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.
Early Responses of Neurosurgical Practice to the Coronavirus Disease 2019 (COVID-19) Pandemic: A Rapid Review

John Gerrard Hanrahan1,2, Charlotte Burford3, Gideon Adegboyega4, Marios Nicolaides4, Louis Boyce4, Kendra Wong2, Michail Sideris5

BACKGROUND: The novel coronavirus and subsequent pandemic have drastically transfigured health care delivery. Surgical specialties have seen severe alterations or reductions to practice, with neurosurgery being one example in which staff and resource reallocation has occurred to meet wider public health needs. This review summarizes the published evidence detailing early experiences and changes to neurosurgical practice in response to the coronavirus disease 2019 (COVID-19) pandemic.

METHODS: A systematic review was conducted up until April 21, 2020 in accordance with Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, by searching Medline, EMBASE, PubMed, Scopus, Cochrane Central, and Web of Science Core Collection databases. Individual studies were qualitatively assessed to outline core themes detailing changes to practice. Iterative analysis allowed themes to be developed and applied to all studies included in the review.

RESULTS: In total, 13 themes from 18 studies were identified, grouped into 3 overriding themes: logistics, human resources, and clinical delivery. Studies originated from 3 of the most affected countries (United States, China, and Italy), comprising expert opinions, letters to the editor, editorials, case reports, or perspective pieces. The commonest themes discussed include cancellation of elective operations, reduction in outpatient services, and pandemic rotas.

CONCLUSIONS: This review summarizes the early responses of the neurosurgical community to the COVID-19 pandemic and presents a menu of interventions to be considered in future pandemic response, or in recurrent outbreaks of COVID-19. Whilst our review is limited by the low quality of evidence and rapid rate of change in our understanding of COVID-19, it provides a valuable summary of initial responses by the neurosurgical community to a global pandemic.

INTRODUCTION

The emergence of the novel coronavirus disease 2019 (COVID-19)1 and subsequent pandemic has seen the shape and delivery of health care rapidly change. A worldwide refocusing of health system priorities toward virus detection and response has triggered diversion of resources toward managing the growing burden of medical patients admitted to hospitals with respiratory compromise.2

The COVID-19 pandemic has substantially impacted health systems globally. In developed health systems providing specialized services for patients with complex conditions, urgent reallocation of resources has been required to meet wider public health needs. A classic example is neurosurgical care provision, which often require significant resources, such as multidisciplinary teams and intensive care settings. Such gravid changes in health needs require significant adaptations to service delivery and...
surgical practice. We conducted a systematic review to summarize the published evidence outlining the early experiences and initial changes to neurosurgical practice in response to the COVID-19 pandemic.

METHODS

A scoping review was performed to capture published evidence on early responses to the COVID-19 pandemic in neurosurgery, performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The search was conducted up until April 21, 2020. The initial search included all surgical specialties to improve the sensitivity of the search, with subsequent manual selection of neurosurgical papers from the search results performed by 2 authors (M.N./L.B.). Databases searched included MEDLINE (via Ovid), EMBASE, PubMed, SCOPUS, Cochrane Central, and Web of Science Core Collection. The key words are detailed in Appendix 1.

Each study was assessed by 2 independent reviewers (J.H./G.A.). The origin, design, and subspecialty of each study was noted. Studies were assessed for themes outlining interventions or changes to practice enacted by neurosurgical departments conducted in response to the pandemic. Interventions conducted in response to the pandemic were extracted iteratively from each article, with the final compilation agreed upon by the authorship. Each study was then reanalyzed with the full compilation of interventions. Data were grouped to thematic axes; each axis represented an action or intervention or change to surgical practice. We supplemented the search with policy statements and guidelines from international neurosurgical and surgical bodies providing guidance for service delivery during the pandemic.

Due to the heterogeneity in study design and reporting, quality assessment was performed via structured critical appraisal and synthesis of the data from 3 authors (J.H./C.B./M.S.). Results were accordingly incorporated in the discussion thematic axes.

RESULTS

Scope of Literature

We selected 18 studies4–21 (Figure 1). Table 1 provides a summary of the origin, design, and subspecialty of each study. The majority (N = 9, 50%) were published from the United States, jointly followed by China and Italy (N = 4, 22.2%), comprising perspective pieces, editorials, expert opinions, or letters to the editor. Therefore, a formal quality assessment was performed via critical appraisal of the included manuscripts. One half of the studies provided experiences from the general neurosurgery perspective, with others detailing subspecialty experiences and related recommendations, the most common being neuro-oncology (N = 4, 22.2%).

Themes

An array of 13 discrete thematic (intervention) axes were identified from critical synthesis of the literature (Table 2).

Isolation of Suspected/Confirmed COVID-19 Cases. Ten studies described measures to isolate suspected or confirmed patients with COVID-19,5,7,9,10,13,14,17,18,20 achieved most commonly through designated wards5,9,14,17,18 and intensive care units (ICUs) to manage patients with COVID-19.6,20 Other studies described hospitals allocated to admit suspected patients with COVID-195,20 or to manage non-COVID neurosurgical cases.9 Isolation often began before admission in nonemergency cases and emergencies were treated as suspected COVID-19.1,5,7 In some centers, confirmed patients with COVID-19 were separated from suspected patients with COVID-19.7,18

ICU Capacity. Eight studies outlined interventions to optimize ICU capacity,5,7,9,10,13,16,17,19 with most outlining a need to increase capacity.5,7,9,10,16 Resources were reallocated from operating theaters and previously designed neurologic ICUs reallocated to manage patients with COVID-19.7 Expectation for pediatric resources to supplement the disproportionate disease burden in adults was also noted.19 Postponement or cessation of elective operating, alongside postoperative recovery in alternative care settings, was also initiated to preserve ICU capacity.19

Hub Center Allocation. Three studies all of Italian origin detailed a reorganization of national neurosurgical networks to establish hub centers to deal with specific emergencies.5,8,21

Pandemic Rotas. Introducing pandemic rotas to restructure clinical teams has been proposed to reduce avoidable staff interaction, reducing viral exposure.5,12,14,16,18,20,21 This was achieved by cohorting teams into separate, alternating groups5,10,14,18–21 or encouraging nonessential workers, particularly in the administrative or research faculty, to work from home.22 However, some studies discussed the importance of maintaining essential research facilities such as long-term experiments, employing dual clinical and research staff to continue research duties. This was underpinned in another through the importance of ongoing clinical trials in their later stages.16

Redeployment of Neurosurgical Teams. To maximize the capability of providers to manage the growing burden of medical admissions, neurosurgical staff were reallocated to other departments.5,7,8,11,21 One hospital in Italy saw 75% of their team redistributed to medical teams at one point,5 justified as a rationalization of resources.21 This was mostly to support ward cover,5,21 but one study saw allocation of neurosurgeons to the emergency department.7 In the same study, researchers refocused their efforts from neurosurgery to COVID-19.7

Personal Protective Equipment (PPE). Guidance. A number of studies acknowledged the global shortage of adequate PPE and thus the need to preserve them as much as possible.5,10,12,15,18 Specific guidance on the level of PPE spanned from level 1 for suspected patients with COVID-19, which included surgical cap, surgical face mask, protective gowns, and gloves, to level 3 for confirmed cases, which requires the addition of an N95 mask as well as a face shield and full-face piece respirator.15,17 A particular concern on the rate of false negatives was the focus of 2 studies, urging staff to consider PPE especially in presumed COVID-negative cases.10,15

Cancellation of Elective Surgery. Most studies discussed cancellation of elective surgeries as a priority.4,13,15,16,18,21 This was due to the growing wider public health needs compared with elective surgical care.8,14,16,19 Others highlighted the added risk to patients during
the pandemic. However, one study criticized the dichotomy of emergency and elective care in decision-making, due to the anticipatory harms of delay in those with presently stable disease. Two studies raised the greater risk of transmission to clinicians from surgery. One study highlighted the future need for increased capacity following the pandemic to meet the back-log of delayed elective surgical cases. Remodeling of Outpatient Services. Several alterations to outpatient care were detailed, with most studies describing a reduction in outpatient services. Most studies only allowed urgent or emergency appointments, some with triaging or screening systems in place. Burke et al. scaled provision of clinics depending on pandemic severity. Reductions in services were often compensated with telemedicine alternatives. Disinfection strategies for outpatient departments and patient education on PPE were also implemented, and changes to practice including administration of medications and use of certain procedures were curtailed. However, closer outpatient monitoring of potentially aggressive low-grade gliomas was described as an alternative to standard surgical care.

Patient Education. The responsibility of physicians to educate their patients during this time has been highlighted by the literature. Mohile et al. detailed the need to underpin the importance of handwashing and social distancing measures during patient contact hours. Also, emphasis was placed on communication of potential added vulnerability of certain neurosurgical patients.

Prohibiting Visitors. Several studies limited visitors, some prohibiting them entirely, whereas others allowed patients in pediatric and neonatal ICUs, as well as end-of-life care access to single family member per day. Caridi et al. described a
redeployment of neurosurgical staff to liaison roles facilitating communication between patients and their families.

**Operating Theater Protocols.** Reducing personnel within an operation theater was a common strategy to reduce viral exposure,\textsuperscript{6,12,16,17,19} with specific reference to endonasal interventions.\textsuperscript{15-17,19} Five studies suggested the use of negative-pressure operating theaters to contain airborne pathogens and prevent cross-contamination.\textsuperscript{7,10,12,17,20} Advocation of alternatives to surgery, such as radiosurgery or conservative observation through imaging, were put forward.\textsuperscript{4,16} Intraprocedural antifogging agent for eye protection\textsuperscript{12} as well as the use of double gloves\textsuperscript{17} were pointed out by 2 different studies to ensure accuracy and safety during interventions. Reduced drilling speed was proposed to minimize bone aerosol exposure\textsuperscript{17} in addition to the renunciation of nonessential intraoperative neuromonitoring.\textsuperscript{16} Unnecessary patient interaction was decreased by the use of dissolvable sutures and discharge planning to home rather than care settings.\textsuperscript{9,16}

**Telemedicine.** Telemedicine was discussed as a solution to reducing social contact to mitigate viral exposure.\textsuperscript{6,7,9,11,13,18,19} Video conference sites such as Zoom, Skype, and WeChat have all been put forward as a possible means of secure telehealth platforms for clinical visits and follow-up.\textsuperscript{18,19} Criticisms included socioeconomic barriers posed by this switch, including language barriers, low technical literacy, or little to no internet access.\textsuperscript{15,19}

**Intubation Protocols.** Strict intubation directives aimed to minimize clinician exposure to patient aerosols.\textsuperscript{10,11,16,18,19} Prophylactic as opposed to intraprocedural intubation was favored in most of the literature, with minimal staff present during the procedure.\textsuperscript{10,11,16,19} Mandatory 30-minute delay between intubation and entrance of other operating room staff was trialed by 2 studies to reduce viral particulate exposure.\textsuperscript{11,19}

**DISCUSSION**

This systematic review summarizes the early published responses of neurosurgical departments to the COVID-19 pandemic. It provides a menu of interventions developed and implemented to reduce the spread and impact of the virus. These early experiences provide insights into the initial pandemic responses from health care systems globally, highlighting the common themes in neurosurgical responses during a pandemic. Identifying core themes provides insights to inform responses to future pandemics, or indeed, provide additional considerations in the short term for recurrent outbreaks of COVID-19.

**Scope**

A disproportionate number of studies were published from the United States, likely due to the combination of research capacity...
Table 2. Interventions (Thematic Axes) Described by Individual Studies

| Study ID | Study | ICU Capacity | Isolation of COVID-19 Cases | Staff Deployment | Outpatient Service Reduction | Hub Center Al Location | Elective Case Cancellation | Intubation Protocols | PPE Guidance | Telemedicine | OT Protocols | Prohibiting Visitors | Pandemic Rotas | Patient Education |
|----------|-------|--------------|----------------------------|-----------------|-----------------------------|------------------------|----------------------------|------------------------|--------------|-------------|--------------|----------------|----------------|----------------|-----------------|
| 1        | Bernucci et al., 2020 | +             | +                          | +               | +                          | +                      | +                          | +                      | +            | +           | +            | +             | +             | +             |
| 2        | Burke et al., 2020   | –             | +                          | –               | +                          | –                      | –                          | +                      | +            | +           | +            | –             | –             | +             |
| 3        | Eichberg et al., 2020 | +             | +                          | +               | –                          | –                      | +                          | –                      | +            | +           | +            | +             | +             | –             |
| 4        | Fraser et al., 2020  | +             | +                          | –               | +                          | –                      | +                          | –                      | –            | –           | +            | –             | +             | +             |
| 5        | Ghogawala et al., 2020 | –             | –                          | +               | +                          | –                      | +                          | +                      | –            | –           | +            | –             | +             | –             |
| 6        | Hu et al., 2020      | –             | +                          | –               | –                          | +                      | +                          | +                      | +            | –           | +            | +             | +             | –             |
| 7        | Mohile et al., 2020  | +             | –                          | –               | +                          | +                      | +                          | +                      | –            | –           | +            | +             | +             | +             |
| 8        | Panciari et al., 2020 | –             | +                          | –               | –                          | –                      | –                          | –                      | –            | +           | –            | –             | +             | –             |
| 9        | Ramakrishna et al., 2020 | +             | –                          | –               | +                          | +                      | +                          | +                      | +            | +           | +            | +             | +             | –             |
| 10       | Tan et al., 2020     | +             | +                          | –               | –                          | –                      | –                          | –                      | –            | +           | +            | +             | –             | +             |
| 11       | Wellons et al., 2020 | –             | +                          | –               | +                          | +                      | +                          | +                      | +            | +           | +            | +             | +             | +             |
| 12       | Zhu et al., 2020     | –             | +                          | –               | –                          | +                      | –                          | +                      | –            | –           | +            | +             | +             | +             |
| 13       | Zoia et al., 2020    | –             | +                          | +               | +                          | +                      | –                          | +                      | –            | +           | +            | +             | +             | +             |
| 14       | Caridi et al., 2020  | +             | +                          | +               | –                          | –                      | –                          | +                      | –            | +           | +            | –             | +             | +             |
| 15       | Patel et al., 2020   | –             | –                          | +               | –                          | +                      | –                          | +                      | +            | +           | +            | +             | +             | –             |
| 16       | Alvarez-Pinzon et al., 2020 | –             | –                          | +               | –                          | –                      | –                          | –                      | +            | +           | +            | +             | –             | –             |
| 17       | Wang et al., 2020    | –             | +                          | –               | +                          | –                      | +                          | +                      | +            | +           | +            | +             | +             | –             |
| 18       | Dobran et al., 2020  | –             | –                          | +               | +                          | +                      | –                          | –                      | –            | –           | +            | +             | +             | +             |

ICU, intensive care unit; COVID-19, coronavirus disease 2019; PPE, personal protective equipment; OT, operating theater.
and high disease burden. Four studies provided experiences from China, one of which was a direct account from the central epidemic area where the infection is believed to have originated. Similarly, 4 studies gave accounts from Italy which sustained high infection rates early in the pandemic. This is a strength of this review, as it summarizes primary accounts from the worst-affected nations and their experiences in pandemic response.

**Interventions**

The identified interventions in our review can be grouped into wider over-riding themes: logistics, human resources, and clinical delivery.

**Logistics.** Isolating suspected and confirmed cases required organizational restructuring of hospitals. This requires judicious infection-control practices or division of the multidisciplinary team. With more specialized team members, such as the surgeon or anesthetist, complete team division may be difficult in resource-limiting settings, likely exacerbated by staff redeployment. Such cross-cover may risk contamination of non-COVID-19 wards. Others designated hospitals for patients with and without COVID-19, which may be more effective in preventing contamination but requires a greater pool of resources. This was seen in Italy, where cooperation between centers nationally allowed establishment of hub centers to concentrate specialist resources. Although our review does not compare their efficacy, such approaches should be considered in the context of local resources.

Health systems internationally saw a need to redirect significant resources toward acute medical admissions, particularly ensuring critical care facilities for ventilatory support were made available for patients with COVID-19. Rationalization and competition for these facilities meant providers had to minimize avoidable usage of these resources, through postponing elective surgery. Capacity for COVID-19 admissions was increased through means such as repurposing operating theaters or reallocation of neurological ICU beds. Accounting for the wider public health need, it is incumbent on the neurosurgical team to be perceptive of surges in demand for these facilities in decision-making and patient communication due to competition for high-level resources.

**Human Resources.** Human resource management played an important role in the early responses in this review. The focal role of clinicians providing care means the consequences of health care workers becoming infected is great. Pandemic rota optimizes staffing while maintaining clinician reserves to replace those who develop symptoms, often through minimizing hospital staff attending work or division of teams. Yet, the long-term allocation of clinicians should account for both the pandemic response and the increasing burden of surgical patients who have had interventions cancelled or delayed. Reduced staffing may also risk the quality of care provided by teams during the pandemic, with temporary staff or absence of routine team members impacting continuity of care.

Redeployment of neurosurgical teams to support COVID-19 admissions mirrored the reduction in neurosurgical activity. The impact is likely disproportionately affecting junior staff, where more senior team members were required to manage emergency surgeries to reduce intraoperative time and therefore exposure. Disruption to training programs follows, with implications on the education and progression of trainees. Solutions have been found through online platforms in the continuation of grand rounds, educational conferences, and teaching supported by several webinar series and online lectures provided by international neurosurgical bodies, such as the World Federation of Neurosurgeons (WFNS).

**Clinical Delivery.** Our review saw several significant changes to neurosurgical practice. Triaging of emergencies and urgent cases was seen throughout the literature, requiring centers to carefully select patients to delay intervention. Several studies stated their criteria for such cases, outlining which presentations required emergent management. The American Association of Neurological Surgeons (AANS) and European Association of Neurosurgical Societies (EANS) produced triage guidelines modified from the American College of Surgeons (ACS), who propose a 3-tier system, whereas the Society of British Neurological Surgeons (SBNS) has produced more detailed subspecialty guidance. However, Wollons et al. highlighted the simplification of pathologies to urgent and nonurgent, instead advocating for prioritization based upon anticipated harm of delays. This provides an additional complexity where some diseases may become inappropriate for intervention if delayed. Some studies described a COVID-19 multidisciplinary team who were responsible for such decisions. A consequence of triaging is the cancellation of elective surgeries. Although necessary to allow redirection of resources toward the wider medical needs, the morbidity and mortality of such delays is yet to be seen, alongside the future management of these patients, when normal services resume.

Similarly, a large reduction in outpatient services to provide only essential clinics or treatments was described as another measure to reduce viral exposure. This saw a rapid reliance on telemedicine to provide various aspects of outpatient care. This unprecedented transfiguration of neurosurgical care may have lasting effects on outpatient care. Criticisms to these alternatives focus on the reliance on technology and the disproportionate socioeconomic impact on those who do not have access to such services, alongside the inferior human interface needed for sensitive or significant interactions between neurosurgeons and their patients. Comparisons of these novel services, chiefly focusing on patient outcomes (both clinical and patient-reported outcome measures) to traditional outpatient services will allow true determination of their benefit. It does, however, demonstrate innovation in times of crisis.

Clinical practice was also modified in direct response to the pandemic. Cautions to providing particular surgeries, such as endonasal surgery, intubation protocols, and advocacy of alternative treatment strategies, are examples of early changes to practice. These reflect concerns in the wider literature prompting
strategies to minimize transmission intraoperatively.23 These alterations serve to protect both patients and providers, meaning some actions are not solely patient-centered. Some studies attempted to avoid ICU admissions following certain surgeries, to some actions are not solely patient-centered. Some studies external validity of experiences discussed depend on local resource addressing the pandemic. This was unsurprising due to the rapid learning curve means clinical practice is changing rapidly as more is learned about the virus, impacting the sensitivity of the search. The quality of evidence in this systematic review was limited, formed of editorials, expert opinions, and letters to the editor providing mostly institutional experiences in addressing the pandemic. This was unsurprising due to the proximity of the search to the pandemic outbreak. Further, the external validity of experiences discussed depend on local resource settings and thus may not be globally applicable. However, there is value in corroborating these experiences to inform the wider community on how institutions responded.

Limitations
This review aimed to characterize the scope of the early responses of the neurosurgical community to the COVID-19 pandemic. Thus, the steep learning curve means clinical practice is changing rapidly as more is learned about the virus, impacting the sensitivity of the search. The quality of evidence in this systematic review was limited, formed of editorials, expert opinions, and letters to the editor providing mostly institutional experiences in addressing the pandemic. This was unsurprising due to the proximity of the search to the pandemic outbreak. Further, the external validity of experiences discussed depend on local resource settings and thus may not be globally applicable. However, there is value in corroborating these experiences to inform the wider community on how institutions responded.

CONCLUSIONS
This review provides a summary of published evidence outlining the initial responses of the neurosurgical community to the COVID-19 pandemic. It provides a menu of pandemic response interventions conducted by countries initially with the greatest disease burden of COVID-19 for consideration in response to future pandemics or, in the short term, further peaks in the COVID-19 pandemic. Compiling the early experiences offers health care providers insights into the modeling of neurosurgical units, internationally, to improve service provision and patient safety during a public health crisis.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT
John Gerrard Hanrahan: Conceptualization, Data curation, Formal analysis, Supervision, Writing - review & editing. Charlotte Burford: Formal analysis, Writing - review & editing. Gideon Adegboyega: Data curation, Writing - review & editing, Writing - original draft. Marios Nicolaides: Conceptualization, Data curation. Louis Boyce: Conceptualization, Data curation. Kendra Wong: Data curation. Michail Sideris: Writing - review & editing.
22. Koonin LM, Pillai S, Kahn EB, Moulia D, Patel A. Strategies to inform allocation of stockpiled ventilators to healthcare facilities during a pandemic. Health Secur. 2020;18:69-74.

23. Kolias A, Tysome J, Donnelly N, et al. A safe approach to surgery for pituitary and skull base lesions during the COVID-19 pandemic. Acta Neurochir (Wien). 2020;162:1509-1511.

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 2 June 2020; accepted 20 June 2020
### APPENDIX 1

#### MEDLINE (via Ovid) — April 21, 2020

| #  | Search Term                                | Results |
|----|--------------------------------------------|---------|
| 1  | “2019 nCoV”                                | 640     |
| 2  | 2019nCoV                                   | 4       |
| 3  | “2019 novel coronavirus”                   | 478     |
| 4  | “COVID 19”                                 | 5279    |
| 5  | COVID19                                    | 62      |
| 6  | “new coronavirus”                          | 224     |
| 7  | “novel coronavirus”                        | 1652    |
| 8  | “SARS CoV-2”                               | 1591    |
| 9  | (Wuhan AND coronavirus)                    | 766     |
| 10 | “SARS-CoV”                                 | 3953    |
| 11 | “2019-nCoV”                                | 640     |
| 12 | “SARS-CoV-2”                               | 1591    |
| 13 | OR/1—12                                   | 8556    |
| 14 | exp Specialties, Surgical/                | 197239  |
| 15 | exp Surgeons/                              | 8094    |
| 16 | Surgery                                    | 2612559 |
| 17 | Surgeon OR Surgeons                       | 199120  |
| 18 | Surgical                                   | 1330004 |
| 19 | OR/14—18                                  | 3131041 |
| 20 | 13 AND 19 (2019—Current)                  | 239     |

#### EMBASE — April 21, 2020

| #  | Search Term                                | Results |
|----|--------------------------------------------|---------|
| 1  | “2019 nCoV”                                | 448     |
| 2  | 2019nCoV                                   | 446     |
| 3  | “2019 novel coronavirus”                   | 501     |
| 4  | “COVID 19”                                 | 3141    |
| 5  | COVID19                                    | 3124    |
| 6  | “new coronavirus”                          | 188     |
| 7  | “novel coronavirus”                        | 1450    |
| 8  | “SARS CoV-2”                               | 998     |
| 9  | (Wuhan AND coronavirus)                    | 974     |
| 10 | “SARS-CoV”                                 | 3537    |
| 11 | “2019-nCoV”                                | 448     |
| 12 | “SARS-CoV-2”                               | 998     |
| 13 | OR/1—12                                   | 6820    |
| 14 | ‘surgery’/exp                              | 5258466 |
| 15 | ‘surgeon’/exp                              | 157353  |
| 16 | Surgery                                    | 5011369 |
| 17 | Surgeon OR Surgeons                       | 549723  |
| 18 | Surgical                                   | 2020527 |
| 19 | OR/14—18                                  | 7272063 |
| 20 | 13 AND 19 (2019—Current)                  | 455     |
### PubMed — April 21, 2020

| #  | Search Term                                      | Results |
|----|--------------------------------------------------|---------|
| 1  | “2019 nCoV”                                      |         |
| 2  | 2019nCoV                                         |         |
| 3  | “2019 novel coronavirus”                         |         |
| 4  | “COVID 19”                                       |         |
| 5  | COVID19                                          |         |
| 6  | “new coronavirus”                                |         |
| 7  | “novel coronavirus”                              |         |
| 8  | “SARS CoV-2”                                     |         |
| 9  | (Wuhan AND coronavirus)                          |         |
| 10 | “SARS-CoV”                                       |         |
| 11 | “2019-nCoV”                                      |         |
| 12 | “SARS-CoV-2”                                     |         |
| 13 | OR/1—12 [Title/Abstract]                         | 8228    |
| 14 | Surgical Procedures (MeSH)                       |         |
| 15 | Surgeons (MeSH)                                  |         |
| 16 | Surgery [Title/Abstract]                         |         |
| 17 | Surgeon OR Surgeons [Title/Abstract]             |         |
| 18 | Surgical [Title/Abstract]                        |         |
| 19 | OR/14—18                                         | 1998018 |
| 20 | 13 AND 19 (2019—Current)                         | 242     |

### SCOPUS — April 21, 2020

| #  | Search Term                                      | Results |
|----|--------------------------------------------------|---------|
| 1  | “2019 nCoV”                                      |         |
| 2  | 2019nCoV                                         |         |
| 3  | “2019 novel coronavirus”                         |         |
| 4  | “COVID 19”                                       |         |
| 5  | COVID19                                          |         |
| 6  | “new coronavirus”                                |         |
| 7  | “novel coronavirus”                              |         |
| 8  | “SARS CoV-2”                                     |         |
| 9  | (Wuhan AND coronavirus)                          |         |
| 10 | “SARS-CoV”                                       |         |
| 11 | “2019-nCoV”                                      |         |
| 12 | “SARS-CoV-2”                                     |         |
| 13 | OR/1—12 [Title/Abstract/Keywords]                | 5156    |
| 14 | Surgery                                          |         |
| 15 | Surgeon OR Surgeons                              |         |
| 16 | Surgical                                         |         |
| 17 | OR/14—16                                         | 7132059 |
| 20 | 13 AND 17 (2019—Current)                         | 250     |

### COCHRANE CENTRAL — April 21, 2020

| #  | Search Term                                      | Results |
|----|--------------------------------------------------|---------|
| 1  | “2019 nCoV”                                      |         |
| 2  | 2019nCoV                                         |         |
| 3  | “2019 novel coronavirus”                         |         |
| 4  | “COVID 19”                                       |         |
| 5  | COVID19                                          |         |
| 6  | “new coronavirus”                                |         |
| 7  | “novel coronavirus”                              |         |
| 8  | “SARS CoV-2”                                     |         |
| 9  | (Wuhan AND coronavirus)                          |         |
| 10 | “SARS-CoV”                                       |         |
| 11 | “2019-nCoV”                                      |         |
| 12 | “SARS-CoV-2”                                     |         |
| 13 | OR/1—12                                          | 74      |
| 14 | exp Specialties, Surgical/                       |         |
| 15 | exp Surgeons/                                    |         |
| 16 | Surgery                                          |         |
| 17 | Surgeon OR Surgeons                              |         |
| 18 | Surgical                                         |         |
| 19 | OR/14—18                                         | 232637  |
| 20 | 13 AND 19 (2019—Current)                         | 0       |

### Web of Science Core Collection — April 21, 2020

| #  | Search Term                                      | Results |
|----|--------------------------------------------------|---------|
| 1  | “2019 nCoV”                                      |         |
| 2  | 2019nCoV                                         |         |
| 3  | “2019 novel coronavirus”                         |         |
| 4  | “COVID 19”                                       |         |
| 5  | COVID19                                          |         |
| 6  | “new coronavirus”                                |         |
| 7  | “novel coronavirus”                              |         |
| 8  | “SARS CoV-2”                                     |         |
| 9  | (Wuhan AND coronavirus)                          |         |
| 10 | “SARS-CoV”                                       |         |
| 11 | “2019-nCoV”                                      |         |
| 12 | “SARS-CoV-2”                                     |         |
| 13 | OR/1—12 [Title/Abstract/Keywords]                | 3889    |
| 14 | Surgery                                          |         |
| 15 | Surgeon OR Surgeons                              |         |
| 16 | Surgical                                         |         |
| 17 | OR/14—16                                         | 1633111 |
| 20 | 13 AND 17 (2019—Current)                         | 21      |