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Impact of COVID-19 to Neurosurgical Education: A Systematic Review

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Abstract

BACKGROUND: Coronavirus disease (COVID-19) has disrupted many aspects of healthcare and health education including medical education. Given that neurosurgical training requires direct patient contact, the social distancing policy due to COVID has impacted global neurosurgical education.

AIM: We are conducting a systematic review to determine the impact of COVID-19 on global neurosurgical education.

METHODS: This review adheres to the Preferred Reporting Items for Systematic Reviews and Meta-analyses. The literature search was conducted on three repositories (PubMed, MedRxiv, and bioRxiv) which subsequently screened by two independent reviewers.

RESULTS: Thirteen articles were processed for the systematic review. The impact of COVID-19 has been mainly negative to academic activity due to reduced case number and physical contact hours. Residents were also deployed to provide care for COVID-19-related workload. However, several studies reported a positive impact of COVID-19 on residents' well-being such as increased personal time. Besides current residents, prospective medical students were also affected by COVID-19.

CONCLUSION: Neurosurgical program directors should initiate the introduction of a flexible policy to accommodate case reduction to meet the board standard and guard residents' safety and well-being are required to ensure the sustainability of high-quality neurosurgical education.

Introduction

Since the first report in December 2019, the global coronavirus disease (COVID-19) pandemic has changed the various aspects of medical education including reduced physical contact hours and the increasing use of technology for knowledge transfer [1], [2], [3], [4], [5]. Given that the neurosurgical residency is emphasized on obtaining surgical dexterity by managing various cases, supervised hands-on experience is necessary to achieve the required competence as a neurosurgeon. However, this practice has been disrupted by COVID-19 since its declarations as a pandemic by the World Health Organization [6]. In this article, we are conducting a systematic review of the impact of COVID-19 to the global neurosurgical education.

Methods

This study adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses protocols. We performed the literature search based on the MeSH terms ("neurosurgery education" OR "neurosurgical education" OR "neurosurgery training" OR "neurosurgical training" OR "neurosurgery residency" OR "neurosurgical residency") AND ("COVID*" OR "coronavirus" OR "pandemic*) keywords on PubMed, MedRxiv, and bioRxiv. The inclusion criteria included (1) peer-reviewed articles discussing the effect of COVID-19 pandemics to neurosurgical education, (2) published in English, and (3) full-text articles were retrievable. We excluded studies discussing the neurosurgical education pre-COVID-19, editorial letters, and narrative reviews. The literature search was performed by J.B. and all resulted articles were discussed and selected by two reviewers (J.B and M.T.A) to compile the final list of the articles.

Results

The initial search resulted in 54 articles which were then proceeded into duplicate removal, abstract, and full-text screening. After full-text screening, 13 articles were processed for the systematic review (see supplementary materials). Based on the data collection methods, we classified seven papers as based on

the residents' perspectives and four papers on case volumes in academic centers. From seven papers on residents' perspectives, we further analyzed three main themes which were the impact of COVID-19 to academic activity, COVID-19-related workload, and residents' well-being.

Residents' perspectives

Impact of COVID-19 to academic activity

The list of papers discussing the impact of COVID-19 to academic activity is presented in Table 1. Reduced case volumes tend to be the main negative sentiment among all studies analyzed, with a greater loss of reduction in elective cases compared to urgent or emergency cases in two papers. In the Southeast Asian study, the reduction of both types of surgery was significantly different among surveyed countries, which might be due to different governmental regulation and local hospital protocols. Four studies described that there was a concern of the negative impact of COVID-19 both to the ongoing education including the overall training experience, didactic program quality, and obtained surgical skills and the future prospect including difficulty in finding a fellowship post and delay of surgical milestones. Two studies reported that senior residents were significantly affected particularly in the reduced surgical activity and the overall education quality; however, seniority did not seem to have effect on concern of training quality in one study. Since social distancing measures were enforced in the workplaces, two studies reported difficulty in accessing the hospital and reduced physical time spent in the department. In a study from Africa, the actual impact of COVID-19 might be the hardest as nearly a fifth of respondent reported having their examination cancelled, while more than half reported having theirs postponed. Furthermore, a quarter of respondent had their rotations suspended. In Southeast Asia, the travel restriction imposed by the governments had resulted in missing of international educational experience, for example, conferences or exchanges.

Interestingly, COVID-19 also brought positive sentiments to six of seven studies. Three studies reported increased time for didactic activity, while two studies stated that online didactics were better than the conventional format. Two studies reported increased time for research and number of publication which might be attributable to the reduced case load and a work-from-home attitude due to social distancing. The increased personal time for publication and studying was significantly reported by the senior residents in one study. Regarding the resources for online didactics, almost all respondents reported having adequate access to required resources in the Southeast Asia study. However, the increased personal time for studying was not reported by the Middle-Eastern study as more than 80% of respondent answered reduced studying hours.

Impact of COVID-19-related clinical workload and work condition

The list of papers regarding the impact of COVID-19-related workload and work condition is presented in Table 2. We divided the parameters into COVID-19 increasing risk and lowering risk activities. Five of seven studies had the residents cared or exposed to COVID-19 patients or deployed to COVID-19 units. Regarding the level of supervision, the Italian study described that the residents providing care for COVID-19 patients either under supervision or completely by their own. One study described that a third of the respondents were asked to provide care to non-neurosurgical COVID-19 patients, while another study asked the same question with zero response; however, the sample size was very small. However, 70% of the respondents stated that they felt comfortable in providing care to non-neurosurgical COVID-19 cases.

Two studies from Italy and Africa reported that the residents had inadequate personal protective equipment (PPE) with the number reaching more than half of respondents for both. One study reported that nearly third-quarter of the respondents did not receive proper PPE donning training, while two other papers reported PPE donning training received by nearly half of the participants. Other training provided to the residents including neurosurgical COVID-19 patient management in one study, non-neurosurgical/general COVID-19 patient management in two studies, and nasopharyngeal sample collection and hand hygiene in one study. Two studies from the US and Italy reported that the residents were screened for COVID-19 although the reported rate was different between them (75.0% vs. 35.9%).

Impact of COVID-19 to residents' well-being

The list of papers discussing the impact of COVID-19 to residents' well-being is presented in Table 3. The main negative sentiments of COVID-19 were mental health, future uncertainties, and financial aspects. One paper mentioned that COVID-19 affected more than ninety percent of respondents' mental health particularly in PGY-1, PGY-3, and PGY-6 residents and all respondents answered that the pandemic has affected their social life. Another study revealed that around a quarter of respondents were having burnout, although the majority were in low level of emotional exhaustion and depersonalization. Concerns regarding uncertain futures were also described by the participants particularly in healthcare reform and potential income in the American study. Similarly, 12.2% of the African respondents also showed financial concern with nearly a quarter did not receive any formal income during their training.

A US-based study described that the work-from-home policy due to COVID-19 has resulted in the increased

Table 1: The impact of coronavirus disease-19 to residents' academic activity

Number	Author	Year	Country	Sample size	PGY	Methods	Negative sentiments	Rate (%)	Desc.	Positive sentiments	Rate (%)	Desc.
1	Alhaj, *et al*.	2020	Canada, US, Kuwait, Saudi Arabia, Italy, Serbia	52	1–6	Cross-sectional questionnaire-based survey	Affected training at hospital	98.1		N/A		
							Reduced daily studying hours	80.8				
2	Pelargos *et al*.	2020	US, Canada	197	1–7	Cross-sectional-based survey	Limited elective cases	99.0		Increased didactic hours	58.6	
							Reduced volume of surgery	99.5		Encouraged to attend complementary online lectures	79.0	
							Reduced access to hospital	91.0		Favorable response to virtual lectures	64.6	
							Concern that COVID-19 will negatively affect overall education	33.7	Higher in senior residents			
							Concern that COVID-19 will affect fellowship opportunities	41.3				
3	Khalafallah, *et al*.	2020	US	111	1–7	Cross-sectional -based survey	Reduced working hours	74.8		Increased time for didactic lectures	82.0	
							Reduced ability to meet board surgical case minimum	67.6		Increased time for clinical research	66.7	
							Concern that COVID-19 will inhibit surgical milestones	65.8				
4	Cheserem, *et al*.	2020	Morocco, Algeria, Tunisia, Egypt, Libya, Niger, Mali, Senegal, Cote d'Ivoire, Ghana, Niger, Nigeria, Cameroon, Sudan, Uganda, Kenya, Tanzania, Mozambique, Malawi, Zimbabwe, Botswana, South Africa, Madagascar	129	Preresidency to fellow	Cross-sectional survey	Cancelled departmental meeting	43.9		N/A		
							Postponed examination	57.7				
							Cancelled examination	19.5				
							Redeployment	11.4				
							Suspended rotations	25.2				
							Reduction in clinic volumes	61.0				
							Reduced elective surgery volumes	91.9				
							Reduced emergency surgery volumes	74.8				
5	Wittayanakorn, *et al*.	2020	Indonesia, Malaysia, Thailand, Philippines, Singapore	298	1–6	Cross-sectional survey	Reduced research productivity	33.0		Having adequate access to technological resources	96.0	
							Missing international education opportunity	71.0				
							Concern that COVID-19 will negatively impact neurosurgical training	74.0	No differences based on seniority			
							Reduction of elective surgery	81.4	Significant differences among countries but not seniority			
							Reduction of emergency surgery	60.9	Significant differences among countries but not seniority			
6	Aljuboori *et al*.,	2020	US	8	N/A	Cross-sectional questionnaire	Decreased case volume	100		Online didactics were better than face-to-face format	50.0	
							Concern of negative impact of COVID-19 to training	62.5		Increased time for research	87.5	
							Concern that COVID-19 would negatively affect didactic program	87.5		Increased number of publication	62.5	
							Concern that COVID-19 would negatively affect surgical skills	37.5				
							Training program only provided online didactics	87.5				
7	Zoia, *et al*.	2020	Italy	192	1–5	Cross-sectional web-based survey	Reduced time in neurosurgery department	72.4		Increased time for publication	55.7	Significant differences in senior residents
							Reduced surgical activity	94.7	Significant differences in senior residents	Increased didactic activity	64.6	
										Increased personal time for studying	71.9	Significant differences in senior residents

COVID-19: Coronavirus disease 2019, N/A: Not available, PGY: postgraduate year.

Table 2: Coronavirus disease-19-related residents' clinical workload and work condition

Number	Author	Year	Country	Sample size	PGY	Methods	Increasing risk activity	Rate (%)	Desc.	Lowering risk activity	Rate (%)	Desc.
1	Alhaj, *et al.*	2020	Canada, US, Kuwait, Saudi Arabia, Italy, Serbia	52	1–6	Cross-sectional questionnaire -based survey	N/A			Receiving hand hygiene training	78.8	Significant differences between regions
										Receiving PPE donning training	57.5	
										Knowing how to collect nasopharyngeal swab	50.0	
2	Pelargos *et al*.	2020	US, Canada	197	1–7	Cross-sectional based survey	Asked to provide nonneurosurgical care for COVID-19 patients	35.1	Higher in residents in highly affected states	Feeling comfortable in providing nonneurosurgical care for COVID-19 patients	70.0	
										Receiving training of nonneurosurgical care for COVID-19 patients	57.9	
3	Khalafallah, *et al*.	2020	US	111	1–7	Cross-sectional based survey	Cared for suspected COVID-19 patients	91.9		N/A		
4	Cheserem, *et al*.	2020	Morocco, Algeria, Tunisia, Egypt, Libya, Niger, Mali, Senegal, Cote d'Ivoire, Ghana, Niger, Nigeria, Cameroon, Sudan, Uganda, Kenya, Tanzania, Mozambique, Malawi, Zimbabwe, Botswana, South Africa, Madagascar	129	Pre-residency to fellow	Cross-sectional survey	Lacking adequate PPE	61.8		Received training to manage neurosurgical COVID-19 patients	56.9	
							Exposed to COVID-19 patients	22.8		Received PPE donning training	41.6	
										Received training to manage COVID-19 patients	41.0	
5	Wittayanakorn, *et al*.	2020	Indonesia, Malaysia, Thailand, Philippines, Singapore	298	1–6	Cross-sectional survey	Being deployed to COVID-19 units	36.0		N/A		
6	Aljuboori *et al*.	2020	US	8	N/A	Cross-sectional questionnaire	Redeployed to COVID-19 non-neurosurgical care	0		Program tested residents for COVID-19	75.0	
7	Zoia, *et al*.	2020	Italy	192	1–5	Cross-sectional web-based survey	Did not receive PPE donning training	72.9		Screening rate for residents	35.9	
							Provided care for COVID-19 patients	29.7	Either under supervision or not			
							Received inadequate PPE	55.2				

COVID-19: Coronavirus disease 2019, PPE: Personal protective equipment, N/A: Not available, PGY: postgraduate year.

family time, although another US and Canadian study showed that almost half of the respondents considered no effect of COVID to their personal lives. Both studies also revealed contradictory findings regarding career satisfaction in neurosurgery as the former showing that more than 70% of residents stating a positive answer, while a similar number in the latter describing no effect on career satisfaction. Another positive sentiments recorded in Italy showed that more than half of respondents received good support from their supervisors.

Discussion

Before COVID-19 pandemic, there has been disparities in the neurosurgical education condition among developed and developing countries, particularly in Asia and Africa in terms of educational facilities and human resources [7]. In addition, distribution inequality of neurosurgeons particularly in low- and middle-income countries (LMICs) hindered patients to receive adequate neurosurgical treatments in those areas [8]. One of the initiatives to address this problem is by strengthening local neurosurgical training program and creates a localized curriculum to adjust with the available facilities and resources [9]. However, the COVID-19 pandemic has changed the global neurosurgical education environment from various perspectives. Each reported country has its own neurosurgical educational curriculum, healthcare system, socioeconomic condition, government policy and preparedness level, and also different stages of COVID-19 spread at the time of the writing of its respective article [10].

Table 3: The impact of coronavirus disease-19 to residents' well-being

Number	Author	Year	Country	Sample size	PGY	Methods	Negative sentiments	Rate (%)	Desc.	Positive sentiments	Rate (%)	Desc.
1	Alhaj, *et al*.	2020	Canada, US, Kuwait, Saudi Arabia, Italy, Serbia	52	1–6	Cross-sectional questionnaire-based survey	Affected mental health	90.4	Higher in PGY-1, PGY-3, PGY-6	N/A		
							Affected social life	100				
2	Pelargos *et al*.	2020	US, Canada	197	1–7	Cross-sectional based survey	N/A			No effect on home or family lives	68.2	
										Not feeling unfairly burdened by work schedule alteration	88.7	
										No effect on perception of neurosurgery as a career	74.0	
3	Khalafallah, *et al*.	2020	US	111	1–7	Cross-sectional based survey	Overall burnout rate	26.1	Associated with altered elective and vacation rotation and decision not to pursue neurosurgery	Increased time for family	45.0	
							Low emotional exhaustion	51.4		Career satisfaction on neurosurgery	73.9	
							Low level depersonalization	67.6		High level personal accomplishment	78.4	
							Uncertainty of future healthcare reform	79.3				
							Uncertainty of future earnings	45.9				
4	Cheserem, *et al*.	2020	Morocco, Algeria, Tunisia, Egypt, Libya, Niger, Mali, Senegal, Cote d'Ivoire, Ghana, Niger, Nigeria, Cameroon, Sudan, Uganda, Kenya, Tanzania, Mozambique, Malawi, Zimbabwe, Botswana, South Africa, Madagascar	129	Pre-residency to fellow	Cross-sectional survey	Not receiving formal salary	23.6		N/A		
							Concern of COVID-19 impact to finances	12.2				
5	Zoia, *et al*.	2020	Italy	192	1–5	Cross-sectional web-based survey	N/A			Received good support from supervisor	65.9	

COVID-19: Coronavirus disease 2019, N/A: Not available, PGY: postgraduate year.

The impact of COVID-19 to neurosurgical education was mainly negative due to reduced volume of surgery and studying hours in hospital. This potentially led to reduced surgical skills and prolonged training time since neurosurgical residency requires a minimum amount of case portfolio and longer hands-on hours is essential to achieve better surgical dexterity. The plummeted case volumes in the academic centers supported this argument as there were significant decrease in case loads during the first few weeks of COVID-19 pandemic compared to the previous period. Additional letters from Morocco, Iran, and the UK provided the overview of neurosurgical education in those countries which also faced reduced case volumes and decreased physical hours [11], [12], [13]. Most centers prioritized emergency and life-saving procedures, while elective surgeries such as functional and spine cases or cases with high risk of viral transmission such as endoscopic surgeries were cancelled [14], [15], [16], [17], [18]. Some centers also suggested COVID-19 screening to all patients underwent surgeries and only allowing consultant and senior neurosurgeons to perform the surgery to reduce the surgical duration and minimize the use of high-speed drill and electrocautery [17]. These measures, however, might create a gap in transfer of knowledge since the residents did not receive the opportunity to obtain the necessary skills. Several centers also introduced changes in resident rotation scheduling by deployment of smaller number of on-call residents; therefore, the exposure to cases became more limited [19]. The rise of technology utilization to provide remote-distance learning has been a common practice in many centers around the globe; however, this also poses a problem particularly since there is a difficulty to provide hands-on experience [20], [21]. Furthermore, securing a stable internet access to attend online teachings and conferences remain a problem particularly in LMICs, where the infrastructures were often less ready to support the didactic events.

In several countries, COVID-19 even hindered the training milestones including cancelled or suspended examinations or suspended rotations. Neurosurgery is one of the longest medical residency, for example, 5.5 years in Indonesia, 6 to 8 years in Egypt, and 7 years in the US; therefore, this delay might result in prolonged training duration and interruption to fulfill the community demand [22], [23]. COVID-19 also created future uncertainties for both residents and prospective medical students, although the type of

concern was different between both groups. Residents were more concerned on the ongoing training quality and future prospects after graduate, while medical students were more concerned on the application for residency. Furthermore, the travel restriction due to COVID-19 has been reported to affect the international medical graduates to apply for neurosurgical residency in US hospitals [24]. Besides education quality, personal finances were also reported as an important concern either in the form of present salary or future earning prospect [25], [26].

Neurosurgical residents were also at risk of contracting COVID-19 since some centers redeployed residents to provide care to non-neurosurgical COVID-19-positive patients. However, this practice was not exclusive on neurosurgery as residents in OB/GYN, psychiatry, and pathology were also reported to be redeployed into COVID-19 units [27], [28], [29]. Some centers provided additional training in the management of COVID-19 patients including training on hand hygiene and nasopharyngeal swab collection technique; nevertheless, this policy has not been adopted by all education centers [30]. Issues on preventive measures including inadequate training on PPE donning and PPE shortage were also reported in several centers [25], [31]. Moreover, a pre-COVID-19 study reported that around 90% of health care workers did not follow the correct sequence of PPE doffing which might increase the risk of viral transmission if not performed properly [32]. Financial-wise, COVID-19 affected the worldwide healthcare system, in which the LMICs were hit the hardest compared to higher income countries, resulting in a greater challenge to implement preventive measures of COVID including supplying adequate PPEs [33].

Although the impact of COVID-19 was mainly negative, social distancing measures, for example, work-from-home policy has also brought positive impacts to the academic activity and residents' wellbeing particularly in the manner of personal time utilization. Neurosurgical residency has been traditionally acknowledged as one of the most demanding specialty training; therefore, there might be less time for residents devoted to either didactic activity, research activity, or family. This has been supported by the findings that social connection and personal time availability is correlated with better wellbeing scores during residency [34]. It has been established that poor well-being and physician burnout correlated with patient safety [35]. Almost all but one studies reported the positive sentiments of COVID-19 toward the increased time allotment for clinical research and online didactics, while one described to have reduced studying hours. Due to the busy schedule in neurosurgical residency, performing clinical or basic research including academic writing often requires special time allocation which was easily available during COVID-19 pandemic. However, due to social distancing policy, a remote-oriented research strategy should be prioritized such as focusing on secondary data analysis, for example, bioinformatics, literature review, or grant application [36].

Based on the available data, we suggest that the national neurosurgical board to take action to minimize the negative impact of COVID-19 toward the overall educational experience on their respective country. The program directors should initiate the introduction of flexible policy to accommodate case reduction to meet the board standard and guard residents' safety and well-being are required to ensure the sustainability of high quality neurosurgical education. There was a geographical discrepancy among studies on residents' perspectives versus studies on case volumes and medical students' perspectives. The former had a wide scope of participating countries from four continents which provide the impression of how COVID-19 pandemics impacted neurosurgical education globally. On the contrary, the latter studies were concentrated solely on the United States; therefore, this might not represent the condition on other countries, particularly in LMICs. Therefore, we highly recommend the national neurosurgical board to conduct studies observing the impact of COVID-19 from other world regions to improve our understanding regarding the current situation of global neurosurgical education.

Conclusion

The COVID-19 pandemic has impacted the global neurosurgical education from various perspectives. Although the main effect was largely negative, COVID-19-related social distancing policy also brought positive impact particularly to personal well-being and research activities. Flexible regulation and commitment to protect residents' health and wellbeing are required to maintain high-quality neurosurgical education to meet the community demand of neurosurgical services particularly in LMICs.

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