

# Telemedicine for Neurosurgery Consultations at a Pituitary Center of Excellence: Patient Preference and Willingness to Proceed with Surgery

Alexander Craig McConnell Greven<sup>1</sup> James Miller Douglas<sup>1</sup> Jordan Couceyro<sup>1</sup> Anudeep Nakirikanti<sup>1</sup>  
 Reem Dawoud<sup>1</sup> Manuel Revuelta-Barbero<sup>1</sup> Elisabeth Ward<sup>2</sup> Erica Alexandra Giraldi<sup>2</sup>  
 Adriana Ioachimescu<sup>2</sup> Kimberly Bojanowski Hoang<sup>1</sup> David Painton Bray<sup>1</sup> Nelson M. Oyesiku<sup>1</sup>

<sup>1</sup> Department of Neurosurgery, Emory University School of Medicine, Atlanta, Georgia, United States

<sup>2</sup> Department of Endocrinology, Emory University School of Medicine, Atlanta, Georgia, United States

Address for correspondence Alexander Craig McConnell Greven, MBA, Department of Neurosurgery, Emory University School of Medicine, Atlanta, GA 30306, United States (e-mail: agreven@emory.edu).

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## Abstract

**Objective** The purpose of this study was to evaluate pituitary tumor patient satisfaction with telemedicine, patient preference for telemedicine, potential socio-economic benefit of telemedicine, and patients' willingness to proceed with surgery based on a telemedicine visit alone.

**Method** In total, 134 patients who had pituitary surgery and a telemedicine visit during the coronavirus disease 2019 (COVID-19) pandemic (April 23, 2020–March 4, 2021) were called to participate in a 13-part questionnaire. Chi-square, ANOVA, and Wilcoxon Rank Sum tests were used to determine significance.

**Result** Of 134 patients contacted, 90 responded (67%). Ninety-five percent were “satisfied” or “very satisfied” with their telemedicine visit, with 62% stating their visit was “the same” or “better” than previous in-person appointments. Eighty-two percent of the patients rated their telemedicine visit as “easy” or “very easy.” On average, patients saved 150 minutes by using telemedicine compared with patient reported in-person visit times. Seventy-seven percent of patients reported the need to take off from work for in-person visits, compared with just 12% when using telemedicine. Forty-nine percent of patients preferred in-person visits, 34% preferred telemedicine, and 17% had no preference. Fifty percent of patients said they would feel comfortable proceeding with surgery based on a telemedicine visit alone. Patients with both initial evaluation and follow-up conducted via telemedicine were more likely to feel comfortable proceeding with surgery based on a telemedicine visit alone compared with patients who had only follow-up telemedicine visits ( $p = 0.051$ ).

**Conclusion** Many patients are satisfied with telemedicine visits and feel comfortable proceeding with surgery based on a telemedicine visit alone. Telemedicine is an important adjunct to increase access to care at a Pituitary Center of Excellence.

## Keywords

- ▶ pituitary
- ▶ telemedicine
- ▶ neurosurgery
- ▶ pituitary center of excellence

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## Introduction

Due to the spread of novel coronavirus disease 2019 (COVID-19), health care providers began using telemedicine to reduce transmission of the virus and maintain durable pipelines for patients to access high-quality medical care. Obsolescent governmental/insurance policies concerning reimbursement prevented widespread use of telemedicine prior to the pandemic, but emergency waivers that lifted these restrictions led to expeditious adoption of telemedicine in all aspects of health care, including neurosurgical care. Neurosurgical use of telemedicine prior to the pandemic was intermittent; for example, it was used to triage remote neurotrauma in rural, underserved, resource-poor areas.<sup>1</sup> From the onset of the pandemic, most telemedicine research has been related to provider utilization, patient satisfaction,<sup>2</sup> treatment guidelines during the pandemic, and the use of telemedicine in routine follow-up care.<sup>3</sup> Only one study mentions telemedicine's potential for preoperative assessment.<sup>4</sup>

Telemedicine is a powerful technology that can transform health care by expanding access to specialty care and enhancing clinic efficiency. By increasing access, telemedicine is an important tool for Pituitary Centers of Excellence (PCEs), which rely on broad referral networks to generate high case volumes that create experience and expertise in the surgical care of pituitary pathology.<sup>5</sup> Despite the surge in telemedicine-related research within the past year, there are no studies that investigate patient preference for telemedicine compared with in-person visits, time saved using telemedicine, and the feasibility of using telemedicine for preoperative evaluation of adult cranial neurosurgical patients. Furthermore, there are no studies that address the use of telemedicine in the surgical management of pituitary disease.

### Objective

The purpose of this study was to evaluate patient satisfaction, patient preference, the potential socioeconomic benefit of telemedicine, and patients' willingness to proceed with surgery based on a telemedicine visit alone. Investigating patients' willingness to proceed with surgery provides insight into the feasibility of utilizing telemedicine for the initial surgical evaluation of patients with surgical pituitary disease.

## Materials and Methods

### Design

Internal Review Board (IRB) approval was obtained to access patient electronic medical records and publish findings based on this research. The requirement for patient consent was waived due to the retrospective study design. Due to the COVID-19 pandemic, the Emory Pituitary Center started seeing patients via telemedicine in March 2020 (single surgeon, senior author N.M.O.). Telemedicine visits were done to perform initial evaluations for new patients and conduct follow-up appointments for established patients. We performed a retrospective review of all patients who

both underwent pituitary surgery and had a telemedicine visit from April 1<sup>st</sup>, 2020 to April 1<sup>st</sup>, 2021. All patients had an in-person ophthalmology/neuro-ophthalmology appointment prior to surgery. Internal Review Board approval was obtained to access patient medical records and contact patients by phone to participate in a telemedicine survey. Patients who did not answer the phone were called up to three times on non-consecutive days. Patients who answered the phone but declined to participate were excluded but counted as a part of the total number of patients called.

### Telemedicine Survey

The telemedicine survey was a 13-part questionnaire designed by neurosurgery and endocrinology clinical staff to evaluate patient satisfaction with their recent telemedicine visit. A 5-point Likert scale was used to assess satisfaction, with responses ranging from "Extremely dissatisfied" to "Extremely satisfied." Other questions addressed how their telemedicine visit compared with previous in-person visits, how much time their telemedicine visit took compared with in-person visits (including travel time), how difficult it was to set up their telemedicine appointment, how difficult it was to proceed with ordered tests and follow-up appointments, whether they have to take off from work or require assistance for in-person visits, whether they would have preferred an in-person or telemedicine visit for their appointment if the pandemic never happened, and whether they would feel comfortable proceeding with surgery based on a telemedicine visit alone. If the patient answered "no," they were asked what could have been done during their telemedicine visit to make them more comfortable with proceeding to surgery. If the patient answered "yes," they were asked what about their telemedicine visit makes them comfortable to proceed with surgery. Thematic analysis was used to evaluate these open-ended responses to gain insight into the strengths and weaknesses of the telemedicine experience. Characteristics of the group that would proceed with surgery and the group that would not were analyzed. In addition, characteristics of the group that preferred telemedicine and the group that preferred in-person visits were analyzed.

### Statistical Analysis

Differences in categorical variables were assessed using the Chi-squared ( $\chi^2$ ) or Fisher's exact test, when frequency was less than 5. The Anderson-Darling test was used to assess normality of the distribution of data. Independent samples *t*-tests were used to compare parametric continuous data and the Mann-Whitney test was used to compare non-parametric data. Much of the data was not normally distributed, but mostly parametric results are reported below due to the Central Limit Theorem, stating that data approaches normality given a sufficiently large sample size (i.e.,  $n > 30$ ). All tests were two-sided, and *p*-value  $< 0.05$  was considered statistically significant. All analyses were performed using JMP Pro data analysis software version 15.1.0 (SAS Institute, Cary, North Carolina, United States).

## Results

One hundred and thirty-four patients were included in this study. Ninety-seven patients answered the phone, of which seven declined to participate. Thus, 90 patients (67%) participated in the survey. The mean patient age was 49 years ([SD] = 16). Fifty-eight patients were female (64%) and 32 were male (36%). Forty-seven patients were White (52%), 36 were Black (40%), three were Asian (3%), and four were unreported (4%). Sixty-five patients had non-functioning pituitary disease (72%), 24 had functioning pituitary tumors (27%), and one was unclear from pathology (1%). Prior to surgery, 40 patients had a visual field defect (44%) and nine had diplopia (10%). Fifty-one patients had both an initial evaluation and follow-up appointment conducted via telemedicine (57%), 37 had follow-up telemedicine only (41%), and two had initial surgical evaluation via telemedicine only (2%) (► **Table 1**).

Ninety-five percent of patients were either “satisfied” (14%) or “very satisfied” (81%) with their telemedicine visit. Sixty-two percent of patients said that their telemedicine visit was either “the same” (30%), “slightly better” (9%), or “much better” (23%) compared with previous in-person

**Table 1** Patient demographics

	Number of patients
Total called	134
Total responded	90 (67%)
Gender	
Male	32 (36%)
Female	58 (64%)
Age (years)	
17–40	28 (31%)
41–65	44 (49%)
65+	18 (20%)
Race	
White	47 (52%)
Black	36 (40%)
Asian	3 (3%)
Unreported	4 (4%)
Pathology type	
Functioning	24 (27%)
Non-functioning	65 (72%)
Unclear	1 (1%)
Visual changes	
Visual field defect	40 (44%)
Diplopia	9 (10%)
Telemedicine appointment	
Evaluation only	2 (2%)
Follow-up only	37 (41%)
Both	51 (57%)

**Table 2** Patient reported time

Questionnaire	Median (min–max)
How much time did the entirety of your telemedicine visit take including setup, waiting, and seeing the doctor?	
Time (min)	30 (10–90)
How long does it normally take you to travel to an in-clinic visit?	
Time (min)	56.25 (5–420)
How much time does a normal in-person visit take including traveling to clinic, seeing the doctor, and traveling home?	
Time (min)	180 (40–1,400)
Time saved by using telemedicine (Patient in-person reported time – patient telemedicine reported time)	
Time (min)	150 (–10 to 1,417)

visits, with 87% of patients stating they would use telemedicine again in the future.

The median amount of patient-reported travel time to an in-clinic visit was 56.25 minutes (range 5–420). The median amount of patient-reported time for a typical in-person visit, including travel to and from clinic, was 180 minutes (range 40–1440). There were three patients who listed their in-clinic visit times as 24 hours because they drove from out of state and had to spend the night before their appointment. The median amount of patient-reported time for the entirety of the telemedicine visit was 30 minutes (range 10–90). Patients saved a median of 150 minutes (range: –10 to 1,417) when using telemedicine compared with in-person visits (► **Table 2**). The “–10 minute” value is from one patient who had a 50-minute telemedicine visit but said a typical in-person visit was only 40 minutes. Twenty-two percent of patients normally required assistance to get to in-person visits. Seventy-seven percent of employed patients have to take off from work for in-person visits, compared with just 12% who had to take off from work for telemedicine (► **Table 3**).

On a scale of 1 to 10, 1 being “very easy” and 10 being “very difficult,” 60% of patients rated setting up their telemedicine appointment as “very easy,” with only 3% rating their visit as “very difficult.” Patients who rated their telemedicine visit as more difficult tended to be older than patients who rated their telemedicine visit as “very easy” ( $R^2 = 0.074$ ,  $p = 0.009$ , ► **Fig. 1**). Eighty percent of patients said that it was “very easy” to proceed with ordered tests and follow-up appointments after their telemedicine appointment, 10% said that it was “more difficult than after an in-person visit,” and 2% had “significant issues.”

Forty-nine percent of patients preferred in-person visits to telemedicine, 34% preferred telemedicine, and 17% had no preference. There were no statistically significant differences between these groups in sex, age, race, travel time to clinic, in-clinic appointment time, need for assistance to

**Table 3** Survey results

Questionnaire	Number of patients
How satisfied were you with your visit?	
Very satisfied	73 (81%)
Satisfied	13 (14%)
Somewhat dissatisfied	3 (3%)
Very dissatisfied	1 (1%)
Compared with previous in-person visits with neurosurgeon or neuroendocrinologist, how would you compare your telemedicine visit?	
Much better	21 (23%)
Slightly better	8 (9%)
The same	27 (30%)
Slightly worse	13 (14%)
Much worse	2 (2%)
N/A (refused to answer)	19 (21%)
Can you rate the difficulty of setting up your telemedicine appointment on a scale of 1–10, with 10 being “very difficult” and 1 being “very easy”?	
1–Very easy	54 (60%)
2	13 (14%)
3	7 (8%)
4	1 (1%)
5	6 (7%)
6	3 (3%)
7	1 (1%)
8	1 (1%)
9	1 (1%)
10–Very difficult	3 (3%)
Were you able to proceed with ordered tests (MRIs, etc.) and follow-up appointments after your telemedicine visit?	
Yes, very easily	72 (80%)
Yes, but it was more difficult than after an in-person visit	9 (10%)
No, I had issues	2 (2%)
Not sure	7 (8%)
Would you use telemedicine for a visit in the future?	
Yes	78 (87%)
No	6 (7%)
No preference	6 (7%)
If there was no pandemic, would you have preferred to have an in-person or a telemedicine visit?	
In-person	44 (49%)
Telemedicine	31 (34%)
No preference	15 (17%)

**Table 3** (Continued)

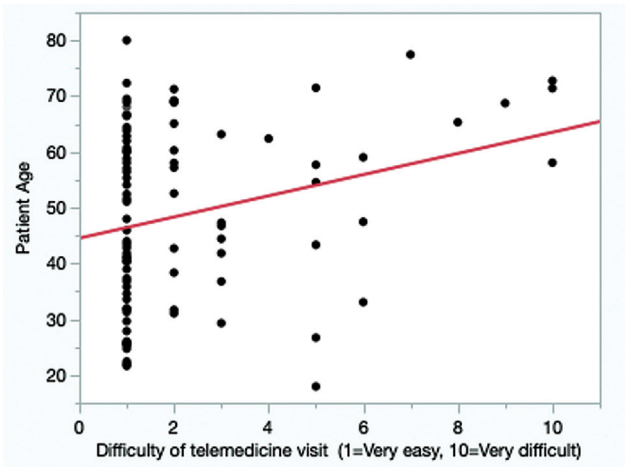
Questionnaire	Number of patients
Do you normally require assistance to get to in-person visits?	
Yes	70 (78%)
No	20 (22%)
Did your telemedicine visit require you to take off of work?	
Yes	7 (8%)
No	53 (59%)
N/A (retired/not working)	30 (33%)
Do you normally have to take off work for in-person visits?	
Yes	48 (53%)
No	14 (16%)
N/A (retired/not working)	28 (31%)
Would you feel comfortable proceeding with surgery based on a telemedicine visit alone?	
Yes	45 (50%)
No	45 (50%)

get to in-person visits, need to take off from work for in-person visits, or whether the patient had a telemedicine visit for initial surgical evaluation, postop follow-up, or both.

Fifty percent of patients said they would feel comfortable proceeding with surgery based on a telemedicine visit alone, while 50% of patients said they would not. There were no statistically significant differences between these groups in sex, age, race, travel time to clinic, in-clinic appointment time, need for assistance to get to in-person visits, or need to take off from work for in-person visits. When excluding the two patients who had initial evaluations only by telemedicine, patients who had both initial surgical evaluation and follow-up appointments with telemedicine were more likely to feel comfortable proceeding with surgery compared with patients who only had follow-up telemedicine visits ( $p = 0.051$ ).

### Thematic Analysis

Themes affecting patient preference for an in-person preoperative visit included a personal preference for in-person visits ( $n = 17$ , 36%), reservations about foregoing an in-person physical exam ( $n = 6$ , 13%), perceptions of diminished quality of the telemedicine interaction compared with in-person visits ( $n = 11$ , 23%), a situational preference—meaning they would rather have telemedicine for follow-up, but in-person for preop ( $n = 10$ , 21%), technical issues ( $n = 4$ , 8%), and reservations based on meeting the surgeon for the first time over teleconference ( $n = 3$ , 6%). Fifteen percent ( $n = 7$ ) stated that nothing could be done to make them comfortable proceeding with surgery based on telemedicine alone. Themes from patients who would proceed with surgery based on a telemedicine preop visit were satisfaction with the quality of care



**Fig. 1** Patient age versus difficulty of telemedicine visit. Patient age (y) related to difficulty rating of telemedicine (x). 1 = “Very easy” (n = 54), 2 (n = 13), 3 (n = 7), 4 (n = 1), 5 (n = 6), 6 (n = 3), 7 (n = 1), 8 (n = 1), 9 (n = 1), 10 = “Very difficult” (n = 3).  $R^2 = 0.074$ ,  $p$ -value = 0.009.

received (n = 16, 39%), a lack of perceived difference to an in-person visit (n = 11, 27%), overall convenience (n = 8, 19%), prior experience with the surgeon (n = 6, 14%), and previous experience at the pituitary center (n = 1, 2%).

**Discussion**

Telemedicine is a powerful technology that has the potential to transform care of the neurosurgical patient. To date, most telemedicine research involves the two extremes of neurosurgical care: triaging of remote neurotrauma and routine follow-up care. There are several studies that investigate satisfaction with telemedicine and time saved using telemedicine, but there are no studies that investigate the potential of telemedicine for initial surgical evaluation. Furthermore, there is no literature that discusses the utility of telemedicine for managing pituitary pathology. Thus, our study aims to better understand the telemedicine experience for patients with pituitary pathology, and to assess their willingness to proceed with surgery based on a telemedicine visit alone.

Our survey results show that patients are highly satisfied with their telemedicine appointments and are willing to use telemedicine in the future. Additionally, many patients had a better experience with telemedicine than with their in-person visits. Roughly one-third of patients preferred telemedicine to in-person visits. This satisfaction with and preference for telemedicine did not correlate with patient age, travel time to clinic, need for assistance for in-person visits, and need to miss work for in-person visits. This is unprecedented, as other literature has identified age as a potential barrier to telemedicine adoption due to comfort level with technology.<sup>6</sup> Other studies have found that patients who live further away and have longer travel times are more likely to prefer telemedicine.<sup>7</sup> It is reasonable to assume that patients who have more difficulty getting to in-person visits (i.e., require assistance or must miss work) would be more likely to prefer telemedicine. A reason for the difference in our analyses includes our small

sample size; it is possible that we simply did not have sufficient power to detect these differences in preference. Thus, larger, multicenter surveys are needed. Second, our results may suggest that telemedicine can benefit all types of patients, regardless of age or their proximity to the clinic.

We also assessed the relationship of patients’ difficulty with using telemedicine and their age, finding that patients who had more difficulty with telemedicine tended to be older ( $R^2 = 0.074$ ,  $p = 0.009$ , **Fig. 1**). The small  $R^2$  is a result of the wide age range (23–81 years) of patients who rated telemedicine as “very easy.” Despite this small  $R^2$ , there is an obvious trend in the data illustrating the correlation between age and perceived difficulty. This finding is consistent with the literature that suggests age as a potential barrier to telemedicine.<sup>6</sup> Despite this trend in our ease-of-use data, there was no effect on satisfaction or preference for telemedicine amongst older patients. This may be due to the preemptive measures taken by the Emory Pituitary Center to facilitate ease of access through clear communication, step-by-step instructions, and a preliminary call from an advanced practice provider prior to the telemedicine visit. It is important to note the age-related trend in difficulty so that measures can be taken to ensure a smooth and productive virtual visit.

With telemedicine, fewer patients had to miss work (70% of patients for in-person, 12% for telemedicine) or receive assistance to get to their in-person visit. Patients saved a median of 150 minutes (–10 to 1,417) by using telemedicine compared with traveling for in-person visits. Given that the median hourly wage in the United States is \$19.33 per hour,<sup>8</sup> patients can save \$48.33 by using telemedicine for just one visit. Measuring from the patients’ home address, the median number of miles traveled to and from clinic was 63.9 (range 1.5–356). Given that the average vehicle gets 20 miles per gallon,<sup>9</sup> and the average cost of unleaded gas in Georgia for 2020 was \$2.906 per gallon, (16) patients also saved \$9.28 on gas by using telemedicine, bringing total savings of \$57.61 per telemedicine visit. With 2.131 lbs of CO<sub>2</sub> emitted into the atmosphere and with the 90 patients from our study using telemedicine for just two visits instead of coming to clinic, it would save 24,510.76 lbs of CO<sub>2</sub> from being emitted into the atmosphere.<sup>10,11</sup> (**Table 4**) These

**Table 4** Fast facts—using telemedicine

Benefit	Per visit, per patient
Money saved	
From not missing work	\$48.33
From not buying gas	\$9.28
Total	\$57.61
Travel	
Miles of car travel saved	63.9
Environment	
Lbs. of CO <sub>2</sub> emissions saved	136.2

<sup>a</sup>Based on one patient utilizing telemedicine one time. Assumptions: Median hourly wage - \$19.33; Avg. MPG 2010 American car: 20 MPG; Avg. cost of gas in GA 2020: \$2.906/gallon; Lbs. of CO<sub>2</sub> emitted per gallon of gasoline: 2.131.



findings are consistent with existing neurosurgical literature that shows telemedicine can save patients substantial travel time, travel cost, and time away from work.<sup>12</sup>

The cost benefit provided by telemedicine is not limited to the patients. Remote consultations for pituitary surgery also have large implications for PCEs. By transitioning a portion of patients to remote visits, centers can decrease their demand for electricity, patient parking, front desk staff, and waiting/exam room space. In addition, telemedicine allows PCEs to expand their geographic range, which can attract more patients. This increase in patients drives case volume, which has been demonstrated to improve efficiency, decrease complications, and improve outcomes of pituitary surgery.<sup>13</sup> Telemedicine can also facilitate multidisciplinary collaboration and participation in pituitary appointments. According to The Pituitary Society, an organized multidisciplinary approach is vital to deliver comprehensive and excellent patient care.<sup>13</sup> With telemedicine, patients have the access to these highly specialized, multidisciplinary teams from their own home.

Half of the patients in our survey felt comfortable proceeding with surgery after a telemedicine visit alone. The other half preferred to have an in-person visit prior to surgery. The willingness to proceed with surgery did not correlate with any of the patient factors that were measured including age, gender, race, travel time, in-clinic visit time, need for assistance to get to in-person visits, or need to miss work for in-person visits. We found that patients who had both their preoperative evaluation and follow-up appointment via telemedicine were more likely to feel comfortable proceeding with surgery than patients who only had follow-up appointments via telemedicine ( $p = 0.051$ ). This makes intuitive sense, since the patients who had already had preoperative evaluation with telemedicine and proceeded with surgery had experience with the practice. These patients witnessed the utility of telemedicine for preoperative evaluation first-hand and experienced a good outcome. Technically this association did not reach statistical significance but given the  $p$ -value of 0.051 we believe this shows a strong trend. Patients undergoing only follow-up telemedicine visits tended to visit in-person prior to surgery. This finding suggests that once patients are exposed to the possibility of telemedicine being used successfully for preoperative evaluation, they are more likely to feel comfortable with telemedicine evaluation going forward. Ultimately, using telemedicine for presurgical evaluation depends on the preference of both the surgeon and the patient. It is imperative that a formal physical exam is done in person on the day of surgery when a patient is scheduled for surgery via telemedicine.

To gain an additional insight into the reasons underlying the differences in patient's comfort proceeding to surgery based on a telemedicine visit alone, a thematic analysis was performed. The analysis was performed on patient responses to one of two qualitative questions asked based on the response to question 13, "Would you feel comfortable proceeding with surgery based on telemedicine visits alone?" If they answered "no," patients were asked, "is there anything that could have been done during your telemedicine visit that would have made you feel more comfortable proceeding

with surgery?" If they answered "yes," patients were asked "what about your telemedicine visit made you feel comfortable proceeding with surgery?"

Major themes from the "no" cohort seemed to emphasize the importance of an in-person interaction prior to surgery, particularly an in-person physical exam. Future directions to ameliorate patient concerns with preoperative evaluations and discussions over telemedicine could involve leveraging technologies such as at home blood pressure monitoring, remote pulse oximetry, or wearable technologies with accelerometers to evaluate movement. While employment of these measures in no way replaces the physical exam, it may help to enhance patient comfort with the telemedicine experience. Interestingly, 21% of patients with a "situational preference" said they would prefer telemedicine for discussion of laboratory results and routine follow-up, but that in-person visits were best suited for initial surgical evaluation. Very few patients reported technical issues ( $n = 4$ , 8%). This suggests that patients are adept at using technology, and that the clear instructions provided by the Emory Pituitary Center facilitated ease of use. Nearly 15% stated that nothing could be done to make them comfortable proceeding with surgery based on telemedicine alone. For these patients, in-person preop visits are vital to establish comfort and trust with the operating surgeon and supporting team.

Major themes from the "yes" cohort were satisfaction with the quality of care received ( $n = 16$ , 39%), a lack of perceived difference to an in-person visit ( $n = 11$ , 27%), and overall convenience ( $n = 8$ , 19%). With the ability to remotely share prior imaging, laboratory results, and discuss with the surgeon face-to-face, these patients saw no difference between a telemedicine and in-person visit. Several patients had already formed a strong level of trust with the surgeon and/or pituitary center, which made them feel that telemedicine was appropriate for a preop visit.

### Limitations

Limitations include both a small sample size and a population of patients specific to a single center, Emory University. There is also likely a selection bias from the 67% of patients that agreed to participate in this telephone survey. Larger, multicenter studies should be conducted to confirm and further validate the trends found in this study. All patient-reported times were retrospective and subject to inaccurate estimation and bias. This may over- or underestimate the time saved using telemedicine. We attempted to control for this recall bias by performing distance from clinic calculations based on the home address of patients. Furthermore, the calculations of money and CO<sub>2</sub> emissions saved were guided by assumptions based on national averages, which leave a large range of error. In depth financial analysis should be performed to further elucidate the socioeconomic impact of telemedicine for both patients and providers.

### Conclusion

Telemedicine is a powerful technology that has the potential to transform health care by increasing patient access,

increasing clinic efficiency, and lowering the cost of health care delivery. Patients are highly satisfied with their telemedicine experience with a portion of patients preferring telemedicine to traditional in-person visits. Half of patients feel comfortable proceeding with surgery based on a telemedicine visit alone, indicating the potential utility of telemedicine for preoperative evaluation. PCEs are patient centric organizations that aim to provide the very best standard of care to patients with pituitary tumors and disorders. By using telemedicine, PCEs are able to expand their geographic reach, increase patient volumes, improve provider-patient communication, and organize a specialized multidisciplinary team approach that is vital for surgical pituitary treatment. PCEs can use telemedicine to increase access to standard of care and increase patient volume and surgical experience. This will lead to increased efficiency, decreased complications, and overall better outcomes for patients.<sup>13,14</sup>

#### Conflict of Interest

None declared.

#### References

- Olldashi F, Latifi R, Parsikia A, et al. Telemedicine for neurotrauma prevents unnecessary transfers: an update from a nationwide program in Albania and analysis of 590 patients. *World Neurosurg* 2019;128:e340–e346
- Yoon EJ, Tong D, Anton 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
- 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(05):E17
- Mihalj M, Carrel T, Gregoric ID, et al. Telemedicine for preoperative assessment during a COVID-19 pandemic: Recommendations for clinical care. *Best Pract Res Clin Anaesthesiol* 2020;34(02):345–351
- Frara S, Rodriguez-Carnero G, Formenti AM, Martinez-Olmos MA, Giustina A, Casanueva FF. Pituitary tumors centers of excellence. *Endocrinol Metab Clin North Am* 2020;49(03):553–564
- Scott Kruse C, Karem P, Shifflett K, Vegi L, Ravi K, Brooks M. Evaluating barriers to adopting telemedicine worldwide: a systematic review. *J Telemed Telecare* 2018;24(01):4–12
- Greven ACM, McGinley BM, Guisse NF, et al. Telemedicine in the evaluation and management of neurosurgical spine patients: questionnaire assessment of 346 consecutive patients. *Spine* 2021;46(07):472–477
- Gould E. State of working America wages 2019. *Economic Policy Institute*. Report. February 20, 2020. Accessed June 13, 2021 at: <https://www.epi.org/publication/swa-wages-2019/>
- Automotive Trends Report. United States Environmental Protection Agency. Accessed June 13, 2021 at: <https://www.epa.gov/automotive-trends/highlights-automotive-trends-report>
- Gas Prices. AAA. Accessed June 13, 2021 at: <https://gasprices.aaa.com/state-gas-price-averages/>
- Calculate your carbon footprint: Quality, transparency, and the highest standards. *Terrapass*. Accessed June 13, 2021 at: [https://www.terrapass.com/carbon-footprint-calculator?utm\\_source=ppc&utm\\_medium=search&utm\\_campaign=experiment\\_2&utm\\_term=exp\\_2\\_calculator\\_2&gclid=Cj0KCQjw5auGBhDEARIsAFyNm9E4oEWw4AoUzbHvllqxn02p3YdgCGewB0Qj2Wsy1qL5Ny9wNIEM-QaAkaPEALw\\_wcB](https://www.terrapass.com/carbon-footprint-calculator?utm_source=ppc&utm_medium=search&utm_campaign=experiment_2&utm_term=exp_2_calculator_2&gclid=Cj0KCQjw5auGBhDEARIsAFyNm9E4oEWw4AoUzbHvllqxn02p3YdgCGewB0Qj2Wsy1qL5Ny9wNIEM-QaAkaPEALw_wcB)
- Hayward K, Han SH, Simko A, James HE, Aldana PR. Socioeconomic patient benefits of a pediatric neurosurgery telemedicine clinic. *J Neurosurg Pediatr* 2019;1–5:1–5
- Casanueva FF, Barkan AL, Buchfelder M, et al; Pituitary Society, Expert Group on Pituitary Tumors. Criteria for the definition of Pituitary Tumor Centers of Excellence (PTCOE): a pituitary society statement. *Pituitary* 2017;20(05):489–498
- McLaughlin N, Laws ER, Oyesiku NM, Katznelson L, Kelly DF. Pituitary centers of excellence. *Neurosurgery* 2012;71(05):916–924, discussion 924–926