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"Leading Health Outcomes by Design"

COR PROJECT REPORT
Adoption of telemedicine for post-surgical follow-up visits

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Executive Summary

Houston Methodist Hospital has integrated a telemedicine platform within the electronic medical record for use as an alternative to the clinical post-surgical visits within the department of surgery. Currently only one surgeon is actively using the platform, and uncovering the reason for this low adoption is of particular interest. We conducted a usability study in which nine surgeon-participants were engaged in a mock patient interaction through the telemedicine platform and encouraged to talk aloud through their thought process. The transcripts of the talk-aloud activity and four established technology adoption relevant surveys were used both to assess the current attitudes of the clinicians towards telemedicine and to uncover potential hurdles to adoption in the present form of the service.

We found that, while culturally all of the available participants are supportive of telemedicine, there are significant concerns that telemedicine may not be appropriate for all of the surgical patient populations seen at Houston Methodist.

- Concerns were expressed for the some patient populations being encouraged to use telemedicine; specialties such as surgical oncology felt that their patient pool would be inappropriate.
- Some patients themselves may be personally averse to the notion of care delivered by telemedicine and in some cases even when presented with the option, choose to make the trip to the physician's clinic in person.
- Among those patients receptive to the use of telemedicine, the individual comfort with technology and ability to aim the camera at the surgical site was a concern.
- Concern was expressed for the legal and malpractice liability when seeing patients through a telemedicine system, suggesting whatever arrangements are in place may not be well communicated to the physicians at this time.
- Adoption requires additional support from office staff, who require specific training.

From a usability standpoint, the current telemedicine platform would benefit from alterations in future installations.

- Ensure the user interface to initiate the telemedicine visit is clear and obvious.
- Embed the telemedicine interface into Epic; the current iteration manifests as a floating window that can obstruct Epic access during clinical care.

Responses to the survey tools suggest that participation in the telemedicine platform should be significantly higher than it presently is. While nearly every participant indicated support for the adoption of telemedicine and recognized the potential benefits, only one out of the eight surgeons who were previously aware of its availability had attempted to adopt it (one was unaware). When asked about incorporating telemedicine into their practices, all of the surgeons were positive, but felt that their particular patient pools or workflows were not ideal. Surgeons felt that their patients typically prefer to have the first, if not all, follow-up sessions in person, due to the sensitive nature of care. Relatedly, the surgeons who handle breast cases especially indicated that hands-on patient care was a necessity for their patients and that there is not presently a substitute for that interaction.

Surgeons perceive patients' preference for in-person visits as a significant barrier for them to adopt the telemedicine platform in their practices, leading to lower adoption rates than expected. Therefore, further extension of this study can include patients among the interview or survey participants so that patient perceptions can also be elicited regarding the usage of telemedicine platform. Physicians will find the existing telemedicine platform more useful if it is demonstrated to

improve their efficiency, thereby reducing workload. Efforts on improving the design of the HMH telemedicine platform should continue.

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Introduction

The Institute of Medicine defines telemedicine as "*the use of electronic information and communication technologies to provide and support healthcare when distance separates participants.*"[1] Present adoption of telemedicine in U.S. hospitals is estimated to have surpassed 50% and is anticipated to continue growing.[2,3] By facilitating patient care interactions without requiring direct proximity, telemedicine can deliver high quality healthcare to a wider population, at potentially reduced cost. The constant improvement of the supporting technology, i.e. internet connectivity, and home computing, has further encouraged the development of telemedicine. The benefits are wide-ranging and include increased access to specialty care and time and cost savings, especially for patients living in rural environments.[4,5] Thus, telemedicine can be an essential tool to facilitate patients' convenience and reduce the loss of hospital resources by arranging scheduled follow-up, routine and ongoing monitoring, and handling the management of issues as they arise.[6]

For simple medical checkups, telemedicine has the potential to reduce workload and hospital costs as well as improve convenience for the patients. In pursuit of these benefits, Houston Methodist has installed a telemedicine platform to handle medically simple post-surgical follow up visits where possible. The determination of medical complexity is left to the individual surgeon to decide.

Post-surgical follow-up appointments to assess patient recovery and incision are typically conducted within two weeks of the initial surgical procedure. In many cases, these routine visits include a brief physical examination to collect patient vitals and an inspection of the surgical site. These follow-up encounters provide quality of care to the patients but also lead to a significant expenditure of operational resources in the clinic, as well as opportunity costs for the patients. Follow-up visits not only require the patient to take time off from work, drive to the medical facility, and pay for gas and parking, but also require the clinic to arrange for room changeover and staffing to manage the workflow. These requirements are in addition to the time allocated by the surgeons, who continuously face increasing time constraints and high-performance demands. Furthermore, the postoperative follow-up visits do not generate additional financial benefits to the surgeon or the healthcare institution since these visits are bundled into the surgical global package. Therefore, it is imperative to find alternative healthcare delivery options to provide quality follow-up care to postoperative patients while optimizing the use of valuable clinic resources.

Studies have found that the use of telemedicine for follow-up postoperative visits results in brief encounters that provide high quality of care and satisfaction to the patients while reducing visit duration, patient waiting time, direct patient expenses, and patient travel time, and providing efficiency and operational gains to the surgeons and clinics.[6–9] Despite myriad ongoing pilot programs at healthcare systems across the United States, uptake of telemedicine for surgical specialties has been relatively slow, even for low-risk postoperative care. Telemedicine is one of the most understudied clinical tools, even when this platform is convenient for medication refills, scheduling appointments, and communication with healthcare providers.

In order to explore why telemedicine platforms are being underutilized in surgical specialties and what is necessary for broader postoperative utilization, a user-focused study was conducted in the Department of Surgery in the Houston Methodist Hospital (HMH).

Findings from academic literature regarding the adoption of telemedicine systems in clinical domains suggest that even when studies have shown evidence of beneficial reductions in the duration of healthcare interventions, other factors (technological, task-related, and organizational) hinder clinicians' buy-in of the technology and lead to low adoption rates in healthcare settings. Concerns regarding the integration of the technology into clinical workflow,[10–12] unbalanced workload,[10] misaligned incentives,[11,12] lack of reimbursement,[11] usability of the technology,[11,12] non-integration issues with other systems such as the electronic health records (EHR),[12] length of implementation time,[13] and staff requirements,[13] among other relevant factors, have been identified as barriers to widespread use of telemedicine systems. Most of the work in this area has focused on hospitals and primary care settings, and for medical conditions such as diabetes, hypertension, heart diseases, and complex pediatric conditions. Research regarding the identification of barriers for telemedicine adoption for postoperative care is limited. Therefore, it is necessary to understand the perceived barriers for the adoption of telemedicine to provide follow-up care to postoperative patients.

Justification for Selected Approach

An underutilized or low-adopted technology, no matter how technically capable it may be, ends up being operationally ineffective due to the opportunity costs regarding the time and resources wasted. Achieving increments in the adoption of new technologies requires understanding the level of acceptance and readiness of potential users. User technology acceptance is a topic that has been widely investigated in the research community, whose findings have suggested that user acceptance is a significant success factor for the adoption of information technology.[14] One of the most influential contributions in this area is the Technology Acceptance Model (TAM).[15] This framework, grounded in the Theory of Reasoned Action,[16] provides a deeper understanding of the system characteristics that influence user acceptance of computer-based information systems, in addition to an applicable methodology to evaluate new information technologies prior to implementation. According to TAM, user acceptance of information technology is explained by the causal relationships of two major determinants: (1) perceived usefulness, and (2) perceived ease of use, which influences the user attitudes towards using the technology and their intention to use it. This model has been applied for the evaluation of multiple information technologies, in different organizational contexts and user groups.[16]

In the case of telemedicine, TAM, as well as modified versions, have been applied to study physicians' acceptance of telemedicine technology.[16–18] Results from these studies have shown that the applicability of TAM provides a reasonable predictive model of physicians' intention to use telemedicine systems. However, TAM is not the only approach that has been used to measure physicians' technology acceptance in the context of telemedicine. Researchers in this area have also used multidimensional assessment questionnaires that include acceptance as one of the dimensions to determine physicians' acceptability and satisfaction with telemedicine technologies.[19–21] The use of these questionnaires is limited by the lack of theoretical foundation compared to TAM. However, although TAM has a robust theoretical basis, it is much more complex in comparison with other technology acceptance tools, such as the Van der Laan's Technology Acceptance Questionnaire (TAQ) for the assessment of acceptance of new technology.[22] Van der Laan's TAQ is a simple bi-dimensional assessment that utilizes users' attitudes towards both usefulness and satisfaction to measure their level of technology acceptance. To the best of our knowledge, this procedure has not been implemented to assess physicians' technology acceptance in the context of telemedicine. Therefore, there is a potential benefit in the parallel use of both tools, TAM and Van der Laan's TAQ, to evaluate physicians' acceptance of telemedicine systems.

Assessing users' readiness is another crucial aspect to predict user acceptance and adoption behaviors. Research focused on readiness has targeted two areas: (1) assessing people's readiness for organizational change, and (2) assessing people's readiness to interact with technology. For the specific case of users' interaction with technology, the Technology Readiness Index (TRI)[23] has received significant attention in the domain of technology readiness. The TRI applies a multi-item scale with questions addressing four dimensions: (1) optimism, (2) innovativeness, (3) discomfort, and (4) insecurity. The first two dimensions, optimism and innovativeness, are used as drivers to assess users' readiness to adopt a technology, while the last two dimensions, discomfort and insecurity, are considered inhibitors to technology readiness. In the context of telemedicine, the academic literature has focused on addressing readiness for organizational change,[13,24,25] including aspects of technology readiness, while providing a broader organizational perspective about users' readiness for telemedicine adoption. Tools like the TRI, which provides a more specific perspective of users' general inclination toward adopting a technology, have been applied for the evaluation of readiness for other health information technology (HIT), such as electronic medical records,[26] but no evidence regarding its use for evaluation telemedicine technologies has been found.

Usability issues have been identified as another significant barrier to the adoption and acceptance of HIT.[27] Usability, which can be defined as "the extent to which technology can be used efficiently, effectively, and satisfactorily,"[27] has gained significant emphasis after the establishment of the Health Information Technology for Economic and Clinical Health (HITECH) Act which promotes the adoption and integration of HIT in healthcare settings.[27] Therefore, multiple usability study methods have been applied for the HIT usability evaluation.[28] In the context of telemedicine, studies including usability evaluations for the multiple modalities of telemedicine are rare. Even with the availability of multiple methods for usability evaluation, such as observation, interviews, and the application of think-aloud verbal protocols, for example, the use of questionnaires remains as the most common method applied in this area.[29] In addition to the talk-aloud approach, an subjective evaluation of the interface design in the System Usability Scale (SUS) provides a measurable perception of key usability metrics.[30] SUS encourages user perceptions of aspects of interface and system interaction in easily understood scaled response format. Usability evaluations are a powerful tool to identify usability issues. In the case of technologies already implemented that are underutilized or have low adoption rates, it is relevant to expose the potential users to the technology to understand the usability issues that may arise from the human-technology interaction.

The application of tools and methods to assess acceptance, readiness and usability issues, in addition to the identification of barriers for the widespread use of telemedicine, provides a robust framework to investigate the low adoption of telemedicine platforms for postoperative follow-up care.

Objective

The objective of this study was to explore why the adoption rate of a telemedicine platform for postoperative visits, already in place in HMH, is significantly lower than anticipated despite the full availability of this support. The study specifically sought to identify provider-driven improvements in the current telemedicine platform and workflow, which will increase provider utilization of the telemedicine platform and inspire other telemedicine applications within the Department of Surgery. The aims of the study were to (1) understand the surgeons' readiness for, and general awareness of, the telemedicine technology, (2) expose surgeons to the telemedicine platform, observe usability issues, and solicit their feedback, and (3) understand the barriers to implementation of telemedicine post-op visits, insights on successes and failures, and best practices for implementation. The strategy to achieve these aims was two-fold: (1) to qualitatively explore perspectives from surgeons from HMH regarding adoption of telemedicine portal through the analysis of interviews, and (2) to correlate the determinants of telemedicine adoption with a quantitative analysis of surgeons' opinion and experience related to usability, function, visual appeal and satisfaction with the telemedicine platform.

Materials and Methods

This study is an exploratory, descriptive study based on information and data collected from a series of brief interviews, the use of the Technology Readiness Index (TRI) as a pre-exposure survey, a mock patient interaction via telemedicine and post interaction survey using Van der Laan's Technology Acceptance Questionnaire (TAQ), System Usability Scale (SUS), and Technology Acceptance Model (TAM), in addition to a brief post exposure interview. Participants were interviewed to establish their thoughts and feelings towards the use of telemedicine and hence understand the current limitations of the telemedicine platform. All procedures were approved by the HMH Institutional Review Board.

Setting and Study Material

Houston Methodist Hospital has integrated a telemedicine platform into the surgical department for use as an alternative to the clinical post-surgical visits. The patients can schedule follow-up appointments with their providers as required and receive consultation and treatment using the telemedicine platform. The appointment is scheduled for video conferencing, called a video visit, for surgical patients. Video visits are offered through computer/mobile phone/tablet with Wi-Fi or high speed internet access. The patients can connect to this telemedicine service through a MyChart account. MyChart is part of a system-wide EHR-integrated patient portal system available at all Houston Methodist facilities. This system provides a more efficient patient experience by allowing secure access to patients' health records, test results, and communication with doctor's office, bill payment, scheduling and reviewing appointments, etc.

The study population consists of Houston Methodist employees from the Department of Surgery who qualify to use the post-surgery telemedicine platform at Houston Methodist. Inclusion criteria were aims-driven. There were no gender, age, or race/ethnicity exclusions within this population; vulnerable groups (children, those lacking capacity to consent) were not applicable to this population.

Data Collection

Our team has interviewed surgeons from the Department of Surgery within HMH. Sessions were conducted in the clinicians' office at their indicated convenience. Individual research sessions were conducted to facilitate understanding of the current limitations of the telemedicine platform. A series of brief surveys, TRI, TAM, TAQ, and SUS, were collected to quantify the individuals' particular opinions on technology adoption. Finally, an interaction with a mock patient was used as an informal summative usability evaluation. Throughout all the segments of the study session, participants were encouraged to talk aloud through their thought process. The results from a rapid coding of the transcripts of those sessions provide the details of the physician perspectives on telemedicine.

Data Analysis Methods

Qualitative Analysis

An inductive and deductive Qualitative Data Analysis (QDA) of the audio-recorded sessions was conducted using a grounded theory approach,[31] with the purpose of understanding surgeons' perspectives about barriers and facilitators for telemedicine adoption, in addition to identifying potential usability issues with the HMH telemedicine platform. Two team members participated as analysts in the data coding process. The MAXQDA-12 software was used to analyze the interviews as it facilitates the analysis and visualization process. Each analyst used MAXQDA-12 to develop a codebook, following a set of established stages. The first stage, known as initial coding, included the identification of a thematic framework, where the analysts assigned preliminary codes to the data to describe the content. The initial coding was followed by a second stage of focused coding, where specific patterns or themes across the different interviews were identified within each of the preliminary initial codes. Then, a third stage was held to interpret the identified patterns and provide an explanation for the data. The codebooks generated by the two analysts were then discussed in an internal meeting to develop a unique final QDA codebook. The analysts agreed in 90 percent of the statements. In the cases of disagreement, the analysts discussed the codes and the statements until reaching an agreement. When necessary, an additional team member participated in the discussion as a third analyst.

Quantitative Analysis

Data collected from the brief surveys were used as the input for the statistical analyses. The survey elements included tested and validated instruments.[22,32] Each question was scored from 1 to 5 on a Likert scale, with 1-rating indicating strong disagreement and 5-rating indicating strong agreement. At first, a correlation matrix was developed to quantify the strength and association between each predictor variable. Then, based on their significance level (i.e., significant if p-value < 0.05) the strongly correlated parameters were identified. Finally, three structural equation models were developed to investigate whether the elements of relevant adoption models are interrelated and have impacted the adoption of telemedicine at HMH. Since the number of survey participants (n=9) limited our ability to estimate an appropriate distributional assumption, the Partial Least Square (PLS) estimation technique was employed for the structured equation modeling approach, as this method makes no distributional assumption.

Results

Qualitative Results

A total of nine participants were successfully recruited, ranging in age from 35 to 70, and practicing as surgeons for three months to 39 years. The sessions conducted with surgeons provided a number of insights into their self-identified technology readiness and their perceptions of telemedicine in general. Five main thematic categories were deduced from the initial coding stage of the QDA process (Figure 1): (1) awareness of the availability of a telemedicine platform, (2) reasons for not implementing, (3) perceived benefits and advantages from implementation, (4) perceived concerns (challenges and disadvantages) from implementation, and (5) usability. The prevalence of each thematic category is presented in Figure 1. The focused coding produced themes under the five high-level thematic categories. Findings relevant to the identified themes are provided below.

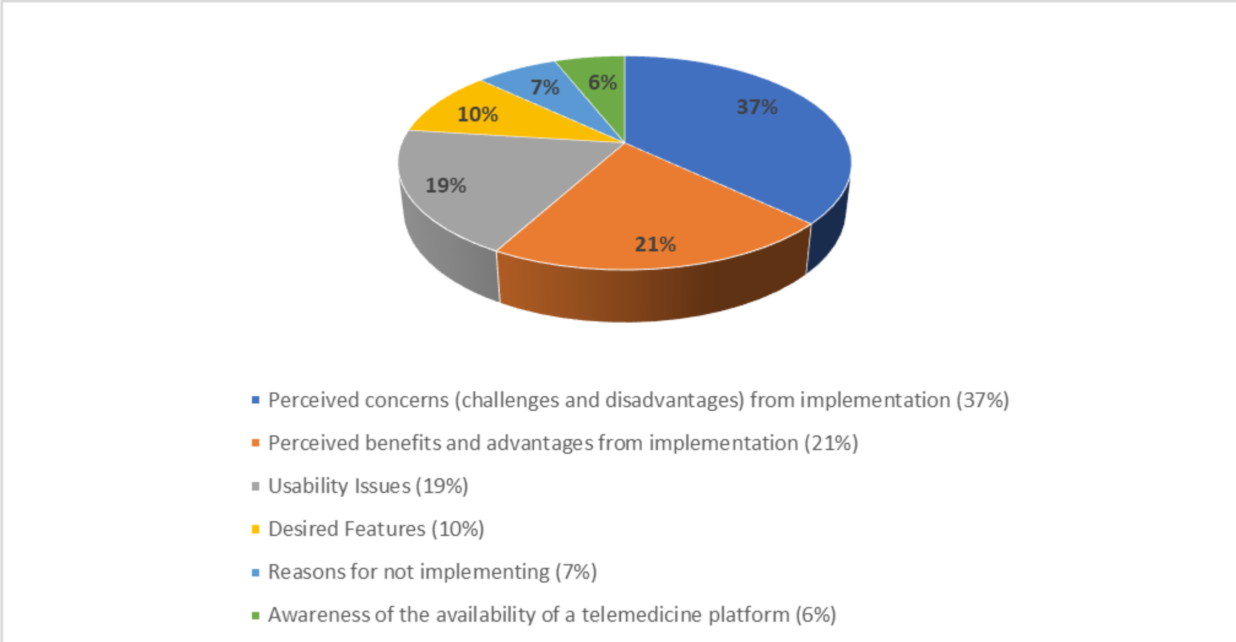

Figure 1 - Prevalence of Thematic Categories

Awareness of the availability of a telemedicine platform

Participants made direct or indirect reference to whether they were aware about the availability of a telemedicine platform for surgeons to perform post-op visits remotely. Eight out of the nine participants expressed that they were aware of the availability of the telemedicine platform. One participant indicated multiple times to be unaware of the availability of the telemedicine platform, and another participant expressed that while they were aware and interested, to their knowledge, the service was not offered for their specialty yet. Some participants knew about it through word of mouth (i.e. conversations with other surgeons) or because they had received orientation from the Surgery Department. Others had the opportunity to participate in a dry trial run of the telemedicine platform, or were enrolled in the initiative but not actively using the telemedicine platform.

Reasons for not implementing

The reasons provided for not implementing telemedicine, despite recognition of the benefits, ranged significantly. Some participants indicated that they did not have time for the training during go live; others had signed up but found that patients preferred in-person interaction when offered telemedicine. Many indicated that their particular patient demographics in oncology-related care prefer in-person visits and similarly some care processes require hands-on care. One participant raised the concern that there are few studies demonstrating the efficacy of telemedicine versus in-person visits as a safe care practice. Additionally, some physicians' reserved or apprehensive attitude towards new changes and technologies was mentioned by a participant as a reason that hinders telemedicine implementation.

Perceived benefits and advantages from implementation

Participants discussed their perceptions that telemedicine adoption would be helpful. Of the 32 statements made in response to the question about telemedicine benefits, ten statements mention aspects of benefiting patient-centric care. Overall, participants perceive the major advantages of telemedicine to be for patients as opposed to physicians. Convenience to patients, in terms of time and cost savings, were mentioned by participants who recognized the potential to reduce the time and costs associated with taking time off from work, traveling, alleviating the parking demand at the Texas Medical Center, and waiting in the office. One participant extended the notion to the general parking situation at the healthcare institution, suggesting that if patient adoption of telemedicine could be increased, it would significantly ease parking in addition to saving patients the parking expenses. Participants also identified benefits for clinicians. Seven statements were related to benefits to the clinician such as streamlining clinic hours. Expanding the clinical reach of the hospital was mentioned three times, as was benefits to financial operations due to telemedicine implementation. The remaining topics were related to the benefit of specific non-complicated patients, reduction of unnecessary visits, and following healthcare trends.

Perceived concerns (challenges and disadvantages) from implementation

Participants shared considerations that caused them feelings of unease, uncertainty, or apprehension regarding the implementation of a telemedicine platform for postoperative visits in their practices. Of the 58 statements made in response to the question about telemedicine challenges and disadvantages, 14 statements mention concerns regarding the suitability of telemedicine based on type of consultation needed, the patient health status, or the patient medical condition. Some participants consider that telemedicine encounters are not appropriate for the initial patient visit or initial evaluation. Furthermore, participants expressed that telemedicine is not suitable for patients with certain medical conditions, such as breast cancer, for example, which has a tactile requirement for the examination. Additionally, participants mentioned that the use of telemedicine encounters may be inappropriate for consultations where they have to share sensitive information or have difficult conversations with the patients. Having information about the patient's health status prior to the moment of the telemedicine encounter is an essential factor for the surgeons to decide whether the use of telemedicine for postoperative visits is appropriate. Therefore, telemedicine encounters may not be suitable for all postoperative patients, and its use may need to be evaluated on a case by case manner.

The loss of in-person interaction is another aspect that concerns the interviewed participants. Apprehensions regarding the impact in the quality of the physician-patient relationship were mentioned. Furthermore, some perceived patients' preference for in-person visits as a barrier for physicians' adoption of telemedicine systems. One of the participants expressed, "*the patients say that just coming to clinic and seeing me makes them feel better, and they don't wanna do that remotely.*" Other topics in this line were related to the inability to get patients' vital signs, patients' need for assistance during the telemedicine encounter, and barriers in technology adoption for the elderly population, who may present more limitations in their skills and willingness to adopt new technologies.

Aspects related to disruption to clinical workflow and unbalanced workload were mentioned as potential challenges from implementing a telemedicine platform for postoperative visits. Patients' lack of understanding of the appropriate use of the telemedicine platform, being disruptive and wanting to contact the physician at any time, was a concern expressed by the participants. One participant mentioned the need to create effective schedules to balance the number of patients scheduled for in-person visits and the number of patients scheduled for telemedicine encounters. Ignoring this has the potential of creating unbalanced workloads for the surgeons, either by generating sedentarism and dissatisfaction for surgeons because all the visits are scheduled through the telemedicine platform, or by creating highly stressful workloads if all the simple cases are scheduled via telemedicine and the difficult cases are scheduled back-to-back as in-person visits. Disruptions due to technical failures during the telemedicine encounter, including problems with the quality of the image and sound due to lost connection or improper lighting, as well as breaches in the system that could lead to issues regarding the security and privacy of the patient information, are concerns that the participants expressed. The remaining themes in this topic are related to the need to train clinical staff, physicians' potential resistance to adopt new technologies, and concerns regarding the malpractice and liability of seeing patients through a telemedicine platform.

Usability

During the usability evaluation the participants were asked to think aloud while interacting with the telemedicine platform. The participants expressed discomfort or difficulties while using the telemedicine platform and mentioned features they would like to be included. Therefore, the initial code has been subdivided into two focused codes: (1) usability issues and (2) desired features.

Usability Issues

The video conferencing telemedicine platform available in HMH for postoperative follow-up is integrated with the institution EHR. Therefore, in order to access the telemedicine platform, the surgeons have to log in to the EHR, and some participants confronted problems when attempting to log in to their EHR accounts, causing dissatisfaction. The participants also expressed dissatisfaction with some aspects of the general interface design of the telemedicine platform, such as the visual appeal and the layout. Specifically, participants faced major issues when attempting to initiate the telemedicine encounter and when trying to take a picture of the patient incision. Some participants showed dissatisfaction with the location and the size of the telemedicine encounter initiation icon in the interface. Similarly, some participants showed difficulties while trying to identify the icon to take pictures, expressing dissatisfaction with the small size and location of the icon at the bottom of the interface.

Desired Features

Although the participants showed overall satisfaction with the telemedicine encounter, they suggested the integration of new features to enhance the experience with the telemedicine platform. Among the mentioned features is the integration of a function that allows information sharing. Some participants expressed the desire to share notes about the telemedicine encounter with referring physicians or to share documents (i.e. education material and guidelines) with the patient during and after the telemedicine encounter. Two participants recommended adding a function that allows the patient to fill out a health assessment prior to the telemedicine encounter, so the physicians have that information available beforehand. Additionally, three participants mentioned the desire to be able to schedule the patient's next telemedicine visit right after the telemedicine encounter and share that information with the patient. Some physicians also expressed their desire for the interface to be customizable, in addition to having more control over some functionalities, such as the camera (e.g., zoom-in, zoom-out, and focus) and having the capability to write or draw on the screen to provide indications to the patient. One participant expressed the desire to be able to access the telemedicine platform in portable devices, such as cellphones and tablets, since it provides flexibility for the physician to conduct telemedicine encounters in different healthcare settings.

Quantitative Results

The aim of our quantitative analysis was to investigate the opinions and thoughts of the participants that explain and predict user adoption of the telemedicine platform at HMH. First, the correlation coefficient and corresponding p-values are calculated to check the level of correlation between all the variables of the survey elements. The correlation coefficient values are summarized in Table 1. The yellow highlighted cells indicate that the correlation coefficient is statistically significant at the 0.05

level. Based on the correlation coefficient matrix and the corresponding p-values, significant strong positive correlation between optimism and usefulness, optimism and satisfying, and usefulness and satisfying were noticed; the correlation between visual appeal and usefulness was significantly negative.

Table 1 - Correlation Matrix

	Optimism	Innovativeness	Discomfort	Insecurity	Impression	Layout	Appeal	SUS	PU	PEOU	Usefulness	Satisfying
Optimism	1.00											
Innovativeness	0.32	1.00										
Discomfort	-0.05	-0.47	1.00									
Insecurity	-0.23	-0.20	-0.16	1.00								
Impression	0.10	-0.12	0.40	-0.03	1.00							
Layout	0.49	-0.18	-0.02	0.14	-0.39	1.00						
Appeal	0.15	0.01	-0.08	-0.38	-0.11	-0.39	1.00					
SU	0.04	0.04	-0.36	-0.22	-0.34	0.42	-0.41	1.00				
PU	0.60	0.52	-0.24	0.05	0.21	0.42	-0.57	0.34	1.00			
PEOU	-0.05	0.19	0.00	0.29	-0.04	0.43	-0.96*	0.47	0.67*	1.00		
Usefulness	0.77*	0.40	-0.20	0.16	-0.09	0.50	-0.09	-0.12	0.68*	0.22	1.00	
Satisfying	0.89*	0.06	0.09	0.12	0.16	0.57	0.01	-0.11	0.57	0.05	0.83*	1.00

Abbreviations: PEOU, Perceived ease of use; PU, Perceived usefulness SUS, System Usability Scale

In the existing literature, several studies[26,33] evaluated technology acceptance by integrating the TRI and TAM into one model and investigated how each dimension of technological readiness affects the predictors in TAM. Following those studies, we also combined the TRI and TAM into one model and measured the relation between TRI's personality trait dimensions—optimism, innovativeness, discomfort, and insecurity—and the cognitive dimensions of TAM—perceived ease of use (PEOU) and perceived usefulness (PU). Other measuring indexes like Visual Appeal and Van der Laan's TAQ were also analyzed with a one-to-one relationship with TAM and TRI respectively. Three structured models have been developed and investigated to estimate the expected relationship supporting some predefined hypothesis. In total thirteen hypotheses have been defined and tested to theorize the insights of the HMH physicians' readiness for and perceptions of telemedicine.

Model 1: Effect of Technology Readiness on Technology Acceptance for telehealth technology adoption at HMH (TRI + TAM model)

Using TRI and TAM as starting points, the influence of the four dimensions of TRI on the two levels of TAM was analyzed to shed more light on technology acceptance and to understand the importance of personality differences on telehealth technology implementation and adoption. The integrated model illustrated in Figure 2 proposes the following five hypotheses.

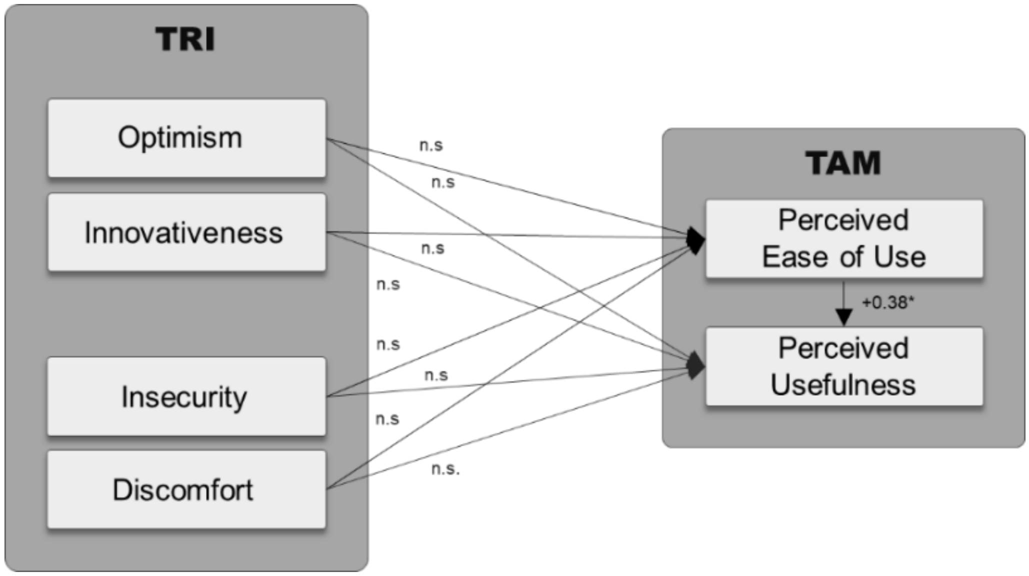

Figure 2 - Overview of the TRI + TAM Structured Model.
Numerical values on the arrows indicate the estimate of regression coefficient
*Parameter estimate significant at the 0.05 level; n.s.= non-significant

Hypothesis 1 (H1): The effect of optimism on perception of technology

H1a. High personal optimism leads to higher PEOU of telemedicine adoption at HMH

H1b. High personal optimism leads to higher PU of telemedicine adoption at HMH

Hypothesis 2 (H2): The effect of innovativeness on perception of technology

H2a. High personal innovativeness leads to higher PEOU of telemedicine adoption at HMH

H2b. High personal innovativeness leads to higher PU of telemedicine adoption at HMH

Hypothesis 3 (H3): The effect of insecurity on perception of technology

H3a. High personal insecurity leads to lower PEOU of telemedicine adoption at HMH

H3b. High personal insecurity leads to lower PU of telemedicine adoption at HMH

Hypothesis 4 (H4): The effect of discomfort on perception of technology

H4a. High personal discomfort leads to lower PEOU of telemedicine adoption at HMH

H4b. High personal discomfort leads to lower PU of telemedicine adoption at HMH

Hypothesis 5 (H5): PEOU of the participants positively influences their PU of telemedicine adoption at HMH

The PLS estimation results for the TRI + TAM structural model are summarized below in Table 2. Overall, the model did not show a good fit to the data as evidenced by the p-values ($p > 0.05$) for the R^2 values for both dependent variables PEOU and PU. Turning to the individual coefficients, we noticed that all TRI dimension did not show significant influence on PEOU and PU in the hypothesized direction and hence did not support the hypothesis. However, our results showed a strong positive relationship between PEOU and PU.

Table 2 - Estimation Results of the TRI + TAM Structured Model

Relationship	R^2	β	*t*-value	*p*-value	Conclusion
Optimism-PEOU	-0.122	-0.066	-0.133	0.898	H1a Not supported
Optimism-PU	0.28	1.0379	2.129	0.066	H1b Not supported
Innovativeness-PEOU	-0.085	0.245	0.544	0.602	H2a Not supported
Innovativeness-PU	0.185	0.8326	1.744	0.119	H2b Not supported
Discomfort-PEOU	-0.125	0.007	0.009	0.993	H3a Not supported
Discomfort-PU	-0.574	-0.701	-0.715	0.495	H3b Not supported
Insecurity-PEOU	-0.033	0.367	0.843	0.423	H4a Not supported
Insecurity-PU	-0.121	0.852	0.154	0.881	H4b Not supported
PEOU-PU	0.382	0.551	2.564	0.033	H5 Supported
Abbreviations: PEOU, Perceived ease of use; PU, Perceived usefulness					

Model 2: Effect of Technology Readiness on Van der Laan's Technology Acceptance Questionnaire for telehealth technology adoption at HMH (TRI + Van der Laan TAQ model)

We also analyzed the influence of the four dimensions of TRI on the two levels of Van der Laan's TAQ in the similar way we did for Model 1. Figure 3 illustrates our structured model and the estimates of the expected relationship based on following five hypotheses.

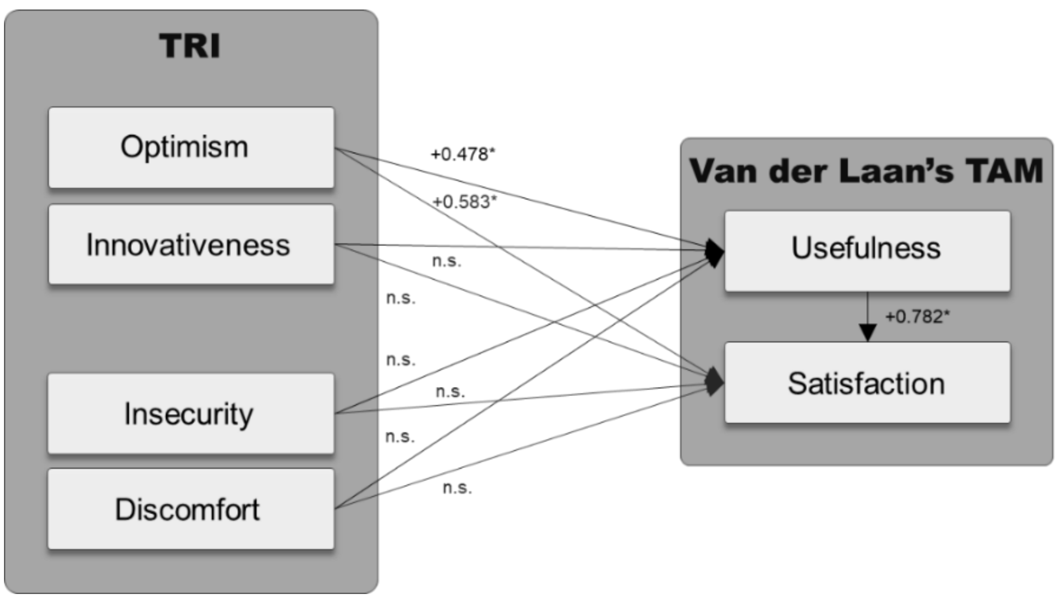

Figure 3 - Overview of The TRI + Van der Laan's TAQ.
Numerical values on the arrows indicate the estimate of regression coefficient
**=parameter estimate significant at the 0.05 level; n.s. = non-significant*

Hypothesis 6 (H6): The effect of optimism on perception of technology

H6a. High optimism leads to higher perceived usefulness of telemedicine adoption at HMH.

H6b. High optimism leads to higher perceived satisfaction of telemedicine adoption at HMH.

Hypothesis 7 (H7): The effect of innovativeness on perception of technology

H7a. High innovativeness leads to higher perceived usefulness telemedicine adoption at HMH.

H7b. High innovativeness leads to higher perceived satisfaction of telemedicine adoption at HMH.

Hypothesis 8 (H8): The effect of insecurity on perception of technology

H8a. High insecurity leads to lower perceived usefulness of telemedicine adoption at HMH.

H8b. High insecurity leads to lower perceived satisfaction of telemedicine adoption at HMH.

Hypothesis 9 (H9): The effect of discomfort on perception of technology

H9a. High discomfort leads to lower perceived usefulness of telemedicine adoption at HMH.

H9b. High discomfort leads to lower perceived satisfaction of telemedicine adoption at HMH.

Hypothesis 10 (H10): The effect between ease of usefulness and satisfaction

Given that usefulness is defined as the prospective user's subjective probability that using a specific technology will increase his or her satisfaction, usefulness and satisfaction will be positively related.

The PLS estimation results for the TRI + Van der Laan's TAQ are summarized below in Table 3. Overall the model did not show a good fit to the data as evidenced by the p-values ($p > 0.05$) for the R^2 value for dependent variable 'usefulness', but the model showed a good fit for dependent variable 'satisfaction' with the p-value ($p < 0.05$) for the $R^2 = 0.914$.Turning to the individual coefficients, we saw that TRI dimension optimism showed significant influence on usefulness and satisfaction in the hypothesized direction and hence supported the hypothesis. But the other TRI dimensions did not show statistically significant influence on usefulness and satisfaction in the hypothesized direction and hence didn't support the hypothesis. Finally, our results showed a statistically significant strong positive relationship between usefulness and satisfaction.

Table 3 - Estimation Results of the TRI + Van der Laan's TAQ Structured Model

Relationship	R^2	β	*t*-value	*p*-value	Conclusion
Optimism-Usefulness	0.539	0.478	3.398	0.009*	H6a Supported
Optimism-Satisfaction	0.761	0.583	5.442	0.0006*	H6b Supported
Innovativeness-Usefulness	0.057	0.230	1.243	0.249	H7a Not supported
Innovativeness- Satisfaction	-0.121	0.034	0.159	0.878	H7b Not supported
Discomfort- Usefulness	-0.08	-0.206	-0.578	0.579	H8a Not supported
Discomfort- Satisfaction	-0.115	0.101	0.263	0.799	H8b Not supported
Insecurity- Usefulness	-0.094	0.093	0.47	0.651	H9a Not supported
Insecurity- Satisfaction	-0.109	0.070	0.334	0.747	H9b Not supported
Usefulness-Satisfaction	0.6421	0.782	4.141	0.003*	H10 Supported
*Significant relation					

Model 3: Effect of Visual Appeal on TAM (Visual + TAM model)

We also analyzed the influence of the three dimensions of visual—impression, layout and appeal—on the two levels of TAM. Figure 4 illustrates our structured model and the estimates of the expected relationship based on following three hypotheses.

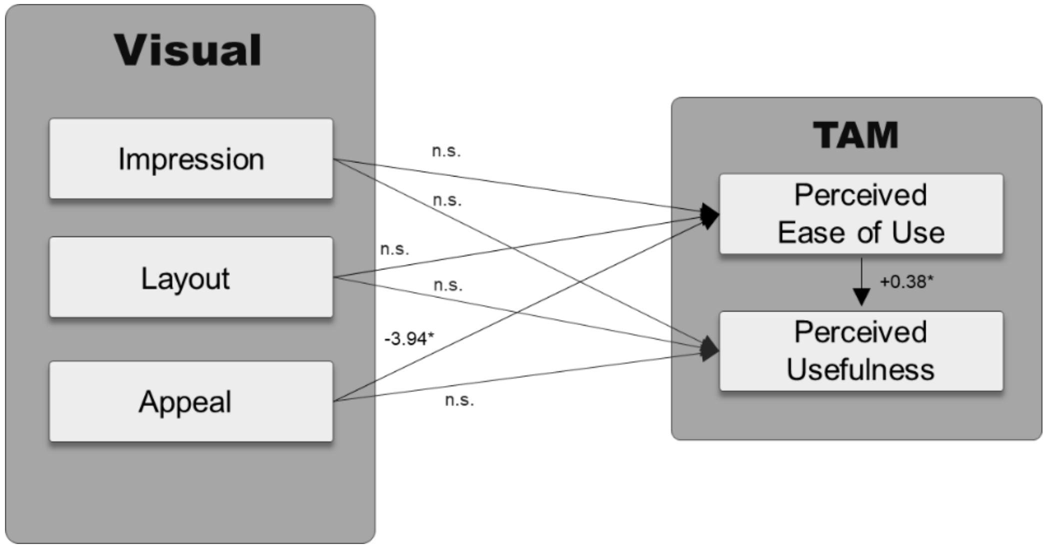

Figure 4 - The Overview of the Visual + TAM Structured Model and Results
Numerical values on the arrows indicate the estimate of regression coefficient
**=parameter estimate significant at the 0.05 level; n.s. = non-significant*

Hypothesis 11 (H11): The effect of visual impression on perception of technology
H11a. Better visual impression leads to higher PEOU of telemedicine adoption at HMH.
H11b. Better visual impression leads to higher PU of telemedicine adoption at HMH.
Hypothesis 12 (H12): The effect of visual layout on perception of technology
H12a. Better visual layout leads to higher PEOU of telemedicine adoption at HMH.
H12b. Better visual layout leads to higher PU of telemedicine adoption at HMH.
Hypothesis 13 (H13): The effect of visual appeal on perception of technology
H13a. Better visual appeal leads to higher PEOU of telemedicine adoption at HMH.
H13b. Better visual appeal leads to higher PU of telemedicine adoption at HMH.

The PLS estimation results for the Visual + TAM structural model are summarized below in Table 4. Overall the model did not show a good fit to the data as evidenced by the p-values ($p > 0.05$) for the R^2 value for dependent variable PU, but the model showed a good fit for dependent variable PEOU with the p-value ($p < 0.05$) for the $R^2 = 0.9$. Visual appeal showed negative significant influence on PEOU. Turning to the individual coefficients, we saw that visual appeal showed significant influence on PEOU in the opposite hypothesized direction and hence did not support the hypothesis. But the other visual dimensions did not show statistically significant influence on PU in the hypothesized direction.

Table 4 - Estimation Results of the Visual + TAM Structured Model

Relationship	R^2	*β*	*t*-value	*p*-value	Conclusion
Impression-PEOU	-0.124	-0.074	3.398	0.9216	H11a Not supported
Impression -PU	-0.076	0.522	-0.102	0.565	H11b Not supported
Layout-PEOU	0.082	0.483	1.345	0.215	H12a Not supported
Layout-PU	0.070	0.034	1.297	0.231	H12b Not supported
Appeal-PEOU	0.902	-3.944	-9.166	<0.0001*	H13a Not supported
Appeal-PU	0.235	-2.844	-1.939	0.089	H13b Not supported
*Significant relation. Abbreviations: PEOU, Perceived ease of use; PU, Perceived usefulness.					

Discussion of Findings

The quantitative results revealed that physicians' personality traits, i.e., surgeons' readiness and personal belief and perception to embrace new technology, have a positive impact on the HMH telemedicine platform usage; this significant positive relationship between the optimism trait of the physicians and tendency to adopt the HMH telemedicine platform was highlighted through the combined TRI-Van der Laan's TAQ analysis. However, the combined TRI-TAM analysis resulted in a 'no significance' between the same factors, which could be mainly due to the small number of participants. Increasing the sample of participants is necessary to clearly understand whether personality traits like optimism and innovativeness indeed influence the post-surgery telemedicine platform at HMH.

On the other hand, inhibiting factors to adopt a new technology, i.e., discomfort and insecurity, also did not affect the HMH telemedicine platform significantly. Additionally, like most other studies, our analysis demonstrated a strong positive influence of PEOU on PU as well as a positive relation between usefulness and satisfaction to the adoption of the telemedicine platform for HMH. This result indicates that the physicians will find the existing telemedicine platform more useful if it can be demonstrated to improve their efficacy, thereby reducing workload. So, efforts on improving the design of the HMH telemedicine platform should continue. In this regard, one surprising outcome was that Visual Appeal had a negative relationship with PEOU. This can be partially due to the healthcare setting in which, unlike technology adoption or online services in other domains, the quality and effectiveness of the service being delivered via telemedicine platforms are more important than visual appeal.

Analyzing the participants' feedback and concern qualitatively, we noticed a perception among the surgeons that telemedicine is beneficial as a tool but perhaps not appropriate for the post-surgery patients for various reasons. Some interesting points brought up by the participating surgeons for not implementing telemedicine in their practical use include: lack of time for proper training, lack of patients' interest, and the requirement of including more features in the existing platform. Most importantly some of the surgeons are still doubtful about the effectiveness of telemedicine care compared to an in-person visit, as also captured in the construct TRI (i.e. survey outcome for insecurity).

All the participants recognized the potential benefits of implementing telemedicine, namely that it would allow them to see patients who were located farther away and provide the convenience of having follow-up sessions without traveling to the hospital. Even when the participants perceive telemedicine to predominantly benefit patients as opposed to physicians, they were able to identify cost- and time-related benefits for their clinic operations.

Some participants had counterpoints to telemedicine adoption. While they acknowledge the patient-facing benefits, when taken in the context of the clinical workflow, there are situations when patient interaction via technology is not ideal. In many cases the clinicians wanted to provide educational materials to the patient; a mechanism for such an exchange is not apparent in the current form of the system and would be necessary in future versions. Additionally, the participants highlighted concerns regarding the potential disruption to clinical workflow, the creation of unbalanced workload, and the impact on the physician-patient relationship.

The inability to collect vitals, in tandem with how the patient will hold the camera to view the wound, was identified as a significant shortcoming of the system. With some specialty-related and procedure-specific exceptions, surgical sites can be anywhere on the body, and pointing a phone-based camera at the site with accuracy is not always possible. It is likely that many patients would require family or home care assistance to fully utilize the system. Accomplishing this task may be more challenging for the elderly, and so implementing a telemedicine platform may be more challenging for physicians with a higher volume of older patients.

Even when they were satisfied with the mock-up telemedicine encounter, some participants had minor issues with the general interface design, and the size and location of important icons and buttons. Therefore, changes to the current interface layout must be made in future versions. Those changes must also incorporate the desired features mentioned by the participants, to enhance the telemedicine experience.

Responses to the survey tools suggest that participation in the telemedicine platform should be significantly higher than it presently is. While nearly every participant indicated support for the adoption of telemedicine and recognized the potential benefits, none of those who were previously aware of its availability had attempted to adopt it except for one. When asked about incorporating telemedicine into their practices, all of the surgeons were positive, but felt that their particular patient pools or workflows were not ideal. Many of the participants performed oncological surgeries. They felt that their patients typically prefer to have the immediate, if not all, follow-up sessions in person, due to the sensitive nature of oncology care. Relatedly, the surgeons who handle breast cases especially indicated that hands-on patient care was necessary and that there is not presently a substitute for that interaction.

Supplemental Interview with a Telemedicine Subject Matter Expert

In addition to the surgical follow-up interviews, a urology surgeon who had previously implemented telemedicine extensively was identified and interviewed for perspectives on the system intended for post-surgical follow-up. The physician had previously completely integrated telemedicine for patient outreach as a means to expand clinical coverage to areas with geographically limited medical resources. The recurring theme in the conversation was that significantly more support from the medical assistants, in addition to enhanced support staff training to facilitate telemedicine use at HMH, is necessary. Current workloads were too high to allow time to train and reincorporate telemedicine into the clinical schedule. In many ways a dedicated workflow path specific to supporting and seeing patients through telemedicine is necessary in the participant's opinion.

Limitations

Participant recruitment was particularly challenging for this study. Since the participants are surgeons, their schedules are somewhat unpredictable during the workday—clinical hours can run long, and a new surgery can take priority. Due to these limitations, a total of 9 participants were recruited. The available surgeons were primarily performing procedures related to oncology diagnosis and care. As such, while they were supportive of telemedicine and recognized the benefits it could provide, they felt that for the nature of the care their patients expect and the sensitive nature of cancer care, telemedicine may be too impersonal for their practices. This result may not generalize to other specialties.

Conclusions

Even when the vast majority of the participants were aware of the availability of a telemedicine platform for postoperative visits, several reasons, such as lack of time, patient demographics, and concerns regarding safety, have constrained their adoption of the system. The participants foresee multiple benefits from implementing a telemedicine platform in their practice; however, they also have concerns regarding the challenges that may result. Issues regarding disruption to clinical workflow, unbalanced workload, the impact in the physician-patient relationship, and the unsuitability of telemedicine for specific medical conditions, among other issues, are perceived by the participants as potential challenges of adopting a telemedicine platform for postoperative visits. Despite these challenges, the participants showed a positive attitude towards telemedicine, and the results of the quantitative assessment tools administered reinforce their acceptance and readiness to adopt the technology. However, the participants also perceive patients' preference for in-person visits as a significant barrier for them to adopt the telemedicine platform in their practices, leading to lower adoption rates than expected. Therefore, further extension of this study should include patients among the interview or survey participants so that patient perceptions can also be elicited regarding the usage of the telemedicine platform. Patient feedback can also be useful to understand barriers and any usability issues of the platform along with evaluating surgeons' readiness for and general awareness of the telehealth technology implementation and adoption.

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Appendix

A.1 Technology Acceptance Model

TAM: Technology Acceptance Model measures 2 different aspects of the potential use of new technologically advanced products/services:

	Strongly Agree						Strongly Disagree
Perceived Usefulness (PU)							
Using Telehealth would enable me to accomplish tasks more easily							
Using Telehealth would increase my productivity							
Using Telehealth would enhance my effectiveness on the job							
Using Telehealth would make it easier to do my job							
I would find Telehealth useful in my job							
Perceived Ease of Use (PEOU)							
Learning to operate Telehealth would be easy for me							
I would find it easy to get the Telehealth system to do what I want it to do							
My interaction with Telehealth would be clear and understandable							
I would find Telehealth to be flexible to interact with							
It would be easy for me to become skillful at using telehealth							
I would find Telehealth easy to use							

A.2 Technology Readiness Index 2.0

This survey assesses people's propensity to embrace and use cutting-edge technology.

Optimism

1. New technologies contribute to a better quality of life

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

2. Technology gives me more freedom of mobility

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

3. Technology Gives people more control over their daily lives

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

4. Technology makes me more productive in my personal life

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

Innovativeness

5. Other people come to me for advice on new technologies

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

6. In general, I am among the first in my circle of friends to acquire new technology when it appears

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

7. I can usually figure out new high-tech products and services without help from others

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

8. I keep up with the latest technological developments in my areas of interest

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

Discomfort

9. **When I get technical support from a provider of a high-tech product or service, I sometimes feel as if I am being taken advantage of by someone who knows more than I do**

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

10. **Technical support lines are not helpful because they don't explain things in terms I understand**

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

11. **Sometimes, I think that technology systems are not designed for use by ordinary people**

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

12. **There is no such thing as a manual for a high-tech product or service that's written in plain language**

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

Insecurity

13. **People are too dependent on technology to do things for them**

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

14. **Too much technology distracts people to a point that is harmful**

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

15. **Technology lowers the quality of relationships by reducing personal interaction**

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

16. **I do not feel confident doing business with a place that can only be reached online**

Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
☐	☐	☐	☐	☐

A.3 System Usability Scale

The System Usability Scale: The SUS is a 10-item questionnaire with 5 response options.

	1 Strongly Disagree	2	3	4	5 Strongly Agree
I think that I would like to use this system frequently					
I found the tool unnecessarily complex.					
I thought the tool was easy to use.					
I think that I would need the support of a technical person to be able to use this tool.					
I found that the various functions in this tool were well integrated.					
I thought there was too much inconsistency in this tool.					
I would imagine that most people would learn to use this tool very quickly.					
I found the tool very cumbersome to use.					
I felt very confident using the tool.					
I needed to learn a lot of things before I could get going with this tool.					

A.4 Van der Laan's Technology Acceptance Questionnaire

This scale assesses system acceptance on two dimensions, a *Usefulness* scale and an affective *Satisfying* scale. It can be insightful to first describe the system and have the scale filled in as a before-measurement, to assess ideas people have, and then again after experience with the system. The scale is simple, nine Likert items:

I find such a system / the (...) system (please tick a box on every line)

1 Useful |__|__|__|__|__| Useless
2 Pleasant |__|__|__|__|__| Unpleasant
3 Bad |__|__|__|__|__| Good
4 Nice |__|__|__|__|__| Annoying
5 Effective |__|__|__|__|__| Superfluous
6 Irritating |__|__|__|__|__| Likeable
7 Assisting |__|__|__|__|__| Worthless
8 Undesirable |__|__|__|__|__| Desirable
9 Raising Alertness |__|__|__|__|__| Sleep-inducing

A.5 Categories and Themes from Interviews

Category	Theme	Frequency
Awareness of the availability of a telemedicine platform	Surgeon was aware	8
	Surgeon was unaware	1
Reasons for not implementing	Not used or offered in the department	3
	Patient's reject telemedicine	1
	Lack of time	1
	Low volume of patients in clinic	1
	Apprehensive attitude towards new changes	1
	Concerns regarding safety	1
	Unaware of availability	1
Perceived benefits and advantages from implementation	Perceived benefits and advantages from implementation	10
	Time and Cost effectiveness for clinician	7
	Avoid unnecessary visits to the clinic	4
	Access to healthcare	4
Perceived concerns (challenges and disadvantages) from implementation	Inappropriateness for certain medical conditions	8
	Workflow considerations	6
	Inappropriateness for patient initial evaluation	5
	Quality of image	4
	Physician resistance to change and new technology adoption	4
	Technology adoption of elderly population	4
	Physician-patient relationship	4
	Patient desire to contact physician at any time	3
	Technical failure during telemedicine visit	3
	Inappropriateness for patient health status	3
	Patients prefer in person visit	3
	Inappropriateness for type of consultation	3
	Inability to get patient vitals	3
	Security and privacy	2
	Telemedicine quality vs in person visit	1
	Patient need for assistance during telemedicine visit	1
	Lack of training for clinical staff	1
Usability		
Usability Issues	General interface design issues	17
	Difficulties initiating the telemedicine encounter *Location and size of initiate button	8
	Location and size of the icon to take a picture	4
	EHR Log-in issues	1
Desired Features	Control over camera functionality	5
	Schedule future visits after telemedicine encounter	3
	Patient fill out health assessment previous to the encounter	2
	Function to share documents with patients	2
	Customize the interface	1
	Use the platform on mobile devices	1
	Drawing on the screen	1
	Communicate notes from telemedicine encounter with referring physician	1