



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.



Neurosurgical Practice During the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Pandemic: A Worldwide Survey

Marco M. Fontanella¹, Lucio De Maria¹, Luca Zanin¹, Giorgio Saraceno¹, Lodovico Terzi di Bergamo², Franco Servadei³, Bipin Chaurasia⁴, Alessandro Olivi⁵, Peter Vajkoczy⁶, Karl Schaller⁷, Paolo Cappabianca⁸, Francesco Doglietto¹

BACKGROUND AND OBJECTIVE: The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic has consistently changed medical practice throughout specialties, regardless of their contribution in facing the disease itself. We surveyed neurosurgeons worldwide to investigate the situation they are experiencing.

METHODS: A 17-question, web-based survey was administered to neurosurgeons worldwide through the World Federation of Neurosurgical Societies and the Neurosurgery Cocktail from March 28 to April 5, 2020, by web link or e-mail invitation. Questions were divided into 3 subgroups: general information, health system organization, and institutional plans for the SARS-CoV-2 outbreak. Collected data were initially elaborated using SurveyMonkey software. Country-specific data were extracted from the World Health Organization website. Statistical analysis was performed using R, version 3.6.3.

RESULTS: Of the 446 respondents, most were from Italy (20%), India (19%), and Pakistan (5%). Surgical activity was significantly reduced in most centers (79%) and dedicated in-hospital routes were created for patients with SARS-CoV-2 (58%). Patient screening was performed only when there were symptoms (57%) and not routinely before surgery (18%). The preferred methods included a nasopharyngeal swab and chest radiograph. Health professionals were rarely screened (20%) and sometimes, even if SARS-CoV-2 positive, were asked to work if asymptomatic (26%). Surgical planning was

changed in most institutions (92%), whereas indications were modified for nonurgent procedures (59%) and remained unchanged for subarachnoid hemorrhages (85%).

CONCLUSIONS: Most neurosurgeons worldwide reported work reorganization and practices that respond to current international guidelines. Differences in practice might be related to the perception of the pandemic and significant differences in the health systems. Sharing data and experiences will be of paramount importance to address the present moment and challenges in the near future.

INTRODUCTION

We are in the midst of a pandemic caused by a novel coronavirus, severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), first detected in Wuhan (China) in December 2019. Since then, coronavirus disease 19 (COVID-19) has spread quickly, with more than 2,000,000 confirmed cases and more than 100,000 deaths on April 19, with 213 countries involved worldwide.¹ Given the serious public health risk, medical practice has consistently changed during the SARS-CoV-2 pandemic. The impact of the COVID-19 outbreak might change in relation to the diffusion of the virus, as well as the health system of the individual country; furthermore, this pandemic is influencing different medical specialties in a variety of ways.² Most surgical subspecialties are not primarily involved in

Key words

- COVID-19
- Neurosurgery
- Survey

Abbreviations and Acronyms

COVID-19: Coronavirus disease 19

CT: Computed tomography

SAH: Subarachnoid hemorrhage

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

WFNS: World Federation of Neurosurgical Societies

Italy; ⁴Neurosurgery, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh; ⁵Neurosurgery, Agostino Gemelli Foundation, Rome, Italy; ⁶Neurosurgery, Charité University Medicine, Berlin, Germany; ⁷Neurosurgery, University of Geneva, Geneva, Switzerland; and ⁸Neurosurgery, Federico II University, Naples, Italy

To whom correspondence should be addressed: Lucio De Maria, M.D.
[E-mail: l.demaria@unibs.it]

Citation: *World Neurosurg.* (2020) 139:e818-e826.
<https://doi.org/10.1016/j.wneu.2020.04.204>

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

Available online: www.sciencedirect.com

1878-8750/\$ - see front matter © 2020 Elsevier Inc. All rights reserved.

From the ¹Neurosurgery, University of Brescia, Brescia, Italy; ²Institute of Oncology Research, Bellinzona, Switzerland; ³Neurosurgery, Humanitas University and Research Institute, Milan,

fighting the disease itself, but they must still change their organization, as most national and international societies suggest stopping all elective activity, maintaining only emergent and urgent procedures.²⁻⁸

Neurosurgeons might feel fairly useless during the SARS-CoV-2 pandemic. However, international guidelines have been introduced calling for a tailored triage according to the degree of emergency,^{3,9,10} and we believe that sharing information about the organization of neurosurgical activity throughout the world might be helpful at this time. Furthermore, it might be interesting to investigate whether there is any association between the level of infection and consequent country reorganization of the neurosurgical system, as well as the neurosurgeons' practice. We, therefore, conducted an online survey that was submitted to neurosurgeons worldwide between March 28 and April 5, 2020, through the World Federation of Neurosurgical Societies (WFNS)¹¹ and the Neurosurgery Cocktail.¹²⁻¹⁴

METHODS

Study Design and Group of Responders

A 17-question, web-based survey was administered to neurosurgeons worldwide through the WFNS and the Neurosurgery Cocktail from March 28 to April 5, 2020, by web link or e-mail invitation (**Supplementary Material**).

The questions were divided into 3 subgroups:

1. Information on the country and its involvement by COVID-19: neurosurgeons were asked about their country of practice, its involvement by the pandemic, and duration of the emergency.
2. Health system organization and screening for health professionals: national and regional measures adopted to face the outbreak were queried, as well as the screening rate and precautions undertaken for SARS-CoV-2–positive health professionals.
3. Institutional plans for the SARS-CoV-2 outbreak: any special measures adopted for SARS-CoV-2–positive neurosurgical patients were investigated, i.e., their screening rate and method, any changes in surgical indications, planning and activity for oncologic procedures, nonemergency surgeries, and subarachnoid hemorrhages (SAHs).

Most questions were closed-ended, multiple choice. Some allowed also an open answer (Q7, 15, and 17; **Supplementary Material**).

The primary goal was to collect data on neurosurgeons' perceptions of the health emergency, the national/regional measures undertaken for health professionals and throughout neurosurgical departments, and the changes in neurosurgical indications, planning, and activity. The secondary aim was to investigate correlations between the data collected and the epidemiologic scenario in each country. The third aim was to look into differences among regions, nations, and territories along with possible causes and consequences of diversities.

Data Collection and Statistical Analyses

Data were initially elaborated using SurveyMonkey software online (SurveyMonkey; San Mateo, California, USA); country-specific

historical data were extracted from the World Health Organization website.¹ For open answers, the most recurring terms were rendered as a "word cloud," in which a population of words is represented with different sizes according to their frequency. Survey's responses to Q3 were first converted into estimates in days (<1 week: 3 days; >1 week to <1 month: 15 days; >1 month to <3 months: 45 days; >3 months: 100 days).

Pearson's correlation was used to estimate the correlation between the number of answers in the surveys with the number of new cases in each country and the duration of the pandemic. The latter was calculated as the difference in days from the first confirmed case to the last day of the survey. A linear regression model was fit to the data. For each country (i), a Deviation from Expected Value (D_i) was calculated as the difference between the observed number of answers and the expected number of answers (E_i) estimated from the linear regression model, such that $D_i = A_i - E_i$, where A_i is the observed number of answers registered for country i. For each country, the median of the differences between each survey's entry date and perception date was calculated. Statistical analysis was performed using R, version 3.6.3.¹⁵

RESULTS

On April 5, 2020, the survey was closed and 446 responses had been collected. The skipping rate for each question ranged from 0% (Q1) to 89% (Q17). Most responses (85%) were filled during only 3 days in March (Saturday 28, Sunday 29, and Tuesday 31).

General Information on COVID-19 Involvement

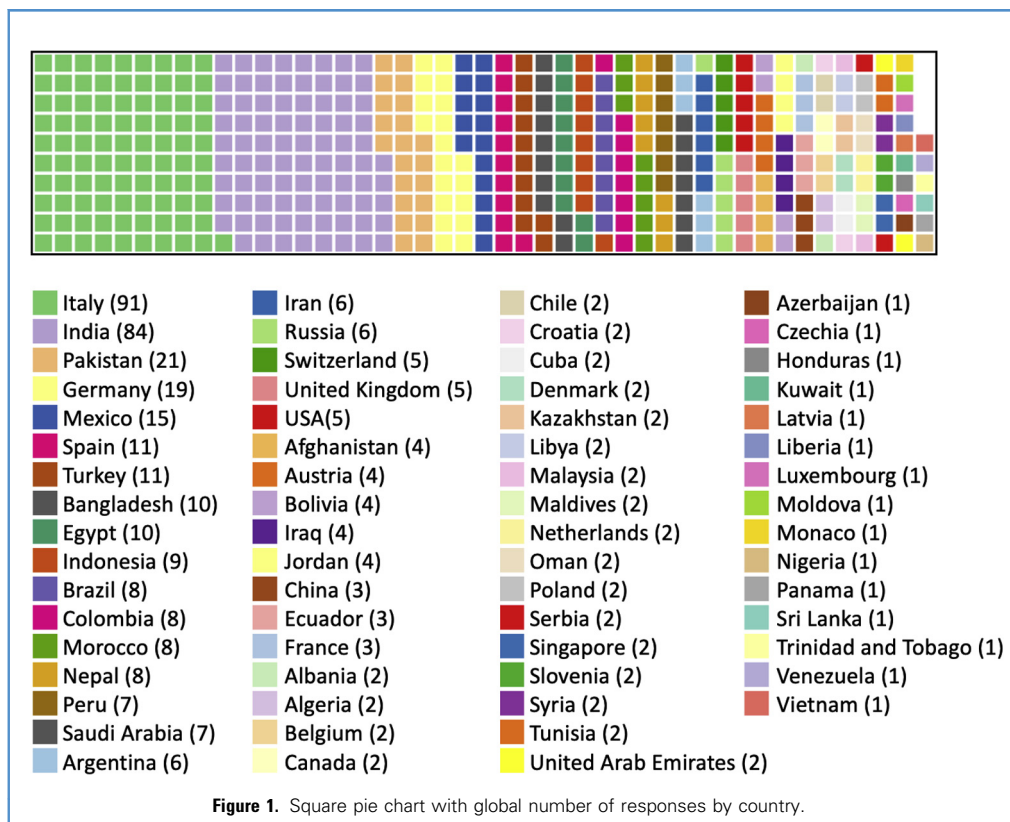
A total of 66 countries worldwide responded to the survey (**Figure 1**). Most respondents were from Italy (20%), followed by India (19%) and Pakistan (5%). Statistical analysis did not reveal a significant correlation between the incidence of disease and number of responses by country (**Figure 2**).

For the majority of respondents (97%), the nation was facing a SARS-CoV-2 outbreak. The duration of the health emergency was between 1 week and 1 month for most respondents (63%), between 1 month and 3 months for 32% respondents, shorter than 1 week for 3% respondents, and longer than 3 months for 2% respondents. **Figure 3** shows correlations between disease activity during the survey and time–length perception of respondents from some countries.

Health System Organization

Regarding the special measures adopted in neurosurgical departments to face the SARS-CoV-2 outbreak, in most cases there was a reduction of surgical activity without centralization (79%), whereas there was a centralization of surgery in high-volume centers in 9% cases and full closure of neurosurgical departments in 5%. No special measures to face the outbreak were reported in 7% of centers. **Figure 4B** shows the categorizations of special measures undertaken by countries in relation to the incidence of disease.

The overall reported screening rate of health professionals for SARS-CoV-2 was 20%; 26% respondents reported that SARS-CoV-2–positive health professionals were asked to keep working if asymptomatic.



Institution Plans for SARS-CoV-2 Outbreak

With respect to the precautions adopted worldwide for SARS-CoV-2—positive neurosurgical patients, in most cases hospitals reserved dedicated routes for them (58%), in 27% cases specific operating rooms were dedicated to patients with SARS-CoV-2, and in 21% cases neurosurgical units were reserved for patients with SARS-CoV-2. Other respondents (21%) replied with open answers and among them, no special measures were usually undertaken.

The overall screening rate for SARS-CoV-2 was 57% for symptomatic patients and only 18% for patients undergoing surgery. The preferred methods for screening was nasopharyngeal swab (86%), followed by computed tomography (CT) scan of the chest (26%) and chest radiograph (25%).

Surgical planning was globally changed in most institutions (92%): only urgent or emergency procedures were performed in 49% cases; urgencies/emergencies and procedures that could not be postponed were performed in 45% cases. Oncologic procedures were preserved in 71% cases. The resulting reduction rate in number of surgical procedures was >70% for almost one half of respondents (47%). Surgical indications for patients with SARS-CoV-2 were modified in 59% cases for pathologies such as chronic subdural hematomas and tumors, whereas the modus operandi in treating aneurysmal SAHs did not change in 85% of centers.

DISCUSSION

This survey, dedicated to neurosurgery and SARS-CoV-2 worldwide, demonstrated a number of interesting findings. A high number of responses ($n = 446$) was received, suggesting a relevant global impact of COVID-19 on the neurosurgical community, even though it is a surgical specialty that is not primarily involved in fighting the disease.¹⁶

General Information on COVID-19 Involvement

Italy and India were the countries with the most respondents (Figure 1). This finding is independent of the incidence of disease, as shown in Figure 2. Conversely, the United States was the country with least number of respondents in relation to the incidence of disease during the study period. Although it might be tempting to relate the number of answers to perception of the health emergency, we should point out that the survey circulated widely among neurosurgeons, but we cannot state that the percentage of respondents (i.e., respondents/nonrespondents) was the same among the different nations. The same correlation was found with regards to the medical perception of disease activity (Q2) in different countries, and only few respondents (3%) claimed their country was not facing the outbreak during the time period studied: among them, neurosurgeons from Germany were probably the

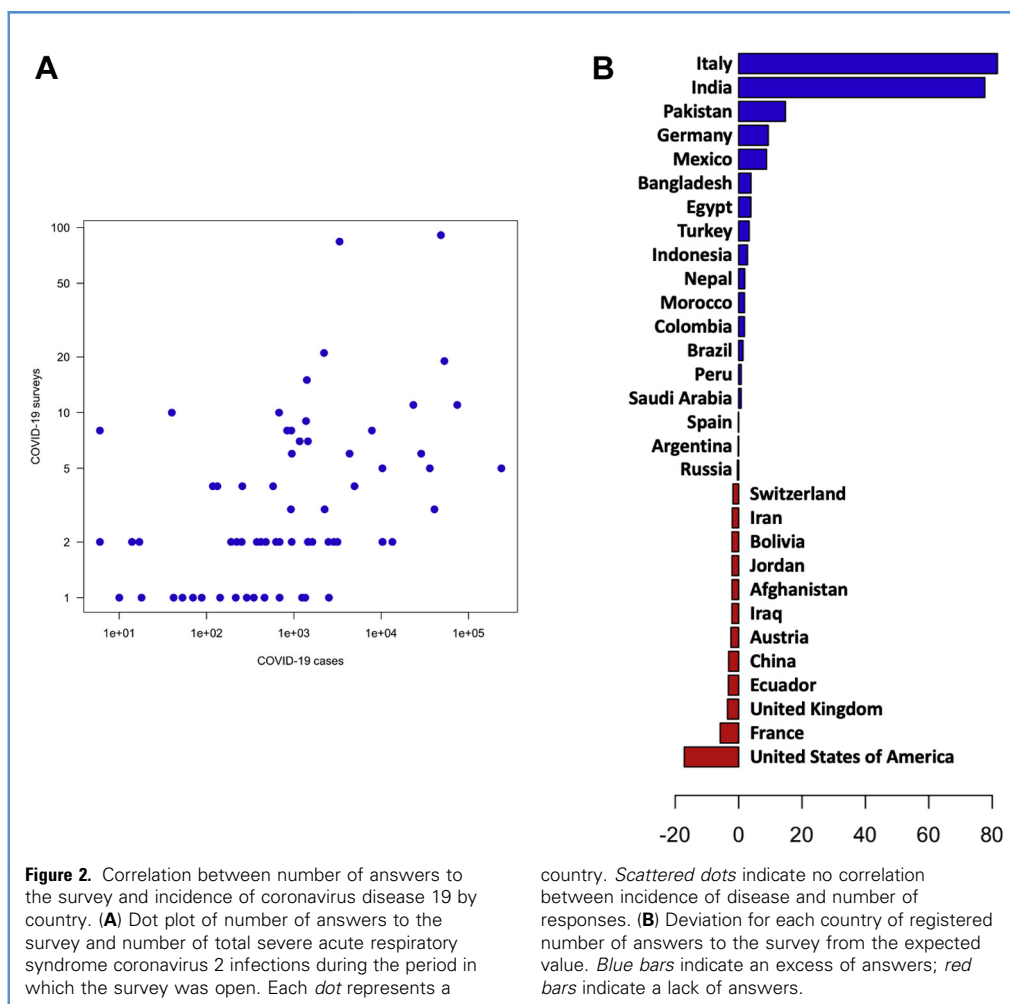


Figure 2. Correlation between number of answers to the survey and incidence of coronavirus disease 19 by country. **(A)** Dot plot of number of answers to the survey and number of total severe acute respiratory syndrome coronavirus 2 infections during the period in which the survey was open. Each dot represents a

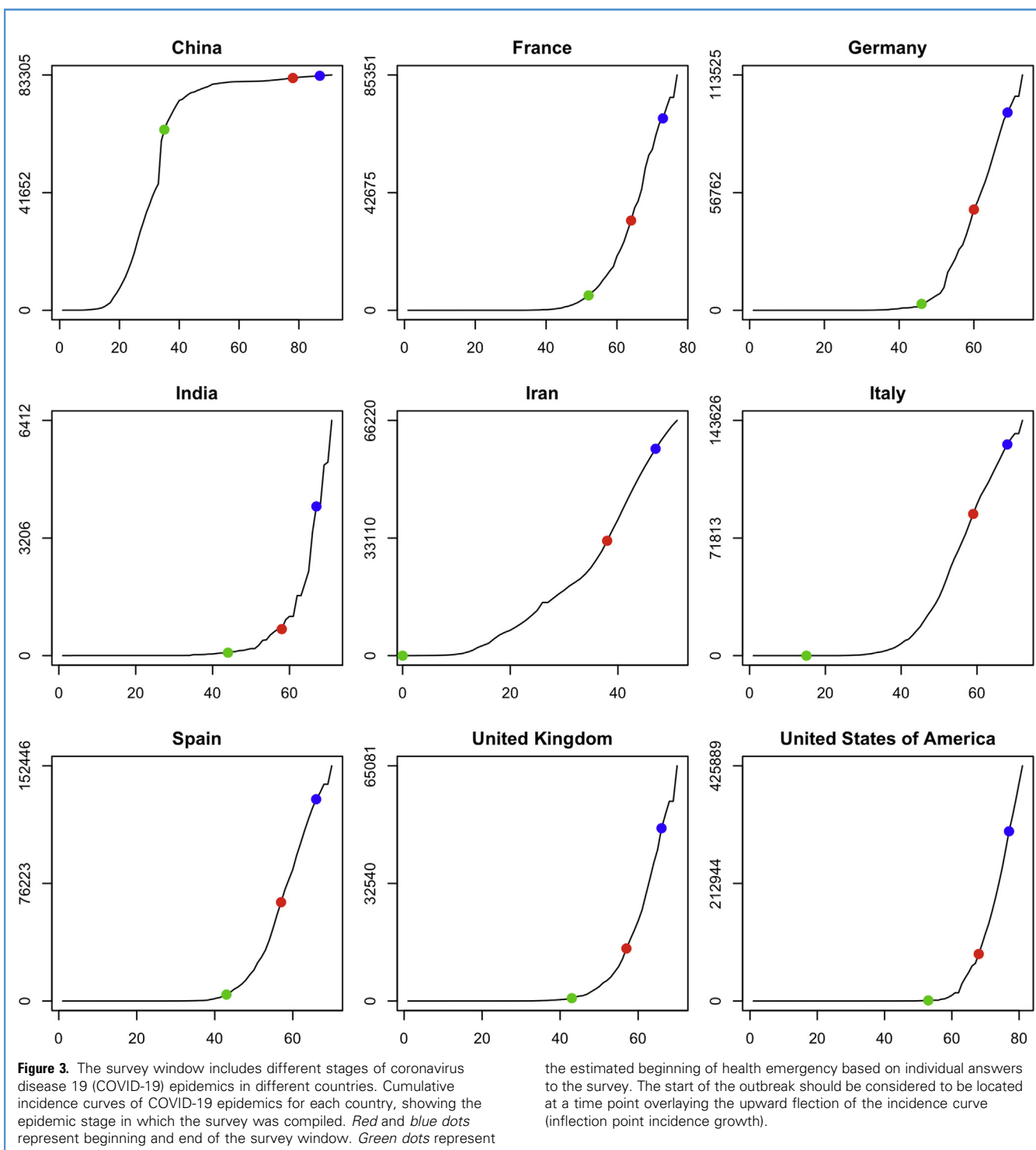
country. Scattered dots indicate no correlation between incidence of disease and number of responses. **(B)** Deviation for each country of registered number of answers to the survey from the expected value. Blue bars indicate an excess of answers; red bars indicate a lack of answers.

most “wrong,” since their country had between 10^4 and 10^5 patients with SARS-CoV2 during the study period (Figure 4A). Notably, reactions and perceptions of COVID-19’s impact on a country may be consistently driven by government actions, as happened in India and Pakistan, where most strict lockdown measures were undertaken with respect to other world countries,^{17,18} possibly influencing general and health professional awareness of the health emergency. Nonetheless, the differences in number of responses might be due to a heterogeneity of the survey distributions among different countries. Furthermore, the perception of the emergency might be related to the health system, with Germany having the greatest rate of intensive care unit beds/population.¹⁹ Regarding the time–length perception of COVID-19, Italian and Iranian respondents perceived the start of the health emergencies much earlier than the actual one (Figure 3); Chinese neurosurgeons, instead, located the start of the health emergency almost at the inflection point of decrease in incidence rate, when the SARS-CoV-2 pandemic was about to reach the plateau phase (Figure 3). The perception corresponded well to reality among the other respondents.

It is tempting to interpret these data as the consequence of the strain that physicians are experiencing in countries with the longest disease involvement at the moment of the study: some might perceive that the emergency is longer than reality due to the continuous stress, or because of media pressure about other countries (i.e., China and Iran) experiencing the outbreak. On the other hand, accumulating evidence shows that SARS-CoV-2 might have been circulating in Italy well before February 21, 2020, thus explaining the significant outbreak that took place in Lombardy in northern Italy.²⁰ Others may perceive that the emergency is shorter than reality due to epidemiology for complex reasons: Chinese people outside Wuhan experienced the outbreak at a later stage of the epidemic and individuals emigrating from Wuhan were the main infection source for other provinces, causing a rapid increase in case load when Wuhan was already in the plateau phase; the general perception in China about the national involvement might have been in reality delayed.²¹

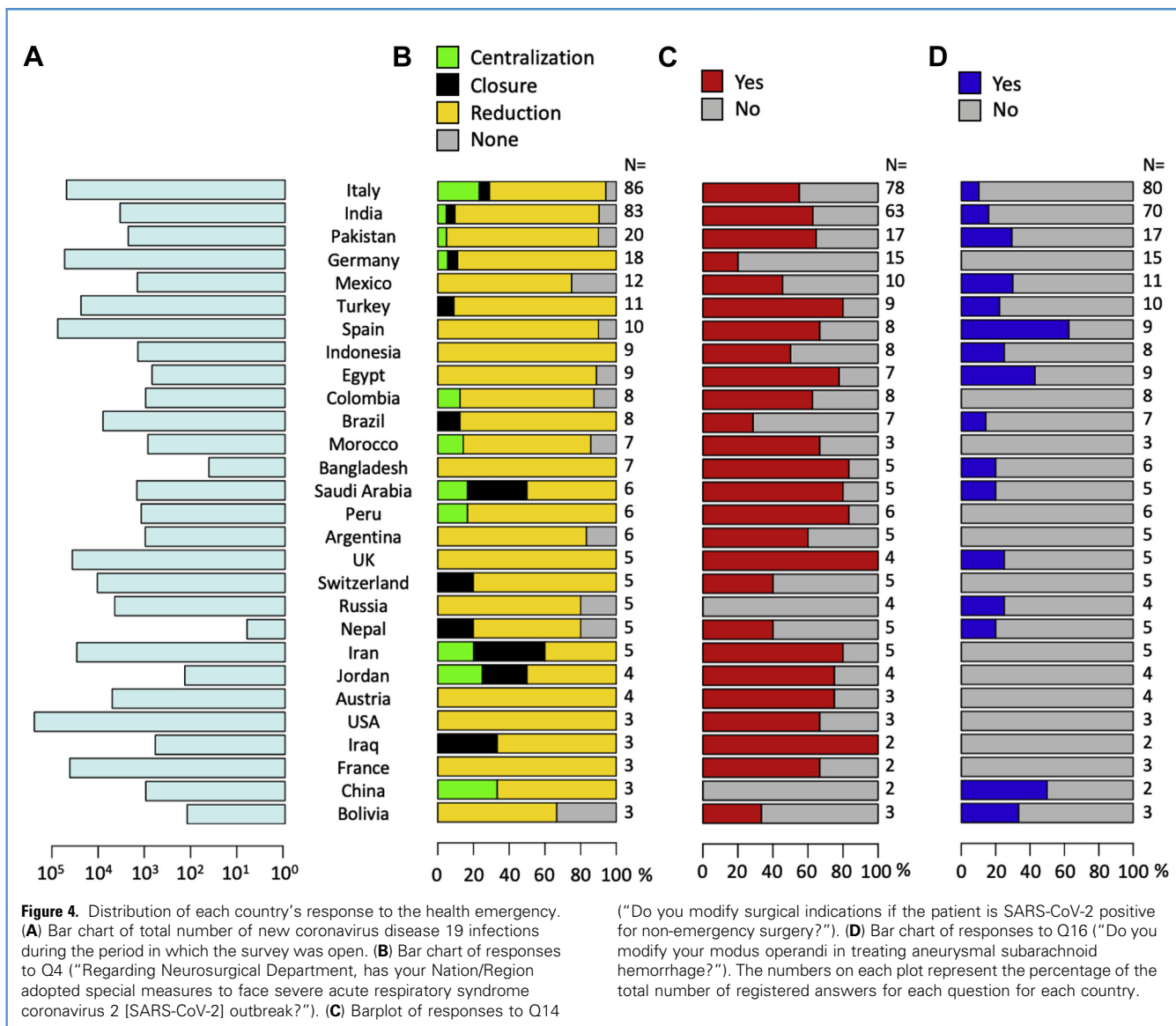
Health System Organization

With respect to health system organization, the most frequent action undertaken globally was reduction of surgical activity without centralization (79%, yellow bars on Figure 4B). Significant



high rates were registered in India (81%) and Pakistan (85%). Centralization of surgery to high-volume centers was reported in only 9% of cases, and Italy was the country with the greatest number of positive respondents (23%), followed by Germany (6%) and

India (5%). Only 7% of respondents report that their country did not undertake any special measure. These data show how most countries acted according to international guidelines in the management of elective procedures.⁵ India and Pakistan have been

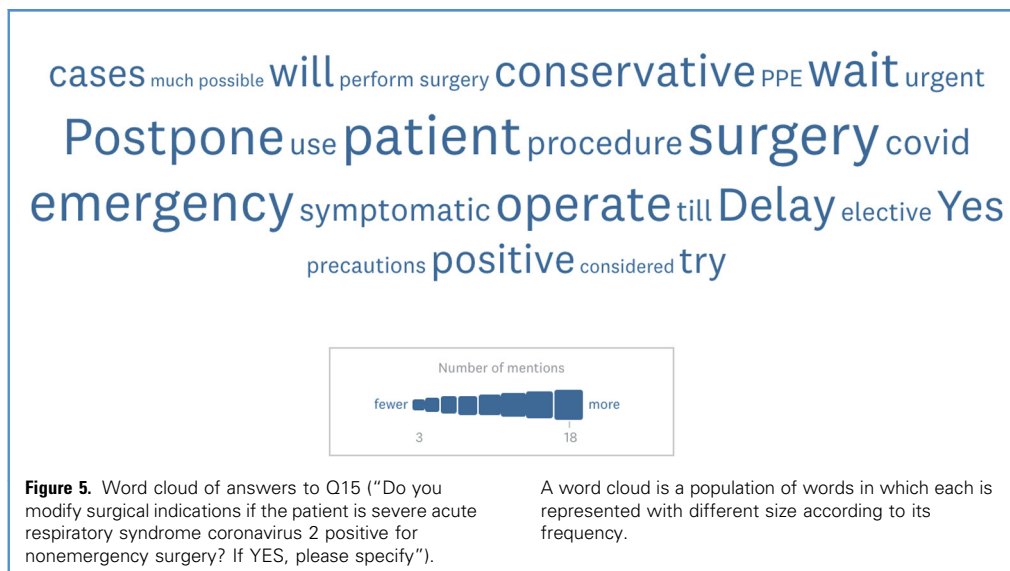


reported to be the world's best respondents to the SARS-COV-2 pandemic,²²⁻²⁴ thus reflecting high rates of neurosurgical activity reorganizations. Neurosurgical centers should undertake national and regional measures to meet patients' needs with logistical capabilities, as reported by guidelines.³ Interestingly, health reorganization may vary significantly even within the same country. More than 100,000 positive cases were confirmed in Italy by April 19, 2020, with more than 30,000 in Lombardy alone.²⁰ In this region, which is still at the center of the health emergency in Italy, neurosurgical departments were urgently reorganized and centralization of surgery in high-volume centers was decided.⁶⁻⁸ Other Italian regions are still facing the health emergency, but at lower levels with incidences that tend to decrease from the north to the south.²⁰ The same incidence disproportion between regions within a country is clearly visible

in even smaller european countries such as Switzerland, where the Cantons of Vaud and Geneva account for more than 4000 cases each, whereas the Canton of Schaffhausen has not yet reached 100 cases.²⁵ These significant variations in a single country justify the different regional reorganizations.

Guidelines for risk assessment and management of exposure of health care workers vary according to the risk of SARS-CoV-2 infection (categorized as high or low) and recommend COVID-19 testing only for workers at a high risk of infection.²⁶ In this sense, the global attitude did not deviate significantly from recommendations,^{3,16} as only 21% of respondents reported ongoing screening for health professionals, mainly from Brazil (50%), Mexico (42%), and Germany (28%).

A minority of respondents (26%) declared that SARS-CoV-2-positive health professionals kept working if asymptomatic, and a large portion of these respondents were from Italy (36%). Indeed,



no clear national guidelines are available for SARS-CoV-2–positive health professionals,²⁷ resulting in heterogeneity of recommendations throughout the country. COVID-19–positive Italian health professionals have reached more than 13,000, with more than 100 deaths of physicians (most of them are general practitioners) and almost 30 nurses.²⁸ At Spedali Civili Hospital, in Brescia in northern Italy, SARS-CoV-2–positive health professionals are not allowed to work, and daily temperature screening procedures are undertaken at the hospital entrance for both health professionals and visitors.²⁹ Nonetheless, there is a general perception that health professionals might have been asymptomatic carriers of the disease.³⁰

Institution Plans for SARS-CoV-2 Outbreak

Regarding precautions adopted worldwide for SARS-CoV-2–positive neurosurgical patients, the most widely undertaken measure globally was to reserve dedicated routes to patients with SARS-CoV-2 (58%), whereas specific operating room and entire neurosurgical units were created in a minority of cases. Some respondents (21%, mainly from Austria, Germany, and United Kingdom) reported not taking any special measures for patients with SARS-CoV-2. However, guidelines clearly state that SARS-CoV-2–positive patients should be cohorted in a separate location from SARS-CoV-2–negative patients and specific hospital policy for management of known or suspected SARS-CoV-2–positive patients in the operating room should be developed.^{31,32} Concerning the screening of neurosurgical patients, facilities should use portable radiography when chest radiographs are considered necessary, thus avoiding the need to bring patients into radiography departments; CT scan of the chest has been recently reported to have a high sensitivity (97%) for COVID-19 screening but lower specificity and accuracy.^{33,34}

A recently published paper in JAMA analyzed the sensitivity of different reverse transcription polymerase chain reaction screening sources demonstrating that bronchoalveolar lavage fluid is the most sensitive specimen (93%), followed by sputum (72%), nasal swab

(63%), fibrobronchoscope brush biopsy (46%), pharyngeal swabs (32%), feces (29%), and blood (1%); the authors underline that multiple testing from different sites improve sensitivity and reduces false-negative results.³⁵ Most guidelines at present recommend a single upper respiratory nasopharyngeal swab for suspect cases.³ In this survey, most respondents referred that nasopharyngeal swab was the preferred method for screening (86%), followed by CT scan (26%), and chest radiograph (25%). Some respondents indicated more than one screening method, especially those from Italy (57%) and India (19%), where the most common combination was the nasopharyngeal swab with chest radiograph.

The COVID-19 outbreak had a relevant impact on surgical planning, with most respondents reporting a significant change in surgical activity in their institutions (92%). The majority (94%) performed only procedures that could not be postponed (i.e., tumors with evident mass effect) and/or urgent/emergency procedures, whereas in a few cases (6%) the entire neurosurgical department was closed. This obviously resulted in a significant reduction of the overall number of surgical procedures: most respondents claimed more than 70% reduction of surgical interventions. Delaying elective procedures has been one of the crucial indications delivered by international societies^{3–5} with many important aims: 1) to contain the spread of SARS-CoV-2, by reducing visits to hospitals by people with no urgent medical issue; 2) to reduce the patient load in intensive care units with non-COVID-19 patients; 3) to reduce the possibility of treating asymptomatic patients with SARS-CoV-2 who would be at high risk of deteriorating due to the surgical stress and would increase the risk of infecting health professionals.

Surgical indications for nonemergency patients with SARS-CoV-2 (i.e., chronic subdural hematomas and tumors) have been modified in only 59% cases, whereas 41% neurosurgeons worldwide referred that their institutions continued operating on elective neurosurgical patients in the same way as the pre-outbreak era; international guidelines clearly state that nonemergency procedures should be delayed.^{3,7} Studying correlations between incidence of disease and

actions undertaken by various countries (Figure 4C), we found that Middle-Eastern nations (i.e., Turkey, Egypt, Saudi Arabia, etc.) were the most reactive to the health emergency, followed by European countries (i.e., Italy, Spain, Austria, etc.), and the Americas (i.e., United States, Mexico, Brazil, etc.).

As for aneurysmal SAHs, most respondents (85%) did not change their indications and treatment (Figure 4D). Even if some of these findings might seem against guidelines, the word cloud resulting from the open answers puts “patient” at the center and sums up what international societies have been suggesting: “Postpone surgery and be conservative as much as possible, delay elective procedures, but, as for emergency symptomatic patients, try to operate with all recommended precautions” (Figure 5). We must indeed stress that all medical efforts, institutional plans, and health system organization would be useless without the appropriate and recommended use of personal protective equipment.^{26,36,37} Although India is the world’s second most populous country, the incidence rate of SARS-COV-2 infections has risen less than other countries since the beginning of the outbreak.³⁸ The reason might be found in the earlier government actions that India undertook while the virus was spreading out from China.^{17,18,39}

Limits of the Study

Our study has many limits. First, it is not an epidemiologic study and does not allow drawing conclusions about the actual prevalence and incidence of the variables investigated. It does allow, though, to draw conclusions regarding the perception of neurosurgeons about the COVID-19 health emergency with respect to the actual epidemiology data. Second, although this survey spread out widely among neurosurgeons, respondents were mostly from Italy, India, and Pakistan, whereas the rest of the world was represented with lesser numbers. Heterogeneity of the survey’s percentage of respondents (i.e., respondents/nonrespondents) among different countries might have biased some responses.

Notwithstanding, this is the first survey conducted on the impact of COVID-19 on the neurosurgical community, and we

believe that data from this study can help neurosurgeons and global health organizations to tackle this health emergency.

CONCLUSIONS

The SARS-CoV-2 pandemic has consistently changed medical practice, with an enormous impact on all specialties, regardless of their contribution in facing the disease itself. Neurosurgeons worldwide have changed their surgical planning and activity, in most cases following national and international guidelines.

Dedicated routes were put in place for patients with SARS-CoV-2 in most cases and surgical activity was limited to procedures that could not be postponed, resulting in an overall reduction of surgeries by more than 70%.

The lockdown will be soon followed by the rebuilding phase, when delayed elective procedures will need to be performed, thus opening a new challenge that to be addressed, possibly by sharing current knowledge and experience worldwide.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Marco M. Fontanella: Conceptualization, Methodology, Validation, Resources, Writing - original draft, Writing - review & editing, Supervision, Project administration. **Lucio De Maria:** Formal analysis, Investigation, Data curation, Writing - original draft, Visualization. **Luca Zanin:** Investigation, Resources, Data curation. **Giorgio Saraceno:** Investigation, Resources, Data curation. **Lodovico Terzi di Bergamo:** Methodology, Software, Validation, Formal analysis, Data curation. **Franco Servadei:** Writing - review & editing. **Bipin Chaurasia:** Resources. **Alessandro Olivi:** Writing - review & editing. **Peter Vajkoczy:** Writing - review & editing. **Karl Schaller:** Writing - review & editing. **Paolo Cappabianca:** Writing - review & editing. **Francesco Doglietto:** Conceptualization, Methodology, Software, Validation, Resources, Data curation, Writing - review & editing, Supervision, Project administration.

REFERENCES

1. Coronavirus Disease (COVID-19). Available at: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019>. Accessed April 19, 2020.
2. CDC. Coronavirus Disease 2019 (COVID-19). Centers for Disease Control and Prevention. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/lab/guidelines-clinical-specimens.html>. Accessed April 11, 2020. Published February 11, 2020.
3. COVID-19 in Neurosurgery News, Guidelines and Discussion Forum. Available at: <https://www.eans.org/page/covid-19>. Accessed April 13, 2020.
4. Current emergencies | CMS. Available at: <https://www.cms.gov/About-CMS/Agency-Information/Emergency/EPRO/Current-Emergencies/Current-Emergencies-page>. Accessed April 13, 2020.
5. American College of Surgeons. COVID-19: Recommendations for Management of Elective Surgical Procedures. March 13, 2020. Available at: <https://www.facs.org/covid-19/clinical-guidance/elective-surgery>. Accessed April 11, 2020.
6. Cenozo 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://doi.org/10.3171/2020.3.JNS20960>, accessed April 13, 2020.
7. Perin A, Servadei F, DiMeco F, ‘Hub and Spoke’ Lombardy Neurosurgery Group. May we deliver neuro-oncology in difficult times (e.g. COVID-19) [e-pub ahead of print]? *J Neurooncol* <https://doi.org/10.1007/s11060-020-03496-7>, accessed April 14, 2020.
8. Zoia C, Bongetta D, Veiceschi P, et al. Neurosurgery during the COVID-19 pandemic: update from Lombardy, northern Italy [e-pub ahead of print]. *Acta Neurochir (Wien)* <https://doi.org/10.1007/s00701-020-04305-w>, accessed April 14, 2020.
9. Actualités/recommandations pour la prise en charge des pathologies neurochirurgicales en période de crise liée au COVID-19/Société Française de Neurochirurgie. Available at: https://www.sfnurochirurgie.fr/fr/actus/pandemie-covid-19-recommandations-pour-la-prise-en-charge-des-pathologies-neurochirurgicales-en-periode-de-crise-liee-au-covid-19/art_id/45. Accessed April 16, 2020.
10. Deutsche Gesellschaft für Neurochirurgie (DGNC). Statements. Available at: <https://www.dgnc.de/gesellschaft/aktuelles/statements/>. Accessed April 16, 2020.
11. World Federation of Neurosurgical Societies. Available at: <https://www.wfnis.org/>. Accessed April 11, 2020.
12. Neurosurgery Cocktail (@BipinChaurasia_)/Twitter. Twitter. Available at: https://twitter.com/bipinchaurasia_?fbclid=IwAR3gRisIeMRfuZsITwP8tQjICQayV9r3j8ixHijvdaWiAYY6Zvo5TglQ3hc. Accessed April 11, 2020.
13. Telegram: Join Group Chat. Available at: <https://t.me/joinchat/GOUlfoGLZb2TEkK2AkQp2wthia?fbclid=IwAR3gRisIeMRfuZsITwP8tQjICQayV9r3j8ixHijvdaWiAYY6Zvo5TglQ3hc>. Accessed April 11, 2020.

14. WhatsApp Group Invite. Available at: https://chat.whatsapp.com/DIWQog2IrbBBSAoFprLd5I7fbclid=IwAR2np6xSLpLakfUgFonNLkSajOYt8xbMzOq8FbgFxyvjQDP8_VzllZeQWW4. Accessed April 11, 2020.
15. R: The R Project for Statistical Computing. Available at: <https://www.r-project.org/>. Accessed April 11, 2020.
16. Burke JF, Chan AK, Mummaneni V, et al. Letter: The coronavirus disease 2019 global pandemic: a neurosurgical treatment algorithm [e-pub ahead of print]. *Neurosurgery* <https://doi.org/10.1093/neuros/nyaa116>, accessed April 16, 2020.
17. Daniyal S. India is enforcing the harshest and most extensive Covid-19 lockdown in the world. Quartz India. Available at: <https://qz.com/india/1828915/indias-coronavirus-lockdown-harsher-than-china-italy-pakistan/>. Accessed April 25, 2020.
18. Coronavirus in South Asia, April 15, 2020: India, Pakistan, and Others Extend Lockdowns; Surge in Bangladesh. Council on Foreign Relations. Available at: <https://www.cfr.org/blog/coronavirus-south-asia-april-15-2020-india-pakistan-and-others-extend-lockdowns-surge>. Accessed April 25, 2020.
19. Rhodes A, Ferdinande P, Flaatten H, Guidet B, Metzitz PG, Moreno RP. The variability of critical care bed numbers in Europe. *Intensive Care Med*. 2012;38:1647-1653.
20. EpiCentro. Focolaio di infezione da nuovo coronavirus SARS-CoV-2: la situazione in Italia. Available at: <https://www.epicentro.iss.it/coronavirus/sars-cov-2-italia>. Accessed April 14, 2020.
21. Chen Z-L, Zhang Q, Lu Y, et al. Distribution of the COVID-19 epidemic and correlation with population emigration from Wuhan, China. *Chin Med J (Engl)*. 2020;133:1044-1050.
22. Coronavirus Disease (COVID-19). Available at: <https://www.who.int/india/emergencies/novel-coronavirus-2019>. Accessed April 25, 2020.
23. Pakistan's response to coronavirus among world's best, says WHO country head. Available at: <https://gulfnnews.com/world/asia/pakistan/pakistans-res-ponse-to-coronavirus-among-worlds-best-says-who-country-head-1.70388431>. Accessed April 25, 2020.
24. How India is responding to COVID-19: quarantine, travel limits and tests. World Economic Forum. Available at: <https://www.weforum.org/tagenda/2020/03/quarantine-india-covid-19-coronavirus/>. Accessed April 25, 2020.
25. COVID19 in der Schweiz. Tableau Software. Available at: https://public.tableau.com/views/Covid19_15852360559170/Dashboard1rd?:embed=y&showVizHome=no&host_url=https%3A%2F%2Fpublic.tableau.com%2F&embed_code_version=3&tabs=no&toolbar=yes&animate_transition=yes&display_static_image=no&display_spinner=no&display_overlay=yes&display_count=yes&publish=yes&loadOrderID=0. Accessed April 16, 2020.
26. World Health Organization. Guidance for health workers. Available at: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/health-workers>. Accessed April 11, 2020.
27. Della Salute M. Covid-19-Raccomandazioni per gli operatori sanitari. Available at: <http://www.salute.gov.it/portale/nuovocoronavirus/dettaglioContenutiNuovoCoronavirus.jsp?lingua=italiano&id=5373&area=nuovoCoronavirus&menu=vuoto>. Accessed April 11, 2020.
28. Coronavirus in Italia, morti altri sette medici: il totale sale a 116. *la Repubblica*. Available at: https://www.repubblica.it/cronaca/2020/04/14/news/coronavirus_in_italia-253948574/. Accessed April 14, 2020. Published April 14, 2020.
29. Asst Degli Spedali Civili Di Brescia. Available at: http://www.asst-spedalivicivi.it/servizi/notizie/notizie_homepage.aspx. Accessed April 11, 2020.
30. Rose C. Am I part of the cure or am I part of the disease? keeping coronavirus out when a doctor comes home. *N Engl J Med*. 2020;382:1684-1685.
31. American College of Surgeons. Maintaining trauma center access and care during the COVID-19 pandemic: guidance document for trauma medical directors. March 20, 2020. Available at: <https://www.facs.org/covid-19/clinical-guidance/maintaining-access>. Accessed April 11, 2020.
32. Congress of Neurological Surgeons (cns.org). Available at: <https://www.cns.org/Default.aspx>. Accessed April 11, 2020.
33. Caruso D, Zerunian M, Polici M, et al. Chest CT features of COVID-19 in Rome, Italy [e-pub ahead of print]. *Radiology* <https://doi.org/10.1148/radiol.2020201237>, accessed April 13, 2020.
34. Ai T, Yang Z, Hou H, et al. Correlation of chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases [e-pub ahead of print]. *Radiology* <https://doi.org/10.1148/radiol.2020201237>, accessed April 16, 2020.
35. Wang W, Xu Y, Gao R, et al. Detection of SARS-CoV-2 in different types of clinical specimens [e-pub ahead of print]. *JAMA* <https://doi.org/10.1001/jama.2020.3786>, accessed April 16, 2020.
36. Guidance for wearing and removing personal protective equipment in healthcare settings for the care of patients with suspected or confirmed COVID-19. European Centre for Disease Prevention and Control. Available at: <https://www.ecdc.europa.eu/en/publications-data/guidance-wearing-and-removing-personal-protective-equipment-healthcare-settings>. Accessed April 14, 2020. Published February 28, 2020.
37. European Centre for Disease Prevention and Control. Guidance for health system contingency planning during widespread transmission of SARS-CoV-2 with high impact on healthcare. Stockholm: ECDC; 2020.
38. India: WHO COVID-19 Dashboard. Available at: <https://covid19.who.int/region/searo/country/in>. Accessed April 25, 2020.
39. Hollingsworth J, McKeehan B, John T, Alfonso F III, Vera A. Coronavirus live news and updates from around the world. CNN. Available at: <https://www.cnn.com/world/live-news/coronavirus-pandemic-04-25-20-intl/index.html>. Accessed April 25, 2020.

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 19 April 2020; accepted 27 April 2020

Citation: World Neurosurg. (2020) 139:e818-e826. <https://doi.org/10.1016/j.wneu.2020.04.204>

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

Available online: www.sciencedirect.com

1878-8750/\$ - see front matter © 2020 Elsevier Inc. All rights reserved.