Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
A Tale of Two Cities: Residents’ Operative Experience in the United Kingdom and Germany During the Coronavirus Disease 2019 Pandemic

Nithish Jayakumar¹, Sönke Hellwig², Callum Allison³, Walter Stummer², Markus Holling², Surash Surash¹

BACKGROUND: The coronavirus disease 2019 (COVID-19) pandemic has had a detrimental effect on residents’ operative training. Our aim was to identify the proportion of procedures performed by residents across 2 neurosurgical centers (1 in the United Kingdom and 1 in Germany) during the pandemic-affected months of March 2020–May 2020, inclusive, compared with March 2019–May 2019, inclusive.

METHODS: All neurosurgical procedures performed at the United Kingdom and German institutions, between March 1, 2019 and May 31, 2019 (pre-COVID months) and March 1, 2020 and May 31, 2020 (COVID months), were extracted and operative notes evaluated. Statistical analysis was performed on SPSS version 22.

RESULTS: There was a statistically significant reduction in operative volume in the United Kingdom center from the pre-COVID months to the COVID months ($\chi^2(5) = 84.917; P < 0.001$) but no significant difference in the operative volume in the German center ($P = 0.61$). A Mann-Whitney U test showed a statistically significant difference in the volume of residents operating in the COVID months compared with pre-COVID months in both United Kingdom and German centers ($P < 0.001$). The average number of procedures performed by residents in the United Kingdom center as the primary surgeon decreased from 82 to 72 per month (pre-COVID vs. COVID months), whereas German residents’ operating volume increased from 68 to 89 per month (pre-COVID vs. COVID months).

CONCLUSIONS: The COVID-19 pandemic has significantly reduced the volume of operating by neurosurgical residents in the United Kingdom center, whereas residents in the German center performed more procedures compared with 2019. This finding may reflect variations in national practice on maintaining surgical activities and provision of critical care beds during the first wave of the pandemic.

INTRODUCTION

The novel coronavirus disease 2019 (COVID-19) pandemic spread rapidly worldwide in 2020, with >150 million confirmed cases and 3 million deaths reported at the time of writing.¹ The United Kingdom and Germany have been severely affected, with around 4 million and 3 million cases, respectively,¹ since January 2020.

Health care services in both nations extensively reorganized to be able to accommodate this increased demand. In the United Kingdom, all elective operations were postponed² and a country-wide lockdown was enforced on March 23, 2020³ to limit community transmission. Within the United Kingdom neurosurgery community, the Society of British Neurosurgeons published guidelines on triaging cases so that life-threatening and sight-threatening conditions were prioritized for surgery⁴ during the pandemic. Similar guidance was being followed worldwide.⁵,⁶ The lockdown was eased on May 10, 2020⁷; however, a second wave of the pandemic emerged in September 2020⁸ and a second national lockdown was enforced from November 5, 2020 until December 2, 2020⁹. The emergence of a new, highly infectious variant in December 2020¹⁰ led to severe...
strain on health care resources\textsuperscript{25} and a third national lockdown was implemented on January 5, 2021.\textsuperscript{15}

In Germany, the government also postponed all elective operations to preserve capacity in intensive care units and maintain adequate staffing to care for the surge in COVID-19 cases. A nationwide lockdown was enforced on March 22, 2020.\textsuperscript{11} The German Society of Neurosurgery (Deutsche Gesellschaft für Neurochirurgie) also published guidelines\textsuperscript{14} similar to the Society of British Neurosurgeons on triaging operations during the pandemic. Because of the emergence of a second wave of infections in October 2020, new restrictions to public life were implemented on November 2, 2020,\textsuperscript{15} after the first national lockdown restrictions had been gradually eased from June 2020.\textsuperscript{30} Further limitations to socializing were required from December 1, 2020\textsuperscript{17} and, as evidence emerged of a highly transmissible variant in the United Kingdom, a second national lockdown was enforced from January 11, 2021.\textsuperscript{18}

These changing practice patterns have affected the training of neurosurgical residents worldwide. Evidence from the United States,\textsuperscript{9,23} Australia,\textsuperscript{24} and Indonesia\textsuperscript{24} has shown a drastic decrease in operating volume and a global survey of neurosurgeons suggested that the number of operations had reduced by up to half in some countries.\textsuperscript{35} Spinal surgery, in particular, has been greatly affected.\textsuperscript{20,26,27} Similar issues have been noted across Europe, in reports from Italy,\textsuperscript{28,29} France,\textsuperscript{37} and Germany.\textsuperscript{26} This reduction in institutional surgical volume has concerned neurosurgical trainees and training program directors about the effect that this will have on developing operative competencies.\textsuperscript{19,29,31} especially for senior residents.\textsuperscript{32} Apart from operative training, resident exposure to outpatient clinics and research activities has also been curtailed,\textsuperscript{33,34} with resultant anxieties about career prospects.\textsuperscript{32}

Although the literature clearly shows a decrease in operative volume during the COVID-19 pandemic, it is unclear whether the procedures that have been performed have had any resident involvement at all. Neither is it apparent which subspecialties have seen a decrease in procedures performed by residents. The training impact on European trainees has also not been fully established.

Our primary aim, therefore, was to identify the proportion of procedures that were performed by a resident as the lead surgeon across 2 high-volume European neurosurgical centers (1 in the United Kingdom and 1 in Germany) during the first wave of the pandemic; in the months of March 2020–May 2020, inclusive, compared with residents’ operating volume between March 2019 and May 2019, inclusive (as a baseline). The secondary aim was to identify any differences among the type of procedures that were affected during the pandemic.

\textbf{METHODS}

\textbf{Study Setting}

This was a retrospective observational study conducted at 2 major European neurosurgical centers.

The neurosurgical department in the United Kingdom center is based at a level 1 trauma center and serves a population of $>$3 million people. Thirteen consultant neurosurgeons provide the full spectrum of adult and pediatric neurosurgical services, with 71 inpatient beds. Ten residents, of varying experience, support the service. Four dedicated neurosurgical theaters are run on weekdays, including a dedicated emergency theater. The department is a high-volume center and one of the busiest in the United Kingdom for both cranial and spinal neurosurgery.\textsuperscript{35}

The German department is one of Germany’s 25 university hospitals, with a catchment population of 1.3 million. Fourteen consultants provide adult and pediatric neurosurgical services, supported by 11 residents of varying experience, with 35 inpatient beds. There are 3 dedicated neurosurgical theaters on weekdays.

\textbf{Neurosurgical Training in the United Kingdom}

The United Kingdom neurosurgical training program\textsuperscript{36,37} lasts for 8 years and is open to application after medical graduates complete 2 years of internship after graduation (foundation years). A minimum total of 1200 procedures, across all subspecialties, should be performed by residents by the end of training before they are certified to practice independently.\textsuperscript{38}

\textbf{Neurosurgical Training in Germany}

In Germany, neurosurgical training programs differ from region to region. In general, the neurosurgical training program lasts for 6 years. In the area of Westphalia, where the German center is located, trainees are expected to perform around 1000 procedures before certification. This total includes, for example, 100 spinal procedures, 50 supratentorial and infratentorial operations, and 50 traumatic brain injury–related operations.

\textbf{Data Collection and Analysis}

All neurosurgical procedures performed at the United Kingdom and German institutions, between March 1, 2019 and May 31, 2019 and March 1, 2020 and May 31, 2020, were extracted from their respective operating theater databases. Operative notes were evaluated to identify the lead surgeon and the surgery was coded as being performed by either a resident or a consultant. Patient demographics, procedure date, urgency of the procedure, and the procedure type were captured on an Excel (Microsoft, Redmond, Washington, USA) spreadsheet.

Included procedures were categorized using procedure codes from the theater databases. Procedures were categorized as follows: 1) cranial/spinal trauma including subdural collections; 2) oncology (cranial/spinal); 3) pituitary and related surgery; 4) degenerative spine; 5) neurovascular including stroke-related; 6) pediatric (other); 7) shunts/other cerebrospinal fluid (CSF)-related including endoscopic third ventriculostomy, external ventricular drain, and intracranial pressure monitoring; 8) functional/pain procedures; 9) adult hindbrain hernias/congenital anomaly repair; 10) craniofacial reconstruction including cranioplasty; 11) epilepsy-related surgery including deep brain stimulation/vagal nerve stimulation; 12) wound/other postoperative complication; and 13) washout and/or drainage of spontaneous infections or abscesses.

Statistical analysis was performed on SPSS version 22 (IBM Corp., Armonk, New York, USA). Differences between the number of procedures over time were evaluated by $\chi^2$ testing. A Mann-Whitney U test was used to compare mean resident operating volumes between 2019 and 2020.

Ethical approval was not sought because this study was performed under the auspices of service evaluation and clinical audit.
Patient consent was not sought because the data set was anonymized and consent is implied for the purposes of clinical audit.

RESULTS

Demographics
Patient demographics, overall operative volumes, and types of procedures performed in both centers during the study period are shown in Table 1.

Change in Operative Volume
Figure 1 shows the change in operative volumes between the 2 centers before and during the COVID pandemic.

There was a statistically significant reduction in operative volume in the United Kingdom center from the pre-COVID months to the COVID months ($\chi^2(5) = 84.917; P < 0.001$), with the total number of procedures decreasing by 39.8% between these two periods. There was a smaller reduction in the total operative volume in the German center from the pre-COVID months to the COVID months (8%), compared with the United Kingdom center. However, there was no significant difference in the operative volume across the study period ($\chi^2(5) = 3.588; P = 0.61$) in the German center.

Residents’ Operative Experience
There were statistically significant differences between the proportion of operations performed by residents as the primary surgeon between the pre-COVID months and COVID months in both the United Kingdom ($\chi^2(5) = 35.483; P < 0.001$) and the German ($\chi^2(5) = 33.865; P < 0.001$) centers.

In the United Kingdom center, residents performed, on average, less than a third of procedures (31.6%) as the primary surgeon in the pre-COVID months, whereas in the German center, residents were the primary surgeons in 41.4% of procedures in the pre-COVID months. During the COVID months, United Kingdom residents performed almost half of procedures as the primary surgeon (45.1%), whereas German residents performed 58.0% of operations as the primary operator. Although the proportion of operations performed by residents was higher in both the United Kingdom and German centers in the first wave of the pandemic, the total number of procedures performed was lower in the United Kingdom center during the COVID months.

A Mann-Whitney U test showed a statistically significant difference in the volume of residents operating in the COVID months compared with pre-COVID months in both United Kingdom ($Z = -4.043; P < 0.001$) and German ($Z = -5.346; P < 0.001$) centers.

The average number of procedures performed by residents in the United Kingdom center as the primary surgeon decreased from 82 per month (pre-COVID months) to 72 per month (COVID months). However, German residents’ operating volume as the primary surgeon increased from 68 per month (pre-COVID months) to 89 per month (COVID months).

Table 1. Patient Demographics, Operative Volumes, and Types of Procedures Performed in the United Kingdom and German Centers, Respectively

| Procedure types by center, n (%) | United Kingdom Center | German Center |
|---------------------------------|------------------------|--------------|
| Degenerative spine              | 372 (29.8)             | 126 (13.1)   |
| Shunts and other cerebrospinal fluid–related including endoscopic third ventriculostomy, external ventricular drain, and intracranial pressure monitoring | 246 (19.7)             | 133 (13.9)   |
| Oncology (cranial and spinal)   | 236 (18.8)             | 298 (31.0)   |
| Functional and pain             | 103 (8.2)              | 72 (7.5)     |
| Cranial or spinal trauma including subdural collections | 97 (7.8)              | 91 (9.5)     |
| Wound or other postoperative complication | 64 (5.1)              | 53 (5.5)     |
| Neurovascular including stroke-related | 39 (3.1)              | 11 (1.1)     |
| Adult hindbrain hernias and congenital anomaly repair | 22 (1.8)              | 15 (1.6)     |
| Washout and/or drainage of spontaneous infections or abscesses | 17 (1.4)              | 22 (2.3)     |
| Pituitary and related surgery   | 16 (1.3)               | 38 (4.0)     |
| Craniofacial reconstruction including cranioplasty | 15 (1.2)              | 15 (1.8)     |
| Epilepsy-related surgery including deep brain stimulation and vagal nerve stimulation | 12 (1.0)              | 25 (2.6)     |
| Pediatric (other)               | 11 (0.9)               | 61 (6.4)     |
Differences by Procedure Type

Overall, at least 75% of procedures performed at both centers belonged to 5 categories: 1) cranial or spinal trauma including subdural collections; 2) oncology (cranial and spinal); 3) degenerative spine; 4) shunts and other CSF-related procedures including endoscopic third ventriculostomy, external ventricular drain, and intracranial pressure monitoring; and 5) functional and pain. Degenerative spine procedures were the commonest procedure type performed in the United Kingdom center, whereas oncology procedures were the commonest type in the German center (Table 1).

Figure 2 shows the change in the overall operative volumes for the 5 commonest procedure types during the study period, from the pre-COVID months to the COVID months, in both centers. There was a statistically significant difference in the volumes of these 5 commonest procedures across the study period in the United Kingdom center ($\chi^2(20) = 75.859; P < 0.001$). The volumes of degenerative spine and functional/pain procedures decreased by 83.7% and 92.0%, respectively, between March 2019 and April 2020. In the German center, there was no significant difference in the volumes of these 5 procedure types during the study period ($\chi^2(20) = 29.907; P = 0.071$).

Resident Operating and Procedure Type

Figure 3 shows the residents’ operative volumes in both United Kingdom and German centers, stratified by the 5 commonest procedures performed in both units, in 2019 (pre-COVID months) and 2020 (COVID months). A Mann-Whitney U test showed a statistically significant difference in residents’ operative volumes when performing the 5 commonest procedures at the United Kingdom center, between 2019 and 2020 ($Z = -2.083; P = 0.037$). Of these 5 commonest procedure types in the United Kingdom center, a decrease in resident operating was noted between 2019 and 2020 for 3 procedure types: 1) functional and pain (64.3% decrease); 2) degenerative spine (27.1% decrease); and 3) shunts and CSF-related procedures (14.7% decrease).

However, in Germany, residents’ operative volumes when performing the 5 commonest procedure types were not significantly different between 2019 and 2020 (Mann-Whitney U; $Z = -0.316; P = 0.752$). German residents performed fewer degenerative spine procedures (14.7% decrease) and marginally fewer oncology procedures (3.95% decrease) in 2020 compared with 2019.

Consultants and Residents

Figure 4 shows the changes in the proportions of operations performed by residents and consultants, respectively, in each of the 5 commonest procedure types at both centers between 2019 and 2020.

Mann-Whitney U tests showed a significant difference in the proportion of operations performed by residents and consultants in both United Kingdom ($Z = -4.740; P < 0.001$) and German ($Z = -5.304; P < 0.001$) centers. In the United Kingdom center, of the 5 commonest procedures, residents performed a higher proportion of operations, comparing 2019 with 2020, in 4 of these categories (cranial/spinal trauma; oncology; degenerative spine; and CSF-related). The proportion of degenerative spine operations performed by residents nearly doubled from 2019 (17.7%) to 2020 (35.0%), whereas the proportion of cranial/spinal trauma, oncology, and CSF-related operations performed by residents increased from 2019 to 2020 by a similar percentage. In the German center, residents also performed a higher proportion of operations in 2020, compared with 2019, in 4 categories (oncology, degenerative spine, CSF-related, and functional/pain).

The proportion of oncology operations performed by residents more than doubled from 2019 (30.3%) to 2020 (63.0%), and a similar case was evident for functional/pain procedures, with residents performing 27.0% of these cases in 2020 compared with 11.4% in 2019.

**Figure 2.** The monthly operative volume of the 5 commonest procedure types from March 2019 to May 2020, at both the United Kingdom (A) and German (B) centers. CSF, cerebrospinal fluid; ETV, endoscopic third ventriculostomy; EVD, external ventricular drain; ICP, intracranial pressure.
DISCUSSION

We report a multicenter comparison of European residents’ operative experience during the COVID-19 pandemic to identify the impact on neurosurgical training as both countries grappled with the first wave of the pandemic.

Fewer Operations During the Pandemic

As expected, both centers reported a decrease in the overall volume of neurosurgical procedures performed during the COVID months compared with the pre-COVID months, with the United Kingdom center seeing a more drastic reduction in volume than the German center. This difference is likely to the result of the nationwide cancellation of all elective operating in the United Kingdom, as infections increased exponentially, to optimize resource use in the National Health Service. Lockdown measures in the United Kingdom strictly curtailed travel and social gatherings and road traffic volume decreased significantly; all these factors played a role in the decrease in trauma-related procedures during the COVID months. Fear of nosocomial transmission and appeals by the health service to the public to avoid accessing health care unless in an emergency also kept patients away from hospitals, which may have delayed their presentation to neurosurgical services and, consequently, may have led to a decrease in the overall operative volume during the pandemic. Prioritization of procedures, according to national guidance, to operate only on those with life-threatening, limb-threatening, or vision-threatening illnesses also restricted the number of operations performed in the United Kingdom.

However, in Germany, the German Society of Neurosurgery (Deutsche Gesellschaft für Neurochirurgie) declared all intracranial and spinal tumors as nonelective and encouraged centers to continue performing these procedures during the pandemic. Although road traffic accidents decreased in Germany during the pandemic (similar to the United Kingdom), the German center is a supraregional trauma center, and one of Germany’s biggest hospitals, so trauma and emergency services continued to be triaged to this center even as surrounding hospitals reduced their capacity. A decrease in spinal operations was also seen in the German center albeit not as dramatic as in the United Kingdom center, which likely reflects the decreased focus on spinal surgery, in general, at the German center. The overall increase in functional procedures is biased by the rebound in these operations in May 2020, as elective services resumed in the German center after April 2020. Another factor for the largely constant number of procedures may be the COVID-associated reduction in the performance of the surrounding departments.

Residents’ Operative Volumes—Increased or Decreased?

The total number of procedures performed by United Kingdom residents decreased during the COVID months unlike in the German center. As the departmental operative volume decreased, it was natural to expect a decrease in the residents’ operative volumes as well. Furthermore, because only life-threatening, limb-threatening, or vision-threatening elective cases were treated, the severity of the disease being treated placed the onus of responsibility on consultants to perform the procedure instead of supervising a resident. Concerns about time taken for the operation, if performed by a junior resident, may have also played a role. On the other hand, the lower departmental workload offered ample time for residents to be trained in theater, even with fewer cases being performed during the COVID months. United Kingdom residents performed significantly fewer wound-related and spinal procedures during the COVID months. The decrease in operative volume in 2020 explains the lower rates of wound-related complications that needed a return to theater, whereas the volume of spinal procedures was greatly reduced during the study period. In particular, the paucity of spinal procedures performed by residents could negatively affect training progression, including success in obtaining consultant posts, especially...
considering that new consultant posts in the United Kingdom have predominantly been focused on spinal surgery as a subspecialty. Across the United Kingdom, the number of trainees who have finished training and are awaiting a consultant post, despite the United Kingdom having the lowest consultants per population ratio in Europe, is estimated to be >50, which is in addition to the number of nontrainee residents who are vying for the same posts. Although this study did not differentiate between trainee and nontrainee residents, the decrease in trainee operating during the pandemic could also be influenced by an increase in nontrainee operating numbers.

German residents performed more operations during the COVID months compared with 2019. This finding may be the result of an increase in the number of more experienced trainees in 2020 at the German center compared with 2019. The relatively smaller decrease in operative volume at the German center during the pandemic may also reflect a variation in governmental guidance on continuing surgical activities and provision of critical care beds compared with the United Kingdom. Although German residents performed fewer spinal and oncology procedures in 2020, this was not statistically significant and further emphasizes the ability of the German center to maintain operative volumes despite the restrictions imposed by the pandemic. The problems seen in the United Kingdom with senior trainees awaiting a consultant post are not applicable in Germany.

Nevertheless, the proportion of operations performed by residents in both centers was higher during the COVID months. This finding reflects a large decrease in the operations performed by consultants, in areas such as functional/pain, pituitary, or pediatric procedures. In both centers, the commonest types of procedures performed by residents remained the same during the COVID months compared with the pre-COVID months. United Kingdom and German residents performed significantly higher proportions of degenerative spine and oncology procedures, respectively, in 2020, which may indicate a relatively lower complexity of procedures that were being performed.
Implications for Training

Similar results have been evident in other surgical specialties. Operative volume and residents’ operative volume were reported to be lower in oral and maxillofacial surgery, orthopedic surgery, otolaryngology, cardiothoracic surgery, urology, ophthalmology, vascular surgery, plastic surgery, and general surgery. Outside surgery, resident training was also hampered by the pandemic and provision of critical care beds. The impact on training, especially in the United Kingdom center, is likely to be long-lasting because residents may struggle to achieve the necessary operative volumes required for certification and additional training time may be required.

This report remains the first of its kind to examine the effects of the first wave of the COVID-19 pandemic on training in a niche surgical subspecialty across 2 major European centers. We believe that our findings are a surrogate for reflecting on the way national health care policy, in a European setting, has affected the provision of non-COVID health care services, and its impact on future neurosurgeons.

CONCLUSIONS

The COVID-19 pandemic has significantly reduced the volume of operating by neurosurgical residents in the United Kingdom center, whereas residents in the German center performed more procedures compared with 2019, which may be related to variation in governmental guidance on maintaining surgical activities during the pandemic and provision of critical care beds. The impact on training, especially in the United Kingdom center, is likely to be long-lasting because residents may struggle to achieve the necessary operative volumes required for certification and additional training time may be required.

REFERENCES

1. World Health Organization, WHO Coronavirus Disease (COVID-19) Dashboard. Available at: https://covid19.who.int?gclid=EAIaIQobChMfre7 y3s2PMQIVBDucC32THgQAYAAADNEGLX3_D_BWE. Accessed May 25, 2020.
2. BBC News. £50bn to help UK firms, while operations delayed. Published March 17, 2020. Available at: https://www.bbc.com/news/uk/54933400. Accessed May 25, 2020.
3. Stewart H, Mason R, Dodd V. Boris Johnson orders UK lockdown to be enforced by police. The Guardian. Published March 23, 2020. Available at: https://www.theguardian.com/world/2020/mar/23/boris-johnson-orders-uk-lockdown-to-be-enforced-by-police. Accessed May 25, 2020.
4. Society of British Neurosurgeons. SBNS: COVID-19 Guidelines. Available at: https://www.sbson.org.uk/index.php/policies-and-publications/covid/. Accessed May 25, 2020.
5. Germanó A, Raffa G, Angileri FF, Cardali SM, Tommasello F. Coronavirus disease 2019 (COVID-19) and neurosurgery: literature and neurosurgical societies recommendations update. World Neurosurg. 2020;139:e812-e817.
6. Ozoner B, Gungor A, Hasanov T, Toktas ZO, Kılıc T. Neurosurgical practice during coronavirus disease 2019 (COVID-19) pandemic. World Neurosurg. 2020;140:198-207.
7. Walker P. Coronavirus lockdown: what are the new rules announced by Boris Johnson? The Guardian. Published May 11, 2020. Available at: http://www.theguardian.com/world/2020/may/11/uk-coronavirus-lockdown-what-has-boris-johnson-announced. Accessed May 1, 2021.
8. Coronavirus: “We must act” to prevent second lockdown, says PM. BBC News. Published September 9, 2020. Available at: https://www.bbc.com/news/uk-54933465. Accessed May 1, 2021.
9. Covid-19: PM announces four-week England lockdown—BBC News. Available at: https://www.bbc.co.uk/news/uk-54795265. Accessed May 1, 2021.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Nithish Jayakumar: Methodology, Investigation, Formal analysis, Writing — original draft, Visualization. Sönke Hellwig: Methodology, Investigation, Formal analysis, Validation, Writing — review & editing. Callum Allison: Methodology, Investigation, Formal analysis, Validation, Writing — review & editing. Walter Stummer: Conceptualization, Methodology, Writing — review & editing, Supervision. Markus Holling: Conceptualization, Methodology, Writing — review & editing, Supervision. Surash Surash: Conceptualization, Methodology, Writing — review & editing, Supervision.
10. Wise J. Covid-19: new coronavirus variant is identified in UK. BMJ. 2020;371:m4057.
11. Pressure on hospitals “at a really dangerous point”. BBC News. Available at: https://www.bbc.com/news/health-53666801. Accessed May 1, 2021.
12. Covid: new lockdowns for England and Scotland ahead of “hardest weeks.” BBC News. Available at: https://www.bbc.com/news/uk-55358337. Accessed May 1, 2021. Published January 5, 2021.
13. The Local. German bans gatherings of more than two to control coronavirus spread. Published March 22, 2020. Available at: https://www.thelocal.de/20200322/germany-bans-gatherings-of-more-than-two-to-control-coronavirus-spread. Accessed November 14, 2020.
14. Tronnier V, Conzen M. Non-elective surgical interventions. Published March 30, 2020. Available at: https://www.dgnc.de/fileadmin/media/dgnc_homepage/publikationen/downloads/DGNC_NON-ELECTIVE_SURGICAL_INTERVENTIONS.pdf. Accessed January 18, 2021.
15. Coronaschutzverordnung. Verordnung zum Schutz vor Neuinfektionen mit dem Coronavirus SARS-CoV-2 vom 10/06/2020. Available at: https://www.lanwg.de/sites/default/files/asset/document/2020-10-30_coronaschutzverordnung_vom_30_oktober_2020.pdf. Accessed May 13, 2021.
16. Coronaschutzverordnung. Verordnung zum Schutz vor Neuinfektionen mit dem Coronavirus SARS-CoV-2 vom 30/11/2020. Available at: https://www.lanw.g.de/sites/default/files/asset/document/2020-11-30_coronaschutzverordnung_vom_30_november_2020.pdf. Accessed May 13, 2021.
17. Coronaschutzverordnung. Verordnung zum Schutz vor Neuinfektionen mit dem Coronavirus SARS-CoV-2 vom 07/01/2021. Available at: https://www.lanw.g.de/sites/default/files/asset/document/2021-01-07_coronaschutzverordnung_vom_07_januar_2021.pdf. Accessed May 13, 2021.
18. Coronaschutzverordnung. Verordnung zum Schutz vor Neuinfektionen mit dem Coronavirus SARS-CoV-2 vom 07/01/2021. Available at: https://www.lanw.g.de/sites/default/files/asset/document/2021-01-07_coronaschutzverordnung_vom_07_januar_2021.pdf. Accessed May 13, 2021.
19. Field NC, Plattanitis K, Paul AR, Dalifino J, Adamo MA, Boulos AS. Letter to the Editor: Decrease in neurosurgical program volume during COVID-19: residency programs must adapt. World Neurosurg. 2020;134:556-557.
20. Patel PD, Kelly KA, Reynolds RA, et al. Tracking the volume of neurosurgical care during the COVID-19 pandemic. World Neurosurg. 2020;134:1183-1194.
21. Eichberg DG, Shah AH, Luther EM, et al. Letter: Academic neurosurgery department response to COVID-19 pandemic: the University of Miami/Jackson Memorial Hospital Model. Neurosurg. 2020;87:E65-E65.
22. Kilgore MD, Scullin T, Mathlouthi M, et al. Effects of the COVID-19 Pandemic on operative volume and residency training at two academic neurosurgery centers in New Orleans. World Neurosurg. 2021;142:e68-e77.
23. Antony J, James WT, Nierrampambillial AI, Barot DD, Withers T. An Australian response to the COVID-19 pandemic and its implications on the practice of neurosurgery. World Neurosurg. 2020;139:e864-e871.
24. Manussubroto W, Wicaksono AS, Tamba DA, et al. Neurosurgery services in Dr. Sardjito General Hospital, Yogyakarta, Indonesia, during the COVID-19 pandemic: experience from a developing country. World Neurosurg. 2020;140:e560-e566.
25. Jean WC, Ironside NT, Sack KD, Felbaum DR, Syed HR. The impact of COVID-19 on neurosurgeons and the strategy for triaging non-emergent operations: a global neurosurgery study. Acta Neurochir (Wien). 2021;162:e1223-e1240.
26. Mehta AI, Chiu RG. COVID-19 Non-essential surgery restrictions and spine surgery: a German experience. Spine. 2020;45:942-945.
27. Meyer M, Prost S, Farah K, et al. Spine surgical procedures during coronavirus disease 2019 pandemic: is it still possible to take care of patients? Results of an observational study in the first month of confinement. Aesciun J Spine. 2020;14:356-350.
28. Bernucci C, Brembilla C, Veicsechi P. Effects of the COVID-19 outbreak in Northern Italy: perspectives from the Bergamo Neurosurgery Department. World Neurosurg. 2020;137:e495-e506, e1.
29. Zaia C, Raffa G, Somma T, et al. COVID-19 and neurosurgical training and education: an Italian perspective. Acta Neurochir (Wien). 2020;162:1786-1794.
30. Pennington Z, Lubelski D, Khalafallah AM, et al. Letter to the Editor “Changes to neurosurgical resident education since onset of the COVID-19 pandemic.” World Neurosurg. 2020;139:e734-e740.
31. Bray DP, Strick GP, Malcolm J, et al. Letter: Maintaining neurosurgical resident education and safety during the COVID-19 pandemic. Neurosurg. 2020;87:E189-E191.
32. Pelargos PE, Chakraborty A, Zhao YD, Smith ZA, Dunn SF, Bauer AM. An evaluation of neurosurgical resident education and sentiment during the COVID-19 pandemic. World Neurosurg. 2020;139:e381-e386.
33. Kessler RA, Oermann EK, Dangayach NS, Bederson J, Mocco J, Shrivastava RK. Letter to the Editor: Changes to neurosurgical resident education since onset of the COVID-19 pandemic. World Neurosurg. 2020;139:e734-e740.
34. Clark VE. Editorial. Impact of COVID-19 on neurosurgery resident research training. J Neurosurg. 2020;2:e1-2. https://doi.org/10.3171/2020.4.JNS201034, Accessed July 30, 2021.
35. Society of British Neurological Surgeons. Neurosurgical National Audit Programme. Available at: www.sbnns.org.uk/hospital/...
COVID-19 pandemic. Laryngoscope. 2020;130:2330-2337.

90. Crosby DL, Sharma A. Insights on otolaryngology residency training during the COVID-19 pandemic. Otolaryngol Head Neck Surg. 2020;163:38-41.

91. Caruana EJ, Patel A, Kendall S, Rathinam S. Impact of coronavirus 2019 (COVID-19) on training and well-being in subspecialty surgery: a national survey of cardiothoracic trainees in the United Kingdom. J Thorac Cardiovasc Surg. 2020;160:980-987.

92. Shaﬁ AMA, Atieh AE, Harky A, Sheikh AM, Awad WI. Impact of COVID-19 on cardiac surgical training: our experience in the United Kingdom. J Cardiothorac Vasc Anesth. 2020;34:1954-1957.

93. Fero KE, Weinberger JM, Lerman S, Bergman J. Perceived impact of urologic surgery training program modifications due to COVID-19 in the United States. Urology. 2020;143:62-67.

94. Khussid JA, Weinstein CS, Becerra AZ, et al. Well-being and education of urology residents during the COVID-19 pandemic: results of an American National Survey. J Urol. 2020;194:1355-1359.

95. Teoh JY-C, Ong WLK, Gonzalez-Padilla D, et al. A global survey on the impact of COVID-19 on urological services. Eur Urol. 2020;78:705-713.

96. Mishra D, Nair AG, Gandhi RA, et al. The impact of COVID-19 related lockdown on ophthalmology training programs in India—outcomes of a survey. Indian J Ophthalmol. 2020;68:1004-1009.

97. Ferrara M, Romano V, Steel DH, et al. Reshaping ophthalmology training after COVID-19 pandemic. Eye (Lond). 2020;34:2089-2097.

98. Hemingway JF, Singh N, Starnes BW. Emerging practice patterns in vascular surgery during the COVID-19 pandemic. J Vasc Surg. 2020;72:436-437.

99. Zingaretti N, Contessi Negrini F, Tel A, Trezoldi MM, Bressada V, Parodi PC. The impact of COVID-19 on plastic surgery residency training. Aesthetic Plast Surg. 2020;44:1381-1385.

100. Dharini, Kumar S, More A, Harikar M. The impact of COVID-19 and lockdown on plastic surgery training and practice in India. Indian J Plast Surg. 2020;53:273-279.

101. Aziz H, James T, Remulla D, et al. Effect of COVID-19 on surgical training across the United States: a national survey of general surgery residents. J Surg Educ. 2021;78:431-439.

102. Coleman JR, Abdel fattah JM, Glocker RJ. RAS-ACS COVID-19 Task Force. COVID-19 pandemic and the lived experience of surgical residents, fellows, and early-career surgeons in the American College of Surgeons. J Am Coll Surg. 2021;232:119-133.e20.

103. Veerasuri S, Vekeria M, Davies SE, Graham R, Rodrigues KCL. Impact of COVID-19 on UK radiology training: a questionnaire study. Clin Radiol. 2020;75:876.e1-876.e14.

104. Odedra D, Chahal BS, Patlas MN. Impact of COVID-19 on Canadian radiology residency training programs. Can Assoc Radiol J. 2020;71:482-489.

105. Pawlak KM, Kral J, Khan R, et al. Impact of COVID-19 on endoscopy trainees: an international survey. Gastrointest Endosc. 2020;92:925-935.

106. Sneyd JR, Mathoulin SE, O’Sullivan EP, et al. Impact of the COVID-19 pandemic on anaesthesia trainees and their training. Br J Anaesth. 2020;125:459-465.

107. Civantos AM, Byrnes Y, Chang C, et al. Mental health among otolaryngology resident and attending physicians during the COVID-19 pandemic: national study. Head Neck. 2020;42:1597-1609.

108. Khan KS, Key R, McLellan M, Mahmud S. Impact of the COVID-19 pandemic on core surgical training. Scott Med J. 2020;65:133-137.

109. Dedelis A, Sotiropoulos MG, Hamran JG, Junga D, Dedelis P, Sideris M. Medical and surgical education challenges and innovations in the COVID-19 era: a systematic review. Virol J. 2020;17:349. https://doi.org/10.1186/s12985-020-1367-x.

110. Chen CH, Mullen AI. COVID-19 can catalyze the modernization of medical education. JMIR Med Educ. 2020;6:e15755.

111. Chick RC, Clifton GT, Peace KM, et al. Using technology to maintain the education of residents during the COVID-19 pandemic. J Surg Educ. 2020;77:779-782.

112. Coe TM, Jogerst KM, Sell NM, et al. Practical techniques to adapt surgical resident education to the COVID-19 era. Ann Surg. 2020;272:1239-1241.

113. García Vaquero A, Verde JM, Dal Mas F, et al. Image-guided surgical e-learning in the post-COVID-19 pandemic era: what is next? J Laparoendosc Adv Surg Tech A. 2020;30:993-997.

114. Hall AK, Nousiainen MT, Campisi P, et al. Training disrupted: practical tips for supporting competency-based medical education during the COVID-19 pandemic. Med Teach. 2020;42:756-761.

115. McKechnie T, Levin M, Zhou K, Freedman B, Palmer V, Gnancharow TP. Virtual surgical training during COVID-19: operating room simulation platforms accessible from home. Ann Surg. 2020;272:815-814.

Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 22 May 2021; accepted 12 July 2021

Citation: World Neurosurg. (2021) 154:e428-e436.

https://doi.org/10.1016/j.wneu.2021.07.053

Journal homepage: www.journals.elsevier.com/world-neurosurgery

Available online: www.sciencedirect.com

© 2021 Elsevier Inc. All rights reserved.