In addition to resulting in the death of more than 5.4 million persons worldwide, the ongoing coronavirus disease 2019 (COVID-19) pandemic has resulted in significant disruptions in every aspect of life. Included within this are changes in the means by which healthcare is delivered in the US, with McKinsey & Company estimating that nearly $250 billion of US healthcare spending could be diverted from in-person or face-to-face (F2F) care to virtual care. As a reflection of this, an analysis of telehealth services use by the Centers for Disease Control...

Abbreviations: CDC = Centers for Disease Control and Prevention; COVID-19 = coronavirus disease 2019; F2F = face-to-face.
and Prevention (CDC) saw a 50% increase\(^1\) in telehealth utilization in the quarter leading up to the national emergency declaration on March 13, 2020,\(^2\) and a 154% year-over-year increase in the utilization of these visits in the week following the emergency declaration.\(^3\) Social distancing restrictions and limitations on in-person visits\(^5\) led many patients to delay seeking care in the months after the onset of the pandemic.\(^6,7\) However, indefinite deferral is neither feasible nor in the best interest of the patient. This is particularly true for neurosurgical pathologies, many of which benefit from semi-urgent management.\(^8\) The increased availability of telehealth services\(^7,9\) serves as one potential solution that can help to enable delivery of care while limiting the spread of COVID-19.

Despite the potential ability of telehealth to reduce the spread of COVID-19, it carries the potential downside of limiting the spread of COVID-19. Specifically, for patients undergoing evaluation for neurosurgical complaints, it is unclear how the utilization of virtual care impacts patient satisfaction, the timely delivery of care, and the overall efficiency of care delivery. Our objective in the present paper was to examine the impact of virtual care utilization on these factors for patients undergoing evaluation in a high-volume neurosurgical department.

**Methods**

**Data Source and Collection**

In this study, we utilized data on neurosurgical consultations within a single quaternary academic institution. These data were prospectively collected by a departmental quality surveillance system for the purposes of quality improvement. The data for the period between January 1, 2019, and December 31, 2021, were analyzed to determine the impact of the pandemic on clinical workflow. March 13, 2020—the date that a national emergency was declared by the CDC—was used as the defining point for the pandemic onset.

**Definitions**

In-person or F2F visits were defined as those consultations in which the patient was physically present for the surgical consultation or follow-up appointment. All other consultations were considered telehealth consultations, which included both appointments conducted via video calls and those using conventional telephone calls. Appointments were also categorized as internal consultations, new patient visits, and established follow-up visits. Internal consultations were those visits in which patients were referred from within our institution. New patient visits comprised all visits in which the patients had not previously been seen by a provider within our institution before the index neurosurgical visit. Lastly, established follow-up visits were those visits in which patients were seen more than 90 days after an operation in our institution.

Care efficiency was defined by surgical yield, time to appointment, rate of on-time appointments, and patient-reported satisfaction. Surgical yield was defined as the percentage of consultations that led to the patient undergoing surgery within our department. Time to appointment was the number of days between the placement of the initial appointment request and the date of the surgical consultation or follow-up visit. The rate of on-time appointments was defined as the proportion of appointments within a month in which the patient checked in before the scheduled start time. Time to surgery was the duration between the appointment date and the operation date for cases that eventually underwent surgery. Patient-reported satisfaction was defined as “very good likelihood of recommending practice,” according to the Press Ganey scale. A random sample of the total number of patients was asked to complete the Press Ganey patient satisfaction questionnaire; however, differentiating between patients who experienced in-person and virtual appointments was not feasible. Instead, the mixed quarterly rate of patients reporting satisfaction was analyzed.

**Statistical Analysis**

Categorical variables are presented as frequencies and proportions. Continuous variables were analyzed via two-sample Student t-tests, and categorical variables were analyzed via chi-square tests. Statistical analysis was performed on Microsoft Excel and R (version 4.1.1, R Foundation for Statistical Computing), and statistical significance was determined at a level of p < 0.05.

**Results**

From January 1, 2019, to December 31, 2021, 54,562 clinic appointments were recorded in our department. Of these, the most common visit types were established follow-up visits (n = 28,248, 51.8%), followed by internal referrals (n = 13,349, 24.5%) and external referrals (n = 10,798, 19.8%). The remaining 2167 visits (4%) were postoperative appointments scheduled within 90 days of surgery. The monthly trends in the four visit categories within the 3 years of interest are presented in Fig. 1. Significantly fewer visits occurred during March, April, and May 2020 (Table 1). The mean number of visits per month during these 3 months was 899.7—42.8% lower than the 1571.6 visits per month recorded for the remaining period.

Following May 2020, the total number of visits returned to levels not significantly different from those prior to the pandemic onset. Comparison of the mean monthly visits performed before and after the pandemic onset showed no significant differences (1521.3/month vs 1512/month, p = 0.917). A steep increase in established follow-up patient visits was noted after spring 2020, which can likely be attributed to compensating for a delay in scheduled follow-up visits during spring 2020 (Table 2). New patient visits following spring 2020 reached the prior levels when comparing the average monthly prepandemic volume to the average volume for the entire postpandemic period (321.9/month vs 304.8/month, p = 0.356). This was not the case for internal consultations, which were found to occur at a significantly lower rate postpandemic than prior to the pandemic onset.

Analysis of the different visit modes showed a significant decrease in F2F visits following the pandemic onset (1517 vs 1220 monthly, p < 0.001). There was an approximately 53.6% decrease in F2F visits during the 3 months

Unauthenticated | Downloaded 06/08/22 10:43 AM UTC
following pandemic onset (704 vs 1517 monthly), which rebounded to a new, lower baseline of 1302 visits per month following May 2020 (p < 0.001; Fig. 2A). Overall, it is estimated that approximately 8600 in-person visits were deferred because of the pandemic.

The decrease in F2F visits was accompanied by a reciprocal increase in virtual visit utilization (Fig. 2B). Telemedicine visits were sparingly used prior to March 2020 (4.7 appointments monthly), while in the month immediately following the pandemic onset (April 2020), telehealth appointments were more commonly used than in-person visits (360 vs 247). Eventually, telehealth appointments plateaued at an average of 292 appointments per month since March 2020. Before the pandemic, telehealth appointments accounted for only 0.3% of the total visits; however, after its onset nearly 20% of visits occurred via telemedicine (Table 3).

To assess the quality and effectiveness of telemedicine visits in the clinical setting, we evaluated four metrics of clinical workflow: time to appointment, rate of on-time appointments, and surgical yield. Figure 3 illustrates the distribution of the time-to-appointment metric noted for in-person visits prior to the pandemic, in-person visits after the initiation of the pandemic, and telehealth appointments. As illustrated, time to appointment was significantly lower for telemedicine appointments; time to appointment was not appreciably different for F2F visits conducted before and after the pandemic onset.

A total of 6481 telemedicine appointments were recorded during the period of interest. Among 6411 telemedicine appointments with an available time of patient check-in, in 5575 appointments (87%) the patients were available before the scheduled time of appointment initiation. Approximately half of the remaining patients (n = 428, 6.7% of the 6411 appointments with an available time of patient check-in) were late by no more than 5 minutes, while 183 patients (2.9%) were between 6 and 10 minutes late.

Surgical yield data were only available after December 2020 (Table 4). From December 2020 to December 2021, 16,342 in-person visits, 3512 video appointments, and 846 telephone appointments were recorded. Of 20,700 total cases, 6577 (31.8%) led to surgery. Established patient visits following surgery were less likely to lead to surgery than internal consultations and new patient visits. Overall, in-person visits were more likely to lead to surgery than telemedicine appointments (35.5% vs 17.8%, p < 0.001). Among patients without a history of operation at our institution—namely, excluding the established patients—in-person visits led to surgery in 51.8% of cases, while telemedicine appointments led to surgery in 31.8% of cases. In a subgroup analysis between video and telephone sessions, the former was associated with higher surgical yield (18.6% vs 14.5%, p = 0.005).

Finally, patient-reported likelihood to recommend the practice—a surrogate for patient satisfaction—was not impacted during the study period. Between the last quarter of 2018 and the third quarter of 2021, 5085 outpatients were sampled, and an average of 87.2% (range 84.2%–90.7%) declared that they would highly recommend the practice in our department (Fig. 4). Compared with those before the beginning of the pandemic, quarterly satisfaction rates after the second quarter of 2020 were slightly but statistically significantly higher (85.9% vs 88.5%, p = 0.027). Despite the fact that a comparison of telemedicine with F2F appointments was not possible, the data suggest that the introduction of telemedicine into daily outpatient prac-

### TABLE 1. Mean monthly number of visits during March, April, and May 2020 compared with the remaining period

|                           | Monthly Visits During Spring 2020 | Monthly Visits Excluding Spring 2020 | % Decrease During Spring 2020 |
|---------------------------|-----------------------------------|--------------------------------------|-----------------------------|
| Internal referral         | 222.3                             | 384.3                                | 42.2                        |
| Established FU visit      | 487                               | 811.7                                | 40                          |
| New patient visit         | 166.3                             | 312.1                                | 46.7                        |
| Returns w/in 90 days      | 24                                | 63.5                                 | 62.2                        |
| Total visits              | 899.7                             | 1571.6                               | 42.8                        |

FU = follow-up.
settings of the COVID-19 pandemic. Data for 54,562 patients were randomly sampled for the completion of the surveys. Our findings suggest that telemedicine consultations were an effective means of identifying surgical patients. Consequently, the data argue that telemedicine appointments were associated with more rapid scheduling of patient visits relative to F2F consultations. Although unclear from the data, it is likely that this difference stems from innate differences in the efficiency of the logistics for virtual and in-person consultations. Telemedicine visits were also associated with punctual care, as 87% of visits started on time and an additional 6.7% of consultations commenced within 5 minutes of the scheduled start. Importantly, while surgical yield for telemedicine consultations was lower (17.8% vs 35.5%), nearly 1 in 5 telemedicine patients was found to have a surgical indication. Consequently, the data argue that telemedicine may be an effective means of identifying surgical patients. As discussed below, the basis for this decreased surgical yield may stem from limitations in the ability to examine patients in telemedicine visits. However, the role of restrictions in surgical volume imposed by local COVID-19 fluctuations cannot be effectively assessed.

The implementation of telemedicine practices was not temporally associated with a decrease in the overall patient satisfaction rates. In fact, patient satisfaction indexes remained high despite the increased use of virtual consultations. Admittedly, the lack of a direct comparison between F2F and telemedicine visits limits the ability to examine any causality of the observed relationship. However, patients from both groups were randomly sampled for the completion of the surveys. Our findings suggest that the implementation of telemedicine in some neurosurgical consultations may improve the efficiency of delivered care without sacrificing patient experience. Recent studies on the application of telemedicine within the pandemic corroborate this hypothesis. Notably, Yoon et al. presented a survey of 310 patients offered virtual outpatient appointments and reported an average satisfaction rate of 6.3 on a 7-point Likert scale. Nevertheless, such findings should be interpreted in the context of the pandemic, which may be associated with lower patient expectations from care and hesitation to pursue in-person care.

Previous Examinations

Although several studies have examined changes in the delivery of neurosurgical care following the onset of the COVID-19 pandemic, relatively few have examined the impact of telehealth utilization on the efficiency of care delivered. One study, published by a group at the Cleveland Clinic, examined the impact of virtual care escalation on patient impact scores over the 12-month period immediately following the pandemic onset in the US. The department deployed a series of robotic televideo systems to conduct consultations for hospitalized patients as a means of reducing the exposure of medically vulnerable neurosurgical personnel (e.g., senior staff) to potentially COVID-19–infected patients. Additionally, virtual visits were offered, which played an increasingly important role in outpatient evaluation, increasing from 3% to 40% of all outpatient spine encounters from 2019 to 2020. These virtual visits accounted for the majority of visits in the 3 months following the national emergency declaration. Similarly, in the present study, telemedicine consultations accounted for most of the appointments during April 2020 and reached a peak in absolute number in December 2020 (n = 413, 29.5% of total appointments). Importantly 31.8% of internal consultations and new patient visits performed via telemedicine resulted in operative intervention. While lower than the rates seen for in-person visits, these data suggest that telemedicine may still allow for constructive patient-physician interaction with explanations about treatment options, counseling/education, or inclusion in treatment decision-making. It is unclear exactly why surgical yield in the present data is higher for F2F visits. One possible explanation is that virtual appointments afford patients the opportunity to obtain a second opinion without...
incurring the costs associated with travel to an in-person consultation. Under such a paradigm, patients could seek consultation from a high-volume academic institution and then pursue surgery at a facility closer to their residence. Additionally, the lower surgical yield in virtual visits may result from differences in case severity or differences in the ability to forge a therapeutic bond between surgeon and patient. Both factors are unfortunately not captured in the data and are therefore beyond the scope of the present study. However, prior data reported by Mohanty et al.¹³ suggest that differences in the ability to establish a therapeutic bond may not explain the discrepancy. In their study, the authors surveyed 607 patients treated using telemedicine consultations and 85 providers. Of the 122 patient respondents, 88% reported that telehealth visits were more convenient; a smaller proportion (63%) of the 40 respondent providers found telehealth visits to be more convenient. Ninety-two percent of patients were satisfied with

FIG. 2. A: Trend in the utilization of in-person and telehealth visits. Telehealth visits comprise video and telephone sessions, which are presented separately in this graph. B: Trend in the utilization of telemedicine visits. The y-axes represent the number of visits.
In other realms of medicine, there has been more extensive investigation of the feasibility of telehealth in cerebrovascular technology, with many centers creating “telestroke” services that allow neurologists to remotely assess patients suffering acute stroke. In this context, telehealth has a significant potential upside, as the management of stroke patients is very much time dependent, with quick assessment being necessary to determine whether patients qualify for thrombolytic therapy. Additionally, because more rapid intervention is associated with improved long-term functional outcomes, the implementation of telestroke programs designed to achieve this goal is recommended. Consistent with this, a recent investigation of telestroke utilization across two provider networks found a more than 10-fold increase in telestroke service utilization across the 7-year period examined. Importantly, this increased telestroke utilization was also associated with a decrease in door-to-needle time, suggesting that patients for whom telestroke services were available received more rapid intervention. Although overall outcomes were not examined, prior clinical trial data have suggested that this accelerated intervention time frame would be expected to have improved patient functional outcomes.

**Limitations to Telehealth in Neurosurgical Care Delivery**

The data presented here suggest that telemedicine can play a pivotal role in improving clinical workflow and care delivery in a setting of social distancing. Given the effectiveness of telemedicine visits in maintaining workflow (i.e., time to appointment, total clinical volume), the data also present preliminary evidence that telemedicine may be an effective means of maximizing departmental efficiency when integrated into routine clinical practice. Nevertheless, telehealth possesses several limitations. Notably, the physical examination, a cornerstone of surgical evaluation for many neurosurgical pathologies, can only be performed in a limited fashion. The physical examination versus clinical prodrome may have utility that scales in proportion to the degree to which the physical examination versus clinical prodrome dictates surgical candidacy. Additionally, ongoing concerns about data security carry with them commensurate risks of patient privacy compromise. Many patients also have limited access to or skill with the technologies employed in telehealth, and so they may be unable to take advantage of these platforms. These patients often live in more rural regions with more limited access to neurosurgical care and are therefore the patients most likely to benefit from telemedicine consultation. As demonstrated by Dadlani and colleagues, the cost savings to patients seen via telemedicine can be substantial, highlighting the societal benefit that could be achieved by investing in these systems. A follow-up study by the same group suggested that financial incentives also exist for the health system implementing the care. Performing a cost-effectiveness analysis using a 52-month experience including 1200 unique patients, the authors found that total costs for telehealth were less than half the costs of in-person care. Telehealth visits were also reported to be 97% effective, although success for a telehealth visit in this scenario was one that allowed the patient to forego further evaluation or treatment that would require in-person visitation. Another caveat to these findings is that they relied on the assump-

| Table 3. Monthly proportion of telehealth appointments to total patient visits |
|----------------------------------|--------|--------|-----------------|
| **Month** | **No. of In-Person Visits** | **No. of Telehealth Visits** | **% Telehealth to Total Appointments** |
| January 2019 | 1427 | 1 | 0.1 |
| February 2019 | 1321 | 1 | 0.1 |
| March 2019 | 1379 | 1 | 0.1 |
| April 2019 | 1684 | 4 | 0.2 |
| May 2019 | 1560 | 2 | 0.1 |
| June 2019 | 1510 | 6 | 0.4 |
| July 2019 | 1681 | 7 | 0.4 |
| August 2019 | 1703 | 6 | 0.4 |
| September 2019 | 1545 | 3 | 0.2 |
| October 2019 | 1791 | 4 | 0.2 |
| November 2019 | 1397 | 5 | 0.4 |
| December 2019 | 1349 | 8 | 0.6 |
| January 2020 | 1456 | 11 | 0.7 |
| February 2020 | 1379 | 7 | 0.5 |
| March 2020 | 979 | 43 | 4.2 |
| April 2020 | 247 | 360 | 59.3 |
| May 2020 | 886 | 184 | 17.2 |
| June 2020 | 1334 | 168 | 11.2 |
| July 2020 | 1373 | 184 | 11.8 |
| August 2020 | 1206 | 203 | 14.4 |
| September 2020 | 1402 | 265 | 15.9 |
| October 2020 | 1341 | 285 | 17.5 |
| November 2020 | 1084 | 300 | 21.7 |
| December 2020 | 989 | 413 | 29.5 |
| January 2021 | 1142 | 318 | 21.8 |
| February 2021 | 1214 | 320 | 20.9 |
| March 2021 | 1428 | 343 | 19.4 |
| April 2021 | 1501 | 378 | 20.1 |
| May 2021 | 1285 | 308 | 19.3 |
| June 2021 | 1491 | 366 | 19.7 |
| July 2021 | 1355 | 334 | 19.8 |
| August 2021 | 1414 | 362 | 20.4 |
| September 2021 | 1421 | 357 | 20.1 |
| October 2021 | 1403 | 327 | 18.9 |
| November 2021 | 1340 | 327 | 19.6 |
| December 2021 | 1014 | 270 | 21.0 |
tion that the neurological examination performed remotely was equally as effective as that performed in person, an assumption that may be untrue. Furthermore, patients being evaluated for spine-related complaints disproportionately sought care in person, suggesting that telehealth may be better optimized for select patients. Lastly, reimbursement questions have been a traditional barrier to the adoption of telehealth services, which have conventionally been compensated at lower rates than in-person consultation. However, during the COVID-19 public health emergency, the Centers for Medicare & Medicaid Services (CMS) granted waivers (1135 waivers) that compensated providers for telehealth visits as if care were provided in person.9,22 It is unclear whether such policies will continue with resolution of the declared emergency, and currently, only 10 states have laws offering "payment parity" between in-person and telehealth services.9 It seems likely that changes in reimbursement rates may, in part, dictate the extent to which telemedicine adoption persists in the long term.

Future Directions
Despite the limitations of telehealth, the unclear end of the COVID-19 pandemic and increased utilization of these technologies make it likely that telehealth will persist as a part of neurosurgical care in some form.19 In their survey, Mohanty et al.13 noted that 85% of providers indicated they would desire to continue telehealth visits. However, only 36% of patients indicated they would desire to continue to use telehealth. The extent of implementation may therefore depend on a compromise between the desires of the two parties, perhaps with patients undergoing surgical consultation in person and follow-up using telehealth services.5,13

Study Limitations
The present investigation represents the clinical experience at a single quaternary care center. The results of the investigation may therefore not be broadly generalizable to all neurosurgical practices or even all academic departments. Additionally, the data themselves were evaluated in retrospective fashion, limiting our ability to ascertain the degree to which a causal relationship exists between departmental efficiency and the adoption of telehealth services. The present analysis also compares efficiency before and after the onset of the COVID-19 public health emergency. While our department had prior experience with telehealth services and rapidly deployed them in the wake of the emergency, there was undoubtedly a learning phase in the first weeks following the transition. Efficiency during this period would likely be below that seen following full integration of the telehealth services. Notably, the period of the pandemic spans several surges, which have notably impacted the ability to perform elective and non-emergent surgical cases. This would, in turn, be expected to prolong the time between consultation and surgery for

![Bar chart presenting the recorded times to appointment for in-person visits prior to March 13, 2020; in-person visits following March 13, 2020; and telemedicine appointments. The x-axis represents the number of days in classes and the y-axis the rate of each class among all visits of a specific type.](image)

**TABLE 4. Surgical yield between different consultation modes and visit categories**

| Consultation Mode          | Internal Consults | Established Patients | New Patients | Total     |
|----------------------------|-------------------|----------------------|--------------|-----------|
| In person                  |                   |                      |              |           |
| Total cases                | 3947              | 9055                 | 3340         | 16,342    |
| Surgical yield             | 53.7%             | 23.0%                | 47.9%        | 35.5%     |
| Telemedicine: video call   |                   |                      |              |           |
| Total cases                | 522               | 2170                 | 820          | 3512      |
| Surgical yield             | 35.1%             | 10.2%                | 30.4%        | 18.6%     |
| Telemedicine: telephone    |                   |                      |              |           |
| Total cases                | 119               | 692                  | 35           | 846       |
| Surgical yield             | 22.7%             | 11.4%                | 48.6%        | 14.5%     |
| Telemedicine overall       |                   |                      |              |           |
| Total cases                | 641               | 2862                 | 855          | 4358      |
| Surgical yield             | 32.8%             | 10.5%                | 31.1%        | 17.8%     |
surgical cases. However, the present analysis was limited in its ability to control for the aforementioned covariate. Lastly, the use of telemedicine potentially allows for significant expansion of a practice’s catchment area and therefore the patient population it can serve. This has been demonstrated by others. However, as anonymized patient responses were used, the ability to examine this outcome is beyond the scope of the present analysis.

Conclusions

In the present analysis of the impact of the COVID-19 pandemic on a quaternary care center neurosurgical department, we found that there was increased adoption of telehealth services. Despite a significant decrease in in-person visits, the increase in telemedicine appointments contributed to maintaining the monthly visits at the pre-pandemic levels. Telehealth services were associated with a shorter time-to-appointment period, a high on-time appointment rate, and a lower surgical yield than in-person visits. Overall patient satisfaction indexes were not adversely affected by the increased use of virtual consultations within the clinical practice. Although the present results reflect the experience of a single center, they help provide support for the continued integration of telehealth services as a means of providing efficient outpatient neurosurgical care.

References

1. Johns Hopkins University & Medicine. Home—Johns Hopkins Coronavirus Resource Center. Accessed April 5, 2022. https://coronavirus.jhu.edu
2. Bestsenny O, Gilbert G, Harris A, Rost J. Telehealth: a post-COVID-19 reality? McKinsey & Company. Updated July 9, 2021. Accessed April 5, 2022. https://www.mckinsey.com/industries/healthcare-systems-and-services/our-insights/telehealth-a-quarter-trillion-dollar-post-covid-19-reality
3. Koonin LM, Hoots B, Tsang CA, et al. Trends in the Use of Telehealth During the Emergence of the COVID-19 Pandemic—United States, January-March 2020. MMWR Morb Mortal Wkly Rep. 2020;69(43):1595-1599.
4. Centers for Disease Control and Prevention. Coronavirus Disease 2019 (COVID-19) Update and Infection Prevention and Control Recommendations. Clinical Outreach and Communication Activity (COCA) Webinar. Accessed April 5, 2022. https://stacks.cdc.gov/view/cdc/85901
5. Daggubati LC, Eichberg DG, Ivan ME, et al. Telemedicine for outpatient neurosurgical oncology care: lessons learned for the future during the COVID-19 pandemic. World Neurosurg. 2020;139:e859-e863.
6. Whaley CM, Pera MF, Cantor J, et al. Changes in health services use among commercially insured US populations during the COVID-19 pandemic. JAMA Netw Open. 2020;3(11):e2024984.
7. Patel PD, Kelly KA, Reynolds RA, et al. Tracking the volume of neurosurgical care during the coronavirus disease 2019 pandemic. World Neurosurg. 2020;142:e183-e194.
8. Sciubba DM, Ehresman JS, Pennington Z, et al. Scoring system to triage patients for spine surgery in the setting of limited resources. Neurosurgery. 2020;67(suppl 1):235.
9. Cruz MJ, Nieblas-Bedolla E, Young CC, et al. United States medicolegal progress and innovation in telemedicine in the age of COVID-19: a primer for neurosurgeons. Neurosurgery. 2021;89(3):364-371.
10. Richards AE, Curley K, Christel L, et al. Patient satisfaction with telehealth in neurosurgery outpatient clinic during COVID-19 pandemic. Interdiscip Neurosurg. 2021;23:101017.
11. Yoon EJ, Tong D, Antom GM, et al. Patient satisfaction with neurosurgery telemedicine visits during the coronavirus disease 2019 pandemic: a prospective cohort study. World Neurosurg. 2021;145:e184-e191.
12. Sharma A, Winkelman RD, Schlenk RP, Rasmussen PA, Angelov L, Benzel DL. The utility of remote video technology in continuing neurosurgical care in the COVID-19 era: reflections from the past year. World Neurosurg. 2021;156:43-52.
13. Mohanty A, Srinivasan VM, Burkhardt JK, et al. Ambulatory neurosurgery in the COVID-19 era: patient and provider satisfaction with telemedicine. Neurosurg Focus. 2020;49(6):E13.
14. Panesar SS, Volpi JJ, Lumsden A, et al. Telerobotic stroke intervention: a novel solution to the care dissemination dilemma. J Neurosurg. 2019;132(3):971-978.
15. Tsivgoulis G, Saqquar M, Sharma VK, et al. Timing of recanalization and functional recovery in acute ischemic stroke. J Stroke. 2020;22(1):130-140.
16. Khatri P, Yeatts SD, Mazihi M, et al. Time to angiographic reperfusion and clinical outcome after acute ischemic stroke: an analysis of data from the Intervventional Management of Stroke (IMS III) phase 3 trial. Lancet Neurol. 2014;13(6):567-574.
17. Saver JL, Goyal M, van der Lugt A, et al. Time to treatment with endovascular thrombectomy and outcomes from ischemic stroke: a meta-analysis. JAMA. 2016;316(12):1279-1288.
18. Chisison KS, Sharma R, Wang Y, Mehrotra A, Schwamm LH. National trends in telestroke utilization in a US commercial platform prior to the COVID-19 pandemic. J Stroke Cerebrovasc Dis. 2021;30(10):106035.
19. Blue R, Yang AI, Zhou C, et al. Telemedicine in the era of coronavirus disease 2019 (COVID-19): a neurosurgical perspective. World Neurosurg. 2020;139:549-557.
20. Daallani R, Mani S, AU JG, et al. The impact of telemedicine in the postoperative care of the neurosurgery patient
in an outpatient clinic: a unique perspective of this valuable resource in the developing world—an experience of more than 3000 teleconsultations. World Neurosurg. 2014;82(3-4):270-283.

21. Thakar S, Rajagopal N, Mani S, et al. Comparison of telemedicine with in-person care for follow-up after elective neurosurgery: results of a cost-effectiveness analysis of 1200 patients using patient-perceived utility scores. Neurosurg Focus. 2018;44(5):E17.

22. Hamadi HY, Zhao M, Haley DR, Dunn A, Paryani S, Spaulding A. Medicare and telehealth: the impact of COVID-19 pandemic. J Eval Clin Pract. 2022;28(1):43-48.

Disclosures
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions
Conception and design: Bydon, Pennington. Acquisition of data: Biedermann, Ziegler, Durst. Analysis and interpretation of data: Michalopoulos. Drafting the article: Pennington, Michalopoulos. Critically revising the article: Bydon, Biedermann, Spinner, Meyer, Daniels. Reviewed submitted version of manuscript: Ziegler. Statistical analysis: Michalopoulos, Durst. Study supervision: Spinner, Meyer, Daniels.

Correspondence
Mohamad Bydon: Mayo Clinic, Rochester, MN. bydon.mohamad@mayo.edu.