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# Neurosurgical Referral Patterns During the Coronavirus Disease 2019 Pandemic: A United Kingdom Experience

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**BACKGROUND:** Coronavirus disease 2019 (COVID-19) is a severe respiratory viral illness that has spread rapidly across the world. However, the United Kingdom has been particularly affected. Evidence has suggested that stroke, cardiac, and spinal presentations decreased during the pandemic as the public avoided seeking care. The effect on neurosurgical presentations and referrals during COVID-19 is unclear. Our aim, therefore, was to describe the referral patterns to a high-volume neurosurgical department in the United Kingdom during the COVID-19 pandemic.

**METHODS:** Electronic referrals were identified from the referrals database from January 1, 2020 to May 31, 2020, inclusive, with January used as the baseline. The demographic data and referral diagnoses were captured on Excel (Microsoft, Redmond, Washington, USA). Statistical analyses were performed using SPSS, version 22 (IBM Corp., Armonk, New York, USA). Differences between referral volumes were evaluated using  $\chi^2$  goodness-of-fit tests.

**RESULTS:** A total of 2293 electronic referrals had been received during the study period. The median age was 63 years. Overall, the referrals had decreased significantly in volume during the study period [ $\chi^2(4) = 60.95; P < 0.001$ ]. We have described the patterns in the daily referrals as the pandemic progressed. The reduction in the volume of referrals for degenerative spine cases and traumatic brain injuries was statistically significant ( $P < 0.001$ ).

**CONCLUSIONS:** The referrals for degenerative spine and traumatic brain injuries decreased significantly during the pandemic, which can be explained by the lower vehicular

traffic and patient avoidance of healthcare services, respectively. The risk of neurological deterioration and increased morbidity and mortality, as a consequence, is of concern, and neurosurgeons worldwide should consider the optimal strategies to mitigate these risks as the pandemic eases.

## INTRODUCTION

Coronavirus disease 2019 (COVID-19) is a severe respiratory illness transmitted by severe acute respiratory syndrome coronavirus 2, which has spread rapidly worldwide in the first one half of 2020 since the first cases were detected in Wuhan, China. At the end of June 2020, >10 million cases had been diagnosed worldwide, and with >500,000 deaths.<sup>1</sup> The United Kingdom has been severely affected, with >250,000 cases, causing substantial strain on the National Health Service (NHS).<sup>2</sup>

As the number of COVID-19 cases increased, the UK government advised the public to avoid nonessential travel and to self-isolate if symptomatic.<sup>3</sup> A country-wide lockdown was instituted on March 23, 2020 to reduce community transmission and prevent NHS resources from being overwhelmed.<sup>4</sup> To aid this, all nonurgent operations were postponed,<sup>5</sup> and services were reorganized, which included opening “Nightingale” hospitals<sup>6</sup> to cater for the burgeoning COVID-19 cases. The lockdown measures were continued until May 13, 2020.

The Society of British Neurosurgeons, in conjunction with the UK Royal Colleges of Surgeons, published guidelines<sup>7</sup>—similar to the reported practice around the world<sup>8</sup>—on optimizing resource allocation during the pandemic. The guidelines also offered guidance on prioritizing elective neurosurgical operations to ensure that patients at risk of life- and sight-threatening

### Key words

- COVID-19
- Neurosurgery
- Pandemics
- Physicians
- Practice patterns
- Referral and consultation
- Workload

### Abbreviations and Acronyms

**CES:** Cauda equina syndrome

**COVID-19:** Coronavirus disease 2019

**NHS:** National Health Service

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deterioration could be treated promptly. Therefore, and as a part of our institution's COVID-19 response, our department halved the neurosurgical operating workload, postponed nonurgent operations, converted a 30-bed neurosurgical ward to a "COVID-19" ward, and reallocated junior medical staff to other medical specialties.

As both the lockdown and the pandemic progressed, it was apparent that a drastic decrease had occurred in the number of patients presenting to the emergency department, including stroke and cardiac patients,<sup>9</sup> likely resulting from patient anxieties about infection and overburdening healthcare services. Similar concerns, especially with the decrease in stroke admissions, were echoed across the world.<sup>10-12</sup> Within neurosurgery, the numbers of admissions or presentations for spinal pathological entities also decreased significantly in volume during this time in Italy<sup>13-15</sup> and Germany.<sup>16</sup> In contrast, road traffic collisions had been reported to be lower during the pandemic, because the public was avoiding nonessential travel.<sup>17</sup> Nevertheless, neurosurgeons had an underlying concern that neurosurgical patients could experience neurological deterioration if access to treatment and surgery were delayed.<sup>18-20</sup>

Although the decrease in the number of spinal and trauma patients was noted during this time, it was unclear whether any other neurosurgical conditions had been similarly affected. Also, no data have been available on these presentations during the pandemic from the United Kingdom.

Our aim, therefore, was to quantify the referral patterns to our neurosurgical department during the COVID-19 pandemic. The study period was set from January 1, 2020 (roughly 1 month before the first UK cases had been diagnosed) to May 31, 2020 (which included the 2 weeks after the lockdown had been eased) to identify the trends in referrals from the beginning of the UK experience, through the lockdown, and after the lockdown had been relaxed.<sup>21</sup>

## METHODS

### Study Setting

Our institution is a level I trauma center in the northeast of England serving a population of >3 million people. A total of 71 inpatient neurosurgical beds are available in 2 wards and a day surgery unit. On-call spinal services are provided by both orthopedic and neurosurgical spinal consultants. Four neurosurgical operating theaters are run on weekdays, including a dedicated emergency theater.

### Referral Platform

Referrals for both emergency and nonurgent referrals are received via the referapatient website (Bloomsbury Health Ltd., London, UK).<sup>22</sup> All those providing referrals are encouraged to use the website to ensure that all referrals have been logged, monitored, and responded to in a timely manner, unless it is a life-threatening emergency. For emergency referrals, those providing referrals are encouraged to send a retrospective electronic referral. The referrers are required to provide patient demographics and clinical details, including the relevant history, examination, and imaging reports. The referrals are read and responded to by the

on-call resident. Follow-up queries by either the referrers or the residents can be sent through the same platform.

### Data Collection

All referrals recorded on the referapatient database from January 1, 2020 to May 31, 2020 were reviewed under the auspices of service evaluation. Duplicate referrals were excluded. Referrals for spinal trauma, spinal infections, and extradural spinal tumors were excluded for the dates for which the neurosurgical service was not on-call for spinal referrals. January was used as the baseline to compare the referral patterns across the subsequent months.

The patient demographics, time and date of the referral, and diagnoses were captured using an Excel (Microsoft, Redmond, Washington, USA) spreadsheet. The referral diagnoses were grouped into the following categories: 1) traumatic brain injury (including acute subdural hematoma); 2) degenerative spinal diseases of the whole spine (including suspected or confirmed cauda equina syndrome [CES]); 3) intracranial and intradural spinal tumors; 4) spontaneous intracerebral hemorrhage or ischemic stroke; 5) spontaneous subarachnoid hemorrhage and other neurovascular lesions (e.g., arteriovenous malformation, arteriovenous fistula, unruptured aneurysm); 6) chronic subdural hematoma and subdural collections or hygroma; 7) hydrocephalus or shunt-related issues; 8) postoperative complications; 9) spinal fractures; 10) infections of the central nervous system (not postoperative); 11) Chiari or other hindbrain anomalies; 12) pituitary lesions; 13) congenital spinal lesions or spinal dysraphism; 14) congenital cranial lesions; and 15) spontaneous or traumatic cerebrospinal fluid leakage.

### Statistical Analysis

Statistical analyses were performed using SPSS, version 22 (IBM Corp., Armonk, New York, USA). Differences between the referral volumes were evaluated using  $\chi^2$  goodness-of-fit tests. Statistical significance was set at the 95% level ( $P = 0.05$ ).

## RESULTS

### Demographics

A total of 2293 electronic referrals were received from January 1, 2020 to May 31, 2020, inclusive. The median patient age was 63 years, and men represented 50.5% of all referrals. The total volume of referrals stratified by each month of the study period is presented in **Table 1**. Most referrals had been received on either a Friday (17.2%) or Wednesday (15.8%), with the fewest number of referrals occurring on the weekends.

### Referral Patterns During the Pandemic

The daily referrals compared with the number of UK-wide COVID-19 cases and deaths, respectively, are shown in **Figure 1**. Overall, the number of referrals had decreased significantly in volume during the study period [ $\chi^2(4) = 60.95$ ;  $P < 0.001$ ]. The referral volume in the baseline month of January and during the early phase of the COVID-19 pandemic—between the first cases of COVID-19 in the United Kingdom (January 31, 2020) and the UK government's advice to the public to self-isolate if they had symptoms (March 12, 2020)—were consistently between 15 and 20 referrals daily. The referral volume had subsequently decreased

**Table 1.** Total Volume of Referrals per Month

Month	Total Referrals (n, %)
January	572 (24.9)
February	505 (22.0)
March	423 (18.4)
April	352 (15.4)
May	441 (19.2)

gradually as the number of COVID-19 cases increased, the NHS decided to postpone all elective surgery (March 17, 2020), and schools were ordered to close (March 18, 2020). A steeper decline in referrals was noted when the UK government announced a lockdown to limit community transmission (March 23, 2020) to a 7-day rolling average of 10 referrals daily. The referral volume remained steady at ~10 daily referrals for the subsequent 4 weeks, as the number of COVID-19 cases and deaths increased significantly. On April 25, 2020, attendance to emergency departments was shown to have halved, and the public were encouraged to seek healthcare, if needed. Thereafter, daily referrals had increased to an average (7-day rolling) of 15 referrals daily, well before the lockdown had been eased (May 13, 2020). This pattern held steady for the rest of May.

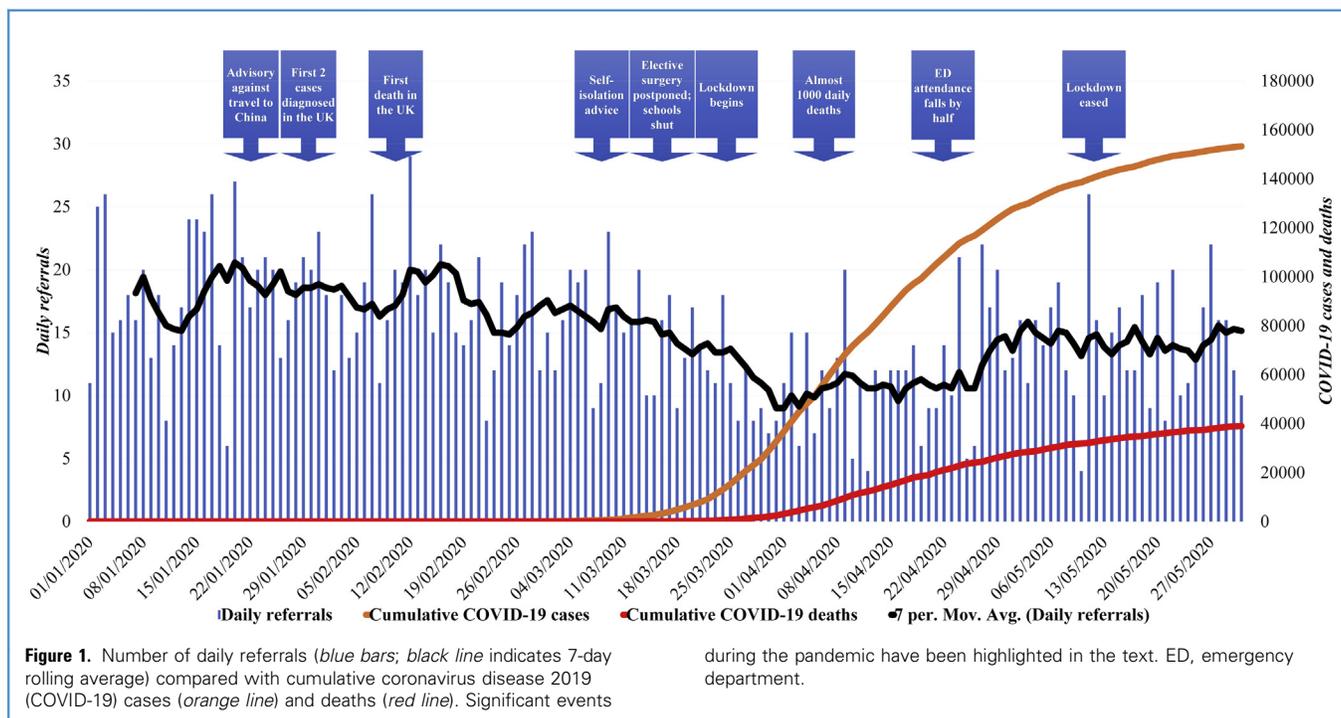
### Diagnoses

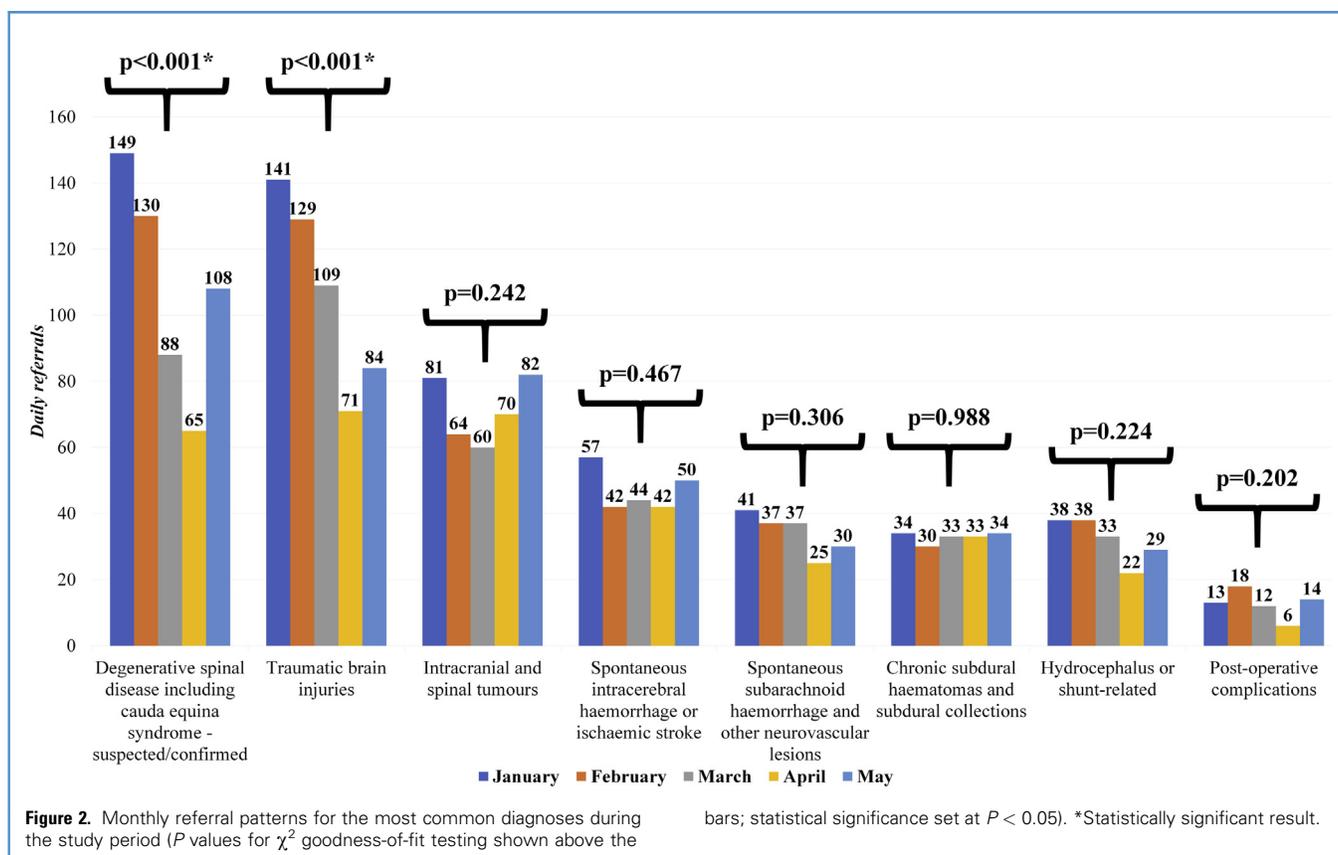
The referral volume stratified by the diagnosis during the study period is shown in **Figure 2**. Overall, the most common reasons

for referral to neurosurgery during the study period were 1) degenerative spinal disease, including suspected or confirmed CES (24.3%); 2) traumatic head injuries (24.0%); 3) intracranial and intradural spinal tumors (16.1%); 4) spontaneous intracerebral hemorrhage and ischemic stroke (10.6%); 5) spontaneous subarachnoid hemorrhage and other neurovascular lesions (7.6%); 6) chronic subdural hematoma and subdural collections (7.4%); 7) hydrocephalus and shunt-related issues (7.2%); and 8) postoperative complications (2.8%). Together, these 8 categories of referrals comprised 96.9% of the overall workload during the study period. Of the degenerative spinal conditions referred to the institution, only 16.4% had been regarded as suspected or confirmed CES.

A statistically significant reduction had occurred in the volume of referrals for degenerative spinal conditions and traumatic brain injuries ( $P < 0.001$ ). Referrals for degenerative spinal conditions had decreased by 56.4% from January to April but had increased by two thirds (66.2%) from April to May. Of the degenerative spinal condition cases, referrals for suspected or confirmed CES had decreased drastically from 31 in January to 9 in March. In the subsequent 2 months, a slow increase had occurred in the number of these referrals (12 in April and 14 in May). Referrals for suspected or confirmed CES also comprised one fifth of all degenerative spine referrals (20.8%) in January. During the following months of February to May, the referrals for suspected or confirmed CES constituted a much smaller proportion of all the degenerative spine referrals, comprising 7.7% of referrals in February before increasing to 18.5% of referrals in April and 13.0% of referrals in May.

The referrals for traumatic brain injuries had decreased by almost one half (49.6%) from January to April. Similar to the





degenerative spine referrals, the head trauma referrals had decreased steeply from January to April but then increased from April to May by 18.3%. No statistically significant differences were found in the referral volumes across the study period for any of the other referral categories.

Oncology-related referrals appeared to decrease from January to March but had increased in April and May to the same level as in January. Likewise, referrals for stroke syndromes had decreased by 26.3% from January to February and then remained constant at ~40 referrals until April before the volume had increased to a level similar to that in January.

The referrals for spontaneous subarachnoid hemorrhage and neurovascular diseases were consistent from January to March but then decreased by 39.0% in April. Although the number of referrals had increased in May, it was still less than that in the initial few months of the study period. The referrals for hydrocephalus and shunt-related issues followed the same pattern. The differences were not statistically significant for either category. The referrals for chronic subdural collections and postoperative complications were mostly stagnant during the pandemic, although a wider variation was seen for the referrals for postoperative complications.

The referral patterns also differed by gender. Referrals for female patients with degenerative spinal disease had decreased by 64.9% from January to April compared with those for male patients, for whom it had decreased by 40.4% during the same

period. In addition, a slightly greater decrease had occurred in male traumatic brain injury referrals compared with the number of female referrals from January to April (50.6% vs. 48.2%, respectively). The number of oncological referrals were also in stark contrast between the genders. Referrals for intracranial and intradural spinal tumors had increased by 7.9% for male patients from January to April but had decreased by 32.6% for female patients for the same period. A similar pattern was apparent for referrals for chronic subdural hematoma. Other referral categories had generally had a comparable decrease in volume for both male and female patients.

## DISCUSSION

We have reported the neurosurgical referral patterns to our department during a 152-day period as COVID-19 infections spread throughout the United Kingdom. Traumatic brain injury referrals had decreased significantly during the study period. The lockdown, combined with the public avoiding nonessential travel, were likely behind the sizeable reduction in head injuries. The road traffic volume had decreased by >70% during the pandemic; thus, the public health gains—from the standpoint of head injuries—is of great interest.<sup>23</sup> Trauma accounts for 9% of worldwide deaths and has been predicted to become one of the leading causes of death by 2030.<sup>24</sup> Also, road traffic accidents have remained the primary mechanism of injury in these

cases.<sup>25</sup> The benefits resulting from lockdown and travel restrictions—although necessary in a pandemic—in reducing head injuries can be seen from these results (Figure 2). However, road traffic increased again as the lockdown was eased.<sup>26</sup> As the world progresses toward a COVID-free era, the advantages of restricting road traffic and encouraging the public to work from home, where possible, should be strongly considered by healthcare services as a key mechanism in reducing the burden of traumatic brain injuries. Arguably, a worldwide restriction on vehicular traffic could do more to reduce head injury-related morbidity and mortality than any advances in neurosurgical or neurocritical care have accomplished thus far. In contrast to vehicular traffic, alcohol sales during the pandemic increased disproportionately, even as restaurants and bars were closing.<sup>27</sup> The falls and violence related to alcohol use might have been the underlying cause of head injuries during the lockdown period.

Referrals for degenerative spinal conditions had also decreased significantly during the study period. The reported data are also consistent with this finding, with investigators reporting a comparable reduction in spinal case volume in other parts of the world during the pandemic.<sup>13-16,28</sup> Of grave concern, however, was the decline in referrals for suspected or confirmed CES from January to March, which might suggest that patients with critical neurological symptoms were avoiding healthcare services despite their condition. The proportion of spine referrals that had been for suspected or confirmed CES had also decreased from one fifth of cases in January to 7.7% in February. This proportion had increased subsequently to 10.2%, 18.5%, and 13.0% of spine referrals in March, April, and May, respectively. This fluctuation might well reflect a natural variation in the proportion of CES referrals in spinal cases. However, a worry remains that patients with CES symptoms were not presenting to healthcare services. Inappropriate allocation of this diagnostic code might also have played a part in over- or underestimating these CES-related referrals.

For those who chose to stay at home, a lingering concern remains of further neurological deterioration while these patients wait for the healthcare systems to recover, which could mean that the neurological damage becomes irreversible.<sup>19,29,30</sup> Inherent medicolegal and financial implications are also present. Although it could be argued that appropriate triage of these cases during the pandemic would have ensured that such patients had undergone surgery regardless, it is also not unreasonable to assume that a few patients might have “slip through the net” and thus experienced poor outcomes. With the pandemic appearing to be under control, elective operations have been increasingly performed; however, the backlog of patients on waiting lists will mean that a number of patients will have had their treatment delayed considerably, with a potential knock-on effect on neurological function.<sup>31</sup>

The lockdown also restricted the most physically demanding occupations from continuing their trade, and most of the working population was restricted to their home, which could also explain the lower rates of spinal referrals.<sup>13</sup> It is not possible to comment yet on whether any patients with degenerative spinal diseases have experienced any deterioration during this period. However, if no such neurological worsening has occurred, it would reassure us that patients can tolerate conservative management and that

appropriate patient selection for spinal surgery will continue to be of paramount importance. Investigators elsewhere have also reported that patients with back pain might have been improperly accessing healthcare services at hospitals, bypassing primary care providers in “normal” times, which could also explain the decrease in these referrals during the study period.<sup>13,15</sup>

The referrals for stroke syndromes decreased from the baseline month of January to April. This finding is in keeping with the reported data that suggested that stroke admissions had decreased significantly across the world.<sup>10</sup> However, caution must be taken to extrapolate the neurosurgical referrals for strokes to the admission or treatment patterns for patients with stroke in general.

The potential for the neurological function of patients with cancer to deteriorate is ever present; thus, it was worrying to note the decline in such referrals during the pandemic-affected months. This phenomenon might be a reflection of a few scenarios. First, new presentations for tumors could have been delayed as patients chose to isolate at home and avoid presenting for primary or secondary care. Second, access to cancer therapies (e.g., chemoradiotherapy) was severely curtailed during the study period to avoid immunosuppression in this cohort during the pandemic.<sup>32</sup> As such, the decline in referrals might reflect the reduced volume of treated oncology patients. Finally, the restricted operative capacity would also have meant that oncology patients with stable neurological symptoms or non-life- or vision-threatening symptoms were deferred.

Concerns about infection and travel restrictions can raise doubts in patients' minds about the suitability of seeking medical attention for symptoms that might seem innocuous (e.g., headaches). The referral volume for subarachnoid hemorrhage and neurovascular cases had remained steady during the initial months of the pandemic but had decreased in April, which could well reflect seasonal variation. However, this decrease in referrals was concerning because patients might have elected to manage their headaches at home, leading to delayed presentations.<sup>29</sup> The risks of rebleeding, hydrocephalus, electrolyte disturbances, and delayed ischemic neurological deficits are considerable if these patients remain untreated, with consequent risks of morbidity and mortality. Likewise, patients with shunts might have chosen to manage their nondistressing symptoms at home as best as they could, which might explain the lower referral rates in April. The pandemic could have also discouraged the “worried well” from exposing themselves to infection by attending hospitals. The fluctuating referral rates for postoperative complications can be attributed to the greatly reduced operating workload of the department. However, this group of patients—who are at risk of infective complications after major neurosurgery—could have also chosen to manage their complications at home. Thus, the potential for worse postoperative outcomes if that was the case is of concern.

In the future, as the COVID-19 pandemic slows, neurosurgical centers must be prepared to manage an increased demand on resources as referrals and operative volume inevitably increase to pre-COVID-19 levels. Strategies could include adding extra operating lists, extending the working hours of elective theaters, and using spare theater capacities at other regional neurosurgical centers or private hospitals.<sup>33</sup> At our institution, the operating

capacity has been expanded by using available theaters at private hospitals, and consultants have been encouraged to reduce their waiting lists by using these additional operating theaters. Discussions have also been ongoing regarding adding extra elective operating lists on the weekend. Patients have continued to be advised to self-isolate for 2 weeks before an elective procedure and must have had a negative viral swab result for COVID-19 before admission. Emergency admissions have continued to be managed as suspected COVID-19 cases, with isolation until the test result from a viral swab is negative. Outpatient consultations have continued to be held via telephone, and appropriate social distancing measures and personal protective equipment protocols have remained in place to limit transmission. As of late June 2020, all inpatient neurosurgical beds and dedicated neurosurgical theaters are available for use by the department. Nevertheless, sickness and fatigue among the workforce, a lack of critical care beds, the persistent risk of new infections, and the added financial burden of extra operating lists are some of the key issues that could affect the delivery of neurosurgical care in the forthcoming months.

### Study Strengths and Limitations

We have reported the referral patterns from a busy neuroscience center during the pandemic's rise, its peak, and as it has plateaued across the United Kingdom. The large number of referrals allowed for meaningful comparisons and conclusions to be drawn from the dataset. As such, to the best of our knowledge, the present study is the first to report the referral patterns from the United Kingdom, and we hope that our findings will be of assistance to colleagues around the world as they plan how to rebuild their services as the pandemic wanes.

The present study had a few limitations. As a single-center study, it was not possible to extrapolate these patterns to the rest of the United Kingdom or the world. However, we found parallels in the reported data (e.g., degenerative spinal cases). Our institution has a jointly run orthopedic and neurosurgical spinal service; thus, referrals for spinal trauma, infection, and extradural tumors or malignant spinal cord compression were vastly

underrepresented in the present study and could have been a significant part of the neurosurgical workload elsewhere. Just as with other registry and database studies, the quality of the dataset was entirely dependent on accurate data collection by the users, both at the time of the referral and in selection of the appropriate diagnosis by the on-call resident.

### CONCLUSIONS

We have described the pattern of neurosurgical referrals and how they changed as COVID-19 spread throughout the United Kingdom. Referrals for degenerative spine and traumatic brain injuries decreased significantly during the pandemic, which can be explained by the lower vehicular traffic and patient avoidance of healthcare services, respectively. We also noted a nonsignificant decline in the referral volume for stroke syndromes, subarachnoid hemorrhage, and tumor cases during the pandemic months. The risk of neurological deterioration and increased morbidity and mortality, as a consequence, is of significant concern, and neurosurgeons worldwide must consider the optimal strategies to mitigate these risks as the COVID-19 pandemic eases.

### CRedit AUTHORSHIP CONTRIBUTION STATEMENT

**Nithish Jayakumar:** Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft, Visualization. **Oliver Kennion:** Methodology, Investigation, Validation, Writing - review & editing. **Alvaro Rojas Villabona:** Methodology, Investigation, Validation, Writing - review & editing. **Menaka Paranathala:** Methodology, Investigation, Validation, Writing - review & editing. **Damian Holliman:** Conceptualization, Methodology, Writing - review & editing, Supervision.

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