgeries. This may be attributable to psychological factors caused by a large flow of people to and from China due to proximity to China.

The maximal reduction percentage of the elective surgery was 100% in the United Kingdom [42], 84% in Hong Kong [30], 83% in Portugal [53], 64% in Chile [32], and 43.5% in Taiwan (**Figure 2**, [55]). The relatively smaller reduction percentage in Taiwan may be attributable to the lack of restrictions or lockdowns [59]. Taiwan prevented the spread of COVID-19 successfully by adopting effective preventive strategies, such as mandatory mask use in public [60].

6. Workload impact

Service volume impact represents the entire department or hospital, the workload impact represents individuals. Three studies [19, 21, 26] focused on the impact of personal workload during the pandemic in the UK. A study on the workload in the UK revealed the average number of weekly referrals to the service decreased by 33% ($p < 0.0001$). The number of operations performed each week was reduced by 26% ($p = 0.001$). The number of referrals related to domestic abuse or non-accidental injury had not changed. In addition, the number of hip fractures, periprosthetic fractures, and prosthetic joint dislocations did not change. The number of referrals for simple fractures, natural joint dislocations, wounds, and soft tissue injuries had been significantly reduced. Similarly, in the pediatric population, the reduction in referrals for simple fractures had also been demonstrated [19]. Another study on the workload in UK showed acute trauma referrals decreased almost 50%, with similar distribution between pediatric and adult patients, but the required hospital admissions increased significantly by 19% (RR 1.3, OR 2.6, $p = 0.003$). During the COVID-19 outbreak, the total number of surgical cases fell by a third. The usage of aerosol-generating anesthesia technique was reduced by 14% (RR 0.85, OR 0.20, $p = 0.006$) [21]. A study on pediatric trauma in UK during lockdown revealed that acute pediatric trauma referrals were reduced by two-thirds compared with 2019 ($n = 302$ vs. 97, RR 0.55, OR 0.43) ($p = 0.002$). Outpatient telemedicine was used more, virtual fracture clinics were used more (OR 97, RR 84, $p < 0.001$), and fewer patients received consultation and face-to-face follow-up (OR 0.55, RR 0.05) ($P < 0.001$) [26]. Although for individuals, the reduction in clinical workload during this period may bring more rest time, and the extra free time can also be used for writing, reading or personal research, this also means that the economic income will inevitably decrease accordingly.

7. Personal practice change

A nationwide questionnaire survey in Malaysia revealed the majority of respondents are still working (223/235, 94.9%), operating outpatient clinics (168/223, 75.3%), and continuing to perform semi-emergency (190/223, 85.2%) and emergency surgery (213/223, 95.5%). Among surgeons, 11.2% (25/223) did not screen patients for COVID-19 before elective surgery, 30.9% (69/223) did not receive any training on the proper handling of personal protective equipment (PPE), and 84.8% (189/223) made more conservative management decisions due to COVID-19, and 61.9% (138/223) of income was affected. Among surgeons, 19.3% (43/223) started using telemedicine facilities [27].

A questionnaire survey in Spain revealed 85.7% of the respondents had to reduce their surgical activities by 50%–100%. Forty-six percent of them were asked to collaborate in other units or services, and another 43% felt that their work was underutilized. Fifty percent revised the indications for the treatment of various fractures, and there are differences between the center and the community. Thirty percent of the respondents said they were satisfied with the management of the country, and 60% said they were satisfied with the management of their province and center. Seventy percent of the respondents were almost dissatisfied with the training they received on the use of masks and personal protective equipment. Another 80% were not satisfied with the sample-taking training they received. Sixty-five percent of people did not have protective equipment to carry out their work. Forty-six percent refused protective measures to treat patients with suspected or confirmed infections [35].

A nationwide questionnaire survey in India showed most (88.3%) found that trauma surgery and non-traumatic surgery were severely affected (>50%). Significant changes had taken place in individual hospital protocols (91.7%). Most hospitals (74.3%) were equipped with the appropriate personal protective equipment required. Most surgeons (89.5%) did not modify or upgrade the existing operating room infrastructure [41].

A nationwide questionnaire survey in UK showed all 202 respondents reported that their daily practice was disrupted. Ninety-one percent reported that all elective surgeries had been canceled, and only 24% of cases had trauma that continued to be normal. Seventy percent reported interruption of trauma surgery. The capacity of elective clinics was significantly reduced, and there were no elective clinics that were functioning normally. Fifty-five percent reported that their elective clinics were completely canceled, while 38% reported that the operational capacity of elective clinics was reduced and non-emergency appointments were postponed. Only 9% of fracture clinics were operating normally, and 69% had reduced services. Sixty-seven percent of people reported cancelation of teaching and study leave. It is worth noting that 69% of respondents believe that the pandemic will delay the completion of the registrar training program [42].

Finally, a questionnaire survey of orthopedic surgeons received responses from 45 countries. 358 (78.5%) respondents reported the lockdown measures in their area during the survey. Most (n = 337, 94.4%) reported suspension of all elective programs. Surgeons reported that the average number of operations per week has decreased, from 6.89 before the pandemic to 1.25 at the time of the survey. The average weekly number of elective clinic appointments decreased from 67.89 before the pandemic to 11.79 at the time of the survey. A total of 177 (39.4%) surgeons reported using the virtual outpatient appointment model for the first time. Of the 290 surgeons with trainees, 223 (84.5%) reported implementing systems for continuing training, such as webinars or virtual inspections [36].

8. Psychological impact

Psychological factors also have a certain percentage of influence. Stress or fear may come from drastic changes in oneself or the external environment. Psychological stress can be individuals or the public.

As for the surgeon's personal psychological pressure, a questionnaire survey in India was completed by 611 orthopedic surgeons from 140 cities in India. 22.5% of orthopedic surgeons said they must be under pressure, and 40.5% said they have mild pressure. With declining age, the percentage of orthopedic surgeons feeling "a lot of stress" had increased. The interruption of life-work balance and the uncertainty of returning to work were other factors closely related to the "absolutely stressed" group [24]. A questionnaire survey in Singapore showed 32 participants (51.6%) had 7 or more positive reactions. "Work adjustments" (74.2%), "changes in personal plans" (72.6%), and "restrictions" (72.6%) received the most positive responses in the questionnaire. On the other hand, "financial issues" received the least positive responses (21.0%) [31].

As for the public panic, it seems more obvious in some countries. As mentioned earlier, even there were few COVID-19 cases and no lockdowns or restrictions initially in Hong Kong and Taiwan, they still experienced an obvious impact on the number of surgeries. This may be attributable to the public's panic because of its proximity to China. At the beginning of the pandemic, exaggeration of the mass media, rumors or false news, and lack of medical resources may also cause widespread public panic. In Taiwan, the COVID-19-related fear seemed to reduce elderly individuals' willingness to undergo elective surgery. Elderly patients carry a higher mortality risk after being infected and they may have postponed their surgeries [55].

9. Impact on orthopedic research

A questionnaire survey of orthopedic surgeons received responses from 45 countries. Of the 192 respondents who conducted research, 149 (82.8%) reported continuing research activities during the pandemic, and most of them reported that participant recruitment stopped (n = 75, 64.15%) or decreased (n = 25, 29.9%) [36].

10. Conclusions

This chapter provides a comprehensive understanding of the impact of the pandemic on the field of orthopedics globally and aims to review the lessons learned from the impact of the pandemic to prepare for the next possible re-impacts. Although orthopedic surgeons may not be in the front line to fight against COVID-19pandemic, all the fields of orthopedics are still inevitably impacted. Most studies in current literature have reported that the number of cases in all aspects decreased significantly. Education and training, psychological factors, and orthopedic research, which have been less noted, have also been significantly impacted. All the fields of orthopedics were clearly affected by the COVID-19 pandemic. In the future, despite the pandemic, it is important to maintain treatment, especially the surgical care of the patients, to avoid negative effects on the prognosis. Strategies should be developed to enable orthopedic patients to receive timely treatment, even if the pandemic continues. Employees must be properly protected at the same time. This can be achieved by formulating a proper surgical scheduling algorithm for orthopedic patients. Several infection control measures and administrative

management strategies may help maintain the normal operation. The implementation of appropriate preventive strategies may aid the scheduling of surgeries during the pandemic, which may, in turn, reassure the patients and prevent the suspension of normal orthopedic surgery practice. It is also important for orthopedic surgeons to prepare emergency response measures under normal circumstances, to deal with the emergency shortage of personnel caused by the redistribution or redeployment of personnel. The overall impact could be attributable to the staff redeployment in response to the pandemic. Therefore, it is important to maintain a flexible allocation of manpower and more sufficient and reservable staffing measures in case of emergency staff shortages. Orthopedic surgeons are suggested to prepare proper preventive strategies and set up special equipment and places for regular telemedicine for virtual consultations or virtual teaching.

Conflict of interest

The authors declare no conflict of interest.

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