Journal of Neuro-Oncology
https://doi.org/10.1007/s11060-022-04173-7

RESEARCH

Patient satisfaction and cost savings analysis of the telemedicine program within a neuro-oncology department

James K. C. Liu[1,4,5] · Richard Kang[1,5] · Arkady Bilenkin[1,5] · Rachel Prorok[1,5] · Junmin Whiting[6] · Krupal B. Patel[2] · Andre Beer-Furlan[1] · Cristina Naso[7] · Andrea Rogers[1] · Xavier Baez Castro[1] · Edwin Peguero[1] · Sepideh Mokhtari[1] · Nam Tran[1] · Arnold Etame[1] · Yolanda Pina[1] · Philippe E. Spiess[3] · Peter Forsyth[1] · Michael A. Vogelbaum[1]

Received: 6 September 2022 / Accepted: 17 October 2022

Abstract
Purpose Unique challenges exist in the utilization of telemedicine for neurological and surgical specialties. We examined the differences in patient satisfaction for telemedicine versus in-person visits within a Neuro-Oncology Program to assess whether there was a difference between surgical and medical specialties. We also examined the potential cost savings benefits of utilizing telemedicine.

Methods 1189 Press Ganey surveys in the Department of Neuro-Oncology (982 in-person and 207 telemedicine) by surgical and medical neuro-oncology patients between 04/01/2020 and 06/30/2021 were reviewed. Survey results were divided into 4 categories (Access, Provider, Technology (telemedicine only), and Overall Satisfaction). Results were analyzed for the impact of telemedicine versus in-person visits, and gender, age, insurance, and specialty. Cost savings were calculated based on potential travel distance and lost productivity.

Results Survey results from telemedicine visits demonstrated that patients with private insurance returned higher scores in the Provider ($p=0.0089$), Technology ($p=0.00187$), and Overall ($p=0.00382$) categories. Surgical patients returned higher scores for Access ($p=0.0015$), Technology ($p=0.0002$), and Overall ($p=0.0019$). When comparing telemedicine to in-person scores, in-person scored higher in Provider ($p=0.0092$) for all patients, while in-person scored higher in Access ($p=0.0252$) amongst surgical patients. Cost analysis revealed that telemedicine allowed patients to save an average of 4.1 to 5.6 h per visit time and a potential cost savings of up to $\$223.3 \pm 171.4$.

Conclusion Telemedicine yields equivalent patient satisfaction when employed in surgical as compared to medical Neuro-Oncology patients with the potential to lessen the financial and time burden on neuro-oncology patients.

Keywords Telemedicine · Neuro-oncology · Neurosurgery · Press Ganey · Cost savings

This work has not been previously presented.

✉ James K. C. Liu
james.liu@moffitt.org

1 Neurosurgical Oncology, Department of Neuro-Oncology, H. Lee Moffitt Cancer Center and Research Institute, 12902 USF Magnolia Dr, Tampa, FL 33612, USA

2 Department of Head and Neck Oncology, H. Lee Moffitt Cancer Center and Research Institute, Tampa, FL, USA

3 Department of GU Oncology, H. Lee Moffitt Cancer Center and Research Institute, Tampa, FL, USA

4 Department of Tumor Biology, H. Lee Moffitt Cancer Center and Research Institute, Tampa, FL, USA

5 University of South Florida Morsani College of Medicine, Tampa, FL, USA

6 Department of Biostatistics & Bioinformatics, H. Lee Moffitt Cancer Center and Research Institute, Tampa, FL, USA

7 Virtual Health Program, H. Lee Moffitt Cancer Center and Research Institute, Tampa, FL, USA

Introduction

Telemedicine has traditionally been utilized primarily by medical specialties, and often for the delivery of advanced tertiary services to hospitals that could not provide such subspecialty care [1]. With the COVID-19 pandemic, newfound concerns for patient and provider safety, limited resources, and a desire to lessen a compounding patient burden motivated medical facilities across the United States to significantly expand their use of telemedicine [2].

There can be unique limitations of telemedicine for certain specialties, such as neurological and surgical disciplines, due to the limitations of the virtual encounter. In neurological specialties, hesitation to employ telemedicine has stemmed primarily from difficulties associated with conducting the neurological exam virtually [3, 4]. Although there have been numerous studies that document and educate on methods and strategies to obtain an accurate neurologic assessment via telehealth, limitations persist and continue to support apprehension about its use [5–9]. In surgical specialties, the need to build rapport with patients for discussing and planning surgical procedures that carry potentially serious risks may not be ideal in a virtual setting [10]. Also, immediate post-operative visits require the examination of surgical wounds which may be challenging depending on the location.

Like many institutions across the country, the Neuro-Oncology Department/Program at H. Lee Moffitt Cancer Center and Research Institute (MCC) was required to accelerate the adoption of telemedicine due to the pandemic. This need was even more important in the oncologic patient population, as many patients may be immunocompromised and are at greater risk of severe illness if acquiring the infection [11]. Our department is multidisciplinary by design and includes neurosurgeons, neuro-oncologists, and general neurologists within one administrative entity. This structure provided us with the ability to directly compare the usage of telemedicine services between our surgical and medical specialists. Our aim was to evaluate whether the limitations in the use of telemedicine for surgical patients was reflected in patient satisfaction survey results. Additionally, we examined the potential cost savings benefit from telemedicine utilization during this time.

Methods

Clinical review

This retrospective cohort study was approved by the Institutional Review Board at MCC. Telemedicine was defined as care delivered through a videoconferencing platform in real-time. Starting in April 2020, MCC instituted use of the Zoom (San Jose, CA, USA) platform for telehealth visits. The electronic medical records of patients seen in the Neuro-Oncology Department at MCC from 4/1/2020 to 6/30/2021 were reviewed. These included patients seen by neurosurgery, neuro-oncology, and general neurology providers. Neurosurgery was categorized under surgical neuro-oncology, while neuro-oncology and general neurology was categorized under medical neuro-oncology. General neurology consisted of non-oncology neurological pathologies (e.g. headaches, seizures, etc.). The choice for a telemedicine visit was made between each patient and provider. Both patients and providers could request telemedicine visits, and each party could refuse. We obtained patient demographic data (gender, age, insurance type), patient location (address with zip code), and the diagnosis categorized into primary or metastatic brain or spine tumors.

Press Ganey Patient Satisfaction Survey results

The Press Ganey Patient Satisfaction survey is a questionnaire designed by Press Ganey Associates LLC. (South Bend, IN, USA), utilized by numerous United States hospitals designed to assess the patient experience [12]. The Outpatient Oncology Survey was used for in-person outpatient visits and consists of consists of 36 questions divided into multiple categories inquiring about different aspects of the patient experience. Each question is answered on a Likert scale of 1 to 5, 1 representing 'very poor' and 5 representing 'very good.' The Medical Practice Telemedicine Survey was used for telemedicine visits. It consists of 10 total questions separated into 4 categories: Access, Care Provider, Telemedicine Technology, and Overall Assessment.

Telemedicine and in-person Press Ganey Patient Satisfaction survey scores from 4/1/2020 to 6/30/2021 were obtained. To best correlate the telemedicine and in-person surveys, select questions from the in-person survey were selected to correlate with the categories of Access, Provider, and Overall Assessment in the telemedicine survey (Supplemental Figs. 1 and 2). Questions that could not be translated for comparison to telemedicine visits were omitted (registration, facility, nurses, laboratory, personal issues, symptom management). Demographic information was collected for patients that completed the telemedicine and in-person surveys, including patient gender and age (<65 years old and ≥ 65 years old). Insurance type was collected and categorized as private insurance, Medicare, and other, which includes Medicaid, Veterans Affairs coverage, self-pay, and charity. Medicare is a federally supported health insurance program for patients 65 years and older, younger patients with disabilities, and patients with end-stage renal disease [13]. Medicaid is a federally supported health care for patients of low income [14]. Veterans Affairs health care coverage is federally supported health coverage for patients who have served in the military and meet certain service requirements [15]. Patient visits were categorized as new or follow-up visits, and surgical or medical visits.

Travel savings calculation

Potential travel savings analysis was calculated from the addresses of patients who underwent telemedicine visits in the Department of Neuro-Oncology between April 2020 through June 2021. Potential travel was calculated as the round-trip distance in miles the patient would have traveled for an in-person consultation at MCC. Distance was calculated based on the distance between the patient's documented address and MCC. For patients with postal offices as a mailing address, zip codes were used as a driving departure point.

Time savings calculation

Potential time savings were calculated based on the estimated driving time from the calculated travel distances, added to the estimated time for an in-person clinic visit. The mean duration for an in-person visit was determined based on Moffitt Cancer Center institutional estimates for clinic check-in to check-out times, which was 96.4 min for new visits and 58.1 min for follow up visits. An additional 30 min were added for parking. Therefore, a new visit was calculated as 126.4 min and a follow-up visit as 88.1 min.

Cost savings calculations

Cost savings was defined as round-trip costs arising from a potential in-person visit. This included both the (1) direct cost of travel based on mileage and (2) potential lost productivity due to the medical visit. Cost of operating a vehicle was calculate based on either the (a) Internal Revenue Services' 2020 standard mileage rate of $0.56/mile [16] or (b) the American Automobile Association standard mileage rate of $0.82/mile [17], multiplied by distance travelled for each round trip. We did not include the cost of parking as it is provided at no cost to all patients and visitors at MCC. The American Census Survey (ACS) was used to determine census tract level data for hourly median income per year which was divided by 2080 h to determine the hourly wage [18]. The census tract income data was then matched to the patient's address to obtain accurate representation of hourly wages.

Two different models were generated to account for the two different mileage rates and the hourly wage rate determined via ACS census tract level data. Patients 65 years and older were assumed to be retired and assigned an hourly wage of $0. Age 65 was used as an estimation for retirement because in the United States Social Security benefits are activated at this age [19]. A sensitivity analysis was conducted with an assumption that 20% of the 65 and older population continued to be employed based on United States Bureau of Labor Statistics projections [20].

Driving distance travelled in miles and travel time analysis was completed in October 2021 by Buxton Company, Fort Worth, TX. Calculations for different models were conducted using R (R. Core Team, Vienna, Austria).

Statistics

Statistics were calculated using GraphPad Prism or SAS (Version 9.4, SAS Institute Inc, Cary, NC). Student T Test or Wilcoxon Rank Sum Test was used to compare results of telemedicine and in-person Press Ganey Scores. A one-way ANOVA or Kruskal-Wallis Test was used to for Press Ganey score subgroup analysis of insurance coverage. Chi-square test or Fisher exact test was applied to test if there is difference between Neurosurgery and Medical for the demographic variables, or there is difference between telemedicine and in-person for those variables. P-value < 0.05 were considered statistically significant.

Results

Neuro-oncology program telemedicine visits

From April 2020 through June 2021, there were 2089 telemedicine visits in the department of Neuro-Oncology at MCC (Table 1). There were 1210 (58%) female patient visits and 879 (42%) male visits. 1337 (64%) were patients under the age of 65, 752 (36%) were 65 or over (age range 33–86. Median = 65). 606 (29%) visits were with surgical, 1483 (71%) visits were with medical (neurology or neuro-oncology).

For patients seeing surgical neuro-oncology providers, 235 (38.8%) carried private insurance, 291 (48.0%) carried Medicare, and 80 (13.2%) had other payments. 568 (93.7%) patients were seen for oncology reasons, 38 (6.3%) were seen for non-oncology reasons, including general neurosurgery, such as degenerative spine disease. Of the oncology visits, 199 (35.0%) were for primary brain tumors, 176 (31.0%) were for metastatic brain tumors, 47 (8.3%) were for primary spinal tumors, and 146 (25.7%) were for metastatic spine tumors.

Table 1 Demographic of telemedicine visits in the Neuro-Oncology Program at Moffitt Cancer Center

		Surgical N (%)	Medical N (%)	P value
Gender	Female	340 (56.1)	870 (58.7)	0.282
	Male	266 (43.9)	613 (41.3)	
Age	< 65	332 (54.8)	1005 (67.8)	< 0.001
	≥ 65	274 (45.2)	478 (32.2)	
Insurance	Private insurance	235 (38.8)	600 (40.5)	0.459
	Medicare	291 (48.0)	669 (45.1)	
	Medicaid & Other	80 (13.2)	214 (14.4)	
Visit type	Oncology	568 (93.7)	603 (40.7)	< 0.001
	Non-oncology	38 (6.3)	880 (59.3)	
Location	Brain	377 (66.4)	594 (98.5)	< 0.001
	Spine	191 (33.6)	9 (1.5)	
Diagnosis	Primary Brain	199 (35.0)	457 (75.8)	< 0.001
	Metastatic Brain	176 (31.0)	137 (22.7)	
	Primary Spine	47 (8.3)	7 (1.2)	
	Metastatic Spine	146 (25.7)	2 (0.3)	
Total		606 (29.0)	1483 (71.0)	

P values were calculated by Chi-square test or Fisher exact test.

Table 2 Demographic of telemedicine and in-person Press Ganey survey responses

		Telemedicine Survey N (%)	In Person Survey N (%)	P value
Gender	Female	128 (61.8)	536 (54.6)	0.056
	Male	79 (38.2)	446 (45.4)	
Age	< 65	99 (47.8)	516 (52.6)	0.217
	≥ 65	108 (52.2)	466 (47.4)	
Specialty	Medical	133 (64.3)	448 (45.6)	< 0.001
	Surgical	74 (35.7)	499 (50.8)	
	Not specified	0	35 (3.6)	
Insurance	Private insurance	69 (33.3)	380 (38.7)	0.346
	Medicare	121 (58.5)	531 (54.1)	
	Medicaid & Other	17 (8.2)	71 (7.2)	
Total		207 (17.4)	982 (82.6)	

P values were calculated by Chi-square test or Fisher exact test

For patients seeing medical neuro-oncology providers, 600 (40.5%) carried private insurance, 669 (45.1%) carried Medicare, and 214 (14.4%) had other types of payment. 603 (40.7%) were seen for management of oncologic disease, 880 (59.3%) were oncology patients seen for the treatment of general neurological diseases, such as headaches and seizures. Of the oncology visits, 457 (75.8%) were for primary brain tumors, 137 (22.7%) were for metastatic brain tumors, 7 (1.2%) were for primary spinal tumors, and 2 (0.3%) were for metastatic spine tumors.

Telemedicine Press Ganey Survey

A total of 207 Telemedicine Press Ganey Survey results were obtained from April 2020 through June 2021 (Table 2). Of those with identified providers, 133 (64.3%) patients were seen by medical neuro-oncology and 74 (35.7%) by surgical neuro-oncology. There were 128 (61.8%) females and 79 (38.2%) males; 99 (47.8%) were below the age of 65, and 108 (52.2%) were 65 years or older; 69 (33.3%) had private health insurance, 121 (58.5%) had Medicare, and 17 (8.2%) had other forms of payment.

When comparing the Press Ganey Scores based on the 4 question categories, males generally reported higher scores in all categories, but none reached statistical significance (Fig. 1a). No differences were detected between age groups in any of the categories.

When comparing patient responses based on payment type, there were no differences in assessment of Access. However, patients with private insurance (mean (M) = 4.78, median (Mdn) = 5.00, p = 0.0089) and those with Medicare (M = 4.82, Mdn = 5, p = 0.0138) returned significant higher provider ratings compared to those with other (M = 4.46, Mdn = 4.833) coverage. This result was also seen for telemedicine technology when comparing private (M = 4.78, Mdn = 5.00, p = 0.0187) or Medicare (M = 4.82, Mdn = 5.00, p = 0.0437) to other (M = 4.55, Mdn = 5.00). In the overall category, patients with private insurance (M = 4.79, Mdn = 5.00) had significant higher scores overall compared to patients with other insurance (M = 4.70, Mdn = 5.00, p = 0.0382) but did not demonstrate significance when compared with Medicare (M = 4.5, Mdn = 5.00).

When comparing surgical to medical patients, significantly higher scores were detected for surgical patients for the access (surgical: M = 4.86, Mdn = 5.00 vs. medical: M = 4.56, Mdn = 5.00, p = 0.0015), telemedicine technology (surgical: M = 5.00, Mdn = 4.90 vs. medical: M = 4.63, Mdn = 5.00, p = 0.0002), and overall assessment (surgical: M = 4.90, Mdn = 5.00 vs. medical: M = 4.62, Mdn = 5.00, p = 0.0019) categories.

In-person Press Ganey Survey

A total of 982 in-person Press Ganey Survey results were obtained between April 2020 and June 2021 (Table 2). Of these, 448 (45.6%) patients were seen by neuro-oncology or neurology providers, 499 (50.8%) by neurosurgery providers. 35 (3.6%) responses did not include provider information. Among these, 536 (54.6%) patients were female, 446 (45.4%) were male, 516 (52.6%) were below the age of 65, 466 (47.4%) were 65 years or older, 380 (38.7%) had private health insurance, 531 (54.1%) had Medicare, and 71 (7.2%) were other types of payment.

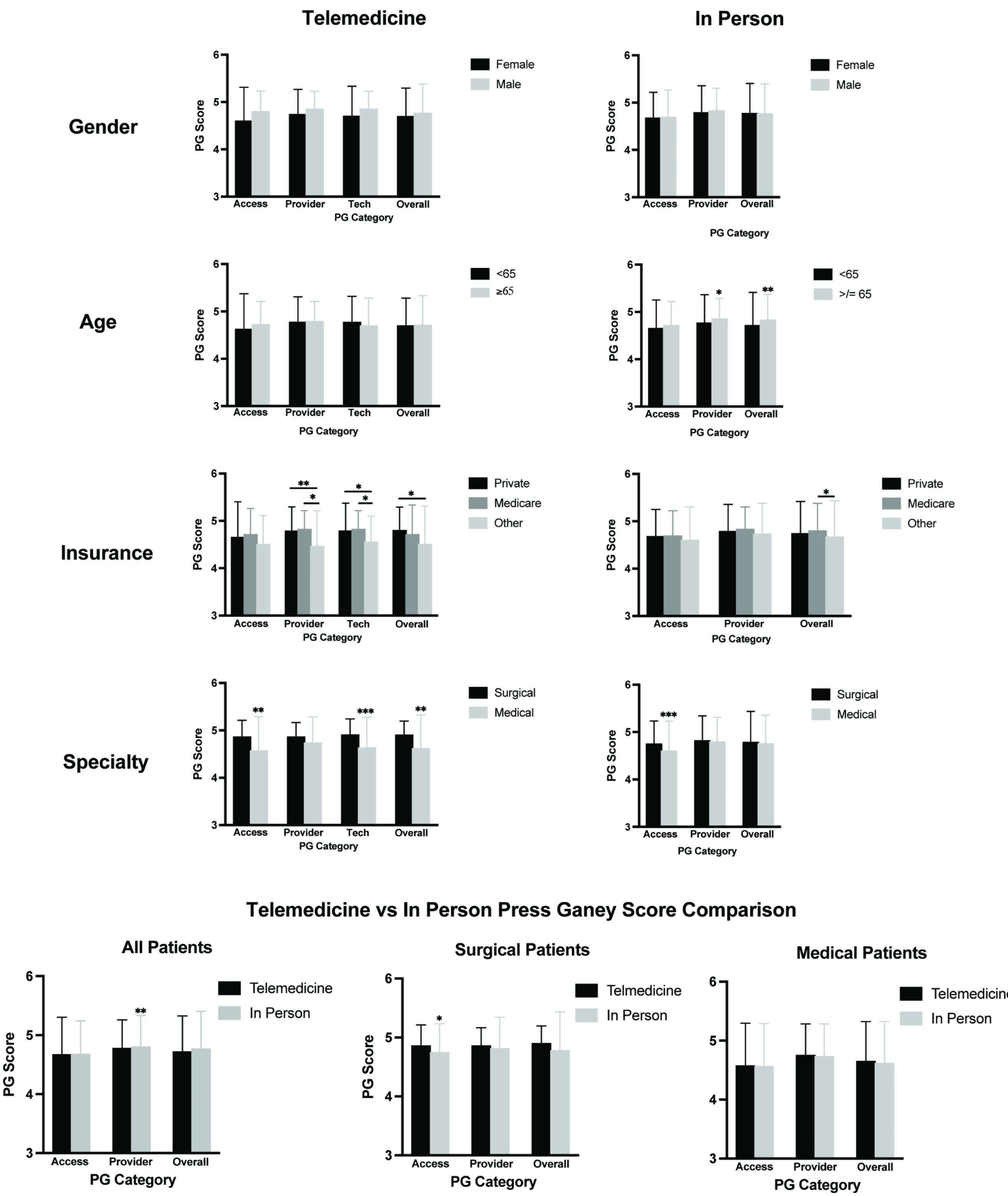

Fig. 1 Press Ganey results for Telemedicine and In-Person visits. (A) Press Ganey results were divided into 4 separate categories: Access, Provider, Telemedicine Technology, and Overall Assessment. The survey results were compared by patient gender, age, insurance type and surgical vs. medical specialty for both telemedicine visits as well as in-person visits. (B) Direct comparisons between telemedicine and in-person survey results were performed for Access, Provider, and Overall Assessment. * = $P \leq 0.05$, ** = $P \leq 0.01$, *** = $P \leq 0.001$

Table 3 Total number of visits, round trip drive time, and round-trip distance of telemedicine visits. Estimated cost savings of telemedicine visits with sensitivity analysis adjustment for patients ≥ 65

		Patients < 65 y/o		Patients ≥ 65 y/o	
		NP	**F/U**	**NP**	**F/U**
Average round-trip distance (miles)		179.1 ± 153.5	129.1 ± 126.5	183.7 ± 113.3	142.9 ± 137.0
Average round-trip time (hrs)		3.4 ± 2.5	2.6 ± 2.1	3.5 ± 1.8	2.9 ± 2.3
Average total visit time saved (hrs)		5.5	4.1	5.6	4.4
Standard Analysis					
Avg. lost productivity ($)		76.4 ± 51.1	56.3 ± 37.5	0.00	0.00
Model 1: $0.56/mile	Avg. savings per visit ($)	176.7 ± 132.2	128.6 ± 104.8	102.9 ± 63.4	80.0 ± 76.7
Model 2: $0.82/mile	Avg. savings per visit ($)	223.3 ± 171.4	162.2 ± 137.3	150.6 ± 92.9	117.2 ± 112.3
Sensitivity Analysis					
Avg. lost productivity ($)		76.4 ± 51.1	56.3 ± 37.5	16.5 ± 8.1	13.0 ± 9.0
Model 1: $0.56/mile	Avg. savings per visit ($)	176.7 ± 132.2	128.6 ± 104.8	119.4 ± 70.1	93.0 ± 84.7
Model 2: $0.82/mile	Avg. savings per visit ($)	223.3 ± 171.4	162.2 ± 137.3	167.1 ± 99.5	130.2 ± 120.2

The survey scores were separated into 3 distinct categories representing parts of the patient experience: Access, Care provider, and Overall assessment. For those categories, there were no significant difference between genders (Fig. 1). Patients ≥65 years old reported significant higher scores compared to < 65 for the provider (≥65: M = 4.85, Mdn = 5.00 vs. < 65: M = 4.76, Mdn = 5.00), p = 0.0368) and overall assessment (≥65: M = 4.82, Mdn = 5.00 vs. < 65: M = 4.71, Mdn = 5.00, p = 0.0010) categories. When comparing based on insurance coverage, Medicare patients were found to have significantly higher overall assessment scores (Medicare: M = 4.80, Mdn = 5.0 vs. other: M = 4.66, Mdn = 5.00, p = 0.0172). When comparing surgical to medical patients, the former reported significantly higher ratings for access (surgery: M = 4.75, Mdn = 5.00 vs. medical: M = 4.60, Mdn = 5.00, p = 0.0002), with no other differences.

Potential time and travel savings

The average clinic visit time estimated based on institutional averages was 2.1h for new patients and 1.5 h for follow-up visits. Patients under the age of 65 had an average round trip distance of 179.1 ± 153.5 miles and 3.4 ± 2.5 h of drive time for new patient visits, and 129.1 ± 126.5 miles and 2.6 ± 2.1 h for follow-up visits (Table 3). Patients > 65 years old had an average round trip distance of 183.7 ± 113.3 miles and 3.5 ± 1.8 h of drive time for new patient visits, and 142.9 ± 137.0 miles and 2.9 ± 2.3 h for follow-up visits. For patients under the age of 65, total time saved was 5.5 and 4.1 h for new and follow-up patients, respectively. For patients 65 and older, total time saved was 5.6 and 4.4 h for new and follow-up patients, respectively.

Potential cost savings

Cost savings analysis was calculated based the distance spent on travel combined with the estimated loss in potential productivity (Table 3). For patients under the age of 65, average savings per new patient visit cost savings were estimated at $176.70 ± 132.21 with Model 1 and $223.27 ± 171.41 with Model 2; while follow up patient visit cost savings were estimated as $128.63 ± 104.79 with Model 1 and $162.20 ± 137.26 with Model 2. For patients 65 years or older, average savings per new patient visit was calculated as $102.88 ± 63.44 using Model 1, and $150.64 ± 92.89 using Model 2. Follow-up visits were estimated as $80.02 ± 76.69 with Model 1 and $117.17 ± 112.30 with Model 2.

Using sensitivity analysis to assume that 20% of individuals over the age of 65 continue to be employed, estimated average savings per new patient visit was $119.35 ± 70.12 with Model 1 and 167.1 ± 99.53 with Model 2, and for follow-up was $93.03 ± 84.7 with Model 1 and $130.19 ± 120.24 with Model 2.

Discussion

At Moffitt Cancer Center, telemedicine has been used by select departments since 2017, and was in the process of wider implementation throughout the institution immediately prior to the onset of the pandemic. The Department of

Neuro-Oncology had just begun to incorporate telemedicine into clinical practice starting in mid-2019. Incorporation of telemedicine was at the discretion of the provider, with greater application by the medical over the surgical providers. The pandemic forced the incorporation of telemedicine to be accelerated in both types of specialties, and we took advantage of this within our department to see if there was a difference between medical and surgical specialties in terms of patient satisfaction.

For the telemedicine Press Ganey survey results, there was no significant difference between gender or age. The fact that age did not show a difference may be surprising as previous studies have shown that older patient populations demonstrated a lower rate of telemedicine use [21, 22]. This result may also represent selection bias as those who may be opposed to telemedicine chose in-person visits.

The most significant differences were seen in comparisons for insurance type and surgical versus medical specialty. In the Provider and Telemedicine Technology categories, patients with private insurance demonstrated higher scores when compared to both patients with Medicare and the other types of payment. In the Overall category, patients with private insurance demonstrated higher scores compared to other payment types. Previous studies have demonstrated that patients with Medicaid were less likely to be seen with telemedicine than patients who were privately insured [23]. This may represent a correlation with access and comfort level associated with education or resources [24].

Press Ganey scores were higher for surgical patients in all categories and statistically significant for Access, Telemedicine Technology, and Overall Assessment. Although historically surgical specialties have been late adopters of telemedicine, as was the case in our Neuro-Oncology Program, the survey results suggest that patient satisfaction is overall favorable. Although this finding may also be secondary to selection bias, as surgeons may have more frequently offered telemedicine for post-operative or routine surveillance visits which are generally less intensive than other visit types.

When comparing telemedicine to in-person visits, in-person patients provided higher Press Ganey scores for providers ($M=4.80$, $Mdn=5.00$ (in-person) vs. $M=4.78$, $Mdn=5.00$ (telemedicine), $p=0.0092$). The only other finding that reached statistical significance was that surgical telemedicine patients provided higher scores than in-person patients (telemedicine: $M=4.86$, $Mdn=5.00$ vs. in-person: $M=4.75$, $Mdn=5.00$, $p=0.0252$). This result may reflect the ease of provider access provided by the telemedicine platform.

Overall, our results demonstrated patient satisfaction for surgical patients was not inferior to medical patients and may be superior in certain survey categories. This result may be a representation of one of the major limitations of this study, which is the presence of a selection bias when a patient is offered, or requests, a telemedicine visit. Surgeons likely would choose follow-up or routine imaging surveillance visits for telemedicine while keeping initial consults which may involve discussion of surgical intervention in-person. Despite the known challenges of surgical telemedicine visits, in many instances, surgical visits may prove to be more straightforward than medical visits given the nature of surgical outpatient encounters, which may include routine post-operative follow-ups or interval imaging reviews of benign lesions. In the case of acute post-operative visits, telemedicine may prove an adequate means of screening patients for surgical complications prior to an in-person meeting. Previous studies have shown that telemedicine can be used effectively to identify surgical site infection, and this approach could save patients and their caregivers significant time and money, as well as alleviate any potential disruptions to their recovery resulting from travel [25]. It will be challenging to use the data to definitively confirm that telemedicine can demonstrate equipoise when compared to in-person visits, but this study indicates that telemedicine can provide acceptable care for appropriately selected patients.

Our analysis of time and cost savings demonstrates the considerable burden that could be lifted from the utilization of telemedicine visits. We observed time savings of 4.1 to 5.6 h depending on the type of visit. We also found that patients 65 years and older had on average a longer round-trip travel time. This result may be secondary to the demographic landscape of the western Florida region, given the large number of retirees and their locations relative to MCC. Dullet et al. examined time and cost savings associated with telemedicine consultations at the University of California Davis Health System and found that patients saved an average of 245 +/-195 min of travel time and $150 +/- $128 in travel expenses when seen virtually [26]. However, the actual cost savings were likely higher because the authors did not consider the loss in patient productivity associated with travel in the calculations. Another factor that can be taken into consideration is the loss of productivity of patient caregivers who may accompany patients to their medical visits.

There are limitations to this study. The satisfaction survey responses are a fraction of the actual visits, and this may represent an attrition bias. In terms of estimating costs savings, the analysis was retrospective and conducted at a tertiary/quaternary referral center where travel distances may be higher due to the center being a destination site for cancer care. Our assumption of employment rate and incomes for younger versus older patients may vary, however a sensitivity analysis was conducted to address this limitation. Previous reports have demonstrated that 54% of cancer patients are no longer working full time, and therefore precise estimations regarding loss of productivity can be challenging [27]. This study only considered telemedicine visits that were completed via synchronous videoconference, and the availability and costs of hardware and internet connection were not considered.

Conclusion

Telemedicine can be effectively applied for both surgical and medical visits. We have demonstrated that in addition to the obvious advantages that telemedicine can offer, there is also a potential for significant costs savings due elimination of travel costs and loss of productivity.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11060-022-04173-7

Acknowledgements The authors would like to thank Cristina Perez, Terry Payton, and Matthew Sears from the Moffitt Patient Experience team for their assistance in providing the anonymized patient satisfaction data, Kavita Ghia from the Moffitt Collaborative Data Services Core for providing demographics data on all visits seen at Moffitt, members of Moffitt Cancer Center's Planning & Market Data Analytics Department for their help with data curation and analysis.

Author's contribution JKCL, KP, PF, MAV contributed to conceptualizing of the project JKCL, RK, AB, RP, AR, XBC contributed to gathering of data JKCL, JW, KP, ABF, CN, AR, XBC, EP, SM, NM, AE, YP, PS contributed to data interpretation and manuscript editing JKCL, AB, KP, YP, PF, MAV contributed to writing and editing of the main manuscript text.

Declarations

Competing interests The authors declare no competing interests.

References

1. Tuckson RV, Edmunds M, Hodgkins ML (2017) Telehealth. N Engl J Med 377:1585–1592. https://doi.org/10.1056/NEJMsr1503323
2. Doraiswamy S, Abraham A, Mamtani R, Cheema S (2020) Use of Telehealth During the COVID-19 Pandemic: Scoping Review. J Med Internet Res 22:e24087. https://doi.org/10.2196/24087
3. Daggubati LC, Eichberg DG, Ivan ME, Hanft S, Mansouri A, Komotar RJ, D'Amico RS, Zacharia BE (2020) Telemedicine for Outpatient Neurosurgical Oncology Care: Lessons Learned for the Future During the COVID-19 Pandemic. World Neurosurg 139:e859–e863. https://doi.org/10.1016/j.wneu.2020.05.140
4. Fonkem E, Gatson NTN, Tadipatri R, Cole S, Azadi A, Sanchez M, Stefanowicz E (2021) Telemedicine review in neuro-oncology: comparative experiential analysis for Barrow Neurological Institute and Geisinger Health during the 2020 COVID-19 pandemic. Neurooncol Pract 8:109–116. https://doi.org/10.1093/nop/npaa066
5. Goyal DKC, Divi SN, Schroeder GD, Pfeifer R, Canseco JA, Bowles DR, Nicholson KJ, Patel PD, Reyes AA, Radcliff KE, Kurd MF, Woods BI, Kaye ID, Rihn JA, Anderson DG, Hilibrand AS, Kepler CK, Harrop JS, Vaccaro AR (2020) Development of a Telemedicine Neurological Examination for Spine Surgery: A Pilot Trial. Clin Spine Surg 33:355–369. https://doi.org/10.1097/bsd.0000000000001066
6. Awadallah M, Janssen F, Körber B, Breuer L, Scibor M, Handschu R (2018) Telemedicine in General Neurology: Interrater Reliability of Clinical Neurological Examination Via Audio-Visual Telemedicine. Eur Neurol 80:289–294. https://doi.org/10.1159/000497157
7. Haddad AF, Burke JF, Mummaneni PV, Chan AK, Safaee MM, Knightly JJ, Mayer RR, Pennicooke BH, Digiorgio AM, Weinstein PR, Clark AJ, Chou D, Dhall SS (2021) Telemedicine in Neurosurgery: Standardizing the Spinal Physical Examination Using A Modified Delphi Method. Neurospine 18:292–302. https://doi.org/10.14245/ns.2040684.342
8. Basil G, Luther E, Burks JD, Govindarajan V, Urakov T, Komotar RJ, Wang MY, Levi AD (2021) The Focused Neurosurgical Examination During Telehealth Visits: Guidelines During the COVID-19 Pandemic and Beyond. Cureus 13:e13503. https://doi.org/10.7759/cureus.13503
9. Hauk H, Bernhard J, McConnell M, Wohlfarth B (2021) Breaking bad news to cancer patients in times of COVID-19. Support Care Cancer 29:4195–4198. https://doi.org/10.1007/s00520-021-06167-z
10. Ryu WHA, Kerolus MG, Traynelis VC (2021) Clinicians' User Experience of Telemedicine in Neurosurgery During COVID-19. World Neurosurg 146:e359–e367. https://doi.org/10.1016/j.wneu.2020.10.101
11. McGrowder DA, Miller FG, Vaz K, Anderson Cross M, Anderson-Jackson L, Bryan S, Latore L, Thompson R, Lowe D, McFarlane SR, Dilworth L (2021) The Utilization and Benefits of Telehealth Services by Health Care Professionals Managing Breast Cancer Patients during the COVID-19 Pandemic. Healthc (Basel) 9. https://doi.org/10.3390/healthcare9101401
12. Press Ganey Associates LLC (n.d (2022)) Patient Experience. https://www.pressganey.com/products/patient-experience. Accessed October 9,
13. US Centers for Medicare and Medicaid Services (n.d.) Medicare. https://www.medicare.gov/. Accessed October 9,2022
14. US Centers for Medicare and Medicaid Services (n.d.) Medicaid(2022) https://www.medicaid.gov/medicaid/index.html. Accessed October 9,
15. US Department of Veterans Affairs (2022) Eligibility for VA Health Care. https://www.va.gov/health-care/eligibility/. Accessed October 9, 2022
16. Internal Revenue Service (2021) IRS issues standard mileage rates for 2021. https://www.irs.gov/newsroom/irs-issues-standard-mileage-rates-for-2021
17. American Automobile Association (2020) Your Driving Costs
18. United States Census Bureau (2019) American Community Survey Data. https://data.census.gov/cedsci/
19. Ci Z (2022) Does raising retirement age lead to a healthier transition to retirement? Evidence from the U.S. Social Security Amendments of 1983. Health Econ 31:2229–2243. https://doi.org/10.1002/hec.4572
20. U.S. Bureau of Labor Statistics (2022) Employment Projections. https://www.bls.gov/emp/tables/civilian-labor-force-participation-rate.htm. Accessed October 9, 2022
21. Chen EM, Andoh JE, Nwanyanwu K (2022) Socioeconomic and Demographic Disparities in the Use of Telemedicine for Ophthalmic Care during the COVID-19 Pandemic. Ophthalmology 129:15–25. https://doi.org/10.1016/j.ophtha.2021.07.003

22. Eberly LA, Kallan MJ, Julien HM, Haynes N, Khatana SAM, Nathan AS, Snider C, Chokshi NP, Eneanya ND, Takvorian SU, Anastos-Wallen R, Chaiyachati K, Ambrose M, O'Quinn R, Seigerman M, Goldberg LR, Leri D, Choi K, Gitelman Y, Kolansky DM, Cappola TP, Ferrari VA, Hanson CW, Deleener ME, Adusumalli S (2020) Patient Characteristics Associated With Telemedicine Access for Primary and Specialty Ambulatory Care During the COVID-19 Pandemic. JAMA Netw Open 3:e2031640. https://doi.org/10.1001/jamanetworkopen.2020.31640
23. Xiong G, Greene NE, Lightsey HMt, Crawford AM, Striano BM, Simpson AK, Schoenfeld AJ (2021) Telemedicine Use in Orthopaedic Surgery Varies by Race, Ethnicity, Primary Language, and Insurance Status. Clin Orthop Relat Res 479:1417–1425. https://doi.org/10.1097/corr.0000000000001775
24. Fischer SH, Ray KN, Mehrotra A, Bloom EL, Uscher-Pines L (2020) Prevalence and Characteristics of Telehealth Utilization in the United States. JAMA Netw Open 3:e2022302. https://doi.org/10.1001/jamanetworkopen.2020.22302
25. Ng HJH, Huang D, Rajaratnam V (2022) Diagnosing surgical site infections using telemedicine: A Systematic Review. Surgeon 20:e78–e85. https://doi.org/10.1016/j.surge.2021.05.004
26. Dullet NW, Geraghty EM, Kaufman T, Kissee JL, King J, Dharmar M, Smith AC, Marcin JP (2017) Impact of a University-Based Outpatient Telemedicine Program on Time Savings, Travel Costs, and Environmental Pollutants. Value Health 20:542–546. https://doi.org/10.1016/j.jval.2017.01.014
27. Blinder VS, Gany FM (2020) Impact of Cancer on Employment. J Clin Oncol 38:302–309. https://doi.org/10.1200/jco.19.01856