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## Telemedicine in Neurosurgery During the COVID-19 Outbreak: Where We Are 1 Year Later

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■ **BACKGROUND:** Telemedicine use skyrocketed in March 2020 on implementation of shelter-in-place measures owing to the coronavirus disease 2019 (COVID-19) pandemic. Within the past year, shelter-in-place measures were lifted and the COVID-19 vaccine was released, resulting in many neurosurgeons returning to in-person outpatient clinics. This study aimed to determine the extent of usage of telemedicine in neurosurgery 1 year into the COVID-19 pandemic.

■ **METHODS:** A retrospective cohort study of patients who received neurosurgical care at a single institution from February 1 to April 18 of the years 2020 and 2021 was performed. The inclusion criteria were met by 11,592 patients. During the 2 study periods, 1465 patients underwent surgery, 7083 were seen in clinic via an in-person meeting, and 3044 were assessed via telemedicine.

■ **RESULTS:** At 1 year after the COVID-19 outbreak, telemedicine usage was at 81.3% of the initial volume on implementation of shelter-in-place measures. In-person outpatient visits increased 40.2% from the early pandemic volume. Among the 4 neurosurgery divisions, telemedicine usage remained high in tumor and functional neurosurgery, significantly increased in vascular neurosurgery, and decreased in spine neurosurgery.

■ **CONCLUSIONS:** Telemedicine use in neurosurgery clinics continues 1 year after the COVID-19 outbreak. Even after the lifting of shelter-in-place measures, many neurosurgeons still use telemedicine, while the operative volume remains stable. Owing to the limited physical examination that can be performed via current telemedicine platforms, telemedicine use in spine neurosurgery is

lower than peak use during the early pandemic, while use has remained high among tumor, vascular, and functional neurosurgery.

### INTRODUCTION

Since the implementation of the coronavirus disease 2019 (COVID-19) lockdown measures on March 13, 2020, there has been a tremendous surge in the use of telemedicine in health care.<sup>1-8</sup> Before the COVID-19 pandemic, Medicare beneficiaries used telemedicine for about 13,000 encounters per week. This number reached nearly 1.7 million by end of April 2020.<sup>1</sup> Use of telehealth increased dramatically across all surgical fields,<sup>2</sup> although this trend varied by location and may have depended on state-specific legislation. In the field of neurosurgery, studies have reported single-center experiences of transitions to telemedicine on implementation of the lockdown measures in 2020.<sup>5-8</sup> While patients are generally satisfied with telemedicine,<sup>4</sup> challenges exist compared with in-person visits.<sup>5,9</sup> These challenges include technical issues regarding network connection as well as concerns about the quality of neurological assessments, postoperative incision checks, imparting bad news, and guiding family discussions. Despite these concerns, higher use of telemedicine has persisted compared with the pre-COVID-19 period.<sup>2</sup> In our prior study, we reported our adoption of telemedicine across several departments at Thomas Jefferson University and reported the increase in usage within all departments.<sup>8</sup> The current study aimed to demonstrate the use of telemedicine 1 year after the COVID-19 outbreak and the distribution of usage stratified by visit type and division.

#### Key words

- COVID-19
- Neurosurgery
- Telemedicine

#### Abbreviations and Acronyms

**COVID-19:** Coronavirus disease 2019

**IQR:** Interquartile range

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## MATERIALS AND METHODS

### Patient Selection, Variables, and Outcomes

The study protocol was approved by the Institutional Review Board of Thomas Jefferson University. A retrospective analysis of patients who received care through the Department of Neurosurgery between February 1 and April 18 in 2020 and 2021 was performed. The inclusion criteria were met by 11,592 patients. During the 2 study periods, 1465 patients underwent surgery, 7083 were seen in clinic via an in-person meeting, and 3044 were assessed via telemedicine (Figure 1). These patients received care from 1 of 14 attending neurosurgeons, 1 interventional neurologist, and 3 neuro-oncologists. Of the attending faculty, 7 were from the tumor division, 5 were from the vascular division (4 were dual-trained in open and endovascular surgery and 1 was trained in endovascular surgery), 4 were from the spine division, and 2 were from the functional division. Data were collected on the number of telemedicine and in-person appointments for each of the 4 divisions within neurosurgery (vascular, spine, tumor, and functional), including the number of new patient visits, established patient visits, and postoperative visits. The COVID-19 lockdown measures were implemented in the United States on March 13, 2020, which is used as the reference point for the study period from 2020. The clinical patient volume was recorded for the same months of the following year (2021). The patients were divided into 4 cohorts of 6 weeks each: February 1 to March 13, 2020, February 1 to March 14, 2021, March 14 to April 18, 2020, and March 15 to April 18, 2021. Study period 1 was defined as the 6 weeks leading up to the initial COVID-19 outbreak in 2020 and the corresponding period in 2021. Study period 2 was defined as the 6 weeks after the initial COVID-19 outbreak in 2020 and the corresponding period in 2021. The analysis was conducted after removal of identifiable patient health information. The main end points of the study were the usage rate of telemedicine 1 year after the COVID-19 outbreak and the distribution of telemedicine use across the neurosurgical subspecialty divisions at Thomas Jefferson University.

### Statistical Analysis

Data are presented as mean and standard deviation for continuous variables and as frequency for categorical variables. Analysis was performed using unpaired *t* test,  $\chi^2$  test, and Fisher exact test, as appropriate. Shapiro-Wilk test was used to determine normality of variables; variables with a *P* value  $\leq 0.05$  were considered non-normally distributed. Mann-Whitney test was performed for continuous variables that did not conform to normal distribution. Non-normally distributed variables were reported as medians if similar distribution was noted and mean ranks if differently distributed. Results are separated by department and visit type as appropriate. *P* values  $\leq 0.05$  were considered statistically significant. Statistical analysis was performed with IBM SPSS Version 28.0 (IBM Corporation, Armonk, New York, USA).

## RESULTS

The study included 11,592 patients. During the study period, 1465 (12.6%) patients underwent surgery, 3044 (26.3%) patients used telemedicine, and 7083 (61.1%) patients were seen via an

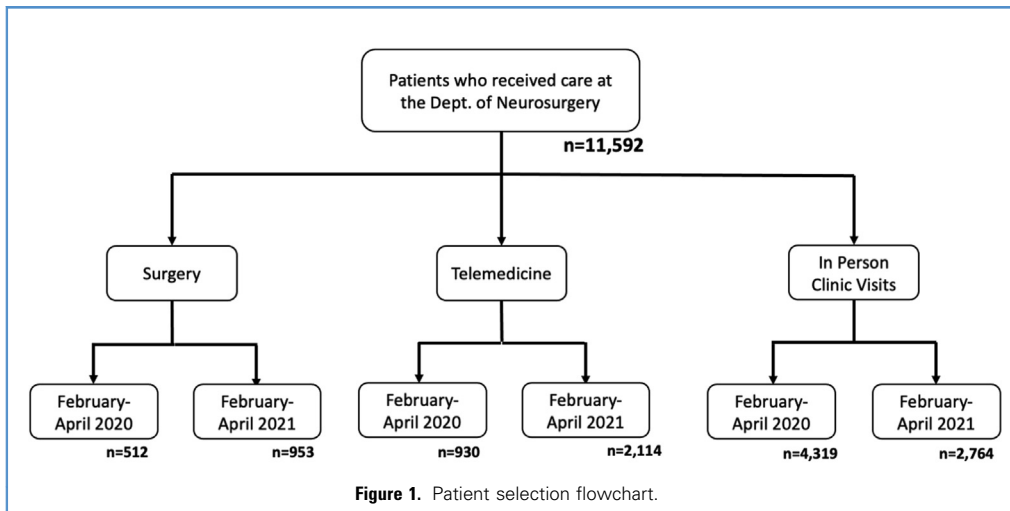
in-person clinic visit. The breakdown of patients undergoing surgery, using telemedicine, or seeing a health care provider via an in-person clinic visits during 2020 and 2021 is demonstrated in Figure 1. The number of in-person outpatient visits decreased significantly after the COVID-19 lockdown measures were implemented (Table 1), but 1 year later they rose to 40.2% of the original volume (Figure 2). The use of telemedicine increased 60-fold immediately on implementation of the lockdown measures to a weekly average of 212 visits. High-volume telemedicine use continued 1 year later at 172 visits, which was 81.3% of the initial surge.

Table 1 shows the average number of operative cases per week, via in-person visits and telemedicine visits, for the 2 study periods. The median number of telemedicine visits per week during study period 1 (February 1 to March 13) significantly increased from 3.5 (interquartile range [IQR]: 1.8–6.5) per week in 2020 to 211.5 (IQR: 157.5–234.5) per week in 2021 ( $P = 0.002$ ). The median number of telemedicine visits per week during study period 2 (March 14 to April 18) was statistically similar between 2020 and 2021: 194.0 (IQR: 148.0–206.0) and 172.0 (IQR: 167.5–197.0), respectively ( $P = 1.00$ ). In-person clinic visits were significantly higher in 2020 than in 2021 during study period 1 (677.5 vs. 264.0;  $P = 0.004$ ), but they significantly increased from 36.0 to 272.0 ( $P = 0.016$ ) during study period 2. A detailed account of the weekly volume of operative cases, telemedicine visits, and in-person clinic visits is provided for each division in Table 2. The initial COVID-19 outbreak led to a 61.0% decrease in in-person clinic volume. The weekly volume of operative cases was significantly greater in 2021 during study period 1 (81.0 in 2021 vs. 65.0 in 2020,  $P = 0.010$ ), and during study period 2 the increase was even higher (96.0 in 2021 vs. 26.0 in 2020,  $P = 0.009$ ).

## DISCUSSION

The COVID-19 lockdown measures implemented in March 2020 initiated widespread adoption of telemedicine in neurosurgery, but whether its use would persist long-term remained unclear. Historically, telemedicine had been reserved for established or postoperative patient visits and was initially intended for serving patients who resided in areas with a physician shortage. Licensing and reimbursement regulations for providing telehealth services originally limited the use of telemedicine; however a number of new policies implemented over the past year have facilitated the regional uptake of telemedicine.<sup>10</sup> In our experience, the use of telemedicine skyrocketed at the beginning of the pandemic and remained high 1 year later (Figure 2). Moreover, our telemedicine volume has comprised a substantive volume of new patient visits, as reflected in the stable number of operative cases (Figure 2). While acknowledging that our data represent the site-specific potential of telemedicine uptake rather than a homogeneous national phenomenon, our findings demonstrate that the initial increase in telemedicine use may persist as lockdown restrictions are lifted, and it has become an integral component of outpatient neurosurgical care.

The patients seen by the various divisions of neurosurgery have different needs, which is reflected in the rates of telemedicine usage by the spine, tumor, vascular, and functional divisions at our institution. Depending on the patient's pathology, providers



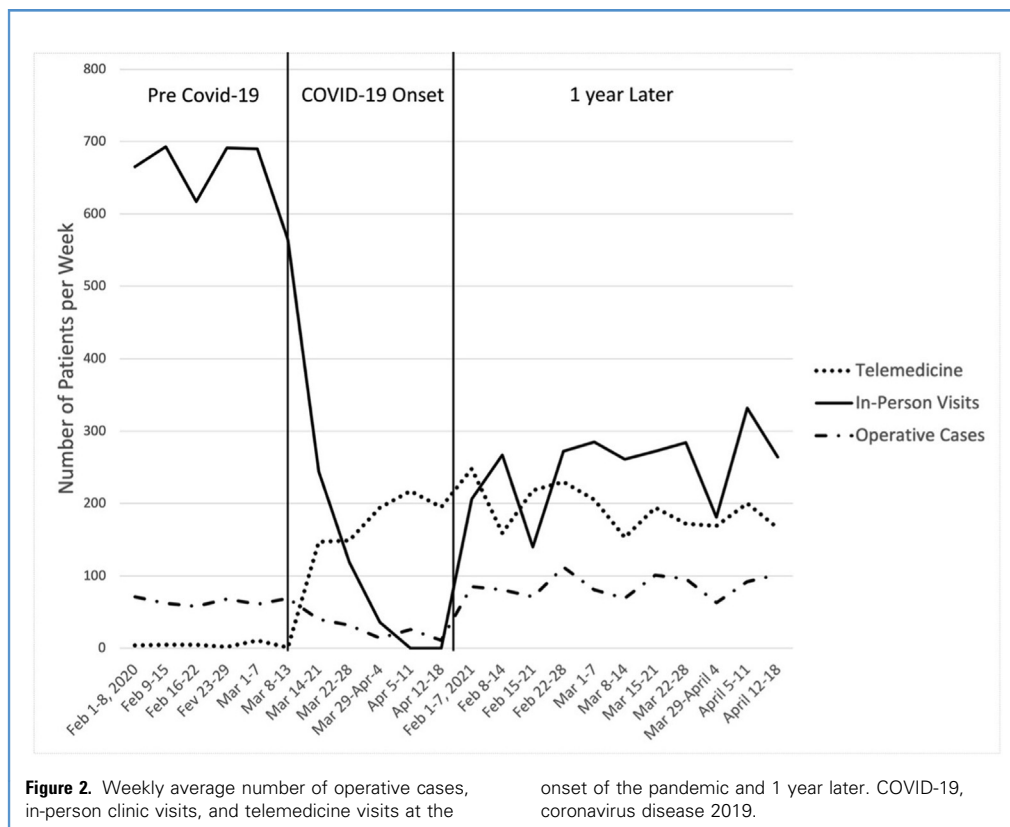
across the 4 divisions preferentially rely more on  $\geq 1$  of the following: physical examination findings, imaging, self-reported symptoms, or laboratory values. For that reason, telemedicine lends itself better to the pathologies that depend less on accurate and thorough physical examination. Our data demonstrate that telemedicine use remained high 1 year after the surge of March 2020 by the tumor and functional divisions, while its use

significantly increased in the vascular division. The spine division was the only division in which telemedicine use decreased in 2021 compared with the initial surge in 2020, but that relationship did not achieve statistical significance. Given that the department's operative case volume resurged to 96 cases per week over a period of sustained high telemedicine use, our findings support the notion that telemedicine is an appropriate platform for the

**Table 1.** Number of Weekly Operative Cases, In-Person Outpatient Visits, and Telemedicine Visits in the Weeks Surrounding the Initial 2020 COVID-19 Pandemic Onset and the Same Weeks 1 Year Later

	February–March 13, 2020	February–March 14, 2021	P Value	March 14–April 18, 2020	March 15–April 18, 2021	P Value
Operative cases, median (IQR)	65.0 (61.3–68.8)	81.0 (70.5–91.8)	0.010	26.0 (14.0–32.0)	96.0 (92.0–101.0)	0.009
Tumor	17.5 (12.8–20.0)	12.5 (12.0–18.8)	0.310	9.0 (6.0–9.0)	16.0 (14.0–19.0)	0.008
Spine	31.0 (28.0–32.5)	25.0 (22.5–29.8)	0.180	7.0 (4.0–9.0)	31.0 (24.0–32.0)	0.032
Vascular	9.0 (5.8–10.8)	33.0 (30.5–37.0)	0.002	2.0 (2.0–3.0)	43.0 (41.0–43.0)	0.008
Functional	8.0 (7.0–9.8)	6.5 (5.3–8.5)	0.180	3.0 (3.0–4.0)	7.0 (5.0–9.0)	0.032
In-person clinic, median (IQR)	677.5 (603.8–691.5)	264.0 (219.8–270.8)	0.004	36.0 (0.0–181.5)	272.0 (264.0–284.0)	0.016
Tumor	159.5 (153.3–165.8)	58.5 (51.0–60.0)	0.002	8.0 (0.0–35.0)	47.0 (43.0–55.0)	0.056
Spine	348.0 (345.5–354.3)	178.0 (147.5–192.0)	0.002	21.0 (0.0–44.0)	183.0 (179.0–206.0)	0.016
Vascular	87.5 (81.3–104.3)	3.5 (3.0–5.5)	0.002	7 (0.0–29.0)	10.0 (8.0–12.0)	0.841
Functional	20.5 (12.0–34.3)	17 (7.8–21.8)	0.589	0 (0)	23.0 (20.0–26.0)	0.008
Telemedicine visits, median (IQR)	3.5 (1.8–6.5)	211.5 (170.5–227)	0.002	194.0 (148.0–206.0)	172.0 (169.0–194.0)	1.00
Tumor	1.0 (1.0–2.5)	75.0 (69.8–81.8)	0.002	74.0 (57.0–76.0)	79.0 (62.0–95.0)	0.690
Spine	1.0 (1.0–1.75)	51.5 (43.8–84.0)	0.002	74.0 (70.0–85.0)	44.0 (44.0–49.0)	0.151
Vascular	0.5 (0.0–1.0)	50 (38–61.3)	0.002	25.0 (21.0–26.0)	48.0 (31.0–55.0)	0.032
Functional	0.5 (0.0–1.75)	9.0 (4.5–12.8)	0.002	10.0 (7.0–12.0)	8.0 (8.0–9.0)	0.548

IQR, interquartile range.



essential steps surrounding surgery, including meeting new patients, describing their pathology and imaging, obtaining informed consent, scheduling them for surgery, and following them postoperatively. Of the 4 neurosurgery divisions, the spine division was the only one with a decline in telemedicine visits in 2021. Obtaining a comprehensive physical examination including motor, sensory, and reflexes is integral for decision making before spine surgery, possibly explaining the decline in usage for the spine division once lockdown measures were reduced. Furthermore, it has been shown that spine patients tend to prefer in-person clinic appointments to telemedicine; however longer travel times decrease this preference for in-person visits.<sup>11</sup> Ongoing research on patients' attitudes and experiences with telemedicine in each of the neurosurgical divisions is forthcoming.

Telemedicine can be useful beyond the minimum requirements for outpatient visits. Traditionally, patient-physician relationships have relied on face-to-face communication, tactile physical examination, and interpretation of cues such as body language to develop and foster trust. Telemedicine encounters necessarily omit some elements of in-person visits, but they have been shown to successfully achieve several important aspects of patient care, despite initial concerns surrounding the use of telemedicine in place of in-person visits. Its continued use has shown that telemedicine is suitable for developing lasting physician-patient relationships, discussing surgical procedures, obtaining informed

consent, tracking progress postoperatively, and answering family questions. Our findings suggest that telemedicine has proven to be an adequate platform even for discussing sensitive topics, such as imaging findings, the need for surgery, disease recurrence, and other forms of bad news. Furthermore, providers in the department have also been able to use telemedicine for multidisciplinary meetings as well as the involvement of residents and fellows in patient visits, similar to existing in-person clinic workflows. Others have noted the potential for adherence to clinic scheduling and patient visit duration.<sup>12</sup>

The COVID-19 pandemic required providers and patients to familiarize themselves with the benefits of telemedicine, such as more frequent and accessible communication with more flexible scheduling. Furthermore, patients are less likely to cancel or miss telemedicine appointments.<sup>13,14</sup> Our analysis of patient encounters within our department illustrates that, in our institution, the number of telemedicine visits rapidly increased in response to the March 2020 lockdown and remained high 1 year later, even as the number of in-person visits began to recover when the lockdown measures were reduced. Despite the decreased number of in-person visits compared with before the COVID-19 pandemic, telemedicine encounters were sufficient for developing the patient rapport required for presurgical evaluation and postoperative follow-up, as reflected by the full recovery in the number of operations per week. The long-term consequences of the widespread and sustained adoption of telemedicine warrants ongoing

**Table 2.** Number of Weekly Telemedicine Visits by Division and Visit Type Between Spring 2020 and 2021

	March 14–April 18, 2020	March 15–April 18, 2021	P Value
Telemedicine, mean (SD)			
Tumor	69.8 (21.2)	75.0 (24.4)	0.728
Spine	76.8 (8.2)	53.4 (23.8)	0.071
Vascular	24.2 (5.6)	43.6 (13.3)	0.028
Functional	9.6 (3.1)	8.2 (0.8)	0.527
Tumor, mean (SD)			
EPV	55.6 (18.3)	58.0 (19.6)	0.847
NPV	9.0 (2.6)	11.0 (5.7)	0.494
Postoperative	5.2 (1.9)	6.0 (1.4)	0.503
Spine, mean (SD)			
EPV	49.0 (3.7)	31.8 (10.4)	0.008
NPV	13.2 (3.3)	9.2 (14.2)	0.556
Postoperative	14.6 (6.5)	12.4 (4.1)	0.542
Vascular, mean (SD)			
EPV	9.6 (3.6)	27.8 (9.5)	0.009
NPV	7.8 (3.6)	10.8 (5.2)	0.316
Postoperative	6.8 (3.6)	5.0 (3.4)	0.437
Functional, mean (SD)			
EPV	4.4 (3.2)	3.2 (1.6)	0.239
NPV	2.6 (2.1)	1.6 (1.1)	0.380
Postoperative	2.6 (1.3)	3.4 (2.1)	0.490

EPV, established patient visit; NPV, new patient visit.

analysis; it is worth noting that while the number of operative cases had fully recovered, the total number of outpatient visits per

week—telemedicine and in-person combined—had not yet returned to pre-COVID volumes by the end of this analysis. For that reason, there was an increase in the number of in-person visits noted in our second study period; however, the proportion of telemedicine visits to total outpatient visits has remained stable throughout our study period. These fluctuations are related to the ongoing pandemic, regional control, remaining restrictions, and their impact on the operative volume. Nonetheless, our trends remain consistent, suggesting the long-term integration of telemedicine into neurosurgical care. We have shown that telemedicine remained a valuable modality in outpatient neurosurgery, even when in-person visits became an option again, and we look forward to improvements in the functionality of telemedicine platforms that might further extend value to the field.

## CONCLUSIONS

The use of telemedicine in neurosurgery clinics continues 1 year after the COVID-19 outbreak in March 2020. Even after the lifting of lockdown measures, many providers still use telemedicine at high rates, and operative volume has remained stable. Owing to the limited physical examination that can be performed via current telemedicine platforms, telemedicine use in spine neurosurgery is lower than the peak use of April 2020, while use has remained high in tumor, vascular, and functional neurosurgery.

## CRediT AUTHORSHIP CONTRIBUTION STATEMENT

**Nikolaos Mouchtouris:** Writing – original draft, Writing – review & editing, Formal analysis. **Siyuan Yu:** Investigation, Data curation. **Giyarpuram Prashant:** Writing – review & editing, Methodology. **Nicolas Nelson:** Writing – review & editing, Formal analysis. **Maikerly Reyes:** Investigation, Data curation. **Glenn Gonzalez:** Investigation, Data curation. **Rupert Smit:** Investigation, Writing – review & editing. **Sarah Collopy:** Writing – review & editing, Resources. **Pascal Jabbour:** Resources, Supervision. **Ashwini Sharan:** Resources, Supervision. **James Harrop:** Project administration, Visualization. **Robert Rosenwasser:** Validation, Resources. **James J. Evans:** Conceptualization, Supervision, Writing – review & editing.

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