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## The Impact of the Coronavirus Pandemic on European Neurosurgery Trainees

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■ **BACKGROUND:** The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic has placed tremendous strain on the national health care systems throughout Europe. As a result, there has been a significant influence on residents' education. We surveyed European neurosurgery residents to estimate the magnitude of the pandemic's impact on neurosurgical training.

■ **METHODS:** An anonymous, voluntary, 44-question, web-based survey was administered to European neurosurgical residents from November 2, 2020, to January 15, 2021, by e-mail invitation. Close-ended, multiple-choice questions were used to examine the perspectives of neurosurgical trainees of different training programs in Europe regarding the pandemic's impact on education, as well as to evaluate the online webinars as a sufficient alternative educational tool, and their future role.

■ **RESULTS:** The total number of participants was 134 from 22 European countries. Nearly 88.8 % of respondents reported that the pandemic had a negative influence on their education. A statically significant decrease in surgical exposure, outpatient clinic involvement, and working hours was observed ( $P < 0.05$ ). Webinars, although widely disseminated, were not considered as a sufficient training alternative.

■ **CONCLUSIONS:** The SARS-CoV-2 pandemic had a significant impact on neurosurgical training. During the last year, with the outbreak of the pandemic, formal training

education was heavily compromised. Online webinars do not seem to be a sufficient alternative, and some trainees estimate that a whole year of training has been compromised. Our current data have to be cautiously considered for possibly reorganizing the whole training experience. The pandemic may well function as a stimulus for optimizing neurosurgical training.

### INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has had a significant impact on everybody's life, with repeat lockdowns and many social and professional restrictions. Social distancing, a new term in our daily vocabulary, dramatically changed our lives. Combined with the increased number of deaths, the pandemic has resulted in exceptional physiological stress levels, especially in health care workers, who constitute the first defense line in these daily battles.

No one could have foreseen the severity and the long-lasting impact of coronavirus disease 2019 (COVID-19). The rapid spread of the virus placed a significant strain on health care systems globally, and governments have diverted the majority of health care resources toward the fight against the pandemic in a heroic effort to contain it. For many, this meant redeployment of physicians of any specialty to COVID-19 departments, restriction of elective surgeries, along with severe restrictions on face-to-face outpatient clinical activity.<sup>1</sup> Neurosurgery did not stay unaffected, as neurosurgery departments throughout the world made

#### Key words

- COVID-19
- Education
- Neurosurgery
- Online education
- Survey
- Training
- Webinars

#### Abbreviations and Acronyms

**COVID-19:** Coronavirus disease 2019

**EANS:** European Association of Neurosurgical Societies

**PGY:** Postgraduate year

**PPE:** Personal protective equipment

**SARS-CoV-2:** Severe acute respiratory syndrome coronavirus 2

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significant changes relevant to the number of the performed elective cases, inpatient and outpatient service management, and their faculty and trainees' schedules.<sup>2-7</sup>

The pandemic has affected training in several medical specialties, including neurosurgery, at national or continental levels.<sup>8-14</sup> Two ingredients essential for the standard procedure of clinical education are surgical exposure and patient management. During the pandemic, the time dedicated to both these cornerstone training activities was decreased. Many reports and studies have reported on this problem.<sup>3,7,15-17</sup> However, the majority of them consist of expert opinion, and only a small percentage derive from data directly originating from residents.<sup>8,10-14</sup>

The primary aim of this European survey was to examine the perspectives of neurosurgical trainees from different training programs throughout Europe in respect to the pandemic's impact on their education and also to evaluate the potential role of online webinars as a sufficient alternative educational and training tool, thereby probing their potential future role.

## METHODS

An anonymous, voluntary, 44-question, web-based survey was administered to European neurosurgical residents from November 2, 2020, to January 15, 2021, via the Google Forms platform. The reporting of the current survey was conducted as described by Kelley et al.<sup>18</sup>

A list of neurosurgical residents in different countries in Europe was obtained by the list of the European Association of Neurosurgical Societies (EANS) training course participants. It has to be clarified that EANS includes neurosurgical societies of countries that are located outside continental Europe. In addition to the initial launch of the survey, 2 reminders were distributed. Residents were invited to complete the survey through a web link. The responders were not incentivized in any way. The questions focused on resident education during the first outbreak of the pandemic compared to the period before it. All questions were close-ended, multiple-choice (**Supplementary Figure 1**), with the exception of the questions requiring the residents' comments, as well as the information regarding the participants' departmental size and the country of practice. Questions were categorized in the following groups: Demographics, General Questions, Anxiety about COVID-19, Before the COVID-19 Pandemic, During the outbreak of COVID-19 Pandemic, After the Pandemic - During the Recovery Phase, Online Theoretical Educational Activity, and Potential Consequences of COVID-19 Pandemic.

The categorical survey questions were summarized using counts and proportions. Variables, such as the training year, were grouped into categories for analysis. Junior residents were defined as those in postgraduate years (PGYs) 1-4, whereas senior residents as those in PGYs 5-7. Fellows were excluded from our current survey. Incomplete survey responses were excluded from our current study.  $\chi^2$  and Fisher exact tests were used to compare the results of specific questions between the junior and senior residents. We used paired ordinal tests with cumulative link models to compare the time spent at the hospital, in the outpatient clinic, in the operating room, and at participating in teaching programs before and during the COVID-19 era. The

analysis was performed using the R statistical environment and the IBM SPSS.<sup>19,20</sup> For all the performed tests, the statistical significance was set at  $P < 0.05$ .

## RESULTS

On January 19, 2021, the survey was closed after 134 responses were received from a total of 810 email invitations, with a response rate of 16.54 %. Residents of all PGYs were represented, although the majority of them were senior. Residents were reassigned to 2 categories: Senior and Junior. Responses were collected from 21 European countries, as well as Israel (**Table 1**). Responses to optional questions regarding departmental size (number of residents, faculty, and operations) were excluded from our current analysis for privacy protection reasons (**Supplementary Figure 2**). Questions were divided into several categories, as mentioned in the Methods section, and the received responses are accordingly presented with a slight modification of the categories for homogeneous analyses purposes.

### General

The majority of responders (88.8 %) answered that the pandemic exerted a negative influence on their education. A reduction in hands-on surgical exposure was reported by 124 residents (92.5 %), of whom 85 (63.4 %) reported that their surgical activity was reduced by more than 30 % in comparison with pre-pandemic levels. Furthermore, 71.6 % of the participants reported a reduction in their theoretical education, whereas 87.3 % reported a decrease in their outpatient clinic exposure. Moreover, 40 participants (29.9 %) were redeployed to a different department of their hospital (mostly to the emergency department, intensive care unit, and COVID-19 units) during the pandemic; 27 of them (20.1 %) for a period of more than 2 weeks. Interestingly, 88 respondents (65.7 %) thought that they had had more time available for self-directed study during the pandemic outbreak, whereas 60 participants (44.8 %) considered they had the opportunity for more research time during the crisis (**Table 2**).

### Anxiety

A total of 105 residents (78.4 %) stated that the fear of acquiring infection did not alter their clinical practice and the way they approached their patients; however, 76 (56.7 %) admitted that they seriously worried about getting infected. Although only 21 trainees (15.7 %) worried about dying from COVID-19, most of them (79.9 %) were concerned about transmitting the infection to their families. Participants also were asked whether there had been appropriate personal protection equipment (PPE) in their working environment. One-half (50 %) answered that PPE was administered most of the time, and 43 (32.1 %) stated that there was sufficient PPE coverage all the time (**Supplementary Figure 3**).

### Comparison of the Period before and During the Pandemic Outbreak

To compare the 2 periods, before and during the pandemic peak, a set of 4 paired questions were posed (**Table 3**). First, the working hours were examined. Before the pandemic, more than one-half of the residents (53.7 %) spent approximately 60-80 working hours

**Table 1.** Data Regarding Residents' Postgraduate Year and Country of Clinical Practice

Number of Responders (Percentage)	
Year of Residency	
1st	11 (8.2)
2nd	10 (7.5)
3rd	18 (13.4)
4th	24 (17.9)
5th	19 (14.2)
6th	31 (23.1)
7th (fellows were excluded)	21 (15.7)
Residency level	
Junior	63 (47.0)
Senior	71 (53.0)
Countries	
Austria	5 (3.7)
Belgium	8 (6.0)
Croatia	10 (7.5)
Cyprus	2 (1.5)
Czech Republic	1 (0.7)
Estonia	2 (1.5)
Finland	1 (0.7)
France	2 (1.5)
Germany	20 (14.9)
Greece	27 (20.1)
Israel	1 (0.7)
Italy	1 (0.7)
Netherlands	3 (2.2)
Poland	4 (3.0)
Portugal	4 (3.0)
Romania	4 (3.0)
Russian Federation	2 (1.5)
Serbia	5 (3.7)
Spain	3 (2.2)
Sweden	7 (5.2)
Switzerland	17 (12.7)
United Kingdom	5 (3.7)

per week. Conversely, after the outbreak, there was a significant decrease ( $P < 0.05$ ) in their working hours (Figure 1A).

Second, approximately one-third of the participants (45 residents, 33.6 %) answered that they were spending >15 hours in the operating room, and another 44 participants (32.8 %) between 10 and 15 hours before the outbreak, whereas only 52 residents spend

more than 10 hours in the operating room during the crisis. Interestingly, 6 residents remained out of the operating room. A statistically significant decrease of the operative time was observed ( $P < 0.05$ ) in our collected data (Figure 1B).

Third, most of the participants (61.9 %) spent >5 hours in the outpatient clinic on a weekly basis before the outbreak, whereas only 39.6 % of the responders spent the same amount of time in the outpatient clinic following the outbreak ( $P < 0.05$ ) (Figure 1C). Finally, there was no difference before and during the pandemic outbreak in the time spent in theoretical educational activities (Figure 1D).

#### After the First Wave of the Pandemic

The residents were asked questions about the period right after the first wave of the pandemic, when health care systems were in the process of coping with the new reality. Most of the residents (61.9 %) reported that their departments had not resumed full activity, with approximately one-half of them (45.8 %) reporting an activity level lower than 50 %. Only 45 residents (33.6 %) reported that their department's operating room activity had returned to normal, whereas 35.8 % of the respondents saw their personal operating room exposure to be normalized. Interestingly, after stratifying our data based on residency level, we found a statistically significant difference in previous responses between the 2 groups ( $P < 0.05$ ). More than 75 % of the junior residents, answered that their operating room and ward activity as well as their surgical exposure did not return to normal levels. Finally, 72 trainees (53.7 %) reported that their postpandemic outpatient clinic exposure never returned to normal levels (Supplementary Figure 3).

#### Online Theoretical Educational Activity

The vast majority of the responders (92.5 %) reported participation in online educational activity, mostly in the emerging form of webinars. Seventy-six residents (56.7 %) believed that web-based educational activities had a positive impact in their training, and 59 responders (44.0 %) thought these could be incorporated on a weekly basis in their future training. Slightly over half of the participants (56.7 %) indicated that 2–4 hours per week is a reasonable period for online education. However, the vast majority of the participants (88.1 %) believed that webinars should not replace face-to-face educational activity. Finally, as far as the type of webinars that the participants experienced, these mainly comprised lectures (86.3 %), with a balanced geographical distribution of webinars (local, national, European, intercontinental) (Supplementary Figure 3).

#### Future Consequences

This survey provided an insight into changes that occurred from the period just before the outbreak of the pandemic and during the pandemic allowing an extrapolation of future consequences of the pandemic. First, the participating residents were asked if they worried about fulfilling graduation requirements, with 56.7 % of them affirmatively responding to this question. Second, 65 respondents (48.5 %) answered that they would consider having an extra year of training to properly complete their residency. This response demonstrated no association with the level of training; even after stratifying the data per year of residency (senior vs.

**Table 2.** Summary of the Participants' Responses in the General Category of Our Survey

Questions	Resident Level			P Value
	Junior	Senior	All	
Q1: Do you believe that COVID-19 pandemic is exerting a negative influence on your education?				0.094
No	4 (6.3%)	11 (15.5%)	15 (11.2%)	
Yes	59 (93.7%)	60 (84.5%)	119 (88.8%)	
Q2: Has there been a reduction in hands-on surgical exposure?				0.043
No	2 (3.2%)	8 (11.3%)	10 (7.5%)	
Yes, less than 30%	14 (22.2%)	25 (35.2%)	39 (29.1%)	
Yes, 30%–50%	32 (50.8%)	22 (31.0%)	54 (40.3%)	
Yes more than 50%	15 (23.8%)	16 (22.5%)	31 (23.1%)	
Q3: Has there been a reduction in theory-based training/education during the pandemic?				0.469
No	15 (23.8%)	23 (32.4%)	38 (28.4%)	
Yes, less than 30%	14 (22.2%)	15 (21.1%)	29 (21.6%)	
Yes, 30%–50%	17 (27.0%)	12 (16.9%)	29 (21.6%)	
Yes, more than 50%	17 (27.0%)	21 (29.6%)	38 (28.4%)	
Q4: Has there been a reduction in outpatient clinic exposure?				0.661
No	7 (11.1%)	10 (14.1%)	17 (12.7%)	
Yes, less than 30%	25 (39.7%)	27 (38.0%)	52 (38.8%)	
Yes, 30%–50%	19 (30.2%)	16 (22.5%)	35 (26.1%)	
Yes, more than 50%	12 (19.0%)	18 (25.4%)	30 (22.4%)	
Q5: Were you redeployed to a different department during the pandemic?				0.184
No	40 (63.5%)	54 (76.1%)	94 (70.1%)	
Yes, less than 2 weeks	8 (12.7%)	5 (7.0%)	13 (9.7%)	
Yes, 2–6 weeks	8 (12.7%)	3 (4.2%)	11 (8.2%)	
Yes, more than 6 weeks	7 (11.1%)	9 (12.7%)	16 (11.9%)	
Q6: Did you benefit from more time for research work during the crisis?				0.331
No	32 (50.8%)	42 (59.2%)	74 (55.2%)	
Yes	31 (49.2%)	29 (40.8%)	60 (44.8%)	
Q7: Did you have more time for self-study?				0.111
No	26 (41.3%)	20 (28.2%)	46 (34.3%)	
Yes	37 (58.7%)	51 (71.8%)	88 (65.7%)	

COVID-19, coronavirus disease 2019.

junior), the results showed no statistically significant differences ( $P > 0.05$ ). Interestingly, 26 of the 71 senior participating residents (36.6%) reported that their final residency examinations had been cancelled or postponed (**Supplementary Figure 3**).

## DISCUSSION

Several survey-based studies have been published examining the impact of the pandemic in neurosurgical training.<sup>8,10–14</sup> All of

them including our current study carry weaknesses, biases, and limitations in various degrees. The unique characteristics of our report are the evaluation of the pandemic's impact from the resident's perspective and the coverage of a large geographic area. In addition, our survey attempted to examine the role of alternative educational activities, such as webinars, in neurosurgical training. Our survey shows that residents across Europe had decreased training opportunities during the pandemic. Most of all, surgical exposure was affected because of the shutdown/decrease of

**Table 3.** Comparative Data of the Period before and During the Outbreak of the Pandemic

Questions	Resident Level		P Value
	Junior	Senior	
Before the Pandemic Outbreak			
Q1: How many hours did you spend working on average per week?			0.389*
Less than 40 hours	2 (3.2%)	1 (1.4%)	
40–60 hours	15 (23.8%)	25 (35.2%)	
60–80 hours	38 (60.3%)	34 (47.9%)	
More than 80 hours	8 (12.7%)	11 (15.5%)	
Q2: How many hours did you spend in the operating room on average per week?			0.002
Zero	0 (0.0%)	0 (0.0%)	
Less than 5 hours	12 (19.0%)	3 (4.2%)	
Less than 10 hours	18 (28.6%)	12 (16.9%)	
Less than 15 hours	20 (31.7%)	24 (33.8%)	
More than 15 hours	13 (20.6%)	32 (45.1%)	
Q3: How many hours did you spend in outpatient clinic on average per week?			0.811
Less than 5 hours	25 (39.7%)	26 (36.6%)	
5–10 hours	29 (46.0%)	32 (45.1%)	
More than 10 hours	9 (14.3%)	13 (18.3%)	
Q4: How many hours did you spend participating in teaching programs on average per week?			0.532*
Less than 3 hours	48 (76.2%)	60 (84.5%)	
3–6 hours	14 (22.2%)	10 (14.1%)	
More than 6 hours	1 (1.6%)	1 (1.4%)	
During the pandemic outbreak			
Q1: How many hours did you spend at work on average per week?			0.089
Less than 40 hours	7 (11.1%)	12 (16.9%)	
40–60 hours	29 (46.0%)	25 (35.2%)	
60–80 hours	25 (39.7%)	24 (33.8%)	
More than 80 hours	2 (3.2%)	10 (14.1%)	
Q2: How many hours did you spend in the operating room on average per week?			0.001*
Zero	3 (4.8%)	3 (4.2%)	
Less than 5 hours	26 (41.3%)	16 (22.5%)	
Less than 10 hours	21 (33.3%)	13 (18.3%)	
Less than 15 hours	11 (17.5%)	24 (33.8%)	
More than 15 hours	2 (3.2%)	15 (21.1%)	
Q3: How many hours did you spend in outpatient clinic on average per week?			0.361
Less than 5 hours	41 (65.1%)	40 (56.3%)	
5–10 hours	17 (27.0%)	20 (28.2%)	
More than 10 hours	5 (7.9%)	11 (15.5%)	
*Fisher exact test was applied.			
			Continues



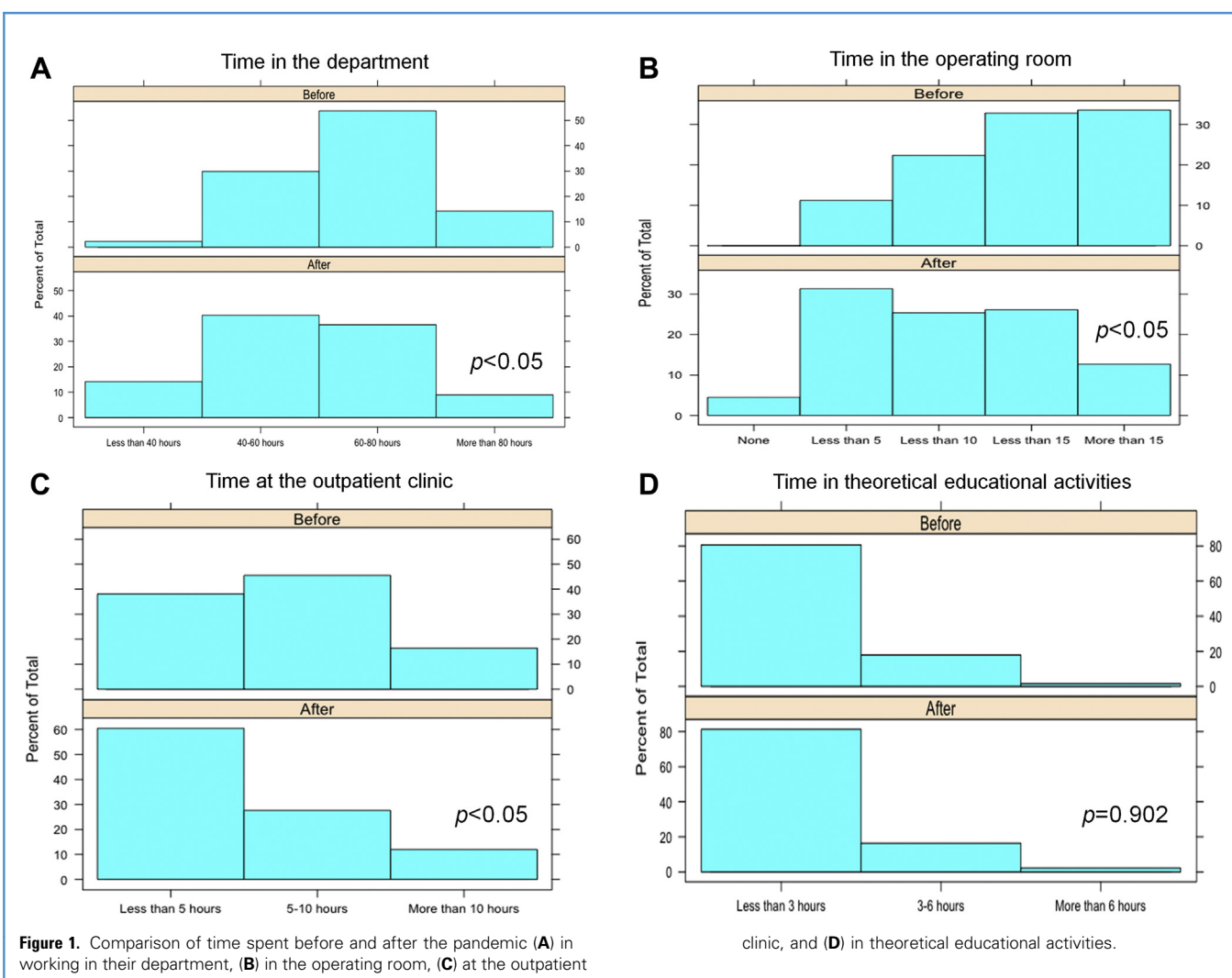
Table 3. Continued

Questions	Resident Level		P Value
	Junior	Senior	
Q4: How many hours did you spend participating in teaching programs on average per week?			1.000*
Less than 3 hours	52 (82.5%)	57 (80.3%)	
3–6 hours	10 (15.9%)	12 (16.9%)	
More than 6 hours	1 (1.6%)	2 (2.8%)	

\*Fisher exact test was applied.

elective surgeries, along with the decrease in the volume of emergent/urgent cases because of the imposed lockdowns. Many departments adapted a method of rotation to have an available workforce in cases of COVID-19 infections.<sup>2</sup> This option was used

by other specialties too, embracing the ideas of a “bench team” and “remote-working.”<sup>21,22</sup> As a result, residents spend less time in their departments. This was translated into less time in the outpatient clinic which, in combination with the extended use



of telemedicine has significantly diminished the direct contact with patients, arguably compromising the development of skills necessary for routine patient management.<sup>2,3</sup> All these measures, although necessary, have a great impact on residents' training.

Another subject to be addressed is the diversion of neurosurgery residents to other positions within their health care systems.<sup>23-25</sup> The percentage of redeployment varied from 29.7 % to 85.5 % across publications from Italy, Latin America, Asia, North America, and Turkey.<sup>8,10,11,13,14</sup> In our study, 29.9 % of the responders were redeployed to a different department during the pandemic. Almost one-half of those had to provide their services to the direct fight against the coronavirus for more than 6 weeks. Although necessary for those health care systems lacking the essential workforce, our data clearly reveal loss of training time for the neurosurgical residents.

Our study tried to observe whether departments could cope with the new reality during the period after the first wave of the pandemic. After stratification of data, the vast majority of junior residents (79.4 %) reported that their surgical exposure did not return to normal, whereas 49.3 % of senior residents identified a normalization in their surgical time ( $P < 0.05$ ). This difference may be suggestive of the possibility that junior residents' surgical education was more affected. However, because of the subjective nature of survey data this result should be considered with considerable caution, as there is a difference of perspective between junior and senior residents. Moreover, the small size of our current sample makes the drawing of any conclusions risky since the observed statistical differences resulted by a subgroup analysis may be the outcome of hazard.

During the first stages of the pandemic, the complex international trading of PPE reduced the availability of PPE for all health care workers.<sup>11</sup> de la Cerda-Vargas et al.<sup>14</sup> reported lack of PPE in 46.4 %, whereas Cheserem et al.<sup>12</sup> reported insufficient PPE among 28 % of their participants. Neurosurgical residents were not unaffected, but fortunately 82.1 % of our survey participants had appropriate PPE coverage. However, we have to interpret this result with caution, as it also contains the experiences of advanced stages of the pandemic, when the administration of the equipment was sufficient, and the health care systems were more organized after the initial shock.

Neurosurgery residents also had to face psychological stress and uncertainty for their professional futures. Working in the first line of defense amidst an uncertainty about their training undoubtedly impacted their sentiment. Also, most of the trainees are at the age of having families, something that contributes to develop more stress and fear during a pandemic.<sup>25</sup> In our current study, fear of transmitting the infection to family members was common among the responders, leading to increased stress levels. However, the fear of infection did not seem to affect patients' management, as stated by 78.4 % of responders. This reflects the high standard of professionalism of neurosurgery residents during the pandemic.

Possible future consequences because of the pandemic should be also addressed with caution. Although previous reports did not show any trainee concerns about achieving the required logbook numbers,<sup>8</sup> 56.7 % of our study participants were worried about completing graduation requirements. Furthermore, Sahin and

Hanalioglu<sup>13</sup> addressed the subject of residency extension reporting, that more than one-half of the participants (57.4 %) had considered extending their residency training to overcome any negative effects of the pandemic. When the subject of requiring an extra year of training was considered, in our study, 48.5 % considered realistic the possibility of having an extra year of training. It is obvious that a large proportion of the trainees are concerned whether their surgical training during this last year was sufficient.

Following the outbreak of the pandemic, online education significantly increased. Many training programs substituted lost hands-on training time with web-based meetings. On many occasions, there have been collaborations between geographically distant residency programs. As a result, many residents, for the first time, could broaden their horizons with national and international experts in the field. In many reports from the beginning of the pandemic, the residents' response to this was positive.<sup>8</sup> In our survey, although most trainees have participated in online webinars of many kinds, a significant proportion (43.3 %) did not find this a good solution. We also found that the emergence of web-based education was not perceived as adequate to replace face-to-face education and hands-on training. However, the vast majority of our participants (95.5 %) considered online education as an efficacious educational tool in their further training.

In our study, we addressed 2 major issues: the first was the training time lost during the COVID-19 pandemic, and the second was the imminent continuation of this situation, since many health care systems still face the pandemic in the form of a second or third wave. Even if the duration of residency is extended by 1 year, this option cannot be the only solution, given the ongoing restrictions, and the possibility of not being able to return to normality in the following year. It is imperative that other solutions should be found to counteract the pandemic's negative effects on neurosurgical training. These measures may be the foundations of new alternative ways of training, which may be used in similar situations in the future. In addition to theoretical lessons and lectures, virtual and augmented reality, as well as 3-dimensional printing technology may provide a safe training environment for residents in cases of reduced surgical exposure.<sup>26-28</sup> It is not a perfect solution, but it is a novel way to develop fine microsurgical techniques essential for any trainees' evolution.

### Limitations

Our study has certain limitations. First, the questionnaire's distribution was through an EANS registry, leading to a response bias. Second, the survey duration was 2 and a half months, from November 2020 to January 2021, and the answers probably express different states of the pandemic as each country would be at a different stage; however, the effect of the pandemic is ongoing and all answers are pragmatic. Third, the overall sample size was relatively small. However, this was expected because of the nature of the survey and the high number of ongoing surveys, contributing to possible "survey fatigue." Increased responsibilities along with physical and mental strain could also lead to a lower response rate. It needs to be pointed out that the lower threshold of response rate was not predetermined. However, we decided to



conclude our current survey, since there were no further responses despite the fact that 2 reminders were sent. Furthermore, another issue that should be taken into account is that countries that were highly affected, like Italy, Spain, United Kingdom, and France, did not have high response rates. Fourth, data such as departmental size were excluded from our current analysis for privacy protection reasons. This, however, may have an impact on the accuracy of our conclusions, since the size of the department may be a major confounder to resident training experience. Fifth, it has to be taken into consideration that each European country was affected in a different degree and each pandemic surge varied significantly. These facts may well represent another confounder in resident burnout and educational experience. Moreover, our current survey was not validated, and there was no standardized scale to assess the resident's anxiety levels. This was done mainly due to our effort to capture a snapshot of the ongoing pandemic's impact. Similarly, the ill-defined first wave of the pandemic which was occurred at different time and with significantly varying intensity in each European country constitutes another potential bias and limitation of our current survey.

## CONCLUSIONS

SARS-CoV-2 levies a significant impact on the normal educational process since the core of neurosurgical training has suffered significant changes. The lack of hands-on surgical exposure has negatively affected the surgical evolution of trainees. Online webinars were not considered to be a sufficient alternative and some trainees estimate that a whole year equivalent of hands-on

training may have been lost. The pandemic has surely created a new reality with restrictions, lockdowns, and a continuous strain on health care systems. Given this situation, it may be considered to find alternative pathways to overcome similar obstacles and to possibly reorganize and optimize the whole training surgical training education for neurosurgical trainees.

## CRediT AUTHORSHIP CONTRIBUTION STATEMENT

**Christos Tzerefos:** Study conception and design, Material preparation, data collection, and analysis, Drafting of the manuscript. **Torstein R. Meling:** Study conception and design, Material preparation, data collection, and analysis. **Jesus Lafuente:** Study conception and design, Drafting of the manuscript. **Kostas N. Fountas:** Study conception and design, Drafting of the manuscript. **Alexandros G. Brotis:** Study conception and design, Material preparation, data collection, and analysis. **Andreas K. Demetriades:** Study conception and design, Material preparation, data collection, supervision, and analysis. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. All authors agree to be accountable for all aspects of the work.

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