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.
Impact of the Coronavirus Disease 2019 Pandemic on Working and Training Conditions of Neurosurgery Residents in Latin America and Spain

Maria F. De la Cerda-Vargas¹, Martin N. Stienen², José A. Soriano-Sánchez³, Álvaro Campero⁴, Luis A.B. Borba⁵, Bárbara Nettel-Rueda⁶, Carlos Castillo-Rangel⁷, Luis Ley-Urzai⁸, Luis H. Ramírez-Silva¹, B.A. Sandoval-Bonilla⁶

BACKGROUND: The coronavirus disease 2019 (COVID-19) pandemic has exerted a significant impact on healthcare workers. Recent studies have reported the detrimental effects of the pandemic on neurosurgery residents in North America, Asia, and Italy. However, the impact of the pandemic on neurosurgical training in Latin America and Spain has not yet been reported. In the present report, we describe effects of COVID-19 on training and working conditions of neurosurgery residents in these countries.

METHODS: An electronic survey with 33 questions was sent to neurosurgery residents between September 7, 2020 and October 7, 2020. Statistical analysis was made in SPSS version 25.

RESULTS: A total of 293 neurosurgery residents responded. The median age was 29.47 ± 2.6 years, and 79% (n = 231) were male. Of respondents, 36.5% (n = 107) were residents training from Mexico; 42% surveyed reported COVID symptoms and 2 (0.7%) received intensive care unit care; 61.4% of residents had been tested for COVID and 21.5% had a positive result; 84% of the respondents mentioned persisted with the same workload (≥70 hours per week) during the pandemic. Most residents from Mexico were assigned to management of patients with COVID compared with the rest of the countries (88% vs. 68.3%; P < 0.001), mainly in medical care (65.4% vs. 40.9%; P < 0.001), mechanical ventilators (16.8% vs. 5.9%; P = 0.003), and neurologic surgeries (94% vs. 83%; P = 0.006).

CONCLUSIONS: Our results offer a first glimpse of the changes imposed by the COVID-19 pandemic on neurosurgical work and training in Latin America and Spain, where healthcare systems rely strongly on a resident workforce.

INTRODUCTION

Coronavirus disease 2019 (COVID-19) is an infection of the respiratory tract, caused by the SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) virus.¹,² It is a potentially fatal disease with a mortality of 3%—4% reported by the World Health Organization.³ COVID-19 represents a challenge for health care personnel, including neurosurgeons and neurosurgery residents.

The quality of resident training has been negatively affected as a result of the COVID-19 pandemic.⁴⁻⁷ Neurosurgery residents face a great challenge, especially those who work in hospitals caring for a high number of patients with COVID-19. Strategies to increase the capacities of intensive care units (ICUs) include a reduction of all (especially elective) surgical activities.⁶ Many neurosurgical centers have postponed their elective surgeries, which decreases

Key words
Coronavirus
Latin America
Mexico
Neurosurgery
Resident
Training

Abbreviations and Acronyms
AHW: Academic hours per week
COVID-19: Coronavirus disease 2019
ICU: Intensive care unit
PCR: Polymerase chain reaction
PGY: Postgraduate year
PPE: Personal protective equipment

From the ¹Department of Neurosurgery, Hospital de Especialidades No. 71, Instituto Mexicano del Seguro Social (IMSS), Torreón Coahuila, Mexico; ²Department of Neurosurgery, Kantonsspital St. Gallen, Switzerland; ³Mexican Society of Neurological Surgery, Mexico City, México; ⁴Latin American Federation of Neurosurgical Societies, Montevideo, Montevideo, Uruguay; ⁵Spine Clinic, The American-British Cowdray Medical Center IAP, Campus Santa Fe, Mexico City, Mexico; ⁶World Federation of Neurosurgical Societies, Nyon, Vaud, Switzerland; ⁷Department of Neurosurgery, Padilla Hospital, Tucumán, Argentina; ⁸Department of Neurosurgery, Federal University of Paraná, Curitiba, PR, Brazil; ⁹Department of Neurosurgery, Hospital de Especialidades, Centro Médico Nacional (CMN) Siglo XX, Instituto Mexicano del Seguro Social (IMSS), Mexico City, Mexico; ¹⁰Department of Neurosurgery, Hospital “1 de Octubre”, ISSSTE, Mexico City, Mexico; and ¹¹Department of Neurosurgery, Hospital Ramón y Cajal, Madrid, Spain

To whom correspondence should be addressed: B.A. Sandoval-Bonilla, M.D., M.Sc.
E-mail: bayrensandoval@gmail.com

Citation: World Neurosurg. (2021) 150:e182-e202.
https://doi.org/10.1016/j.wneu.2021.02.137

Journal homepage: www.journals.elsevier.com/world-neurosurgery
Available online: www.sciencedirect.com
1775-8655/$ - see front matter © 2021 Published by Elsevier Inc.
the exposure of residents with typical neurosurgical diseases and their treatment. Several programs have reduced the number of residents for neurosurgical activities, ordering the remaining trainees to stay at home. Nearly all neurosurgical programs worldwide have switched their academic face-to-face meetings to online communication in an attempt to reduce physical contact.

Few investigators have yet evaluated the impact of COVID-19 on neurosurgical residents (Supplementary Table 1). Hence, it was our objective to survey the impact of this pandemic on theoretic education and training strategies, practical exposure to neurosurgical procedures and management of neurosurgical and patients with COVID-19, as well as on health of neurosurgery residents in Latin America and Spain.

**METHODS**

The survey was created using Google Forms Survey. It was based on previous studies of COVID-19 and its impact on neurosurgical practice and residents (see Supplementary Table 1), but adapted in terms of content and response options to our particular interests. The final survey consisted of 33 questions organized in 4 sections (Supplementary Appendix 1).

The questions referred to demographic data of residents, postgraduate year (PGY), countries of origin and of neurosurgical training, academic strategies and resident workload, the guidelines in neurosurgical and nonsurgical management of COVID-positive patients, the effect on emergency and/or neurosurgical procedures, the use of personal protective equipment (PPE), the supervision that residents received for the management of patients with COVID and the areas in which residents were assigned for supervision that residents received for the management of patients with COVID. Besides the impact of the pandemic on neurosurgery residency, we also assessed its impact on both physical and mental health of residents.

Survey links to versions in Spanish and Portuguese were distributed via e-mail to different training programs to those countries between September 7, 2020 and October 7, 2020. Project collaborators included neurosurgeons involved in the development of academic programs in their respective countries and contributors to both the European Association of Neurosurgical Societies and FLANC (Federation of Latin American Neurosurgical Societies), which helped with the distribution of the survey among certified neurosurgical programs. All results were collected in a Google Forms database. Neurosurgery residents who participated in the survey and agreed to have their names published in this manuscript are seen in the Supplementary Table 2.

**Statistical Analysis**

Descriptive statistical analysis was performed using SPSS version 25 (IBM Corp., Armonk, New York, USA). We performed a univariate analysis using a χ² test in search of the association of the variables within the main topics: work hours before COVID-19 and during the pandemic (≥70 hours vs. <70 hours per week), academic hours before COVID-19 and during the pandemic (≥10 hours vs. ≤10 hours per week), polymerase chain reaction (PCR) test positive for COVID-19, percentage of emergency and elective surgeries during COVID-19, analysis by training countries (Mexico vs. other countries), and analysis by academic training year (junior residents, PGY 1–3 vs. senior residents, PGY 4–5).

The medians of the working hours and academic hours spent before COVID and during the pandemic were obtained to analyze its impact.

**RESULTS**

**Survey Responses: Demographic Information**

A total of 301 responses were obtained, and we included in our analysis the 293 responses from the neurosurgical residents (97.34%). The mean age was 29.49 ± 2.6 years (range, 24–40 years), and 78.8% were male (n = 231) and 21.2% female (n = 62) (Table 1). Residents in training from Mexico comprised 37% of respondents to the survey, followed by Brazil (21%), Colombia (12.5%), and Argentina (7.8%). Spain comprised 2.7% (n = 8) (Figure 1).

| Table 1. Sociodemographic Information |
|--------------------------------------|
| Total of Residents 293 |
| Number of residents per center, mean (range) 10.8 ± 7.8 (1–40) |
| Age (years), mean (range) 29.47 ± 2.6 (24–40) |
| Gender |
| Female 62 (21.2) |
| Male 231 (78.8) |
| Neurosurgical training duration (years), mean (range) 4.99 ± 0.392 (3–5) |
| Postgraduate year, mean (range) 3.10 ± 1.483 (1–5) |
| Neurosurgery training country |
| Mexico 107 (36.5) |
| Other 186 (63.5) |
| Type of center |
| Exclusive hospital for neurologic diseases 18 (6.1) |
| Medical specialty hospital that includes neurosurgery department 138 (47.1) |
| General hospital that includes neurosurgery department 135 (46.1) |
| Others 2 (0.7) |

Values are number (%) except where indicated otherwise.
Neurosurgical Guidelines for Patients with COVID-19
Most responders (90%) worked at centers admitting both patients with COVID and patients without COVID (hybrid hospitals). At the time of the survey, 87.4% (n = 256) were taking part in neurosurgical procedures performed on patients with COVID. Almost 80% (n = 233) reported that these procedures were carried out only if appropriate PPE was available, whereas 20% (n = 57) reported that emergency neurosurgical surgeries were still performed even if adequate PPE was not available at their centers (Table 2).

Working Hours Before and During the COVID-19 Pandemic
Approximately half of residents (51%, n = 150) reported a reduction in the number of workdays per week. Before the pandemic, most residents (95.6%, n = 280) dedicated ≥70 working hours per week. During the pandemic, workload was reduced by 12% (Table 2 and Figure 2). Although >80% of those surveyed mentioned persisting with the same workload during COVID (280 residents responded that they worked ≥70 hours per week before the pandemic, and 86.1% of these residents [n = 241] reported persisting with this workload during the pandemic [P < 0.001]), no association was found with the presence of serious respiratory disease that warranted intensive care (P < 0.001). The results of the analysis of working hours during the pandemic and the other variables were not statistically significant (Table 3).

Academic Strategies During the COVID-19 Pandemic
Approximately 90% of surveyed residents reported that outpatient clinical activities, academic meetings, and conferences were canceled (Table 2). Of these respondents, 43.7% (n = 128) reported an increase in academic activity, whereas 32% (n = 94) mentioned that it decreased, and 17% (n = 50) answered that it remained unchanged. Teleconferences were the most frequent strategy described among respondents (87.1%, n = 256) (Table 2). Of the residents who responded that they spent >10 academic hours per week (AHW) before COVID (n = 44), 52.3% of those surveyed persisted with the same AHW during the pandemic (P < 0.001) (Figure 3).

Role of Neurosurgical Residents in the Management of Patients with COVID-19
Three quarters of participants (76%; n = 222) reported that neurosurgery residents take part in the management of patients with COVID-19 at their hospital. In 84.7% (n = 256) of cases, the residents are assigned to neurologic surgeries, 49.8% (n = 146) assigned to medical care, 32% (n = 93) to the emergency area, 28% (n = 83) to the ICU, and 10% (n = 29) helped in the management of mechanic ventilators. Only 57% of residents (n = 167) were supervised in the management of patients with COVID in both surgical and medical procedures. Of responders, 51.5% (n = 151) answered that appropriate PPE was provided at their center, whereas 46.4% (n = 136) reported insufficient equipment. Of the
### Table 2. Neurosurgical Guidelines in Patients with COVID-19

| Type of care/services requested by your hospital in patients with COVID | n  | %  |
|---------------------------------------------------------------|----|----|
| ICU COVID                                                   | 83 | 28.3 |
| Medical care units                                          | 146 | 49.8 |
| Mechanical ventilators in patients with COVID               | 29 | 9.9 |
| Emergency units                                             | 93 | 31.7 |

| Received supervision in the management of patients with COVID? | n  | %  |
|---------------------------------------------------------------|----|----|
| No                                                            | 126 | 43 |
| Yes                                                           | 167 | 57 |

| Do you feel comfortable treating patients with COVID? | n  | %  |
|------------------------------------------------------|----|----|
| Very comfortable                                     | 13 | 4.4 |
| Comfortable                                          | 30 | 10.2 |
| I do not care                                        | 68 | 23.2 |
| Uncomfortable                                        | 133 | 45.4 |
| Very uncomfortable                                   | 49 | 16.7 |

| Do you feel competent treating patients with COVID? | n  | %  |
|----------------------------------------------------|----|----|
| Very competent                                      | 13 | 4.4 |
| Competent                                           | 119 | 40.6 |
| Little competent                                    | 143 | 48.8 |
| Incompetent                                         | 18 | 6.1 |

| Distribution of PPE in your hospital                  | n  | %  |
|-------------------------------------------------------|----|----|
| The hospital does not provide PPE                    | 6 | 2 |
| Enough PPE                                           | 151 | 51.5 |
| Insufficient PPE                                     | 136 | 46.4 |

| Received training in the use of PPE                   | n  | %  |
|-------------------------------------------------------|----|----|
| No                                                    | 64 | 21.8 |
| Yes                                                   | 229 | 78.2 |

| Did you have symptoms of COVID-19?                    | n  | %  |
|-------------------------------------------------------|----|----|
| No                                                    | 170 | 58 |
| Yes                                                   | 123 | 42 |

| Symptoms that occurred                                 | n  | %  |
|-------------------------------------------------------|----|----|
| Fever or chills                                        | 58 | 19.8 |
| Cough                                                 | 71 | 24.2 |
| Shortness of breath                                   | 27 | 9.2 |
| Fatigue                                               | 59 | 20.1 |
| Muscle or body pain                                   | 78 | 26.6 |
| Headache                                              | 89 | 30.4 |
| Loss of smell or taste                                | 39 | 13.3 |
| Sore throat                                           | 51 | 20.8 |
| Stuffy or runny nose                                  | 52 | 17.7 |

ICU, intensive care unit; PPE, personal protective equipment.

### Table 2. Continued

| Type of care/services requested by your hospital in patients with COVID | n  | %  |
|-----------------------------------------------------------------------|----|----|
| ICU COVID                                                            | 83 | 28.3 |
| Medical care units                                                    | 146 | 49.8 |
| Mechanical ventilators in patients with COVID                         | 29 | 9.9 |
| Emergency units                                                       | 93 | 31.7 |

| Received supervision in the management of patients with COVID?       | n  | %  |
|---------------------------------------------------------------------|----|----|
| No                                                                  | 126 | 43 |
| Yes                                                                 | 167 | 57 |

| Do you feel comfortable treating patients with COVID?                | n  | %  |
|----------------------------------------------------------------------|----|----|
| Very comfortable                                                     | 13 | 4.4 |
| Comfortable                                                          | 30 | 10.2 |
| I do not care                                                        | 68 | 23.2 |
| Uncomfortable                                                        | 133 | 45.4 |
| Very uncomfortable                                                   | 49 | 16.7 |

| Do you feel competent treating patients with COVID?                  | n  | %  |
|---------------------------------------------------------------------|----|----|
| Very competent                                                      | 13 | 4.4 |
| Competent                                                           | 119 | 40.6 |
| Little competent                                                    | 143 | 48.8 |
| Incompetent                                                         | 18 | 6.1 |

| Distribution of PPE in your hospital                                  | n  | %  |
|---------------------------------------------------------------------|----|----|
| The hospital does not provide PPE                                    | 6 | 2 |
| Enough PPE                                                           | 151 | 51.5 |
| Insufficient PPE                                                     | 136 | 46.4 |

| Received training in the use of PPE                                  | n  | %  |
|---------------------------------------------------------------------|----|----|
| No                                                                  | 64 | 21.8 |
| Yes                                                                 | 229 | 78.2 |

| Did you have symptoms of COVID-19?                                  | n  | %  |
|---------------------------------------------------------------------|----|----|
| No                                                                  | 170 | 58 |
| Yes                                                                 | 123 | 42 |

| Symptoms that occurred                                               | n  | %  |
|---------------------------------------------------------------------|----|----|
| Fever or chills                                                      | 58 | 19.8 |
| Cough                                                               | 71 | 24.2 |
| Shortness of breath                                                 | 27 | 9.2 |
| Fatigue                                                             | 59 | 20.1 |
| Muscle or body pain                                                 | 78 | 26.6 |
| Headache                                                            | 89 | 30.4 |
| Loss of smell or taste                                              | 39 | 13.3 |
| Sore throat                                                         | 51 | 20.8 |
| Stuffy or runny nose                                                | 52 | 17.7 |

ICU, intensive care unit; PPE, personal protective equipment.
residents, 78.2% (n = 229) considered that training provided for the use of PPE was adequate. Of residents, 45.4% reported being uncomfortable while handling patients with COVID-19 and 55% the use of PPE was not enough to protect residents from the contagious disease that warranted management in the ICU (Table 2).

Surgeries During the COVID Pandemic
Although 87.4% (n = 256) of those surveyed answered that their hospitals performed surgeries on patients with COVID, approximately 92.4% of residents (n = 276) reported that elective surgeries were postponed at their hospital. Two responders (0.7%) answered that emergency surgeries were canceled (Table 2 and Figure 4). Of the respondents, 98% answered that surgeries decreased ≥50% and despite having sufficient PPE, elective surgeries decreased in >50% of those surveyed (51.2%; P = 0.044). The workload during COVID was inversely related to the number of elective surgeries, because 84.3% (n = 242) of the residents who persisted with a workload of ≥70 hours per week reported a reduction in surgeries. However, the decrease in scheduled neurosurgery did not prevent residents from becoming ill: 1.4% of the residents (n = 4) had respiratory disease that warranted hospitalization (P = 0.006) and 1 resident (0.3%) required management in the ICU (P < 0.001) (Table 5).

Impact of COVID-19 on the Health and Training of Residents
Four of 10 residents (42%; n = 123) reported presenting symptoms compatible with COVID-19 infection. The main symptoms were headache (30%), muscle and body pain (27%), and cough (24%) (Supplementary Figure 1). Fever was reported in only 20% of cases. Hospitalization and intensive care were required in 5 (1.7%) and 2 (0.7%) cases, respectively. At the time of the survey, 180 residents (61%) had been tested for COVID-19 and 21.5% (n = 63) had obtained a positive result (Table 2).

In the statistical analysis, a positive PCR test for COVID-19 was presented more frequently in hospitals of medical specialties (57.1%; P < 0.001), and 8% of these patients (n = 5) presented with a severe respiratory disease that warranted hospitalization (P <0.001). Having sufficient PPE or receiving adequate training in the use of PPE was not enough to protect residents from the disease (46% of residents with sufficient PPE [P < 0.001] and 81% of those who received PPE presented a positive PCR for COVID-19 [P = 0.010]). Of the patients with symptoms, 94% had a positive PCR result (Table 6). In addition, female residents had a higher percentage of positive PCR results than did males (27.4% vs. 20%; P = 0.467) and a higher percentage of respiratory disease that warranted hospitalization (3.2% vs. 1.3%; P = 0.298). On the other hand, male residents presented with a severe respiratory disease that warranted management in the ICU (0.9% vs. 0.0%; P = 0.462) (Table 7).

Two thirds of participants (66%, n = 194) believed that COVID-19 negatively affected their neurosurgical training. More than half of surveyed residents (54.9%, n = 161) reported that the COVID pandemic affected either their mental or physical health (Table 2). Male residents reported a greater negative impact of COVID-19 on their neurosurgical training compared with female residents (75% vs. 25%; P = 0.036). Despite the fact that the most used strategy to reduce the exposure of residents to COVID-19 was the reduction of workdays (reduction of the number of working days per week), 55% of the residents who underwent this type of strategy

| Table 2. Continued |
|---------------------|
| n   | %    |
|---------------------------------|
| Nausea or vomiting             | 23   | 7.8 |
| Diarrhea                        | 52   | 17.7|
| Chest pain or pressure          | 14   | 4.8 |
| Confusion                       | 3    | 1   |
| Inability to wake up or stay awake | 6   | 2.0 |
| Perioral cyanosis               | 1    | 0.3 |
| Respiratory disease that warrants hospitalization | 5   | 1.7 |
| Respiratory disease that warrants management in the ICU | 2   | 0.7 |
| COVID-19 test                   |      |     |
| The COVID test is not available in my hospital or region | 3    | 1.0 |
| Yes, the test was positive      | 63   | 21.5|
| Yes, the test was negative      | 117  | 39.9|
| No, I have not had the test     | 110  | 37.5|
| COVID-19 had a negative impact on your training? |      |     |
| No                              | 99   | 33.8|
| Yes                             | 194  | 66.2|
| COVID-19 affected your physical or mental health? |      |     |
| No                              | 40   | 13.7|
| Yes, my physical health         | 47   | 16.0|
| Yes, my mental health           | 45   | 15.4|
| Yes, my physical and mental health, both equally | 161 | 54.9|
| ICU, intensive care unit; PPE, personal protective equipment. |     |     |

Figure 2. Work hours before and during COVID-19 pandemic.
mentioned a negative impact of COVID-19 in their neurosurgical training ($P = 0.04$), and the management of patients with COVID was also a variable that negatively influenced neurosurgical training according to the results obtained by the surveyed residents (81% vs. 64%; $P = 0.002$).

**Analysis by Place of Neurosurgical Training: Mexico vs. Other Countries**

Residents with neurosurgical training in Mexico reported a higher percentage of positive responses to the management of patients with COVID compared with the other countries (88% vs. 68.3%; $P < 0.001$). These residents were mainly assigned in medical care (65.4% vs. 40.9%; $P < 0.001$), management of mechanical ventilators (16.8% vs. 5.9%; $P = 0.003$), and neurologic surgeries (94% vs. 83%; $P = 0.006$). The neurosurgery residents of Mexico also reported a greater negative impact on their neurosurgical training than did those in other countries (72.9 vs. 62.4%; $P = 0.066$) (Table 8).

**Neurosurgical Training Year**

Junior residents were more frequently assigned to the management of patients with COVID compared with senior residents (82% vs. 66.4%; $P = 0.002$), mainly in medical care (57.5% vs. 38.7%; $P = 0.025$) and emergency units (36.8 vs. 24.4; $P = 0.019$); 2 (1.7%) of the senior residents presented with severe respiratory disease that merited ICU management, whereas no junior resident needed this type of care (Table 9).

**DISCUSSION**

The COVID-19 pandemic affected the neurosurgical training of residents in Latin America and Spain in multiple ways. Several reports have evaluated the impact of COVID and hospital strategies to reduce residents’ exposure to the infection. The reduction of neurosurgical procedures and hours of work caused an increase in the development of theoretic knowledge; however, a negative impact was observed in the practical and surgical training of neurosurgery residents worldwide.10-14

**Table 3. Analysis by Working Hours Before COVID-19 and During the Pandemic**

| Weekly Work Hours Before COVID-19 (≥70), n (%) | $P$ | Weekly Work Hours During COVID-19 (≥70), n (%) | $P$ |
|---------------------------------------------|-----|---------------------------------------------|-----|
| Junior resident (PGY 1−3)                   | 167 (59.6) | 0.677 | 144 (58.8) | 0.631 |
| Senior resident (PGY 4−5)                   | 113 (40.4) | 0.105 | 101 (41.2) |
| Neurosurgery training country               |     |     |     |     |
| Mexico                                      | 105 (37.5) | 0.105 | 92 (37.6) | 0.407 |
| Other country                               | 175 (62.5) | 153 (62.4) |
| Hospital type                               |     |     |     |     |
| Exclusive hospital for neurologic diseases   | 15 (5.4) | 0.078 | 12 (4.9) | 0.179 |
| Medical specialty hospital                  | 133 (47.5) | 119 (48.6) |
| General hospital                            | 130 (46.4) | 112 (45.7) |
| Others                                      | 2 (0.7) | 2 (0.8) |
| COVID hospital                              |     |     |     |     |
| Exclusive COVID hospital                    |     |     | 8 (3.3) | 0.762 |
| COVID hybrid hospital                       |     |     | 222 (90.6) |
| Hospital does not treat COVID               |     |     | 13 (5.3) |
| Strategies to reduce resident exposure to COVID-19: |     |     | 120 (49) | 0.069 |
| Reduction of the number of workdays per week|     |     |     |     |
| Neurologic surgeries in patients with COVID (Yes) |     |     | 212 (86.5) | 0.5 |
| Your Hospital asks you to treat patients with COVID (Yes) |     |     | 182 (74.3) | 0.181 |
| Did you have a respiratory disease that required intensive care? |     |     | 0 (0) | 0.001† |
| Positive polymerase chain reaction COVID-19 test |     |     | 51 (20.8) | 0.775 |

PGY, postgraduate year.  
*Variables that cannot be assessed before the pandemic.  
†Statistically significant variables $P < 0.05$ obtained by the $\chi^2$ test.
In other countries, it was decided to initially restrict resident access to hospitals. In North America and the Middle East, a reduction in the number of resident working days per week was intended to decrease their exposure. In Italy, no neurosurgery residency program stopped working, but the length of stay in the service was shorter.

Neurologic Surgeries
In the literature, a reduction of neurologic surgeries from 67.5% to 99.5% was reported, affecting mainly elective surgeries and older residents. Emergency surgeries were also suspended. Approximately 88% of our respondents performed neurologic surgeries on patients with COVID-19, whereas 92% mentioned that elective surgeries were suspended and 1% mentioned that emergency surgeries were canceled. However, the decrease in scheduled neurosurgery did not prevent the residents from becoming ill, and it was reported that 1.4% of residents had respiratory disease that required hospitalization (P = 0.006) and 1 resident (0.3%) required intensive care (P < 0.001).

Working Hours
Shorter workday hours reduced residents’ exposure to the disease. Other investigators have reported a 44.8%–74.8% reduction in weekly working hours. During the pandemic, we found in our study that 83.6% of the residents persisted with a workload ≥70 hours per week; however, no association was found with the presence of severe respiratory disease that required intensive care (P < 0.001) despite the high hours per workweek exposure.

Academic Hours
The reduction in working hours and the number of neurosurgical procedures favored an increase in academic hours and clinical research studies. In line with previous reports in other regions, teleconferences became the most common format for seminars and classes in Latin America and Spain. Mexico reported a greater number of hours for academics per week (>10 hours) before COVID compared with other countries (57% vs. 43%; P = 0.002). However, during COVID-19, the other countries reported a higher number of academic hours than Mexico, although this finding was not statistically significant (52% vs. 47%; P = 0.051). Depending on the type of hospital, before COVID-19, medical specialty hospitals had a greater number of weekly academic hours compared with other types of hospitals (43%; P = 0.003), but during the pandemic, general hospitals spent a higher number of academic hours compared with other types of hospitals (43%; P = 0.003), because residents of medical specialty hospitals showed a higher percentage of positive COVID tests compared with other hospitals (57.1%; P < 0.001), which caused ill residents to require disability due to illness.

Management of Patients with COVID-19
Wittayanakorn et al. and Dash et al. reported that 87%–88% of their respondents work in a hybrid hospital, whereas 90% of our respondents work in a hospital with the same characteristics. Italy reported that 70.4% of their residents do not participate in the treatment of patients with COVID. Canada, United States, India, and other countries in the Middle East reported that 35.1%–91.1% of residents provided nonneurosurgical care to...
patients with COVID.\textsuperscript{10,11,17,18} In our study, approximately 75.8% of residents were assigned to manage patients with COVID, although only 57% mentioned working under supervision, and PPE was sufficient in only 51.5% of responses. The assignment of residents to medical care services for patients with COVID, especially in ICUs, was a matter of concern for residents, resulting in discomfort because of the lack of skills for this work,\textsuperscript{11-13} in addition to a higher probability of becoming ill with COVID-19.\textsuperscript{16} A few respondents were assigned to COVID ICU (28%) and management of mechanical ventilators (10%). Residents mentioned feeling uncomfortable (45.4%) and incompetent (55.1%) in the management of these patients. Furthermore, 87.4% of the residents at the time of the survey mentioned that they were participating in neurosurgical procedures performed on patients with COVID-19 and 79.5% mentioned that these surgeries were performed only if adequate PPE was available, whereas 20% reported that they were performed even without PPE. Residents of Mexico were more exposed to patients with COVID than were residents in the rest of the surveyed countries (88% vs. 68.3%; \( P < 0.001 \)) in the same way as junior residents (82% vs. 66.4%; \( P = 0.001 \)). Junior residents were assigned mainly to medical care (57.5% vs. 38.7%; \( P = 0.001 \)) and coverage of emergency units (36.8 vs. 24.4; \( P = 0.025 \)), whereas senior residents were assigned mainly to ventilator management (14.3 vs. 6.9; \( P = 0.038 \)) and neurologic surgeries (73.1 vs. 59.8%; \( P = 0.019 \)) of the senior residents (1.7%) presented with severe respiratory disease that warranted management in the ICU, whereas no junior residents required intensive care.

**Impact on the Health and Training of Residents**

Despite the availability of the test in many participating countries, it was not performed routinely and most of the tests were

#### Table 4. Analysis by Academic Hours before COVID-19 and During the Pandemic

| Weekly Academic Hours Before COVID-19 (>10), n (%) | Weekly Academic Hours During COVID-19 (>10), n (%) | \( P \) |
|--------------------------------------------------|--------------------------------------------------|------|
| Junior resident (PGY 1–3)                        | 30 (68.2)                                        | 0.197 |
| Senior resident (PGY 4–5)                        | 14 (31.8)                                        | 0.368 |
| Neuropathology training countries                |                                                  |      |
| Mexico                                           | 25 (56.8)                                        | 0.002*|
| Other country                                    | 19 (43.2)                                        | 0.051 |
| Hospital type                                    |                                                  |      |
| Exclusive hospital for neurologic diseases       | 5 (11.4)                                         | 0.003*|
| Medical specialty hospital                       | 19 (43.2)                                        | 0.004*|
| General hospital                                 | 18 (40.9)                                        | 0.051 |
| Others                                           | 2 (4.5)                                          |      |
| COVID hospital                                   |                                                  |      |
| Exclusive COVID hospital                         | †                                                 | †     | <0.001* |
| COVID hybrid hospital                            | †                                                 | †     | 0.021* |
| Hospital does not treat COVID                    | †                                                 | †     | 0.059  |
| Strategies to reduce resident exposure to COVID-19: | †                                                 | †     | <0.001* |
| Reduction of the number of workdays per week     |                                                  |      |
| Academic strategies: Teleconferences             |                                                  |      |
| Neurologic surgeries in patients with COVID-19 (Yes) |                                                  |      |

PGY, postgraduate year.

*Statistically significant variables \( P < 0.05 \) obtained by the \( \chi^2 \) test.

Variables that cannot be assessed before the pandemic.
performed in residents with symptoms and exposure to COVID-positive patients.13 In the reported studies, >60% of residents were not tested for COVID-19, which could condition many asymptomatic carriers.14 At the time of our survey, 180 residents (61%) were tested for COVID-19 and 21.5% (n = 63) had obtained a positive result. A positive PCR test result for COVID-19 was obtained more frequently in the hospitals of medical specialties (57.1%; P < 0.001) and 8% of these patients (n = 5) presented with a serious respiratory disease that required hospitalization (P < 0.001). Women had a higher percentage of positive PCR results than did men (27.4% vs. 20%; P = 0.467) and a higher percentage of respiratory disease that warranted hospitalization (3.2% vs. 1.3%; P = 0.298), but female residents did not warrant management in the ICU in contrast to males (0% vs. 0.9%; P = 0.462).

Another issue that concerns residents is not reaching the minimum number of cases to be accredited by their training program.12,17,18 Although this variable was not included in our study, we consider it to be an important problem in all grades of neurosurgery residency because it represents a potential deficit, both academic and skills, the loss of which is unlikely to be compensated, especially in senior residents. This situation is particularly important because the pandemic seems to continue with different waves and yet there is no end in sight.

**Negative Impact of COVID on Neurosurgical Training**

Pelargos et al.11 reported a negative pandemic impact in a third of their respondents, and Wittayanakorn et al.13 mentioned a 74% deficit in training. In our study, two thirds (66%, n =

**Table 5. Impact of the COVID-19 Pandemic on Elective Surgeries and Emergency Neurologic Surgeries**

| Impact Category                                      | Elective Surgeries During COVID-19 | Emergency Surgeries During COVID-19 |
|------------------------------------------------------|------------------------------------|-------------------------------------|
|                                                      | Decreased, n (%) | Without Changes, n (%) | Increased, n (%) | P       | Decreased, n (%) | Without Changes, n (%) | Increased, n (%) | P       |
| Junior resident (PGY 1–3)                             | 172 (60)           | 1 (20)                  | 1 (100)          | 0.140   | 151 (64)         | 19 (36.9)            | 4 (44.4)         | 0.005*  |
| Senior resident (PGY 4–5)                             | 115 (40)           | 4 (80)                  | 0 (0)            | 0.553   | 85 (36)          | 29 (60.4)            | 5 (55.6)          | 0.183   |
| Neurosurgery training country                        |                     |                        |                  |         |                   |                      |                  |         |
| Mexico                                               | 106 (36.9)         | 1 (20)                  | 0 (0)            | 0.906   | 89 (37.7)        | 13 (27.1)            | 5 (55.6)          | 0.183   |
| Other country                                        | 181 (63.1)         | 4 (80)                  | 1 (100)          | 0.372   | 147 (62.3)       | 35 (72.9)            | 4 (44.4)          | 0.002*  |
| Hospital type                                        |                     |                        |                  |         |                   |                      |                  |         |
| Exclusive hospital for neurologic diseases            | 17 (5.9)           | 1 (20)                  | 0 (0)            | 0.823   | 15 (6.4)         | 2 (4.2)              | 1 (1.1)           | 0.614   |
| Medical specialty hospital                           | 136 (47.4)         | 2 (40)                  | 0 (0)            | 0.140   | 115 (48.7)       | 18 (37.5)            | 5 (55.6)          | 0.183   |
| General hospital                                     | 132 (46)           | 2 (40)                  | 1 (100)          | 0.140   | 104 (44.1)       | 28 (58.3)            | 3 (33.3)          | 0.183   |
| COVID hospital                                       |                     |                        |                  |         |                   |                      |                  |         |
| Exclusive COVID hospital                             | 10 (3.5)           | 0 (0)                   | 0 (0)            | 0.906   | 10 (4.2)         | 0 (0)                | 0 (0)             | 0.707   |
| COVID hybrid hospital                                | 259 (90.2)         | 4 (80)                  | 1 (100)          | 0.027*  | 210 (89)         | 46 (95.8)            | 8 (88.9)          | 0.005*  |
| Hospital does not treat COVID                         | 16 (5.6)           | 1 (20)                  | 0 (0)            | 0.906   | 14 (5.9)         | 2 (4.2)              | 1 (1.1)           | 0.183   |
| Strategies to reduce resident exposure to COVID-19:  |                     |                        |                  |         |                   |                      |                  |         |
| Reduction of the number of workdays per week         | 148 (51.6)         | 2 (40)                  | 0 (0)            | 0.372   | 131 (55.5)       | 13 (27.1)            | 6 (66.7)          | 0.002*  |
| Weekly work hours during COVID-19 (>70)              | 242 (84.3)         | 3 (60)                  | 0 (0)            | 0.027*  | 199 (84.3)       | 39 (81.3)            | 7 (77.8)          | 0.776   |
| Neurologic surgeries in patients with COVID-19 (Yes) | 250 (87.1)         | 5 (100)                 | 1 (100)          | 0.927   | 204 (86.4)       | 43 (89.6)            | 9 (100)           | 0.593   |
| Your hospital asks you to treat patients with COVID  | 217 (75.6)         | 4 (80)                  | 1 (100)          | 0.830   | 186 (78.8)       | 28 (58.3)            | 8 (88.9)          | 0.007*  |
| (Yes)                                               |                     |                        |                  |         |                   |                      |                  |         |
| Respiratory disease that warrants hospitalization    | 4 (1.4)            | 1 (20)                  | 0 (0)            | 0.006*  | 4 (1.7)          | 1 (2.1)              | 0 (0)             | 0.906   |
| Respiratory disease that warrants management in the  | 1 (0.3)            | 1 (20)                  | 0 (0)            | <0.001  | 1 (0.4)          | 1 (2.1)              | 0 (0)             | 0.431   |
| intensive care unit                                  |                     |                        |                  |         |                   |                      |                  |         |
| Positive polymerase chain reaction COVID-19 test     | 59 (20.6)          | 3 (60)                  | 1 (100)          | 0.163   | 53 (22.5)        | 8 (16.7)             | 2 (22.2)          | 0.088   |
| Sufficient PPE                                       | 147 (51.2)         | 3 (60)                  | 1 (100)          | 0.044*  | 118 (50)         | 27 (56.3)            | 6 (66.7)          | 0.543   |
| PPE training (yes)                                   | 223 (77.7)         | 5 (100)                 | 1 (100)          | 0.425   | 194 (82.2)       | 28 (58.3)            | 7 (77.8)          | 0.001*  |

PGY, postgraduate year; PPE, personal protective equipment.

*Statistically significant variables P < 0.05 obtained by the χ² test.
of the participants reported that COVID-19 negatively affected their neurosurgical training. More than half (54.9%, n = 161) reported that the COVID pandemic affected their mental or physical health. Alhaj et al\textsuperscript{10} concluded that this pandemic affected social life in 100% and mental health in 90% of the participants.

Other situations about which residents mentioned being concerned, not evaluated in our survey, were the marked decrease in their practical surgical experience, uncertainty about their degree examination and possible delay in professional advancement, the increased number of delayed elective surgeries, the risk of acquiring COVID-19 in the workplace, and the possible transmission of COVID-19 to their relatives.\textsuperscript{13,17,18}

**Strengths and Limitations of the Study**

This survey is the first carried out of neurosurgery trainees in Latin America and Spain. It is shocking how 21% of those surveyed reported a positive PCR test result for COVID. According to our results, it is unquestionable that residents, despite hospital strategies to reduce the risk of infection, were exposed to COVID-19 in areas in which patients are carriers of a higher viral load, such as ICUs, or the operating room. We did not evaluate hospital policies

### Table 6. Variables Influencing a Positive Polymerase Chain Reaction Test Result for COVID-19

| Positive COVID-19 Polymerase Chain Reaction Test Result, n (%) | P |
|---------------------------------------------------------------|---|
| Hospital type: | |
| Exclusive hospital for neurologic diseases | 2 (3.2) | <0.001* |
| Medical specialty hospital | 36 (57.1) | |
| General hospital | 25 (39.7) | |
| Others | 0 (0) | 0.105 |
| Neurologic surgeries in patients with COVID-19 (Yes) | 57 (92.1) | 0.063 |
| Strategies to reduce resident exposure to COVID-19: | |
| Reduction of the number of workdays per week | 31 (49.2) | 0.717 |
| Your hospital asks you to treat patients with COVID (Yes) | 50 (79.4) | 0.563 |
| Respiratory disease that warrants hospitalization | 5 (7.9) | <0.001* |
| Respiratory disease that warrants management in the intensive care unit | 2 (3.2) | 0.081 |
| Neurosurgical guidelines in patients with COVID-19 | |
| The department refuses to perform the surgery, even if there is adequate PPE | 0 (0) | 0.227 |
| Surgery is done, even if there is no proper PPE | 15 (23.8) | |
| Surgery is done, only if there is adequate PPE | 48 (76.2) | |
| Decrease in emergency surgeries <50% | 39 (61.9) | 0.022* |
| Received supervision in the management of patients with COVID (Yes) | 32 (50.8) | 0.434 |
| Sufficient PPE | 29 (46) | <0.001* |
| PPE training (Yes) | 51 (81) | 0.010* |
| Did you have symptoms of COVID-19 (Yes) | 59 (93.7) | <0.001* |

PPE, Personal protective equipment.

*Statistically significant variables P < 0.05 obtained by the \( \chi^2 \) test.
for conducting the presurgical COVID-19 test within the surveyed countries, which could increase exposure in the centers in which surgical procedures continued to be performed, and in the same way, we did not evaluate the impact on admissions that occurred during the pandemic and quarantine periods applied to residents, whether infected or not, as did other investigators.\textsuperscript{16,17} We also did not evaluate the impact of burnout and professional satisfaction that our residents experienced during this pandemic and how it could negatively influence their personal satisfaction.\textsuperscript{18} The specific type of surgical procedure was not evaluated, even when 88% of our residents reported that they performed neurologic procedures in patients with COVID in their hospitals. Despite their persisting neurosurgical practice, we are unaware of the complexity of the procedures performed, which undoubtedly may skew the real impact on their neurosurgical training, biased by more emergency surgeries, such as placement of ventriculostomy, valves, or trephine drainage, which are surgeries that require less complexity.

**CONCLUSIONS**

Reduction of neurologic surgeries and workdays, as well as teleconferences, has been the most popular strategy during this pandemic to reduce residents’ exposure to COVID-19. However, the negative impact on practical training and health of the neurosurgery residents reported in the survey is an evident problem. Our study represents the first approximation to measure the impact of COVID-19 pandemic on neurosurgery training in Latin America and Spain. New strategies to improve neurosurgical

---

**Table 8. Analysis by Countries: Mexico vs. Other Countries**

|                                    | Other Countries | Mexico | \( P \) |
|------------------------------------|-----------------|--------|--------|
| Hospital type                       |                 |        |        |
| Exclusive hospital for neurologic diseases | 10 (5.4)       | 8 (7.5) | <0.001* |
| Medical specialty hospital          | 62 (33.3)       | 76 (71) |        |
| General hospital                    | 113 (60.8)      | 22 (20.6) |        |
| Others                             | 1 (0.5)         | 1 (0.9) |        |
| Neurologic surgeries in patients with COVID-19 (yes) | 155 (83.3) | 101 (94.4) | 0.006* |
| Strategies to reduce resident exposure to COVID-19: \( \) | 65 (34.9) | 85 (79.4) | <0.001* |

| Academic strategies: Teleconferences | 156 (83.9) | 101 (94.4) | 0.008* |
| Your hospital asks you to treat patients with COVID (yes) | 127 (68.3) | 95 (88.8) | <0.001* |
| ICU COVID                           | 45 (24.2) | 38 (35.5) | 0.038* |
| Medical care area                   | 76 (40.9) | 70 (65.4) | <0.001* |
| Mechanical ventilators in patients with COVID | 11 (5.9) | 18 (16.8) | 0.003* |
| Emergency area coverage             | 55 (29.6) | 38 (35.5) | 0.293 |
| COVID-19 had a negative impact on your training? (yes) | 116 (62.4) | 78 (72.9) | 0.066 |
| Positive polymerase chain reaction COVID-19 test result | 42 (22.6) | 21 (19.6) | 0.679 |
| Respiratory disease that warrants hospitalization | 4 (2.2) | 1 (0.9) | 0.439 |
| Respiratory disease that warrants management in the ICU | 2 (1.1) | 0 (0) | 0.282 |
| Increase in theoretic and scientific activity | 90 (48.4) | 38 (35.5) | 0.005* |
| Neurosurgical guidelines in patients with COVID-19 |                 |        |        |
| The department refuses to perform the surgery, even if there is adequate PPE | 1 (0.5) | 2 (1.9) | 0.2 |
| Surgery is done, even if there is no proper PPE | 41 (22) | 16 (15) |        |
| Surgery is done, only if there is adequate PPE | 144 (77.4) | 89 (83.2) |        |
| Received supervision in the management of patients with COVID? (yes) | 98 (52.7) | 69 (64.5) | 0.05 |
| Sufficient PPE                      | 98 (52.7) | 53 (49.5) | 0.471 |
| PPE training (yes)                  | 141 (75.8) | 88 (82.2) | 0.199 |

ICU, intensive care unit; PPE, personal protective equipment. *Statistically significant variables \( P < 0.05 \) obtained by the \( \chi^2 \) test.
procedures in the operating room must be found to continue with integrated formation of our residents during this pandemic.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

María F. De la Cerda-Vargas: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing.

Martin N. Stienen: Methodology, Formal analysis, Writing - review & editing.

José A. Soriano-Sánchez: Investigation.

Álvaro Campero: Methodology, Investigation.

Luis A.B. Borba: Investigation.

Bárbara Nettel-Rueda: Investigation. Carlos Castillo-Rangel: Methodology. Investigation. Luis Ley-Urzaiz: Investigation. Luis H. Ramírez-Silva: Investigation, Methodology, Project administration, Validation, Visualization, Writing - original draft, Writing - review & editing. B.A. Sandoval-Bonilla: Methodology, Investigation, Formal analysis, Writing - review & editing, Final approval of the version to be published.

ACKNOWLEDGMENTS

We acknowledge every neurosurgery resident, professor, and member of FLANC who contributed to this project.

REFERENCES

1. World Health Organization Coronavirus disease (COVID-2019) Situation Report-57. 2020. Available at: https://apps.who.int/iris/handle/10665/331442?locale-attribute=es&. Accessed March 29, 2021.

2. Wu YC, Chen CS, Chan YJ. The outbreak of COVID-19: an overview. J Clin Med Assoc. 2020;83:217-226.

3. World Health Organization Coronavirus disease (COVID-2019) Situation Report-45; 2020. Available at: https://apps.who.int/iris/handle/10665/331442. Accessed March 29, 2021.

4. 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. Neurosurgery. 2020;87:E63-E65.

5. Bernstein M. Editorial. Neurosurgical priority setting during a pandemic: COVID-19 [e-pub ahead of print]. J Neurosurg. https://thejns.org/view/journals/j-neurosurg/133/1/article-p18.xml. Accessed March 29, 2021.

6. Cenzato M, DiMeco F, Fontanella M, Locatelli D, Servadei F. Editorial. Neurosurgery in the storm of COVID-19: suggestions from the Lombardy region, Italy (ex malo bonum) [e-pub ahead of print]. J Neurosurg. https://thejns.org/view/journals/j-neurosurg/133/1/article-p33.xml. Accessed March 29, 2021.

7. Bambakidis NC, Tomei KL. Editorial. Impact of COVID-19 on neurosurgery resident training and education [e-pub ahead of print]. J Neurosurg. https://doi.org/10.3774/0399-0622.2020.3.JNS20065, accessed March 29, 2021.
8. Sun Y, Mao Y. Editorial. Response to COVID-19 in Chinese neurosurgery and beyond [e-pub ahead of print]. J Neurosurg. https://doi.org/10.3171/2020.3.JNS20929, accessed March 29, 2021.

9. Carter BS, Chiocca EA. Editorial. COVID-19 and academic neurosurgery [e-pub ahead of print]. J Neurosurg. https://thejns.org/view/journals/j-neurosurg/133/1/article-p8.xml. Accessed March 29, 2021.

10. Alhaj AK, Al-Saadi T, Mohammad F, Alabri S. Neurosurgery residents’ perspective on COVID-19: knowledge, readiness, and impact of this pandemic. World Neurosurg. 2020;139:e848-e858.

11. Pelargos PE, Chakraborty AR, Adogwa O, et al. An evaluation of neurosurgical practices during the coronavirus disease 2019 Pandemic [e-pub ahead of print]. World Neurosurg. https://www.sciencedirect.com/science/article/abs/pii/S1878875020322178. Accessed March 29, 2021.

12. Pennington Z, Lubelski D, Khalafallah AM, et al. Letter to the Editor “Changes to neurosurgery resident education since onset of the COVID-19 pandemic”. World Neurosurg. 2020;139:733-740.

13. Wittayanakorn N, Nga VDW, Sobana M, Bahuri NF, Baticulon RE. Impact of COVID-19 on neurological training in Southeast Asia. World Neurosurg. 2020;144:e174-e177.

14. Zoia C, Raffa G, Somma T, et al. COVID-19 and neurosurgical training and education: an Italian perspective. Acta Neurochir (Wien). 2020;162:1789-1794.

15. Zoia C, Bonetta D, Veiceschi P, et al. Neurosurgery during the COVID-19 pandemic: update from Lombardy, northern Italy. Acta Neurochir (Wien). 2020;162:1221-1222.

16. Chesserem FB, Esene IN, Mahmud MB, et al. A continental survey on the impact of COVID-19 on neurosurgical training in Africa [e-pub ahead of print]. World Neurosurg. https://www.sciencedirect.com/science/article/abs/pii/S1878875020323834. Accessed March 29, 2021.

17. Dash C, Venkataram T, Goyal N, et al. Neurosurgery training in India during the COVID-19 pandemic: straight from the horse’s mouth. Neurol Surg. 2020;49:E16.

18. Khalafallah AM, Lam S, Garni A, et al. A national survey on the impact of the COVID-19 pandemic upon burnout and career satisfaction among neurosurgery residents. J Clin Neurosci. 2020;80:137-142.

19. Pelargos PE, Chakraborty A, Zhao YD, Smith ZA, Dunn IF, Bauer AM. An evaluation of neurosurgical resident education and sentiment during the coronavirus disease 2019 pandemic: a North American survey. World Neurosurg. 2020;140:e381-e386.

20. Wittayanakorn N, Weng Nga VD, Sobana M, Ahmad Bahuri NF, Baticulon RE. COVID-19’s impact on neurological training in Southeast Asia. World Neurosurg. https://www.sciencedirect.com/science/article/abs/pii/S1878875020318404?via%3Dihub. Accessed March 29, 2021.

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 24 December 2020; accepted 27 February 2021

Citation: World Neurosurg. (2021) 150:e182-e202. https://doi.org/10.1016/j.wneu.2021.02.137

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

Available online: www.sciencedirect.com

1878-8750/$ - see front matter © 2021 Published by Elsevier Inc.
SUPPLEMENTARY APPENDIX 1

SURVEY

Situational Diagnosis in the Training of Neurosurgery Residents in Latin America, and Spain: Impact on the Covid-19 Era

Introduction. The quality of resident training has been negatively affected as a result of the recent COVID-19 pandemic. As the number of infected cases increases significantly, neurosurgeons in different countries are significantly affected in multiple ways. Neurosurgery residents face a great challenge, especially those who work in hospitals with a high number of patients with COVID-19. Also, some residents are fully responsible for patients with this infection. The reduction of elective and urgent neurosurgical procedures, online classes, the reduction of shifts in the hospital, have been used as a strategy to increase the number of residents in areas of care for patients with COVID-19, which has led to a 50% reduction in residents in person at the hospital.

The objectives of this survey are:

1) Collect the number or percentage of elective or emergency neurosurgical procedures, hours of work, as well as strategies used in each hospital to propose adjustments in the training and education of neurosurgery residents in the Era of Covid-19.

2) Analyze hospital strategies in the face of the pandemic and how they impact the training of neurosurgery residents in Latin America.

What we offer you:

Any participant who contributes to the collection of information will have a mention in an appendix at the end of the article as a reward, and their full name will appear indexed in PubMed, unless the participant prefers to remain anonymous.

Please note that all data will be collected and analyzed anonymously. Other than indexing purposes, the participant's name will not be displayed and in particular individual data will not be displayed.

Email address:

Instructions: Please read the questions below carefully. Respond as you consider relevant to the situation that arises.

Do you want your full name to appear in the appendix of the article publication and indexed in PubMed? *

- Yes
- No, I prefer to remain anonymous

If you answered Yes, write your full name. Otherwise, continue to the next

1. Are you a resident in neurosurgery? *

- Yes
- No

2. How many residents work in your Neurosurgery department? (just answer with number) *

3. What is your gender? *

- Woman
- Man

4. Age (in years):

5. What is your country of origin? (place of birth):

6. In which country are you doing your residency program in neurosurgery?:

7. How many years does your educational neurosurgery residency program in your country include? (not counting years of previous general surgery):

8. What year are you currently studying in the neurosurgery residency? (not counting years of previous general surgery) *

- 1st year
- 2nd year
- 3rd year
- 4th year
- 5th year
- 6th year or more

9. The hospital where you are currently residing is: *

- Exclusively from neurological diseases
- Hospital of Medical Specialties that includes Neurosurgery
- General Hospital including Neurosurgery
- Others:

COVID-19

10. Which of the following strategies has your department adopted to reduce residents' exposure to COVID-19? Please check the one that best applies to your hospital. *

- You go fewer hours but every day.
- I work for guards.
- There have been no changes.

11. How many hours per week, on average, did you work in your residency program prior to the COVID-19 pandemic? *

- 70 or more
- 60–69
- 50–59
- 40–49
- less than 40

12. How many hours per week, on average, do you currently work in your residency program during the COVID-19 pandemic? *

- 70 or more
- 60–69
13. Does the hospital in which you are currently carrying out your residency hospitalize patients with COVID-19? *
- Yes, exclusive hospital COVID
- Yes, COVID hybrid hospital (Admits positive and negative patients with COVID)
- No, the hospital does not receive patients with COVID
- I’m not sure

14. Does your hospital perform neurosurgical procedures on patients with probable or confirmed COVID-19? *
- Yes
- No
- I’m not sure

15. Which of the following services were canceled at your hospital? You can check more than one or NOT check any if they were not canceled *
- Emergency surgeries
- Elective surgeries
- External inquiries
- Meetings and conferences

16. What percentage of EMERGENCY neurosurgical procedures are currently being performed compared to the pre-pandemic period (6 months)? *EMERGENCY neurosurgical surgeries are defined as surgeries that can result in death or significant morbidity if not performed within 24 hours.
- Decrease less than 50%
- Decreased more than 50% (or emergency cases were not allowed)
- Without changes
- Increase less than 50%
- Increase more than 50%

17. What percentage of ELECTIVES neurosurgical procedures are currently performed compared to the pre-pandemic period (6 months)? *
- Decrease less than 50%
- Decreased more than 50% (or elective surgeries were not allowed)
- Without changes
- Increase less than 50%
- Increase more than 50%

18. If a patient needs an EMERGENCY neurosurgical procedure and has tested positive for COVID-19, what is common practice in your department? *
- Surgery is done, even if there is no proper personal protective equipment
- Surgery is done, only if there is adequate personal protective equipment
- The department refuses to perform the surgery, even if there is adequate personal protective equipment

19. The theoretical (conferences, seminars, magazine clubs, ...) and scientific (production of scientific papers, research projects, etc.) activities in the last 6 months have ...
- Increased
- Remained unchanged
- Diminished
- No teaching activity has been carried out in the last 6 months

20. Has your hospital of residence modified the academic sessions, and if so, how? Check the ones that are necessary *
- Teleconferences (eg Zoom, GoToMeeting, ...)
- Face-to-face (in small groups)
- Simulation laboratories
- Online questionnaires
- Academic meetings and conferences canceled
- They remained unchanged

21. How many hours per week did your program dedicate to didactic learning before the COVID pandemic? *
- More than 10
- 7–9
- 5–6
- 3–4
- 1–2
- None

22. How many hours per week does your program currently dedicate to didactic learning in the COVID-19 pandemic? *
- More than 10
- 7–9
- 5–6
- 3–4
- 1–2
- None

Care For Patients With COVID-19

23. Has your hospital asked you to provide medical services to treat COVID-positive patients? *
24. How comfortable are you providing non-neurosurgical medical care to COVID-positive patients (ICU, ventilator management, triage in the emergency room, etc.) if requested by your hospital? *
- Very comfortable
- Comfortable
- I do not care
- Uncomfortable
- Very uncomfortable

25. How competent do you consider yourself to treat COVID-positive patients? *
- Very competent
- Competent
- Little competent
- Incompetent

26. Have you been under supervision in the management of positive patients with COVID? *
- Yes
- No

27. How would you describe the supply of personal protective equipment (PPE) in your hospital? *
- Enough
- Insufficient
- The hospital does not provide PPE

28. Did you receive any formal training on how to use and remove personal protective equipment (PPE) during this pandemic? *
- Yes
- No

29. Have you ever had symptoms of COVID-19? *
- Yes
- No

30. If you answered Yes to the previous question, please specify what symptoms you experienced
- Fever or chills
- Cough
- Difficulty breathing
- Fatigue
- Muscle and body aches
- Headache
- Loss of smell or taste
- Sore throat
- Stuffy or runny nose
- Nausea or vomiting
- Diarrhea
- Persistent chest pain or pressure
- Confusion
- Inability to wake up or stay awake
- Perioral cyanosis
- Respiratory disease requiring hospitalization
- Respiratory disease requiring intensive care unit

31. Have you ever had a PCR test for COVID-19? *
- Yes, and the test came back positive
- Yes, and the test came back negative.
- No, I haven’t had the test
- COVID-19 testing is not available in my hospital/region

32. Do you think the COVID-19 pandemic will have a significant NEGATIVE impact on your neurosurgery training? *
- Yes
- No

33. Do you think your health could be affected during this pandemic?
- Yes, mainly my physical health
- Yes, mainly my mental health
- Yes, my physical and mental health, both equally
- No
## Supplementary Table 1. Surveys Reported Evaluating the Impact of COVID-19 Pandemic in Neurosurgery Residents

| Reference                  | Country                                                                 | Application Time                                      | Targeted Resident Population | Response Rate, n (%) | Number of Questions |
|----------------------------|-------------------------------------------------------------------------|-------------------------------------------------------|------------------------------|----------------------|---------------------|
| Alhaj et al., 2020         | Canada, United States, Saudi Arabia, Kuwait, Serbia, and Italy          | April 14—28, 2020                                     | 300                          | 52 (17.33)           | 27                  |
| Chesserem et al., 2020     | Africa                                                                  | April 16 and May 21, 2020                             | 123                          | NA                   | 52                  |
| Pelargos et al., 2020      | Canada, United States (28 states)                                       | April 17—30, 2020                                     | 1300                         | 197 (15.15)          | 31                  |
| Khalafallah et al., 2020   | United States (members of the American Association of Neurological Surgeons) | May 2020 (2 weeks)                                    | 1374                         | 167 (12.2) (only 111 completed responses) | 26                  |
| Zoia et al., 2020          | Italia                                                                  | May 3—11, 2020                                        | 331                          | 192 (58)             | 18                  |
| Dash et al., 2020          | India                                                                   | May 7—16 2020                                         | 118                          | NA                   | 36                  |
| Wittayanakorn et al., 2020 | Indonesia, Malaysia, Philippines, Singapore, and Thailand                | May 22—31, 2020                                       | 470                          | 298 (63)             | 33                  |
| Pennington et al., 2020    | Neurosurgery programs accredited by Accreditation Council for Graduate Medical Education | 2 weeks                                                | 116 programs                 | 57 programs (49.1) (average of 2 residents per postgraduate year) | 25                  |

NA, not applicable.
### Supplementary Table 2. Survey responding participants

| Name                      |
|---------------------------|
| Andres Francisco Rojas Gallegos |
| Jesús Eduardo Chan Cerecer  |
| Pablo Andrés Peña Puga    |
| Victoria Evelia Iban Berruete |
| Florencia Rodriguez Basili  |
| Paulo Fiori                |
| PaolaAlejandra Quevedo Castedo |
| Ronmel José Maldonado Machuca |
| Azcona Sergio Víctor      |
| Lucas Maximiliano Gimenez  |
| Alejandro Benjamin Romero Leguina |
| Ángeles Casale            |
| Camila Casal              |
| Tomas Wessel              |
| Rubby Juliana Romero Chaparro |
| Héctor Osvaldo Hernández Valázquez |
| José David Salazar Bello  |
| Sindel Guadalupe Lucatero Rolon |
| Maillyolo Eliezer Pelayo Salazar |
| Catalina Sánchez Delgado  |
| Luis Abraham Castro Toscano |
| Nadia Pérez Peña Rosas    |
| Ramos Delgado José Miguel  |
| Katherine Paola Gallego Henaoc |
| G Faust                   |
| Alberto Antonio Mejía Frías |
| Janina Margoth Cueva Ludena |
| Marco Antonio Jiménez Manrique |
| Ernesto Javier Delgado Jurado |
| Cristina Romero López     |
| Sergio Vera Navarrete     |
| Andres Felipe Mendez Gutierrez |
| Jorge Herrera-Franco      |
| Abraham Alfonso Tafur Grandett |
| Dr. Miguel Ángel Ramírez Sosa |
| Arturo Gómez Jiménez      |
| Verónica Martínez Zerón   |
| Juan Carlos Jiménez Romo  |
| Angélica Maria Tapiachá   |
| Rubén de Jesús Ramírez Rios |
| Francisco Vargas          |

### Supplementary Table 2. Continued

| Name                      |
|---------------------------|
| JC Aguirre               |
| Raul Frade Flores         |
| Gustavo Parra-Romero      |
| Lucy Ivonne Perez Avila   |
| César Alexander Peñate Ahuath |
| Juan Angel Angélo Estrada |
| Kevin César Arí Arce Vera |
| Oscar Josue Montes Aguilar |
| Juan Alberto Torri        |
| Sergio Arizona Garcia     |
| Gamaliel Velaszquez Jiménez |
| María José Cristaldo Santacruz |
| Eguzki Izukaiz Noguera    |
| Gloria Moreno-Madueño     |
| Juarez-Rebollar Daniel    |
| Alan Walter Cerrograndre Ancasi |
| Patricio Sepulveda Massone |
| Evelyn Elena Cornejo Cortez |
| Guillermo Luna Alvarez    |
| Maria Carolina Portela Fernandez |
| José Ernesto Chang Mulato |
| Donellia Carboni          |
| Nestor Fabián Romero Del Puerto |
| Daniela Puerta Bedoya     |
| Henry Giovanni del Cid Solares |
| Gerardo Yoshiaki Guinto Nishimura |
| Javier Alfonso Bellido Rodriguez |
| Isaac Enrique Tello Mata  |
| Frederico Bartz Noy       |
| Francisco Rojas Ramos     |
| Ramón Castruita Meza      |
| Hazzim Israel Benavides Giles |
| Carlos Gonzalez           |
| Kevin Rafael Rojas        |
| Nadin Jesus Abdala Vargas |
| Érico Samuel Gomes Galvão da Trindade |
| Henry Cabrera Medina      |
| Jorge Kevin Bejarano Cardenas |
| Alvaro Bedoya gómez       |
| Hugo García               |
| Hernán Pombo              |

Continues
Supplementary Table 2. Continued

Alexandra María Granados Ferrufino
Juan Manuel Torres
Hebert David Pimienta Redondo
Rogerio Nava Esquivel
José Ramón Olivas Campos
Naiara Wiggers de Souza
Esteban Idarraga Vanegas
Juan Jose Baquias-yax
Amparo Saenz
Marlon David Solano García
Carlos Betancourt Quiroz
Daniel Alejandro Vega Moreno
Luis Alberto Rodríguez Hernández
Rodrigo Uribe-Pacheco
Adán Soto Ramírez
Juan Pablo Ichazo Castellanos
Isaura Zoé Chávez Valderrama
Eduardo Cruz García
Emmanuel Moreno Ortiz
Luis Flores Robles
Job Jesús Rodríguez Hernández
Aldair Buckcanan Vargas
Zita Elizabeth Salazar Ramírez
Christian Janis Sandoval Ramírez
José Luis Gonzalez Hurtado
Carlos Alberto Mendoza García
Josué Alejandro Cervantes González
David de Jesús Mercado Rubio
María Eugenia badaloni
Maidana Florencia Antonella
Pierini Yanel Natalia
Liezle Ullque Caamaño
Christopher Arturo González
Bourilhon Facundo
Emmanuel Maciel-Ramos
Rafael Román Cuéllar
Carmen Rosa Georgina Yanque Baca
Carlos Antonio Cruz Arjüelles
Pablo Adrián Luna Pérez
Mera Cedeno Javier Alejandro
Gastón Ezequiel Bumaguín

Rodríguez Gacio, Leonardo Nicolás
Mikail da Conceição Sallé
Nelson Andres Cadeño Baird
Mariano Teyssandier
Jorge Daniel Pérez Ruiz
Carlos Perez Cataño
Alfredo Vara Castillo
Carlos Morales Valencia
Yovany Andrés Capacho Delgado
Wilson Quispe Alanoa
Gabriela Yesenia Contreras Montes
Diego Tonathi Soto Rubio
Pierre Yves Fonseca Mazeau
Sebastian JM Giovannini
Juan Felipe Mier García
Juan David Rivera G.
Alejandro Gomez Martinez
Teresa Martínez Villelas
Vicente Casitas Hernando
Antonio Selfa Rodriguez
Andres Vargas-Jiménez
Alberto Acitores Cancela
Andoni García-Martín
Daniel de Frutos Marcos
José Antonio Uehara González
Macario Jose Arellano Beltran
Pedro Miguel González Vargas
Maria López Gutiérrez
Aurora Castro Ruiz
César Adán Almendárez Sánchez
Oscar Noe Garcia Galaviz
Edwin Rolando Sánchez Vallejo
Nestor Emmanuel Sanchez Ochoa
Saúl Solonio Pineda
Renato Carvalho Santos
Diego do Monte Rodrigues Seabra
José Alcántara Filgueira Junior
Vithor Ely Bortolin da Silva
Vinícius Rosa de Castro
Antônio Delacy Martini Vial
Eder Rodrigues Queiroz
| Supplementary Table 2. Continued |
|----------------------------------|
| Jhoney Francieis Feitosa         |
| Matheus Torres Dutra Maia da Costa |
| Igor Barreira Magro             |
| Emmanuel De Oliveira Sampaio Vasconcelos e Sá |
| Matheus Pereira Dias           |
| Victor Perez Meireles da Souza  |
| Fernando Levi Alencar Maciel    |
Supplementary Figure 1. Symptoms of COVID-19 presented by residents.