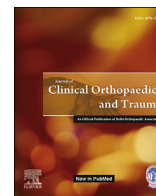




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A look at the global impact of SARS CoV-2 on orthopedic services

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ABSTRACT

Background: The COVID-19 pandemic profoundly impacted healthcare institutions worldwide. Particularly, orthopedic departments had to adapt their operational models.

Purpose: This review aimed to quantify the reduction in surgical and outpatient caseloads, identify other significant trends and ascertain the impact of these trends on orthopedic residency training programs.

Methods: Medline and Embase were searched for articles describing case load for surgeries, outpatient clinic attendance, or emergency department (ED) visits. Statistical analysis of quantitative data was performed after a Freeman-Tukey double arcsine transformation. Results were pooled with random effects by DerSimonian and Laird model. When insufficient data was available, a systematic approach was used to present the results instead.

Results: A total of 23 studies were included in this study. The number of elective surgeries, trauma procedures and outpatient attendance decreased by 80% (2013/17400, 0.20, CI: 0.12 to 0.29), 47% (3887/17561, 0.53, CI: 0.37 to 0.69) and 63% (84174/123967, 0.37, CI: 0.24 to 0.51) respectively. During the pandemic, domestic injuries and polytrauma increased. Residency training was disrupted due to diminished clinical exposure and changing teaching methodologies. Additionally, residents had more duties which contributed to a lower quality of life.

Conclusions: The COVID-19 pandemic has made an unprecedented impact on orthopedics departments worldwide. The slow return of orthopedic departments to normalcy and the compromised training of residents due to the pandemic points to an uncertain future for healthcare institutions worldwide, wherein the impact of this pandemic may yet still be felt far in the future.

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1. Introduction

The COVID-19 pandemic profoundly impacted healthcare institutions worldwide. Various departments were required to shunt manpower to aid in the fight against the pandemic with non-essential medical services being reduced to the barebones and a widespread cancellation of elective surgeries.⁸ Particularly, orthopedic departments around the globe primarily offering elective surgeries were required to change their operational models in order to adapt to the constantly changing pandemic landscape. In this review, we aimed to quantify this reduction in the surgical and outpatient caseloads, as well as to identify other significant trends emerging from pre-pandemic and pandemic-era orthopedic department practices and ascertaining the impact of these trends

on the various orthopedic residency training programs worldwide, with the training of many orthopedic residents potentially being disrupted.

2. Methods

2.1. Research question

We sought out to quantify how the COVID-19 pandemic situation impacted orthopedic centers worldwide, as well as to understand how the training of residents was affected.

2.2. Protocol and registration

Synthesis of this review was performed whilst adhering to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) guidelines.¹⁹ The protocol of this review was subsequently registered in the PROSPERO international prospective register of systematic reviews database on the July 8, 2020

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2.3. Search strategy

An electronic database search of Medline and Embase was performed on July 20, 2020 using keywords and terms synonymous with Orthopedic Surgery and COVID-19. The search strategy for Medline can be found in Electronic Supplementary Material 1.

2.4. Inclusion and exclusion criteria

Articles that reported a comparison in case load for surgeries, outpatient clinic attendance, or emergency department (ED) visits, were included. Additionally, articles detailing the impact of the COVID-19 pandemic on orthopedic residency training programs were included. Qualitative studies that did not show a comparison of elective or trauma surgery numbers to pre-pandemic times were excluded.

2.5. Study selection and data collection

All articles resulting from a systematic database search of Embase and MEDLINE were downloaded and managed using the EndNote X9 software. The studies were then subsequently subjected to a thorough sieving process by a pair of independent authors utilizing the aforementioned inclusion and exclusion criteria for study selection. Any discrepancies were resolved through reaching the consensus with a third, senior author. Following the finalization of the included articles, relevant data, such as patient demographics, pre-pandemic and pandemic reference time periods, and outcomes, was extracted by the similar pair of authors in an independent fashion.

2.6. Statistical analysis and quality assessment

We extracted the pre-pandemic and pandemic-era number of patients for the relevant outcomes and performed a meta-analysis after a Freeman-Tukey double arcsine transformation of continuous data.²⁶ Effect sizes were calculated using the DerSimonian and Laird random effects model.¹¹ Analyses were performed using STATA 16.1, and statistical significance was considered when $p \leq 0.05$. The effect sizes used to compare the difference in pre-pandemic and pandemic era decreases in number of patients is meant to be interpreted as the pooled proportionate decrease in the number of patients for the given outcome measured. When insufficient data was available, a systematic approach was used to present the results instead. The Newcastle-Ottawa Scale (NOS) was used to assess the quality of the included articles.

3. Results

A systematic search of the literature using the search strategy yielded 286 articles. 252 were excluded based on study title and abstract, and 34 underwent full text review, of which 23 articles were included in this study (Fig. 1). All 11 studies included in the quantitative analysis were retrospective in nature, with the remaining 12 studies included in the qualitative synthesis containing a mixture of study designs. Seven were qualitative studies, three were prospective, and one was retrospective in nature. No study included within the quantitative analysis was subsequently included within the qualitative synthesis (Table 1).

3.1. Elective orthopedic services

Nine centers reported the number of elective orthopedic

procedures performed both before and during the COVID-19 pandemic.^{9,10,16,17,20,29,36,38,39} Cumulatively, the number of elective surgeries decreased by 80% (2013/17400, 0.20, CI: 0.12 to 0.29) (Fig. 2). Four centers^{6,20,29,38} reported the attendance figures for outpatient clinics for both pandemic-era and pre-pandemic time periods, with an overall decrease of 63% being observed (84174/123967, 0.37, CI: 0.24 to 0.51).

3.2. Trauma services

A comparison of trauma surgery numbers was reported in nine centers,^{16,17,20,24,28,29,36,38,39} of which six were reported as major trauma centers. Seven centers observed a lower volume of trauma procedures during the pandemic, as compared to pre-pandemic times, amounting to an overall decrease of 47% (3887/17561, 0.53, CI: 0.37 to 0.69) (Fig. 2). Conversely, two studies, Zagra et al. and Tamburrelli et al. reported an increase of 69.6% and 35.7% respectively in trauma surgeries.^{36,39} Interestingly, all the centers included low-energy injuries and orthogeriatric fractures within the number of trauma procedures. This could be a possible explanation behind the phenomenon of the disproportionate decreases between elective and trauma surgeries, as centers listed what were usually non-urgent procedures, as trauma procedures, in order to continue the ability to treat such cases.

Despite the proportional decrease in trauma surgeries, several centers observed an increase in high-energy polytrauma cases during the pandemic. Three studies reported the proportion of polytrauma cases seen in the ED for both pre-pandemic and pandemic periods, with a general trend favoring the increased incidence of polytrauma during the COVID-19 era.^{6,28,36} Bram et al. reported that 14.2% of pre-pandemic and 19.3% of pandemic-era ED cases presented with polytrauma.⁶ Park et al. stated that 18.9% of pre-pandemic and 25.4% of pandemic-era cases presented with polytrauma.²⁸ Tamburrelli et al. reported that 8.8% of pre-pandemic and 15.4% of pandemic-era ED cases presented with polytrauma.³⁶ Whilst the overall number of trauma surgeries decreased throughout these studies, the proportion of patients with polytrauma etiologies increased, potentially suggesting that a smaller proportion of patients presented with minor injuries as compared to those that presented with major, polytraumatic injuries during pandemic times.

3.3. Emergency department services

Visits to the Emergency Department (ED) were generally lower during the pandemic. Giuntoli et al. observed a 70.9% decrease, Zagra et al. a 36.9% decrease, and Wong et al. a 44.7% decrease.^{16,36,38} However, despite this trend in the decreasing number of ED visits, the incidence of domestic injuries within the ED was observed to have increased, with these injuries resulting from etiologies pertaining to domestic violence. Three studies reported the rates of domestic injury cases for both COVID-19 periods and pre-COVID-19 periods.^{16,36,38} Giuntoli et al. reported that 34.5% of pre-pandemic ED cases were due to domestic injuries, compared to 50.8% of pandemic-era ED visits.¹⁶ The study done by Tamburrelli et al. stated that domestic injuries were the cause of 1.96% of pre-pandemic ED visits, but 11.5% of pandemic-era ED visits.³⁶ Finally, Wong et al. reported that 15.0% of pre-pandemic, and 16.8% of pandemic-era ED visits were due to domestic injuries.³⁸

3.4. Qualitative synthesis

All studies included within the qualitative synthesis sought to explore the impact of the COVID-19 pandemic situation on orthopedic residency training programs as their primary outcome.

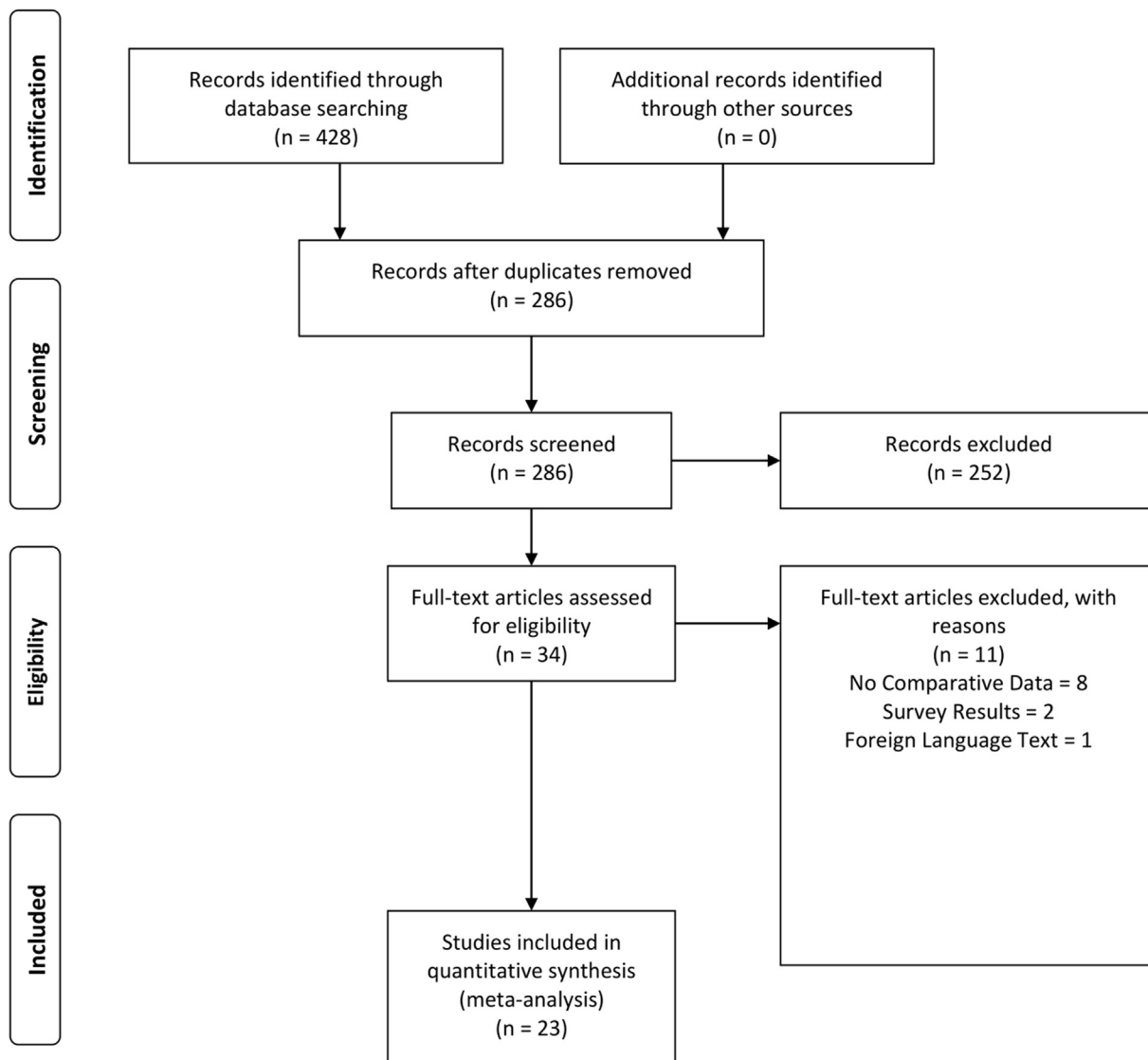


Fig. 1. Prisma flow diagram.

However, as residency training is highly dependent on surgical caseload and overall departmental workload, several of the studies did include insight into the workload of the respective departments.

3.5. Residency training

Ten studies detailed the impact of the COVID-19 pandemic on residency training in their respective institutions.^{1,3,4,7,13,14,18,22,31,33} Firstly, the decrease in elective surgeries performed and reduced outpatient clinic attendance resulted in diminished clinical exposure for residents. Studies by Foong et al. and Chang et al. stated that residents in their respective institutions saw a large overall decrease in time spent performing surgeries as well as seeing patients in clinic.^{7,14} Additionally, the disproportionate decrease in elective surgeries compared to trauma surgeries meant that whilst junior residents were able to gain sufficient clinical exposure to trauma subspecialties, senior residents that had already completed their subspecialty rotations in trauma were unable to gain sufficient exposure to other subspecialties relevant to their training.¹⁴

The effects of the COVID-19 pandemic also saw a large restructuring of didactic teaching methodology for residency programs. Nine studies^{1,3,4,7,13,14,18,31,33} described some form of shift in terms of teaching modalities for residents, due to the restrictions imposed by the pandemic situation. Required learning hours for residents were still maintained, for the most part, due to the shift of teaching sessions to online platforms, virtual reality (VR) based surgical simulators,³¹ and other novel modalities of teaching. Residents were able to receive adequate theory-based teaching through online lectures, journal clubs and various webinars and online symposiums.^{3,7,13,14,18,33} Moreover, due to the decreased surgical exposure, some institutions made VR surgical simulators accessible to residents, allowing them to continue to develop their psychomotor skills required for surgery.^{1,31} Other institutions offered their residents novel means of learning, such as a “virtual” bootcamp,⁴ involving an online training program with accompanying take-home kits for residents to practice an array of surgical techniques from their homes.

Due to the requirement for redistribution of manpower to support COVID-19 related services, many residents found

Table 1
Summary of included studies.

Author	Year	Country	Study Design	Pandemic Period Reported	Elective Surgery Decrease	Trauma Surgery Decrease	Impact on Residency Programs	Newcastle-Ottawa Score
An et al.	2020	USA	Prospective	–	–	–	–	6
Bram et al.	2020	USA	Retrospective	15 Mar – Apr 15, 2020	–	–	–	5
Bhashyam et al.	2020	USA	Qualitative	–	–	–	–	–
Chang et al.	2020	South Korea	Prospective	–	–	–	Decreased OT time	5
D'Apolito et al.	2020	Italy	Retrospective	24 Feb – Apr 10, 2020	76%	–	–	6
De Cruz et al.	2020	Singapore	Retrospective	–	72%	–	–	5
Figueroa et al.	2020	Chile	Prospective	–	–	–	–	6
Foong et al.	2020	Singapore	Qualitative	–	–	–	Decreased OT time	–
Giuntoli et al.	2020	Italy	Retrospective	1–Mar 31, 2020	64%, 81%, 66%*	31%, 14%, 12%*	–	7
Hernigou et al.	2020	Belgium	Retrospective	18 May – Jun 14, 2020	85%	54%	–	7
Kogan et al.	2020	USA	Qualitative	–	–	–	–	–
Luengo-Alonso et al.	2020	Spain	Retrospective	16–Mar 31, 2020	89%	60%	–	–
Malhotra et al.	2020	India	Qualitative	–	–	–	–	–
Murphy et al.	2020	UK	Retrospective	9 Mar – Apr 26, 2020	–	63%	–	6
Ohliger et al.	2020	USA	Retrospective	–	–	–	–	5
Park et al.	2020	UK	Retrospective	17 Mar – Apr 17, 2020	–	30%	–	5
Peiro-Garcia et al.	2020	Spain	Retrospective	14 Mar – Apr 14, 2020	97%	70%	–	5
Plancher et al.	2020	USA	Qualitative	–	–	–	–	–
Sabharwal et al.	2020	USA	Qualitative	–	–	–	–	–
Stambough et al.	2020	USA	Qualitative	–	–	–	–	–
Tamburelli et al.	2020	Italy	Retrospective	1 Mar – Jun 1, 2020	77%	–	–	6
Wong et al.	2020	Hong Kong	Retrospective	25 Jan – Mar 27, 2020	93%	80%	–	6
Zagra et al.	2020	Italy	Retrospective	–	69%	–	–	5

themselves being alternated between operational duties in their orthopedic departments, and frontline duties in ancillary sites such as COVID-19 wards. Six studies^{1,3,14,18,22,33} described an increase in the number of duties for residents whilst stationed in orthopedic departments, with residents experiencing more frequent periods on call. Additionally, residents rostered for COVID-19 related duties experienced increased exposure to COVID-19 patients, especially whilst performing frontline duties.³ The increased frequency of calls, as well as greater exposure to COVID-19 patients proved to be stressors for some residents, with several self-reporting a decreased quality of life score as compared to pre-pandemic working conditions.⁷

4. Discussion

The COVID-19 pandemic has made an unprecedented impact on healthcare services worldwide. Resources such as manpower and equipment are being redirected to meet the care demands of a steadily increasing number of COVID-19 positive patients. Similar to the other arms of healthcare, orthopedic services were not spared the effects of the pandemic. Many centers globally reported steep declines in surgical procedures performed, as well as outpatient clinic attendance. We performed a meta-analysis of proportions, which, to the authors' knowledge, is the first of its kind quantifying the global impact of COVID-19 on orthopedic services. This study noted a sharp decline in elective surgery rates, with pandemic-era rates of elective surgery only being 20% that of pre-pandemic times. Additionally, outpatient clinic attendance during the pandemic was only 37% of the pre-pandemic value. The number of trauma surgeries were not affected as much as elective procedures, with a decrease of 47% noted. The overall reduction in surgeries and outpatient clinic attendance could be attributed to several factors. Firstly, redeployment of manpower due to local staffing needs meant that orthopedic surgeons were redeployed towards the effort to combat the pandemic. Hence, with fewer staff

to continue the operational duties, many orthopedic departments were forced to cancel or postpone non-essential appointments and procedures.²¹ Next, patients may see healthcare institutions as reservoirs of infection, with the fear of contracting the virus outweighing their priority for medical attention.³⁷ Most importantly, global lockdown has placed a curb on many of the non-essential medical services, cancelling or deferring elective surgeries until the pandemic situation stabilizes in an attempt to divert healthcare infrastructure to supporting critical patient care needs.²³

Despite the general trend of decreasing surgery and clinic attendance rates, there have been proportionate increases in ED visits due to particular etiologies. Firstly, the proportion of domestic injury cases seen in the ED was higher during the pandemic, as compared to pre-pandemic times. This is unsurprising as previous studies have shown that incidences of domestic injury rates rise both during and after natural disasters.¹⁵ Several recent studies have put forth hypotheses explaining why similar trends are being observed during this pandemic.^{5,25} The leading hypothesis is that the issuing of stay-home-orders, whilst designed to limit exposure of the populous to COVID-19, results in an increase in opportunities for assault and abuse to occur, simply due to the greater time people spend within smaller confines. Another phenomenon observed during this pandemic is the decline in mental well-being of individuals and the development of anxiety and depressive disorders.³² Both anxiety and depressive disorders are known risk factors for self-harm and impulsive behavior,³⁵ which potentially contributes to the observed increase proportion of polytrauma seen in the ED during this pandemic.

Additionally, due to the pandemic climate, orthopedic surgical residents have been hit hard from a training perspective. The reduction in both surgical and clinical caseloads have resulted in many residents being unable to keep up with the clinical experience requirements of their respective residency training programs. Most residency programs require residents to be proficient in several core competencies, most of which are patient centric.²

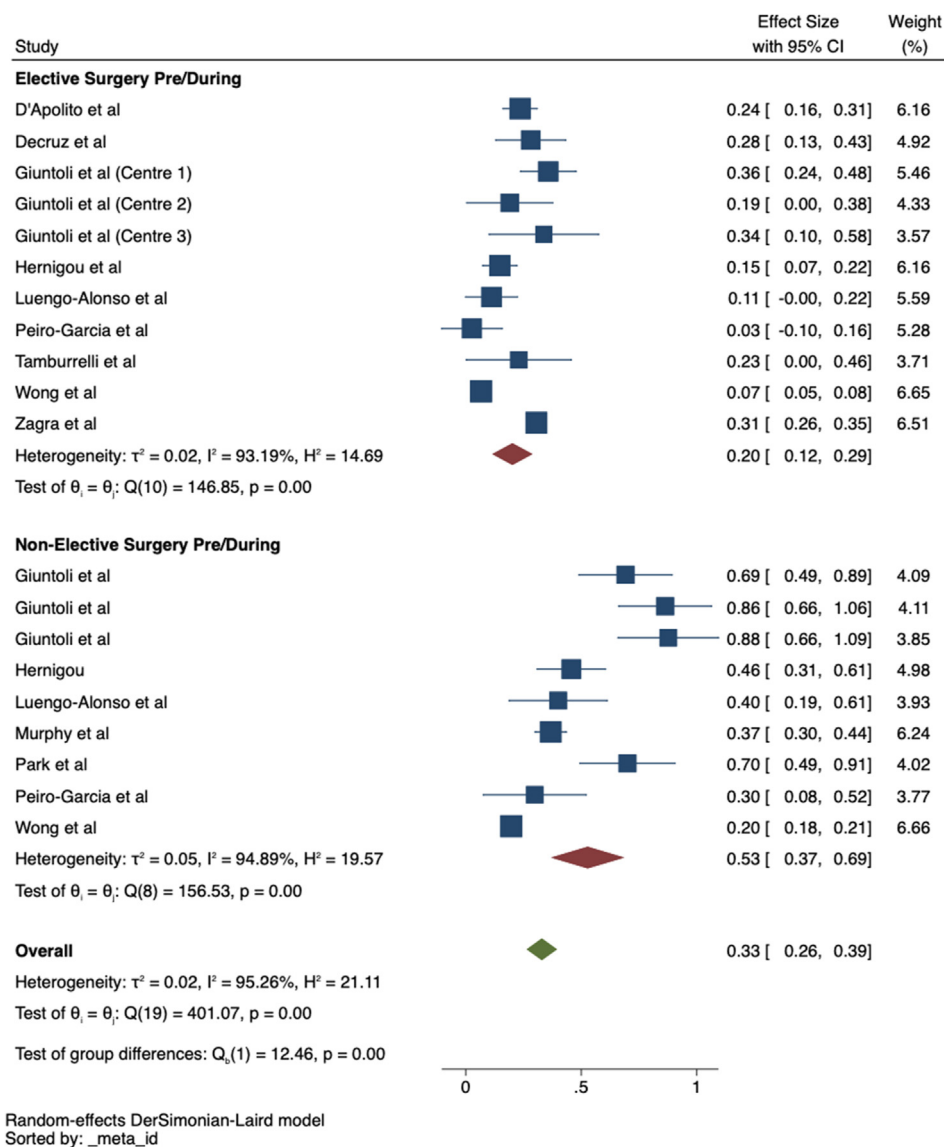


Fig. 2. Forest plot of elective and trauma surgeries.

Hence due to the reduction in patient volume seen in their respective departments, many orthopedic residents were unable to maintain the practice of said core competencies. These challenges faced by orthopedic residents is echoed by residents in other surgical specialties, with many surgical residents being unable to keep up with surgical and clinical exposure due to the dwindling elective surgery rate and clinic attendance numbers.^{27,30} Whilst some governing bodies overseeing the training of residents, such as the Accreditation Council for Graduate Medical Education (ACGME), have adapted their administrative requirements of training, such that the reduced clinical exposure of residents does not impact their ability to receive their eventual specialist accreditation, it remains to be seen whether this reduction in exposure will affect the clinical competency of future specialists trained during this pandemic era. The ACGME system of postgraduate education accreditation originated from the United States of America, and has since expanded internationally, with the system currently being employed in Singapore, Qatar, the UAE, and Saudi Arabia, amongst other countries, with the system replacing previously instituted

postgraduate accreditation programs. The ACGME has also put forth preliminary guidelines on how orthopedic residency training should be conducted during this pandemic, with varying requirements based on the severity of COVID-19 spread in the region of respective institutions.¹² However, it remains to be seen whether these guidelines will allow a balance to be reached between preventing a potential vacuum of future specialist orthopedic surgeons and ensuring that residents graduate their training programs with sufficient clinical competency.

Ultimately, orthopedic departments and healthcare institutions worldwide face a slow road to recovery from the impact of the COVID-19 pandemic. Whilst some departments are slowly starting to restart elective surgeries and prepare for a return to normalcy, others still find themselves in the thick of the pandemic. This staggered recovery has resulted in a generalized lack of standardized guidelines for safe resumption and recovery of orthopedic services.³⁴ One of the first guidelines released was by the European Society of Sports Traumatology, Knee Surgery and Arthroscopy (ESSKA), which detailed the steps towards the

safe resumption of elective surgeries.²³ However, whether these guidelines prove to be applicable universally hinges on its adoption and trial by various orthopedic departments across the world. The slow return of orthopedic departments to normalcy and the compromised training of residents due to the pandemic points to an uncertain future for healthcare institutions worldwide, wherein the impact of this pandemic may yet still be felt far in the future.

4.1. Limitations

This study has the following limitations. As with all systematic reviews, the quality of the meta-analyses is based on the quality of the studies analyzed. All the 23 studies included had low to moderate methodological quality with varying heterogeneity. Although, prospective, randomized trials would be more suitable to assess the outcomes, measuring the decrease in surgical caseload is usually performed with retrospective intent, hence the studies are yet limited to retrospective analyses. Consequently, this review serves not so much as a call to action, but rather as a reflection of the impact of the COVID-19 pandemic on global orthopedic services, with a call to action for organizations to put in place some forms of structure to assist orthopedic centers around the world in their return to normalcy.

Declaration of competing interest

The authors declare that they have no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jcot.2020.10.052>.

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