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 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 neurological education, (2) published in English, and (3) full-text articles were retrievable. We excluded studies discussing the neurological 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 clinical 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

https://oamjms.eu/index.php/mjms/index
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     | N/A              |
| 2      | Pelargos et al.   | 2020 | US, Canada                                                              | 197         | 1–7 | Cross-sectional-based survey               | Limited elective cases | 99.0     | Increased didactic hours | Encouraged to attend complementary online lectures | 58.6     | 79.0 |
| 3      | Khalafallah, et al.| 2020 | US                                                                      | 111         | 1–7 | Cross-sectional-based survey               | Reduced working hours | 74.8     | Increased time for didactic lectures | Increased time for clinical research | 82.0     | 66.7 |
| 4      | Chesserem, et al. | 2020 | Morocco, Algeria, Tunisia, Egypt, Libya, Niger, Mali, Senegal, Cote d’Ivoire, Ghana, Kenya, Nigeria, Cameroon, Sudan, Uganda, Mozambique, Malawi, Zimbabwe, Botswana, South Africa, Madagascar | 129         | Preresidency to fellow | Cross-sectional survey | Postponed examination | 19.5     | Significant differences among countries but not seniority | Significant differences among countries but not seniority | 88.0     | 87.5 |
| 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 | Missing international education opportunity | 96.0     |      |
| 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 | Increased time for research | 50.0     | 87.5 |
| 7      | Zoia, et al.      | 2020 | Italy                                                                   | 192         | 1–5 | Cross-sectional web-based survey           | Reduced time in neurosurgery department | 72.4     | Significant differences in senior residents | Increased time for publication | 55.7     | 62.5 |

COVID-19: Coronavirus disease 2019, 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 neurological 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 neurological education environment from various perspectives. Each reported country has its own neurological 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 2: Coronavirus disease-19-related residents' clinical workload and work condition**

| Number | Author | Year | Country | Sample size | Sample size | PGY | PGY | Methods | Increasing risk activity | Lowering risk activity | Rate (%) | Desc. | Rate (%) | Desc. |
|--------|--------|------|---------|-------------|-------------|-----|-----|---------|--------------------------|----------------------|----------|------|----------|------|
| 1      | Alhaj, et al. | 2020 | Canada, US, Kuwait, Saudi Arabia, Italy, Serbia | 52 | 1–6 | Cross-sectional -based questionnaire | 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 COVID-19 patients | 91.9 | N/A |
| 4      | Chesarern, 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 neurological COVID-19 patients |
|        |        |      |         |             |             |     |     |         | Either under supervision or not | 41.6 |
|        |        |      |         |             |             |     |     |         | Received training to manage COVID-19 patients | 41.0 |
| 5      | Wittayaanikorn, 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 | 0 | Program tested residents for COVID-19 |
|        |        |      |         |             |             |     |     |         | N/A |
| 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 |
|        |        |      |         |             |             |     |     |         | Either under supervision or not | 35.9 |

COVID-19: Coronavirus disease 2019. PPE: Personal protective equipment, 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 hindered the training milestones including cancelled [14], [15], [16], [17], [18]. Some centers also suggested COVID-19 screening to all patients undergoing 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

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

| Number | Author et al. | 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 |      | No effect on perception of neurosurgery as a career | 74.0 |       |
| 2      | Pelargos et al. | 2020 | US, Canada | 197 | 1–7 | Cross-sectional based survey | N/A |      | Career satisfaction on neurosurgery | 73.9 |       |
| 3      | Khalafallah et al. | 2020 | US | 111 | 1–7 | Cross-sectional based survey | Overall burnout rate | 26.1 | Associated with altered elective and vacation, decision not to pursue neurosurgery | 45.0 |       |
| 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 | Low emotional exhaustion | 51.4 |      | Low level of personal accomplishment | 78.4 |       |
|        |              |      |         |             |     |         | Low level of personalization | 67.6 |      | Career satisfaction on neurosurgery | 73.9 |       |
|        |              |      |         |             |     |         | Uncertainty of future healthcare reform | 79.3 |      | High level of personal accomplishment | 78.4 |       |
| 5      | Zoa et al. | 2020 | Italy | 192 | 1–5 | Cross-sectional web-based survey | Not receiving formal salary | 23.6 | Not receiving formal salary | 12.2 | Uncertainty of COVID-19 impact to finances | N/A |       |

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