

SURGICAL EDUCATION AND TRAINING ADAPTATION IN RESPONSE TO THE COVID-19 PANDEMIC: A LITERATURE REVIEW

Reno Rudiman^{1*}, Putie Hapsari¹

¹Department of Surgery, School of Medicine, Universitas Padjajaran, Bandung, Indonesia

Submitted: 18 Jul 2023; Final Revision from Authors: 27 Jun 2023; Accepted: 25 Aug 2023

ABSTRACT

Background: As a global health emergency, the COVID-19 pandemic has affected all medical education and training, including surgical specialities. The number of elective surgeries dropped significantly as both an impact of the pandemic and a way of limiting the spread of the disease. There was confusion about continuing surgical education and training at the beginning of the pandemic. However, as the pandemic continued, we adapted to the new conditions and regulations. Social distancing, testing, and quarantine were promoted. The study aimed to show how surgical education and training adapt to the COVID-19 pandemic worldwide and share how we do it in Indonesia.

Methods: The authors gathered relevant literature from several publications sites, using the keywords “surgical education,” “surgical adaptation,” and “COVID-19.”

Results: In order to decrease contacts, the number of people in the operating room was reduced, clinical rounds were cancelled, and face-to-face training and lectures were moved to online platforms, namely Zoom and Google Meet. The number of residents on clinical duties was decreased to limit the transmission. They are encouraged to study using different models by themselves to keep up with the required skills. They were required to learn and then be tested or reviewed by the supervisor. The use of simulation models and online learning platforms provided by several worldwide institutions has become popular.

Conclusion: We learn that surgical education and training from the pandemic can develop into a more modern way of learning, consisting of a virtual learning strategy and simulation model. This hybrid learning of offline and online courses can aid the growth of not only the residents but also the experienced surgeon.

Keywords: surgical education, surgical training, surgical adaptation, COVID-19

ABSTRAK

Latar belakang: Pandemi COVID-19 telah mempengaruhi seluruh pendidikan dan pelatihan kedokteran, termasuk di dalamnya program spesialisasi bedah. Jumlah operasi elektif turun secara signifikan baik sebagai dampak dari pandemic maupun sebagai cara untuk membatasi penyebaran penyakit. Terdapat kebingungan bagaimana melanjutkan pendidikan dan pelatihan bedah di awal pandemi. Namun, seiring dengan berlalunya pandemi, kami beradaptasi dengan kondisi dan peraturan baru. Pembatasan sosial, pemeriksaan terhadap COVID-19, dan karantina dipromosikan. Penelitian ini bertujuan untuk menunjukkan bagaimana pendidikan dan pelatihan bedah beradaptasi dengan pandemic COVID-19 di seluruh dunia dan membagikan bagaimana kami melakukannya di Indonesia.

Metode: Penulis mengumpulkan literatur-literatur yang relevan, menggunakan kata kunci “pendidikan bedah,” “adaptasi bedah,” dan “COVID-19.”

*corresponding author, contact: rudiman@unpad.ac.id

Hasil: Untuk mengurangi kontak, jumlah orang di ruang operasi dikurangi, rotasi klinis dibatalkan, pelatihan tatap muka dan kuliah dipindahkan ke platform daring, yaitu Zoom dan Google Meet. Jumlah residen yang bertugas di klinik dikurangi dalam upaya membatasi penularan. Mereka didorong untuk belajar mandiri menggunakan berbagai jenis model untuk mendapatkan keterampilan yang dibutuhkan. Mereka diminta untuk belajar dan kemudian, mereka akan diuji atau ditinjau oleh supervisor. Penggunaan model simulasi dan platform pembelajaran daring yang disediakan oleh beberapa institusi di seluruh dunia telah menjadi populer. **Kesimpulan:** Dari pandemi, pendidikan dan pelatihan bedah dapat berkembang menjadi cara belajar yang lebih modern, terdiri dari strategi pembelajaran virtual dan model simulasi. Pembelajaran hibrida dari kursus luring dan daring ini dapat membantu pertumbuhan tidak hanya residen tetapi juga ahli bedah yang berpengalaman.

Kata kunci: pendidikan bedah, pelatihan bedah, adaptasi bedah, COVID-19

PRACTICE POINTS

- All surgical education and training have significantly influenced daily surgical operations.
- A large number of trainees were regarded to have insufficient abilities since it was widely believed that some of them did not complete the required training hours.
- Therefore, various teaching strategies were implemented. Online tools like Zoom and Google Meet were used for all lectures and meetings.
- The most updated training approaches, such as simulation training and virtual learning strategies, are becoming increasingly popular in the educational context, even though face-to-face training is still a crucial component of surgical education and training.

INTRODUCTION

Medical education, among all healthcare activities, is under extreme strain during the Coronavirus disease-19 (COVID-19) pandemic. Conventional medical education and medical students have been negatively affected by the instability in medical education and training, which is likely to have long-term consequences beyond COVID-19.¹

COVID-19 was declared a global health emergency by the World Health Organization (WHO) on January 20, 2020, after the first case of COVID-19 was found in Wuhan, Hubei Province, China, in December 2019.² Despite aggressive global preventive measures such as social distancing, testing, and quarantine, the global prevalence of COVID-19 has risen at an exponential pace, reaching up to 128.5 million confirmed cases of COVID-19, including 2.8 million deaths as of March

31, 2021.³ At the same time, 1.15 million confirmed the Government of the Republic of Indonesia reported cases of COVID-19 with 40.858 deaths.⁴ In an attempt to limit the spread and burden of the healthcare systems, several countries implemented various forms of lockdown, including closing public facilities and other places that enable people to meet and hold large gatherings, including universities and schools. Medical education is switching to online meetings and online clerkship programs.⁵

In recent years, surgery has been acknowledged as a significant public health problem, and access to surgical treatment has been considered crucial. The pandemic of COVID-19 has significantly impacted surgical practice, and priorities in various surgical institutions have shifted. Not only has the current pandemic posed a threat to providing effective

surgical treatment, but it has also had a considerable impact on surgical training and education programs in several countries. For surgical trainees to prepare, perform, and reproduce surgical operations safely and efficiently, institutions must adapt to modern learning methods.⁶

The pandemic offered an excellent opportunity to rethink how surgical trainees learn and adapt to their curricular assignments and revisit current learning, and surgical knowledge approaches. Therefore, this

study aims to first assess the adaption of surgical training and education during the pandemic worldwide and share how the Indonesian surgery residency program thrives.

METHODS

This review is a narrative review, and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2009 flowchart is included in Figure 1.

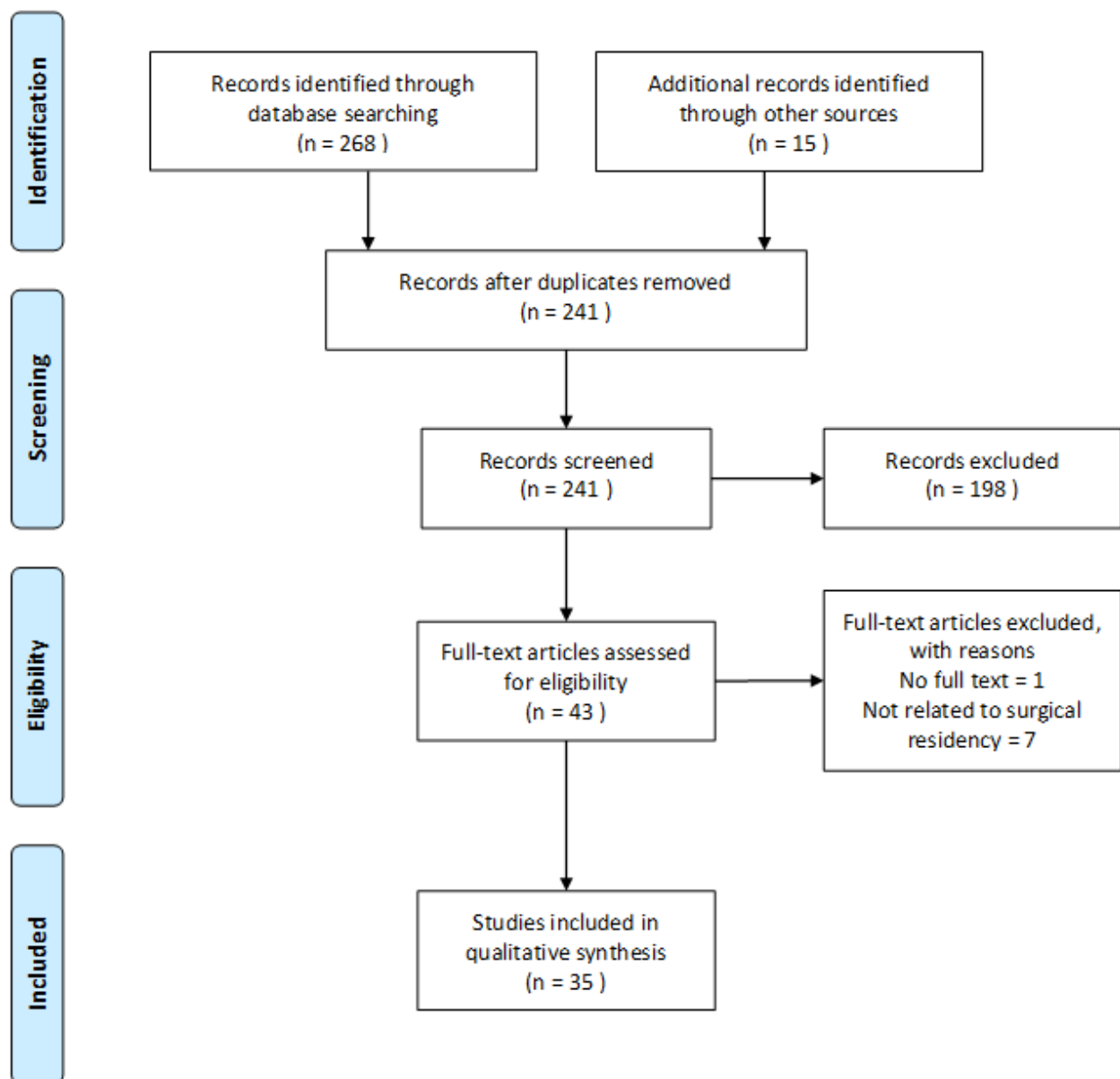


Figure 1. PRISMA Flowchart of the Narrative Review

Various institutions and organizations published the adaptation of surgical education in response to the pandemic. The authors searched for articles related to the adaptation of surgical education and training in several databases, such as Google Scholar, Science Direct, Wiley Online Library, Pubmed Central, and Springer. For the search criteria, the authors used the keywords of “surgical education,” “surgical adaptation,” and “COVID-19.” We do not limit the level of the surgical trainee in our review, but we will discuss the different impacts among junior and senior/chief residents. The inclusion criteria include all studies (case reports, case series, letters to editors, cross-sectional studies, and cohort studies) that describe surgical residency or education during COVID-19. The authors have chosen the review duration over two years, starting from 2019 to 2021, as the time horizon. The reason for selecting the period was to see the impact of the COVID-19 pandemic on surgical education and training. Our exclusion criteria would be those studies that focused on other residency programs other than surgical.

RESULTS AND DISCUSSION

In response to the pandemic, many universities and hospitals began to change their way of conducting clinical activities and surgical education. The changes mainly happened in two categories: work shifts and education.

Adaptation in work shifts

At the University of Washington Medical Center, there were five subspecialty general surgery teams, comprised of an average of four residents each before the pandemic. If one resident falls sick for an extended period, that would negatively affect the team’s ability to work efficiently. Therefore, a larger team of residents from all ranks was made, complemented by nurses. The formation of larger teams would allow for greater resistance to the absence of team members due to one thing or another. The new larger teams, called Alpha, Bravo, and Charlie, were deployed in three patient care settings: inpatient, operative, and clinic. The teams were rotated each week. For example, the Alpha team would attend inpatient care in the first week, clinical

care in the second week, and operating care in the third week. Then, they will return to inpatient care again in the fourth week. These rotations were done to optimize physical distancing while maintaining control of the workload and staffing needs.⁷

Singapore has a different residency program in which the trainees are rotated to three supporting institutions (SIs) for about three to six months each. Each SI has two academic hand surgery units that provide tertiary-level hand and reconstructive microsurgery services. Hence, through all these rotations, the residents will learn various procedures to complete their training. After the pandemic hit, trainees only performed clinical services that were needed. Even though the number of elective surgeries has decreased, emergency cases have remained constant. Each hand surgery department has two self-sufficient teams of consultants and residents, with each resident assigned to a one-out-of-four emergency call. With the support of senior management, improvements were made to ease the residents’ workloads. To begin, just a few outpatient clinic sessions will be scheduled for the “post-call” team in order for the whole team to handle cases from the night before. This will allow the post-call resident to have a full day off. Secondly, all non-critical operations have been postponed until the next operation slot becomes available. Last, to prevent overburdening their constituents, consultants have scheduled themselves to take several direct emergency calls without a resident.⁸

At Vancouver General Hospital, Canada, the acute care surgery (ACS) team was previously made up of three teams of two residents, who will report to a single surgeon. Residents were only allowed to be on call once every four days, resulting in residents and other workers from other teams being regularly placed on the call. In order to avoid this intermingling staff, the number of teams was reduced to two, with two junior-senior resident pairs reporting to one staff surgeon. They served in isolation for two weeks before taking a week off, after which another junior-senior pair replaced them. The remaining 40% were split between the intensive care unit (ICU) and a “reserve deployment unit,” where they self-isolated at home and gave assistance when required. The

residents were equipped with an online intensive care course for patients with and without COVID-19 and other critical care services.⁹

The otolaryngology department took several measures for its residency program in Detroit, US to ensure the residents' safety while still providing the best care for the patients. A five-team approach was implemented among the three possible practice locations. Depending on the locations and the number of patients, the five hospitals were divided into three functional teams. Two separate teams of three residents were allocated to each of the two busiest hospitals. The least busy site was assigned a team of two residents due to the lower clinical volume and decreased call coverage needed. Each team operates for three days at the two busiest sites until the next three-person team takes over. The teams are kept entirely from one another so that they do not communicate with each other or anyone at other sites. This reduces the risk of cross-contamination spreading among a large number of people and also reduces the likelihood of several residents and other workers being quarantined at the same time. Each resident is assigned a backup resident who will take over if the primary residence cannot work. In case of all three residents become sick, a backup team consists of another three residents as a backup plan. The team works for three days and then has three days off. The residents were encouraged to go straight home after duties to rest. They are also granted post-call days whenever possible.¹⁰

Adaptation in surgical education

In response to the pandemic, an online teaching curriculum for core surgical trainees (CSTs) was created by two core surgical trainees (CSTs) and the Training Programme Director from the Yorkshire and Humber Deanery in the United Kingdom. The online program was supervised by a consultant surgeon for most of the classes. This program was conducted from April to June 2020, consisting of twenty recorded live or pre-recorded online teaching sessions provided by CSTs, senior surgical registrars, and consultant surgeons through Zoom. Then, using online questionnaires, participants provided input on the sessions. Youtube analytics

were also used for feedback. Laloo et al. concluded that the online teaching program was feasible and well-received by the CSTs as a new way of learning.¹¹

There are new learning modalities for learning and teaching in the surgical oncology department. Prior specialized training and educational modules were given via face-to-face group tutorials. Then the participants would implement their theoretical knowledge by witnessing operating room procedures and viewing face-to-face video presentations. However, surgical education needs to be restructured and reorganized due to the pandemic. New technology and interactive learning modalities were used to shape the residents to prepare them for their clinical rotations better when they return.^{12,13} Using video-based instructional tutorials such as computer-based surgical platforms such as the American College of Surgeons, WebSurgTM, and Deutsche Gesellschaft für Chirurgie (DGCH), detailed steps and aspects of the most important surgical oncology procedures could be explained, researched, and repeated.^{14,15}

These resources enabled residents to learn about surgical signs, preoperative workups, and operative anatomy and procedures. Structured immersive live or filmed lectures in online classes, analogue, digital handoffs, and podcasts can help residents retain the information obtained.¹⁵ This has made it possible to learn on a more flexible schedule during typical residency and clinical activities. These virtual learning modalities often allow for constructive conversations with surgical teachers for supervision and ability development.

Surgical simulations have become more and more critical, especially during the pandemic. There are various training models to learn or teach laparoscopic surgical skills, including box trainers (BT) and virtual reality simulators (VRS). Though VRS is more expensive and less common, BTs are less expensive and can be made from common household products.¹⁶ Residents on duty can also learn through simulation labs and robotic trainers available in the hospitals.^{15,17}

All residents in Singapore Hand Surgery Department were given didactic pre-recorded

lectures. Didactic teaching series were held weekly, with the pre-reading material and organized pre-lecture questions distributed before, allowing the participants to be prepared for the online classes. Each series will last 45 minutes and will be delivered via teleconferencing software by a resident whom a supervisor has mentored. In rare cases, the discussions were brought up using an email-based worksheet. The worksheet begins with the case issue and a brief vignette, followed by a series of questions on pathophysiology, clinical evaluation, technical issues, and current best practices. To prepare the answer, the resident is allowed to review textbooks and literature and get colleagues' opinions. The supervisor will then conduct a teleconference with all residents and email them individually to go through their responses.⁸

Rounds and educational sessions, as well as other organized group education, have been cancelled. Steps have been taken to minimize this inconvenience. The morning handover and rounds are now conducted entirely online. General surgeons from around the province were invited so that they could get regular updates on the pandemic and review the relevant literature.⁹

Residents must be on "academic time" when they are not in the hospital for clinical duties. This is when they are supposed to do self-study using provided online platforms and research. Before the pandemic, several activities, namely grand rounds, conferences, basic science lectures, and other scientific meetings, needed to be moved to the online platform. Videoconferences were implemented for weekly two-hours grand rounds. Didactic lectures were delivered by the Consortium of Resident Otolaryngologic Knowledge Attainment Initiative in Otolaryngology, the Great Lakes Otolaryngology Consortium, and the Collaborative Multi-Institutional Otolaryngology Residency Education Program. The online materials can also be accessed later if the residents cannot join the live lectures. Decreased number of surgery and clinical visits during the pandemic was covered by allowing the residents to join the telehealth visits.¹⁰

Tele-conference and webinars have been a way of learning since before the pandemic. However, with

the pandemic, its usefulness has become apparent. Applications like Zoom, WebX, Google Hangouts, Skype, and others enable lectures and teaching sessions to be done. Interdisciplinary learning can use the webinar to communicate between rheumatologists, immunologists, and intensivists handling COVID-19 patients. Simulation and virtual reality also provide technical skills training for the residents.¹³

In Singapore, there is a two to three-hour time slot on the weekend when the residents are not required to perform clinical studies but to learn expertise in multiple tissues using several training models. The examinations for the program, including the national examinations, were conducted differently. Multiple-choice questions and oral components were investigated as ways to offer the exam in a structured and decentralized manner across the nation.⁸

Surgical education and training have undergone significant changes worldwide, and Indonesia is also grappling with how to respond to the pandemic. The COVID-19 pandemic has negatively impacted surgical education and training in Indonesia. Surgical cases were reduced by 50 - 70% during the first three months of the pandemic, thus decreasing the opportunity for our residents and trainees to learn and develop their surgical skills as part of their training program.

The impact of COVID-19 pandemic on surgical department/education

There are challenges for surgical training to be continued during the pandemic, namely cessation of clinical activities, both surgical training and academic sessions; short supply of personal protective equipment (PPE), and the possibility of COVID exposure from surgical procedures, especially in countries that have a large number of cases like Italy; exposure, testing, and self-isolation due to COVID-19; cessation of elective surgeries due to limitation of hospital admissions; emergency cases that were handled by senior surgeons only in an attempt to limit the exposure, less number of PPE usage, and decrease the operation duration; and the psychological health of the trainees.¹⁸

Based on the data obtained from a comprehensive survey of all US fellows and fellowship directors under the American Orthopaedic Society for Sports Medicine, over 80% reported more than 50% reduction in elective cases, and more than 50% of working hours per week decreased. Fellows reported that there would be an 11% to 25% decrease in the number of cases by graduation time compared to the number of cases of the fellows that graduated before the pandemic. Most of the fellows surveyed voiced concern about their readiness for independent practice, and over 50% are concerned about their job opportunities due to COVID-19.¹⁹

A voluntary online survey was conducted in the West of Scotland region to surgical trainees. Six weeks into the pandemic, they felt that their opportunities to operate as the first surgeon have decreased, they have not performed any endoscopic procedures, and some have not attended outpatient clinics. The number of trainees that had access to simulation training by using box trainers varied from those who had access to those who did not have access. Most trainees felt that their confidence in performing surgical skills has decreased.²⁰

One cross-sectional study examined burnout among surgical residents in Malang's orthopaedic, general, and urology departments concerning COVID-19. They discovered that burnout affected 56.67% of the 120 residents. Some important linked factors for burnout include marital status, specialization, year of residency, classification of subscale scores of the Maslach Burnout Inventory (MBI), and working hours.²¹ Another study, including five urological education facilities, indicated that 57.8% of 147 urology residents believed COVID-19 had adverse effects. A total of 70.06% of individuals report feeling anxious about their level of expertise. This outcome could be caused by fewer learning opportunities, particularly about surgical abilities. Interestingly, other mental health issues are not impacted.²²

The impact of COVID-19 pandemic on surgical residency in Indonesia

Comparisons between Indonesia and other parts of the world are scarce regarding surgical residency training. One systematic review of neurosurgery

residency training found that resident engagement in surgical procedures, lower operating volume, and time spent in the OR were all noted in surveys of residents from both high-middle income countries (HMICs) and low-middle income countries (LMICs). Elective cases were considerably reduced in Indonesia and the Philippines ($P < 0.001$), which reported the closure of outpatient clinics, with a median closure time of 8 weeks, according to a survey of trainees in 5 Southeast Asian countries. It has been demonstrated that this reduction has a deleterious effect on neurosurgery trainees, particularly in light of the fewer and less diverse cases that are now available. These effects resulted in fewer duties, a subspecialization of procedural skills, weak autonomous management, and less hospital access.²³⁻³¹ This systematic review also reports that reduced surgical caseload, coupled with the recession and lower surgical exposure, also causes residents to experience financial difficulties.³²

In neurosurgery department in one of the teaching centers in Indonesia divide the teaching staff and residents into two separate teams that work for two weeks interchangeably. Nearly all elective procedures were delayed in the early stages of the COVID-19 epidemic. So, starting in June 2020, live surgery was developed as an effective means for the residents to master operating procedures in order to sustain their learning process during the pandemic. The quickest and easiest technique to perform live surgery instruction in this epidemic era is by video streaming of a neurosurgery operation from the operating room to a conference room or mobile phone. With this live surgery, the residents may gain knowledge from and communicate with the attendings while keeping a physical distance.³³

The pandemic brought up new educational resources. Online learning through resources such as webinars, teleconferences, and other digital formats expanded rapidly. In place of the in-person meetings, teleconferences were arranged on a regular basis. It affected resident's expertise, but it also gave them an incredible opportunity to talk about cases with leading neurosurgical figures and authorities from across the world. Scientific conferences, journal reading, and case presentations were all conducted

online using Zoom for academic purposes. Due to shift patterns, fewer people participated in service-based academic activities including the outpatient clinic, neurosurgical ward, and operations than normal. Academic evaluations were conducted online using teleconferencing tools. Case discussions were held twice a week and attended by all residents. Journal reading rose from twice weekly to five times weekly with 1-2 hour sessions throughout the pandemic, enhancing the understanding of evidence-based medicine in neurosurgery.^{33,34}

When clinical practice is unavailable, residents can continue their continuing medical education through webinars. Residents in urology and other healthcare professionals pursuing continuing medical education must adjust to the growing use of telemedicine and innovative teaching techniques. Despite the detrimental effects of COVID-19 on medical education, some advantages should be taken into account. The transition from traditional classroom instruction to online instruction helps residents build their theoretical understanding. The participants believe that the epidemic has provided them more time for writing academic papers and for self-study, respectively.²²

What does the future hold for surgical residency?

The impact of COVID-19 on the competencies of surgical residents remains largely unknown. Although understandably, some assume residents may suffer from lower exposure and hence lower capabilities, there remains a silver lining. One study in California recruited 1,102 general surgery residents to examine COVID-19's impact on resident training, education, and burnout. Residents indicated that the number of pandemic-related cases had significantly decreased. The majority of educational curricula have moved toward online didactics. Most residents claimed to have spent more time studying than before the outbreak. Most locals feared catching COVID-19 or spreading it to their families during the outbreak.³⁵ However, this study also concludes that increased educational didactics is one benefit of the epidemic. In the post-COVID-19 age, online didactics should still be a part

of surgical education.^{35,36} The COVID-19 experience is another unique educational opportunity for surgical residents that test their ability to work as members of larger multidisciplinary teams and exhibit dedication to inter-professionalism, public health, and patient care.^{36,37} One teaching hospital in Surabaya uses simulation-based training to teach hysterectomy using mannequins following video demonstration. This method can be used as a bridging technique to learn abdominal hysterectomy procedures for obstetrics and gynaecology residents that perform surgeries.³⁸

Our review is a comprehensive one that discusses what has happened to the surgical residency program during COVID-19 and in the future. It focuses on the methods of learning, how it can be achieved, as well as the pros and cons. This review also ties back to Indonesia, where we learned how to adapt and improvise the curriculum from other parts of the world. However, this is not a systematic review; hence, several important studies may have been missed, and more studies are included at a rapid pace about this topic. Hence, readers are advised to follow closely on updates about this topic.

CONCLUSION

Amid the pandemic, few organizations were genuinely prepared to deal with the crisis in surgical training programs. Surgical procedures have been severely impacted in all surgical specialities. The elective surgeries were seriously affected, as was the number of emergency cases, but to a lesser degree. Many people believed that certain trainees did not meet the necessary training hours, and as a result, a wide range of trainees was thought to have inadequate skills.

Hybrid surgical education may become the future of surgical training. Those platforms can aid professional growth for experienced surgeons and residents, transcending physical limitations as we adapt to new surgical education and training methods.

RECOMMENDATION

More studies need to be published, especially in Indonesia, to compare surgical residency differences

better.⁵ It is imperative to do a follow-up study on residents who later graduated to become surgeons. If there is a significant difference in skills and the surgeons' perceptions of their skills, it may be wise to rethink hybrid learning in Indonesia.

A more comprehensive review can be done in multiple education centres in Indonesia alongside others from various countries to provide better education and training for the upcoming surgical education and training programme.

ACKNOWLEDGMENTS

The authors wish to thank Lie Rebecca Yen Hwei for preparing the manuscript of this article.

COMPETING INTEREST

The authors declare that they have no competing interests related to the study.

LIST OF ABBREVIATIONS

| | |
|----------|-------------------------------------------|
| ACS | : Acute Care Surgery |
| BT | : Box Trainer |
| COVID-19 | : Coronavirus Disease-19 |
| CST | : Core Surgical Trainees |
| DGCH | : Deutsche Gesellschaft für Chirurgie |
| ICS | : Indonesian College of Surgeons |
| ICU | : Intensive Care Unit |
| MCQ | : Multiple Choice Question |
| OSCA | : Objective Structure Clinical Assessment |
| PPE | : Personal Protective Equipment |
| RCSEd | : Royal College of Surgeon of Edinburgh |
| SI | : Supporting Institutions |
| VRS | : Virtual Reality Simulator |
| WHO | : World Health Organization |

AUTHORS' CONTRIBUTION

Reno Rudiman - the idea for the literature review and contributed to the writing and editing of the review.

Putie Hapsari - writing and editing of the review.

REFERENCES

- Sharma D, Bhaskar S. Addressing the Covid-19 Burden on Medical Education and Training: The Role of Telemedicine and Tele-Education During and Beyond the Pandemic. *Front Public Heal.* 2020; 8: 1–14.

- Sohrabi C, Alsafi Z, O'Neill N, Khan M, Kerwan A, Al-Jabir A, et al. Corrigendum to "World Health Organization declares Global Emergency: A review of the 2019 Novel Coronavirus (COVID-19)" [*Int. J. Surg.* 76 (2020) 71–76] (*International Journal of Surgery* (2020) 76 (71–76), (S1743919120301977), (10.1016/j.ijsu.2020.02.034)). *Int J Surg.* 2020; 77: 217.
- WHO. WHO Coronavirus (COVID-19) Dashboard. World Heal Organ. 2021;
- WHO. Coronavirus Disease 2019 (COVID-19) Situation Report. World Heal Organ. 2021;
- Kelly K, Hwei LRY, Octavius GS. Coronavirus outbreaks including COVID-19 and impacts on medical education: a systematic review. *J Community Empower Heal.* 2020; 3: 130.
- Al-Jabir A, Kerwan A, Nicola M, Alsafi Z, Khan M, Sohrabi C, et al. Impact of the Coronavirus (COVID-19) pandemic on surgical practice - Part 1. *Int J Surg* [Internet]. 2020; 79: 168–79. Available from: <https://doi.org/10.1016/j.ijsu.2020.05.022>
- Nassar AH, Zern NK, McIntyre LK, Lyng D, Smith CA, Petersen RP, et al. Emergency Restructuring of a General Surgery Residency Program During the Coronavirus Disease 2019 Pandemic The University of Washington Experience. *JAMA Surg.* 2020; 155: 624–7.
- Das De S, Puhaindran ME, Sechachalam S, Wong KJH, Chong CW, Chin AYH. Sustaining a national surgical training programme during the COVID-19 pandemic. *Bone Jt Open.* 2020; 1: 98–102.
- Hintz GC, Duncan KC, Mackay EM, Scott TM, Karimuddin AA. Surgical training in the midst of a pandemic: A distributed general surgery residency program's response to covid-19. *Can J Surg.* 2020; 63: E346–8.
- Johnson J, Chung MT, Carron MA, Chan EY, Lin HS, Hotaling J. Novel changes in resident education during a pandemic: Strategies and

- approaches to maximize residency education and safety. *Int Arch Otorhinolaryngol.* 2020; 24: 267–71.
11. Laloo R, Giorga A, Williams A, Biyani CS, Yiasemidou M. Virtual surgical education for core surgical trainees in the Yorkshire deanery during the COVID-19 pandemic. *Scott Med J.* 2020; 65: 138–43.
 12. Fong ZV, Qadan M, McKinney R, Griggs CL, Shah PC, Buyske J, et al. Practical Implications of Novel Coronavirus COVID-19 on Hospital Operations, Board Certification, and Medical Education in Surgery in the USA. *J Gastrointest Surg.* 2020; 24: 1232–6.
 13. Dedeilia A, Sotiropoulos MG, Hanrahan JG, Janga D, Dedeilias P, Sideris M. Medical and Surgical Education Challenges and Innovations in the COVID-19 Era: A Systematic Review. Vol. 34, In vivo (Athens, Greece). *NLM (Medline);* 2020. p. 1603–11.
 14. McKechnie T, Levin M, Zhou K, Freedman B, Palter VN, Grantcharov TP. Virtual Surgical Training During COVID-19: Operating Room Simulation Platforms Accessible From Home. *Ann Surg.* 2020; 272: e153–4.
 15. Coe TM, Jogerst KM, Sell NM, Cassidy DJ, Eurboonyanun C, Gee D, et al. Practical Techniques to Adapt Surgical Resident Education to the COVID-19 Era. *Ann Surg.* 2020; 272: e139–41.
 16. Hoopes S, Pham T, Lindo FM, Antosh DD. Home Surgical Skill Training Resources for Obstetrics and Gynecology Trainees during a Pandemic. *Obstet Gynecol.* 2020; 136: 56–64.
 17. Chick RC, Clifton GT, Peace KM, Propper BW, Hale DF, Alseidi AA, et al. Using Technology to Maintain the Education of Residents During the COVID-19 Pandemic. *J Surg Educ [Internet].* 2020; 77: 729–32. Available from: <https://doi.org/10.1016/j.jsurg.2020.03.018>
 18. Saqib SU, Saleem O, Riaz A, Riaz Q, Zafar H. Impact of a global pandemic on surgical education and training- review, response, and reflection. *J Pak Med Assoc.* 2021; 71: 49–55.
 19. Swiatek PR, Weiner J, Alvandi BA, Johnson D, Butler B, Tjong V, et al. Evaluating the Early Impact of the COVID-19 Pandemic on Sports Surgery Fellowship Education. *Cureus.* 2021; 13: 1–11.
 20. Khan KS, Keay R, McLellan M, Mahmud S. Impact of the COVID-19 pandemic on core surgical training. *Scott Med J.* 2020; 65: 133–7.
 21. Daryanto B, Rahmadiani N, Amorga R, Kautsarani I, Susilo H, Persada Isma SP. Burnout syndrome among residents of different surgical specialties in a tertiary referral teaching hospital in Indonesia during COVID-19 pandemic. *Clin Epidemiol Glob Heal.* 2022; 14: 100994.
 22. Wisda Kusuma A, Danarto R, Ndraha Khairindra A. Shifting paradigm of urology residency after the COVID-19 pandemic in Indonesia. *Urol Sci.* 2022; 33: 119.
 23. Aljuboori ZS, Young CC, Srinivasan VM, Kellogg RT, Quon JL, Alshareef MA, et al. Early Effects of COVID-19 Pandemic on Neurosurgical Training in the United States: A Case Volume Analysis of 8 Programs. *World Neurosurg.* 2021; 145: e202–8.
 24. Cheserem JB, Esene IN, Mahmud MR, Kalangu K, Sanoussi S, Musara A, et al. A Continental Survey on the Impact of COVID-19 on Neurosurgical Training in Africa. *World Neurosurg.* 2021; 147: e8–15.
 25. Khalafallah AM, Jimenez AE, Lee RP, Weingart JD, Theodore N, Cohen AR, et al. Impact of COVID-19 on an Academic Neurosurgery Department: The Johns Hopkins Experience. *World Neurosurg.* 2020; 139: e877–84.
 26. Dash C, Venkataram T, Goyal N, Chaturvedi J, Raheja A, Singla R, et al. Neurosurgery training in India during the COVID-19 pandemic: straight from the horse's mouth. *Neurosurg Focus.* 2020; 49: E16.
 27. Fernandes Cabral DT, Alan N, Agarwal N, Lunsford LD, Monaco EA. Coronavirus Disease 2019 (COVID-19) and Neurosurgery Residency Action Plan: An Institutional Experience from the United States. *World Neurosurg.* 2020; 143: e172–8.

28. Pelargos PE, Chakraborty A, Zhao YD, Smith ZA, Dunn IF, Bauer AM. An Evaluation of Neurosurgical Resident Education and Sentiment During the Coronavirus Disease 2019 Pandemic: A North American Survey. *World Neurosurg.* 2020; 140: e381–6.
29. Saad H, Alawieh A, Oyesiku N, Barrow DL, Olson J. Sheltered Neurosurgery During COVID-19: The Emory Experience. *World Neurosurg.* 2020; 144: e204–9.
30. Swiatek PR, Weiner JA, Butler BA, McCarthy MH, Louie PK, Wolinsky J-P, et al. Assessing the Early Impact of the COVID-19 Pandemic on Spine Surgery Fellowship Education. *Clin Spine Surg A Spine Publ.* 2021; 34: E186–93.
31. Wittayanakorn N, Nga VDW, Sobana M, Bahuri NFA, Baticulon RE. Impact of COVID-19 on Neurosurgical Training in Southeast Asia. *World Neurosurg.* 2020; 144: e164–77.
32. Jain R, Carneiro RA, Vasilica A-M, Chia WL, de Souza ALB, Wellington J, et al. The impact of the COVID-19 pandemic on global neurosurgical education: a systematic review. *Neurosurg Rev.* 2022; 45: 1101–10.
33. Nugroho SW, Pradhana I, Gunawan K. New adaptation of neurosurgical practice and residency programs during the Covid-19 pandemic and their effects on neurosurgery resident satisfaction and welfare at the National General Hospital, Jakarta, Indonesia. *Heliyon.* 2021; 7: e07757.
34. Suryaningtyas W, Wahyuhadi J, Turchan A, Subagio EA, Parenrengi MA, Apriawan T, et al. Neurosurgery at the epicenter of the COVID-19 pandemic in Indonesia: experience from a Surabaya academic tertiary hospital. *Neurosurg Focus.* 2020; 49: E5.
35. Aziz H, James T, Remulla D, Sher L, Genyk Y, Sullivan ME, et al. Effect of COVID-19 on Surgical Training Across the United States: A National Survey of General Surgery Residents. *J Surg Educ.* 2021; 78: 431–9.
36. Obaid O, Zimmermann J, Ares G. Surgical Residents in the Battle Against COVID-19. *J Surg Educ.* 2021; 78: 332–5.
37. da Motta L, Pacheco L. Integrating medical and health multiprofessional residency programs: The experience in building an interprofessional curriculum for health professionals in Brazil. *Educ Heal.* 2014; 27: 83.
38. Syamsuri DD, Askandar Tjokroprawiro B, Kurniawati EM, Utomo B, Kuswanto D. Simulation-based training using a novel Surabaya hysterectomy mannequin following video demonstration to improve abdominal hysterectomy skills of obstetrics and gynecology residents during the COVID-19 pandemic in Indonesia: a pre- and post-intervention s. *J Educ Eval Health Prof.* 2022; 19: 11.