Technological Innovation Adoption Among Swedish Healthcare Professionals: A Contingency Technology Adoption Framework

Technological Innovation Adoption among Swedish Healthcare Professionals: A Contingency Adoption Framework

Abstract

Technological innovation adoption by healthcare professionals directly impacts enhanced patient care and overall community well-being. However, the perspective of healthcare professionals in evaluating and adopting these technological innovations should be addressed. Drawing on innovation adoption and resistance theories, this study aims to capture their perceptions of the barriers they face and the adoption behaviours they express in a contingency framework of adoption. The qualitative investigation on Swedish healthcare professionals shows that complex healthcare innovations are multi-stakeholder systems where the healthcare professional's perception of multiple individual, organisational, and administrative barriers causes hesitancy in adopting technologies. However, this hesitancy does not always lead to resistance; sometimes, it can lead to partial or complete adoption of the technology, contingent on the severity of the barriers and their interrelationship. The findings, summarized in a contingency framework for evaluating barriers to adoption and hesitancy behaviours, highlight the importance of individual perceptions in the adoption and success of complex healthcare innovations. They show why empowering adopters to choose how and when to use the innovation can be a powerful tool in reducing hesitancy.

Keywords: innovation resistance, surgical innovations, technology adoption, surgeon behaviour

1 Introduction

In recent years, the healthcare industry has witnessed a rise in research exploring technological innovations, ranging from consumer-oriented applications to more intricate healthcare technologies (Bird et al., 2021; Patrício et al., 2019). This momentum in innovation adoption by healthcare professionals and institutions has notably elevated patient care standards (Reed et al., 2012) and amplified operational efficiency while minimizing errors. These advancements span the entire healthcare spectrum, encompassing prescription practices (Keyworth et al., 2017), diagnostic capabilities (Serag et al., 2019), surgical procedures (El Bahrawy & Alió, 2015), and diverse healthcare tasks (Escobar-Rodríguez & Romero-Alonso, 2014; Wamble et al., 2019). Notably, the global impact of the COVID-19 pandemic has spotlighted the criticality of embracing radical technological changes, exemplified by the rapid development and adoption of vaccination technologies (Bateman & Cleaton, 2021; Li et al., 2021; Palanica & Fossat, 2020; Rusinko, 2020).

Considering the immense positive outcomes these technological innovations present, how and why healthcare professionals adopt these innovations have now garnered increasing research attention (Escobar-Rodríguez & Romero-Alonso, 2014; Menchik, 2020). However, several research gaps remain related to technology adoption by healthcare professionals. First, from the innovation adoption literature, it is also known that the introduction of technological innovations and their adoption is often met with failure due to resistance to the innovation from technological, human, and skill-based barriers (Herzlinger, 2006). However, historically we see that there is resistance for adoption of healthcare innovation. For instance, when The da Vinci Surgical System was initially introduced, it faced resistance due to high costs, training demands, lack of evidence, and reluctance to change, highlighting common barriers in adopting medical innovations. However, it is widely used today after the technology improves and the value it created was observed.

However, to the best of our knowledge, there have been no studies explicitly on resistance of innovation by healthcare professionals. Example, such as the da Vinci System this, highlights the constant tussle between accepting and rejecting technological innovation in the healthcare industry which over the long run can create significant benefits. Therefore, it is imminent that factors impacting the adoption decision be investigated.

Secondly, existing research studies have investigated consumer technologies without giving adequate attention to more complex healthcare technologies from the perspective of healthcare professionals (Brooke-Sumner et al., 2019) – particularly when considering the adoption of radical innovations, such as the surgical innovations (Fosch-Villaronga et al., 2022). Thus, we currently have a limited understanding of the barriers healthcare professionals face when adopting technological innovations.

Thirdly, the behaviours investigated have been largely dichotomous in nature – that is to say, they have identified enabling or constraining factors that can prompt or inhibit the adoption of technologies without considering contingent scenarios that may lead to other behaviors. Unlike consumer-level investigations, examining technology innovation from the perspective of healthcare professionals offers a novel research avenue. A healthcare-professional perspective is central to understanding technological innovation in the healthcare industry because they may view and experience adoption barriers differently than patients and other hospital stakeholders. They are the key stakeholders in the technology adoption process. Moreover, because of their complex contextual environment where hospitals and law can dictate technology adoption (Barbash et al., 2014), healthcare professionals may be forced to adopt innovations they are reluctant to accept (Telem et al., 2018). That is to say, the nature of the barriers they face is unique and causally complex compared to the traditional consumer. In addition, due to the complex nature of the innovation, it may be possible to both "adopt" and "not adopt" an innovation simultaneously. Therefore, existing theories, such as the theory of reasoned action (TRA) (Fishbein, 1980; Madden et al., 1992), or resistance-focused theories, such as innovation resistant theory (IRT) (Ram & Sheth, 1989; Talwar, Talwar, et al., 2020), are unable to provide a complete picture of adoption behaviour by healthcare professionals intending to adopt radical medical technologies. Therfore, In this study, we argue that adoption behaviour in complex innovations, like surgical innovations, may be understood better by simultaneously looking at both the adoption or rejection intentions of technology innovation rather than looking at them as mutually exclusive behavioral intentions. In summary, prior research indicates the it is important to understand both individual and administrative level factors when investigating surgeon behavior (Talem et al., 2018). Therefore a closer inspection at the intersection of the type of barriers and the behavior types is needed and currently, such a unifying contingency framework that connects barriers to complex adoption behaviour is lacking.

Against this background, we argue that it is important to adopt a contingency perspective on an innovation's adoption and rejection behaviour. Therefore, adopting both adoption and resistance lenses is necessary to adequately understand the behaviours. Without such prior investigations, this research has an opportunity to define the continuum between adoption and resistance behaviours and identify the contingent barriers that lead to different behaviours.

We seek to answer two explorative research questions based on these research gaps.

RQ1. What are the key barriers that drive technological innovation adoption intentions among healthcare professionals?

RQ2. How can a contingency framework be developed that links technology innovation barriers with adoption behaviours?

To answer our research questions, we follow a qualitative research method and investigate the behavioural intentions underlying a radical surgical innovation which is being pioneered for surgeons in Sweden. We chose the surgical healthcare innovation as an empirical context because the technology is sufficiently complex and radical. It requires careful consideration, technological skills, and surgical skills to use safely with minimum consequences for the patient and the surgeon. Furthermore, the technology involves multiple healthcare stakeholders and represents an adequately complex context offering the proposed unique barriers (Shah et al., 2021). Therefore, the perspective of multi-stakeholders and their intentions to adopt can be examined through a single case study, producing better-validated findings.

The findings of this study deliver numerous contributions and contribute to innovation adoption (Fishbein, 1980; Fishbein & Ajzen, 2011; Venkatesh et al., 2012) and resistance theories (Heidenreich & Spieth, 2013; Ram & Sheth, 1989; Talwar, Talwar, et al., 2020) by adding more details to the outcome side with "in-between" behaviours. We observed that when surgeons did not reject the technology outright, they evaluated their options before deciding. We term this behaviour as "hesitancy". Eventually, we observed that hesitancy is resolved into adoption behaviours that took two distinct forms – either (a) the surgeons expressed their helplessness in having to accept an imperfect technology and fully adopt it, which we term "uncensored adoption" or (b) they expressed the intention to use only that part of the innovation that presented no barriers, which we term "censored adoption". More importantly, we find that barriers interact with each other and serve as antecedents to various behaviours. The study's novelty lies in developing a contingency framework to assess how different barriers interact to form different adoption behaviours. The study's uniqueness lies in its results that resistance and adoption can be mutually exclusive states, which occur when a conflict over innovation is either resolved in an adopter's mind or produces hesitancy.

2 Theoretical and Conceptual Background

Innovations in healthcare technologies can come from different fronts, including new healthcare and drugs, new products, and new processes, procedures, and techniques, among others (Wilson, 2006). The adoption of innovative technology in the healthcare field has received some attention in the past (Bateman & Cleaton, 2021; Shah et al., 2021; Yee-Loong Chong et al., 2015). This has been particularly marked in the last decade when technology adoption by stakeholders including but not limited to general consumers (Dam et al., 2018; Lazard et al., 2020), healthcare practitioners, surgeons (Menchik, 2020), and others (Van Velthoven & Cordon, 2019) has been addressed. Introducing and adopting these innovations are often complex and influenced by multiple stakeholders, including patients, professionals, and the hospital administration (Shah et al., 2021). However, a theoretically driven examination of the role of healthcare professionals as adopters of these technologies has received scant attention in the extant literature.

2.1 Technology innovation adoption and resistance

The ability to address unique consumer needs is not only a way to earn financial profit, but it also presents opportunities to earn non-financial benefits, such as firm reputation and trust (Ganguly et al., 2020; Manohar et al., 2019). However, on the other side, failing to convince stakeholders to adopt innovations can result in a severe economic and non-economic loss for the firm. This resistance to the adoption of new technologies is termed "innovation resistance" in the consumer behaviour literature and is discussed in detail in the accompanying innovation resistance theory (IRT) (Heidenreich & Spieth, 2013; Ram, 1987; Talwar, Talwar, et al., 2020). Innovation resistance is a natural response to a change in the status quo, which can bring change to the lifestyle of the adopter (Ram & Sheth, 1989). IRT argues that barriers to adoption cause resistance. A function of these barriers is to determine whether a consumer adopts or resists the technology. As a corollary, IRT posits that the adoption of an innovation is the absence of resistance and is thus indicative of lower barriers to adoption.

In particular, the literature highlights five barriers or risks to adoption, classified into two categories called (a) functional barriers related to the characteristics of the innovations and the value and risk of using the technology (Yu, 2016) and (b) psychological barriers related to users' psychological predispositions to the technology and its outcomes (Kaur et al., 2020). Functional barriers include subtypes named *usage*, *value*, and *risk* barriers. Usage barriers correspond to the compatibility of the innovation with existing systems and practices. Value barriers refer to the cost-to-price trade-off that the innovation presents. Risk barriers are the level of perceived risk from adopting innovations. On the other hand, psychological barriers are divided into tradition- and image-related barriers. Tradition barriers refer to the threat of changing traditions in response to innovation. Image barriers concern how the adoption can impact the image of the adopter from a more subjective standpoint (Ram & Sheth, 1989). However, the extant literature that uses this theoretical perspective has been primarily quantitative and has treated these barriers as mutually exclusive (Kaur et al., 2020; Laukkanen et al., 2007; Leong et al., 2020). However, this may not apply to complex healthcare innovations for two primary reasons. First, due to the multi-stakeholder nature of the system, the barriers are likely to be more complex and multi-dimensional because they include both patient and hospital perspectives. Second, since the barriers are complex, they are also likely to be impacted by each other. For instance, hospitals may insist on using technology even if it can cause traditional barriers to be erected (Barbash et al., 2014). These intricacies are discussed in detail in the following subsection.

Furthermore, IRT currently divides adoption behaviours into three: (a) postponement; (b) rejection; and (c) opposition. All three behaviours indicate a binary state of adoption where an adopter may either not use the innovation until issues are resolved or may protest its use and refuse to use it. Though this is certainly a valid argument for a simple system that can be adopted or rejected, we argue that this classification is ill-suited to investigating resistance in the complex multi-stakeholder and high-stakes context of healthcare innovation. This issue is discussed in the following subsection.

2.2 Adoption of innovative technology by healthcare professionals

One area that has seen increasing technological innovation has been surgery and the adoption of surgical innovations by surgeons (El Bahrawy & Alió, 2015; Loftus et al., 2020; Saun et al.,

2019). Recent advancements show that technological innovations, such as enhanced data capture, analytics, and robotic surgeries (Barbash et al., 2014), provide superior outcomes for patients (Loftus et al., 2020; Muaddi et al., 2021). For instance, several studies show that robotic surgeries that rely on high-quality imaging provide decreased odds of mortality and better recovery times than open surgeries (Anderson et al., 2012; Muaddi et al., 2021). Moreover, with the advancement in machine learning, the availability of good-quality video recordings of surgeries is predicted to significantly impact surgical research, education, and robotic automation (Volkov et al., 2017). Thus, surgical technological innovation presents a unique empirical setting to investigate technology adoption and rejection barriers.

In this discussion, we see that most studies implicitly assume that adoption is already completed and easily accomplished. However, this may not be the case, as highlighted by Perl et al. (2021). In their editorial piece, they argue that the value that a surgical technology provides compared to its cost determines adoption and that it is also essential to take into account of the associated cost. Here, it is crucial to note that the costs may be monetary and non-monetary, such as wasted time and increased risks. Therefore, we argue for the possibility of adoption even under conditions of resistance. Some technological innovations may deliver enough value to the healthcare professional or patient to justify suffering through the barriers.

Furthermore, in some cases, the adoption may be driven at the hospital level, and surgeons may not have the option of outright rejection. For instance, Barbash et al. (2014) studied the adoption of robotic surgery in US hospitals and concluded that competitive pressure from other hospitals in the region was a factor that drove the adoption of innovative technologies. In a related study, Neuner et al. (2012) found that the hospital's aim of gaining market share was a possible reason for the adoption of technology.

Therefore, how this compulsion to adopt can impact resistance behaviour among surgeons warrants further research attention. The problems are also likely impacted by the privileged positions most surgeons hold in their hospitals. For instance, Elledge and Jones (2021), in their study of the character failings of surgeons, argue that some surgeons can exhibit a “god complex”, “reputation over integrity” and “wounded pride” behaviours when confronted with ethics violations. We posit that this may lead to resistance to changes in the status quo and the introduction of new accountability mechanisms through recording technologies. In summary, the factors discussed above present a maze of interconnected barriers to adoption that must be navigated to mitigate resistance and incite adoption. However, on the other hand, it presents significant value addition that can be considered a counterbalance to these barriers. In the following sections, we render a clearer structure to this argument and show why a granular view of the innovation, the adopters (surgeons), and their behaviour is essential to understand innovation adoption in complex contexts, such as the healthcare sector.

3 Research methods

3.1 Research Context

We chose the adoption of experimental surgical-recording technology as the case to address our research questions. This recording and retrieval system is being pioneered at a paediatric heart surgery department and hospital in Lund, Sweden. The technology is complex and consists of two components: (a) a recording system that is used to capture the high-quality three-dimensional (3D) surgical video; and (b) the storage and retrieval system that is used to store and access recordings for research, teaching, and reference purposes.

The recording system is primarily used by the surgeons and is seen by the operating theatre staff, including surgeons, anesthetists, nurses, and other theatre staff. However, this aspect of the technology is not seen or used by other doctors who use only the recordings. Therefore, the retrieval system alone mostly influences their perception of the technology. The recording system is a complex multi-camera setup mounted near the operating table's overhead light. The recording from multiple cameras enables free, high-definition video recording of the surgery from multiple perspectives. The recording may be used for teaching, learning, research, diagnosis, and reference purposes by surgeons, teachers, future surgeons, and doctors, providing significant value to adopters. On the other hand, high-definition surgery recordings can present significant risks to patient and surgeon privacy. In addition, there is a fear that, in the future, the system will be used as an auditing tool by the hospital administration. Thus, experimental surgical recording in this novel context of technological innovation in healthcare provides a valuable focus for research investigation. Figure 1 provides an overview of the technological innovation considered in the study.

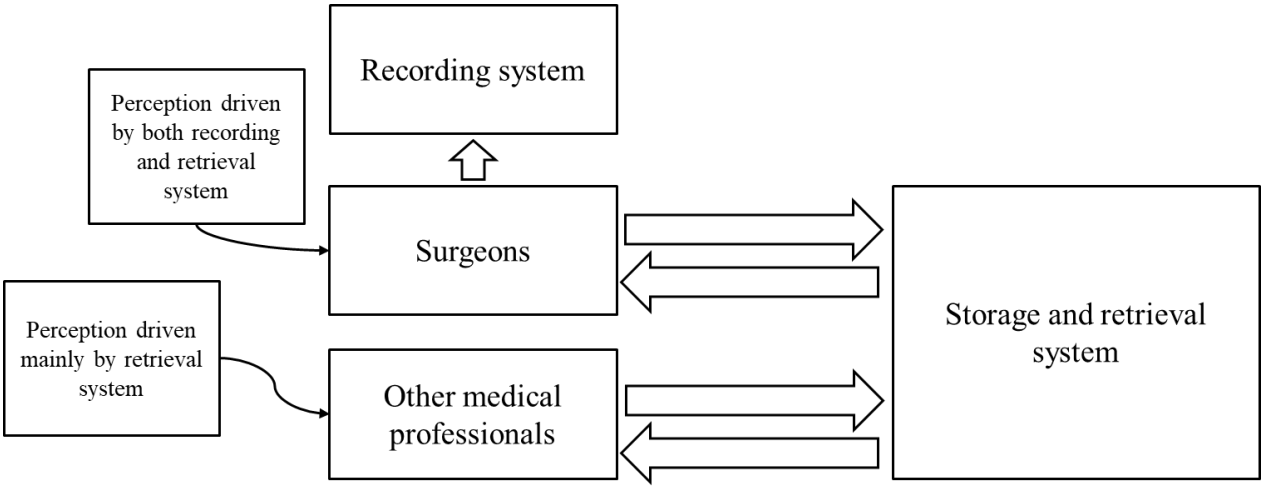

Figure 1. 3D video recording and retrieval system

3.2 Research approach

We utilised a qualitative and exploratory research technique to investigate our research questions. Two aspects dictated the choice. First, there are few studies investigating resistance to technology by healthcare professionals. Therefore, a qualitative research design is best suited to explore the intricacies of this novel context. Second, exploratory qualitative designs have been used by multiple studies in the consumer behaviour field when studying unique and new technological innovations (Kerr et al., 2018; Low et al., 2021; Shaikh et al., 2020). Therefore, this research approach is fitting in our endeavors to address the proposed research questions.

We prepared a draft interview protocol employing the data from an initial pilot survey where we asked surgeons and operating theatre staff for their opinion of the technology. The draft interview protocol was tested with two randomly selected healthcare professionals in April 2021. The protocol was modified in light of their responses.

Finally, using this protocol, we conducted 20 semi-structured interviews with multiple types of users of the technology between May and July 2021 to capture their perception of the technology. We adopted purposeful sampling to recruit the participants to ensure various

stakeholders from multiple technological perspectives. The twenty participants included eleven surgeons who directly used the recording technology or were aware of its existence and were contemplating using it, six other doctors who work with the recordings and interact with surgeons regarding the recordings, and two nurses in charge of handling the post-recording tasks to create educational and research material. One of the participants was a technology developer. To ensure that respondents who did not use the technology were familiar with it, images of the recording equipment and where it is located and how it is used were explained in detail before each interview.

The interview aimed to capture the perceived barriers and usage intentions among the respondents during their regular work. The multiple perspectives capture not only the active users of the technology but also the passive users and what they think of the active adoption. The participants were mainly from Sweden. However, we had two surgeons from India, Russia, and Uganda to provide cultural diversity. In addition, the professionals interviewed had different levels of experience in the healthcare field and were from a broad age group. The demographic profile of the participants is presented in Table 1. In addition to the steps above, we referred to the documentation on the technology to understand the technology better.

3.3 Data collection and analysis

Due to the ongoing COVID-19 restrictions during the interviews (May–July 2021), the interviews had to be performed in video-conferencing mode. All interviews were performed in the English language. Each participant was sent an information document on the nature of the research before being recruited to the study. The document introduced the researchers, explained the study, and informed participants that their participation was voluntary. All participants were assured that data privacy was paramount, and they would not be identified by name at any point in the research. Privacy is a greater concern in our case because any information revealed could be detrimental to the careers of participating healthcare professionals. We employed several techniques to maintain anonymity and privacy, including assigning pseudonyms, recording the interviews in audio only, and then having them transcribed. Explicit consent was obtained before recording the interviews. None of the 20 participants refused to consent to have the interview recorded.

Table 1. Demographic profile of participants

Participant number	Sex	Age	Healthcare profession	Interview durations (minutes)
1	m	35	Resident Adult Cardiac Surgeon	37
2	m	65	Senior Attending Pediatric Cardiac Surgeon	30
3	m	45	Senior Attending Adult Cardiac Surgeon	31
4	f	30	Resident Adult Cardiac Surgeon	32
5	m	29	Resident General Surgeon, start July	40
6	f	32	Resident Ear-Nose-Throat (ENT) Surgeon 3rd year	43
7	m	53	Senior Attending Pediatric Cardiac Surgeon	38

8	f	63	Senior Attending Pediatric Anesthesiologist	45
9	f	65	Senior Attending Pediatric Cardiologist	39
10	m	50	Senior Attending Pediatric Cardiologist	44
11	f	44	Junior Attending Pediatric Cardiologist	33
12	f	40	Senior Attending Pediatric Cardiologist	42
13	f	44	Junior Attending Pediatric Cardiologist	32
14	m	48	Senior Attending Vascular Surgeon	30
15	m	34	Junior Surgeon	35
16	m	32	Orthopedic Surgeon	40
17	m	48	Technology Coordinator and Surgeon	110
18	f	34	Research Scientist	45
19	f	56	Pediatric Heart Care Nurses	39
20	f	51	Pediatric Heart Care Nurses	39

At the beginning of each interview, we asked participants qualifying questions to ensure they had sufficient expertise to comment on the technology. Images of the technology were shared with participants to ensure they knew what it looked like and how it could impact their healthcare practice. This was also undertaken to ensure that all participants had the same visualization of the recording technology because several alternative methods of recording are utilized in operating theatres – for example, recording with mobile phones or single cameras on tripods. It was essential for participants, particularly surgeons, to be aware of how the cameras are set up and how they can impact their surgical routines and careers. Typically, interviews lasted between 30 and 50 minutes. However, Participant 17 was the coordinator of the technology with an intimate knowledge of both the surgical and the technical sides of the technology – consequently, this interview lasted 110 minutes. Each interview was transcribed into text prior to analysis.

The participants were asked questions on how the technology has or can impact their current healthcare work. These included questions such as: “How do you think this will impact your work?” and “Are you willing to use this technology?” Questions were also posited on what would make them not use the technology. These included questions such as: “How can this technology negatively impact you?”; “What are the different technical issues that you foresee in this innovation?”; “What are the reasons that will make you not want to use this technology?”; “Do you perceive any risk to your career from the introduction of this technology?”. The interview guide was updated with new information after each interview. We had reached data saturation by the time we interviewed 15 doctors. Three extra interviews were conducted to ensure no new information emerged. We then interviewed Participants 17 and 18 to validate the findings and to understand what technical aspects led to the issues discussed.

We utilised the thematic content analysis technique to analyse the data collected because it is a well-suited method for pattern identification in complex datasets such as ours (Braun & Clarke, 2006; Kamalaldin et al., 2020). Due to a large amount of qualitative data, we utilised Atlas.ti to consolidate and code the data to arrive at thematic clusters. Open codes were marked in the transcripts based on the concerns raised by the participants. Codes with similar meanings were combined to form first-order categories (Elo & Kyngäs, 2008). The first-order categories were further aggregated based on commonalities. Finally, the second-order codes were aggregated

based on their relationship with technology adoption or resistance decisions, which were finally converted to aggregated themes in the data (Gioia et al., 2013). This step was carried out iteratively and collaboratively by the authors through a discussion of the data. The analysis resulted in four primary themes on barriers at the aggregate level and eight different second-order themes. The categorization can be observed in Figure 2 below.

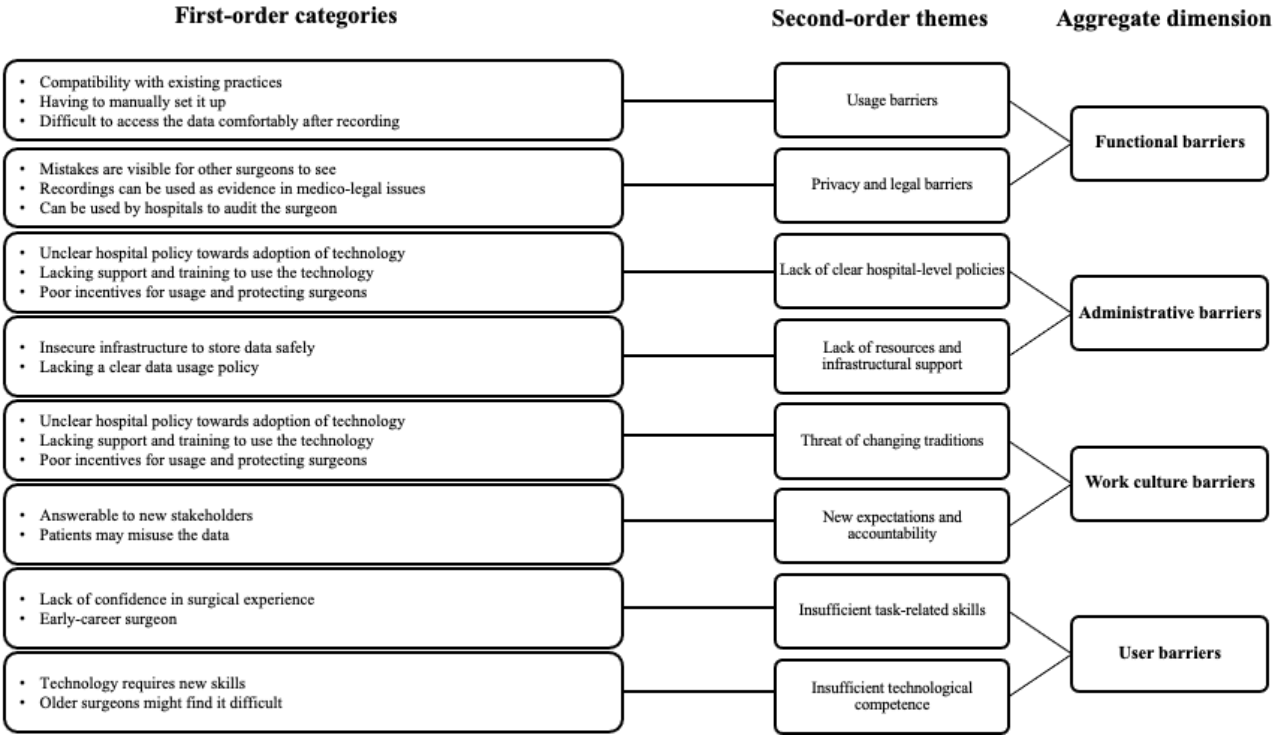

Figure 2. Structure of the data and the coding process

4 Empirical findings

4.1 Barriers to the adoption of innovation

IRT argues that barriers to adoption lead to resistance to innovation (Ram & Sheth, 1989; Talwar, Dhir, et al., 2020). In concurrence with the argument, we identified several barriers to adoption in our interviews. The barriers were coded and clustered into meaningful themes. The themes were discussed between the authors and refined to arrive at four categories of barriers impacting healthcare professionals' adoption of innovation. They are (a) functional barriers to adoption; (b) administrative barriers to adoption; (c) work culture barriers to adoption; and (d) user-oriented barriers to adoption.

4.1.1 Functional barriers to adoption

Functional barriers are the perceived impact on performance or inability to perform tasks adequately due to the characteristics of the innovation (Ram & Sheth, 1989). We identified two

functional barriers to adopting the technology: (a) usage barriers; and (b) privacy and legal barriers.

Usage barriers

Usage barriers are the perceived deviation between the value gained from the product and the actual value that can be gained from it. For a surgeon, usage barriers are primarily determined by their ability to set up the recording technology on time before the surgery. However, several incompatibilities with the existing systems in the surgical theatre made the task cumbersome. These incompatibilities raised fears of performance issues that can negatively impact patient care. For instance, setting up the technology – which needed to be completed before the surgery – took almost 20 minutes, risking a potential delay in the entire surgical process.

"If it's too complicated to set up. If it takes too much time, and it's hard to get, and it doesn't work, and if we don't get that time to do it, because that's always the stress factor. If you have the same time for the surgery, but you have 20 minutes to install the camera, of course, you will feel the pressure that, "I'm not going to finish in time." Participant 6

"Right now, the surgeons have to do that, to put the thing in place, and I don't know if every surgeon would like to do that. Probably they would prefer to have someone go in and do it so that they can do something else. Of course, I don't think right that a paediatric heart surgeon has to come into the operating theatre to put a frame on the table and adjust a camera. I don't think it's appropriate. He has other things to do." Participant 8

Usability issues were also reported by users of the retrieval system alone. It needed to be more intuitive to access the data, and often the surgeon had to manually collect the data from the system using a physical storage device. In addition, there were no defined practices as to whether the data would be stored with other patient files or separately as a reference and teaching database. Moreover, the recordings were often unedited and stored as huge file. The inconvenience of combing hours of footage to find exactly what was required was the main reason for hesitancy among doctors who relied on the recording for reference, research, and teaching purposes.

"If you're going to use it for education, there might have to be someone who takes out the most important parts. It won't be very accessible, as you say to look through five hours of video." Participant 12, in response to being asked whether the length of the recordings was an issue.

"Every IT data is only as useful as access to it. If you can't make use of it, it's just dead data. It's like me taking multiple 3D clips of an echocardiogram on an echo, on the children's outpatient clinic, without post-processing them. It's huge chunks of data in the database that don't get used forever, we don't go back to it. That's exactly, once the surgeon is done, they want to finish their day's work, and they don't want to go back for hours and revise and look and post-process the data that they've recorded. This needs to be slick and easy, so that it's actually not much work for them to do, or it needs to be actually a dedicated person who processes the data." Participant 2

Privacy and legal barriers

Privacy and legal barriers are caused by the uncertain way data storage and usage policies are defined for the technology. Due to the nature of the product, data storage and usage is decided at the level of the individual hospital. Consequently, the extent of such barriers and resistance to

using the innovation will vary. This was particularly true for participants who had yet to use the technology.

"I mean I haven't seen it in use, so I don't really know the ecology of it or so, but I think it had a lot of value at least in learning opportunity for younger surgeons and so on." Participant 3

The fear of bad outcomes and mistakes becoming visible to other surgeons and stakeholders was evident from surgeons who perceived the technology as a potential auditing tool that could be used against them. This anxiety was most substantial among participants who had not used the technology previously. Among participants with prior experience, active resistance was low. However, they understood how it could be daunting for new users. When asked how severe they considered the risk of auditing on a scale of one to five, one of the respondents with experience observed:

"I am just going to say; I'm not scared of that in our current – how it is right now, but I guess that in other hospitals, in other units, I would be around a three." Participant 6

The problem was further accentuated because of the audio recording feature. It was unclear whether audio data would be handled in the same way as video data. Several doubts arose in the interview, such as: "Will the audio be deleted if the video is to be released?" and "Can audio recording be turned off?"

"Actually, when you speak about the audio, I'm not very concerned about me speaking about the case and what is difficult and what I need help with. I think more that, sometimes you speak a little bit about personal things with your colleagues and stuff like that. It will feel a little bit uncomfortable to have that on tape." Participant 4

Furthermore, based on the recordings, there was a perceived risk of being sued. In particular, one of the respondents feared that video might be used as a red herring and some inconsequent aspect of the video or audio recording could be seized on to blame him for something unavoidable.

Uncertainty over ownership of data was a major concern. It was unclear who should have the rights to data and who could enjoy monetary benefits from ownership. While 14 respondents agreed that the hospital should place the data in patient files (journals), others were divided in their opinion. Four respondents believed that patients should own the data. On the other hand, two respondents argued that the technology should be used strictly to improve the skills of the surgeon, that the surgeon should be the owner, and that he/she should have the right to decide what happens to the data.

"It's a very nice thing to say that I own my own patient data as a patient but what does it actually mean? Does it mean that I have free access to every image that has been taken of me? I am not sure that social media would be an easy thing to handle. That is why I think that the hospital has to own it." Participant 6

4.1.2 Administrative barriers to adoption

Administrative barriers to adoption can be defined as barriers perceived by users due to a lack of administrative support, policies, or processes associated with the technology. These may manifest as the need for formal routines and policies outlining the use of the technology, the policy concerning control of the data collected through recording, and the lack of resources to sustain the use of technology.

Lack of clear hospital-level policies regarding data usage and sharing

Due to the complex nature of the technology, organisational support is paramount in determining its adoption and continued usage. Participants expressed concern over how the innovation would be formally adopted in hospitals. As noted in the previous section, hospitals currently need more policy positions and rules to handle the new kind of data that will be released into the system. Some participants opined that the data is no different from an X-ray or a CT scan. Others argued that a recording could have a direct influence on a surgeon's career, whereas X-rays or CT scans could not because their data did not contain the required detail to be professionally damaging. Therefore, comprehensive policies dictate what the data can be used for and when it is clearly needed.

For instance, one major issue was the threat of legal repercussions and how doctors could be put at risk by ill-defined policies. This was echoed by one of the surgeons who had international experience. Lack of clear hospital policies regarding what happens to the data, who can use it, and for what purpose can be a significant risk to a surgeon.

I have worked many, many years overseas. I am educated actually and trained in Australia and the UK. That means, there is always an apprehension from the healthcare profession when recording your work. It is like going to an outpatient clinic appointment and having it all videotaped on YouTube kind of thing, live-streamed online. There is this confidentiality issue about whose data it is and who's keeping it safe, and how long it will be kept safe if it is digitally archived. In other words, who owns this, actually? Is it the university? Is it the surgeons? Is it the patient? That is one thing.

The other thing is, of course, the potential for medical-legal repercussions. You can imagine that there are people in the world who are worried that whatever tiny bit of error or mistake is made will be used against them, and they will be sued. Moreover, that might cost a healthcare system a lot of money, to say the least, to fend off these claims which might be founded. Participant 2 with over 30 years of surgical experience.

The lack of the policies mentioned above indicates that there are no incentives in place to encourage adoption to offset the barriers. This meant some participants felt free to adopt the innovation. Moreover, the experimental nature implied the need for a support and training infrastructure to use the system efficiently.

Lack of resources and infrastructural support for adoption and continued use

Supporting infrastructure makes innovation easier to use and reduces the effort required to adopt the innovation. In the case of the focal innovation, safe and secure IT infrastructure was considered paramount to adopt and use the technology.

"*I can't see a major obstacle in that as long as you have the right IT infrastructures are set in place, but you need to have that backup."* Participant 2

However, the cost of the underlying infrastructure and the innovation is often a major concern for complex innovations. In the case of surgical recording technology, this concern is often handled at the hospital level. Hence, resistance may emanate not from the user but from the hospital. This was cited by one of the Indian participants who worked in a less well-funded hospital. So, even if he wanted to use the technology, his hospital was in no position to afford it.

A similar issue was raised by the Ugandan surgeon who expressed difficulty in justifying the cost of the innovation to hospital management.

"If we are going to incur expenses, then you have to work very hard to convince them that it's a worthwhile expenditure." Participant 7

Another issue frequently discussed in the interviews was the need for more technical assistance. The surgeons were expected to set up the technical equipment themselves, and glitches caused delays.

"I wouldn't want to be responsible for the equipment during surgery. For me, I'd want to have a technician in the room who can repair the glitches." Participant 5

In summary, an organizational structure and a national culture that adopts an evidence-based approach to testing new technologies and gives employees leeway to use the technology and learn from mistakes is essential for the innovation to succeed. More infrastructural support is needed at the hospital and the country level to merely a recording equipment.

"You need to have a positive working environment where to pilot this. There is no way of launching something into the world without having, as I said, buy-in from the driving forces in a health care system. You need to prove the principle, and have it published, as we say in peer-reviewed scientific journals; otherwise, people will not buy into it. They will not accept this just as an intuitive new way of documenting your operating results." Participant 6

4.1.3 Work cultural barriers to adoption

Work cultural barriers represent psychological barriers to adopting the innovation brought about by the change in the status quo of the existing work culture within the organization. They may persist as a threat to existing traditions and how tasks are performed or by creating new stakeholders to whom healthcare professionals are accountable.

The threat of changing tradition

As discussed in the subsection on usage barriers, new technology is often incompatible with existing practices. Moreover, due to constant recording, surgeons reported apprehension in making necessary but risky, unorthodox, on-the-spot decisions required by the very nature of the surgical practice. They were worried that recordings of their actions might be used against them in cases where the steps taken deliver an adverse outcome. Furthermore, an audio-recording feature implied a conscious censoring of self. Surgeons explained that "socially inappropriate" talk and joking were everyday in surgical theatre because they helped relieve the stress of waiting for specific procedures to run their course.

"When people are under high pressure for a certain time period, and it can be 20, 40 minutes, once they have passed through that very dangerous passage during surgery, you need to relieve yourself. You need to laugh, and you need to talk about silly things. It's about culture. Sometimes those silly jokes can be very sexist, very homophobic, very anti-immigrant, and very ironic. The group of staff will understand each other but not the outsider." Participant 16

Another barrier observed was that this technology brings surgeons to the same or higher level of accountability as other healthcare professionals, which was not the case previously. Every action can be analysed, scrutinised, and used for malicious intent if the technology is not deployed under a well-laid-out policy framework.

New expectations and accountability

Given the nature of the recording and the uncertainty over policy, being audited and judged by unqualified stakeholders is a threat. For example, if the recording is held to be equivalent to a scan such as an X-ray, a patient may be able to acquire the recordings. This could lead to the patient suspecting or alleging there was misconduct and, by contacting the hospital or pursuing litigation in court, deflect surgeons' attention away from their essential functions.

"The patient could sit at home and click on the video clip and see the surgery, and they do not really understand that. That could be a real problem, of course, draw false conclusions and things like that. Of course, this is not there, but if the development forces us to put this into medical records, then it would not be possible because we have this system in Sweden, so we have to be aware of it." Participant 5

In addition, malicious use of data by patients or close associates of the stakeholder was a concern because there were no policies in place. It was uncertain how patients may use the data and how their decisions could impact the surgeon.

"*If you should say that the patient should own it, then the patient should also own all the X-ray and ultrasound images. In one way that is correct and very democratic and so on. If you take it one step further, what does it mean to own your data? Does it mean that you can log in from home and look at your ultrasound? If you can log in from home and look at your ultrasound or your surgical film, will you also be able to put it on YouTube and Facebook?"* Participant 5

4.1.4 User barriers

Users are challenged by the change brought about by the innovation, and they may react differently to different barriers based on their idiosyncratic characteristics (Heidenreich & Spieth, 2013; Ram & Sheth, 1989). The barriers can be classified into one of the two types: (a) insufficient confidence in task-related skills; and (b) insufficient technological competence relevant to innovation.

Insufficient confidence in task-related skills

Here, task-related skills refer to skills related to the task that are impacted by the technology. In our case, task-related skills refer to the surgical skills of the surgeon. Since the technology can keep constant track of their actions, surgeons with less confidence in their surgical skills are likely to refrain from adopting the technology. This view was particularly prevalent among younger and less surgically experienced participants who saw an active threat to their careers arising from the greater likelihood of them making mistakes. Furthermore, they were worried about being judged by their colleagues and seniors. However, these issues were much less evidence among experienced surgeons who were confident enough in their skills to ignore the barriers and see the innovation as an instrument for self-improvement and a valuable tool for teaching and learning.

"*"I think sometimes the senior surgeons, they forget that they will not be there forever, [chuckles] and that someone has to fill their shoes. It is really easy for me to see the benefits, like, "Oh, I would use this a lot." Maybe you don't think about that if you're a senior surgeon. Well, education is really important."* Participant 12

Insufficient technological competence relevant to innovation

More confidence in technological competence to tackle the technological requirements of the innovation can also act as a barrier to adoption. However, contrary to task skill-based barriers, technological competence barriers are likely to exist among older surgeons who may resist learning new technological competencies to use the innovation. However, the way to tackle this barrier is by highlighting the value to older surgeons who are reluctant to adopt it.

"If you put it in perspective and tell them, 'Well this is so that we have someone to fill your shoes.' Sometimes you can reach them with that, [chuckles] I think, yes." Participant 12

4.2 Contingency technology innovation adoption framework for healthcare

The multi-stakeholder approach adopted in this study provides unique insights into users' behavioural intentions regarding the factors that influence their decisions to adopt or not adopt an innovation presented. The evidence suggests there are no uniform instances of resistance from users and potential technology users. On the other hand, there are also behavioural patterns that cannot be categorized as adoption. Thus, this reinforces the need for a contingency framework for technology innovation adoption that is contingent on the nature and perceived intensity of the barriers that drive hesitancy-driven adoption barriers.

The results from the interview indicate that the four barriers and the eight subcategories discussed in the previous section influence resistance behaviours through multiple mechanisms. Furthermore, the barriers can interact with each other to influence a particular behavioural intention. For instance, usage barriers can lead to surgeons not using all the innovation features due to their fear that the hospital or the law may not be on their side if something goes wrong. On the other hand, we ascertained that, even though the perception of the risk to career was very much present, several of the participants with high task-related skills still expressed the intention to adopt after weighing the benefit against the risk.

To better understand this contextual interrelationship of barriers and their impact on adoption behaviours, we integrated this interaction dimension into the contingency framework proposed in this study. We utilize a pattern-matching technique to match the perceptions of barriers to behavioural intentions and, ultimately behaviour. A framework depicting this technique is provided in Figure 3 below. Table 2 gives more granular detail on sub-barrier levels. The framework consists of three parts that determine how barriers are evaluated to result in different adoption behaviours. First, the identification of barriers by the user. Their evaluation will be guided by questions such as "Are there any risks that can occur to be by using this technology?" The second part consists of how the barriers are evaluated and how the evaluated barriers can impact each other. When the barriers are low, the user would adopt the technology "as is." On the other hand, in cases where all barriers are unfavourable, the user would likely decide to resist adoption by expressing one of the non-adoption behaviours dictated by IRT – namely, resistance, postponement, or outright opposition. However, under any other configuration of barriers, complete or partial adoption may be suitable. That is to say, they will experience a brief period of hesitancy before evaluating different barriers in the context of each other before substantiating why adoption would be justified. Here, the user may decide to engage in some form of adoption instead of resisting adoption. These adoption behaviours and their manifestations forms the third part of the framework. We argue that this umbrella of usage behaviours between resistance and

complete usage is the outcome of hesitancy to adopt. Here, we define hesitancy as a period of evaluation where users decide on their adoption behaviour based on their perception of the barriers. We find four such adoption behaviours that can occur in the continuum of adoption to resistance for complex healthcare technological innovations. We identify two types of adoption behaviour that are driven by hesitancy: (a) censored adoption; and (b) uncensored adoption. The definitions of each of these hesitancy-driven behaviours are presented in the subsections below.

4.2.1 Censored Adoption Behaviour

In this kind of hesitancy-driven behaviour, the users are assumed to have a choice of either not using some features of the innovation or deciding when they do not want to use it. Therefore, the use of innovation is censored in some way. Users can constrain their behaviour in one of two ways: (a) by limiting the number of features of the innovation they use during their adoption; or (b) by limiting the frequency of use to cases in which they are comfortable using the technology. We term these two behaviours "feature censored adoption" and "case censored adoption," respectively. However, this requires an enabling environment that is tolerant of censored adoption. Therefore, censored adoption would be possible only if no compulsory usage policy exists or an established policy explicitly allows censored adoption.

Feature-censored technology adoption

Feature-censored adoption is an adoption behaviour where the adopters resort to adopting and consequently use only certain features of the innovation in response to barriers they face. Feature-censored adoption is mainly driven by the functional usage barriers of a product, which make using certain features risky. Therefore, when given a choice, users would prefer to adopt the innovation without using the features that cause the barriers. The motivation for censoring can be accentuated by user barriers of both task-based and technology-based skills. Furthermore, high administrative barriers can be a concern because data recorded from certain features may need to be revised in the future. An excellent example in the case of surgical recording technology is the reaction to audio recording features. If surgeons feel that the audio recording during surgery is incriminatory or irrelevant, they may turn off audio recording in their surgeries. They were also concerned that if proper hospital policies for accessing data were not in place, a leaked audio recording could impose unnecessary professional hurdles even when what was said or recorded had no bearing on the outcome of the surgical procedure.

Case censored technology adoption

The other way users can censor their adoption is by restricting the frequency of use to cases where the use of the innovation is considered convenient. This would be particularly useful for surgeons who perceive a high degree of user barriers. In particular, surgeons who need more confidence in task-related skills would prefer not to use the innovation for surgeries that are high risk and more liable to be problematic professionally. This behaviour will be worsened if surgeons feel that their situation forces them to adopt the innovation or if they perceive administrative barriers in the form of inadequate legal protection for the innovation user. For instance, in our case, younger surgeons hesitated about using innovation when undertaking a novel surgery or conducting a surgical procedure for the first time. They favoured having the choice to turn off the equipment because they would feel nervous, commit a mistake, or be judged too harshly later on the recordings. However, they recognized that this would only be possible if administrative barriers were sufficiently low to allow them to switch off the equipment in some instances.

4.2.2 Uncensored adoption

In this type of adoption, the adopters take up all features of the products during every single use and in all scenarios. Uncensored adoption occurs when surgeons are presented with no choice regarding censoring or when they prefer to adopt the innovation regardless of the barriers they perceive. Therefore, we observed two distinct manifestations of uncensored adoption – (a) unwilling technology adoption and (b) enthusiastic technology adoption.

Unwilling technology adoption

In unwilling technology adoption, the user is likely coerced into adopting the technology by law or social pressure. In our case, even though no hospitals mandated compulsory usage, participants observed that the widespread adoption of such a technology in the surgical field was inevitable because of its value. Less experienced surgeons with insufficient confidence in their surgical skills tended to express the fear that hospital policy may force them into adoption. Furthermore, they feared that their careers would be at risk if the tool is used for auditing purposes. We observed, in this case, that the interaction of high user-centric barriers and medium-to-high administrative barriers reinforced each other. This is likely to lead surgeons to adopt the technology, albeit unwillingly.

Enthusiastic technology adoption

Contrary to unwilling technology adoption, enthusiastic adoption occurs when users recognize the barriers but are willing to suffer them to secure the value the innovation provides. In our case, surgeons chose enthusiastic adoption in the operating theatre because they believed the inconveniences were outweighed by the value gained. They considered the technology an essential educational tool that could be used to train future surgeons and, therefore, not recording procedures would preclude future generations of surgeons from benefitting from important information. Therefore, functional barriers and barriers due to change played little or no role in their decision-making. The users were only concerned about the hospital instituting proper data storage and usage policies. Furthermore, low user barriers are essential for this type of usage because only users skilled in their task will willingly adopt. This behaviour was especially prevalent among surgeons who were confident in their task-based skills. Although they perceived technology skills as a barrier, they were willing to learn the new technology to help the surgical profession in general. The sole issue that worried the surgeons was the accessibility of the data to relevant stakeholders. They expressed the concern that misuse of data after adoption could undermine their confidence in its use and that, therefore, administrative barriers should not be high, and proper policies must be put in place to alleviate concerns of misuse of data after adoption.

Table 2. Mapping barriers to adoptions

		Resistance	Censored adoption		Uncensored adoption	
			Feature censored adoption	**Case censored adoption**	**Unwilling technology adoption**	**Enthusiastic technology adoption**

Functional Barriers	Usage barriers	H	H	H	-	-
	Privacy and legal barriers	H	H	H	-	-
Administrative barriers	Lack of clear hospital-level policies	H	H	L-M	H	M
	Lack of resources and infrastructural support	H	M-H	H	M	M
Work culture barriers	Threat of changing traditions	H	L	H	H	-
	New expectations and accountability	H	M	H	H	-
User barriers	Insufficient task-related skills	-	H	M-H	M-H	L
	Insufficient technological competence	-	M-H	-	L	M

L-low barrier, M-medium barrier, H-high barrier**.**

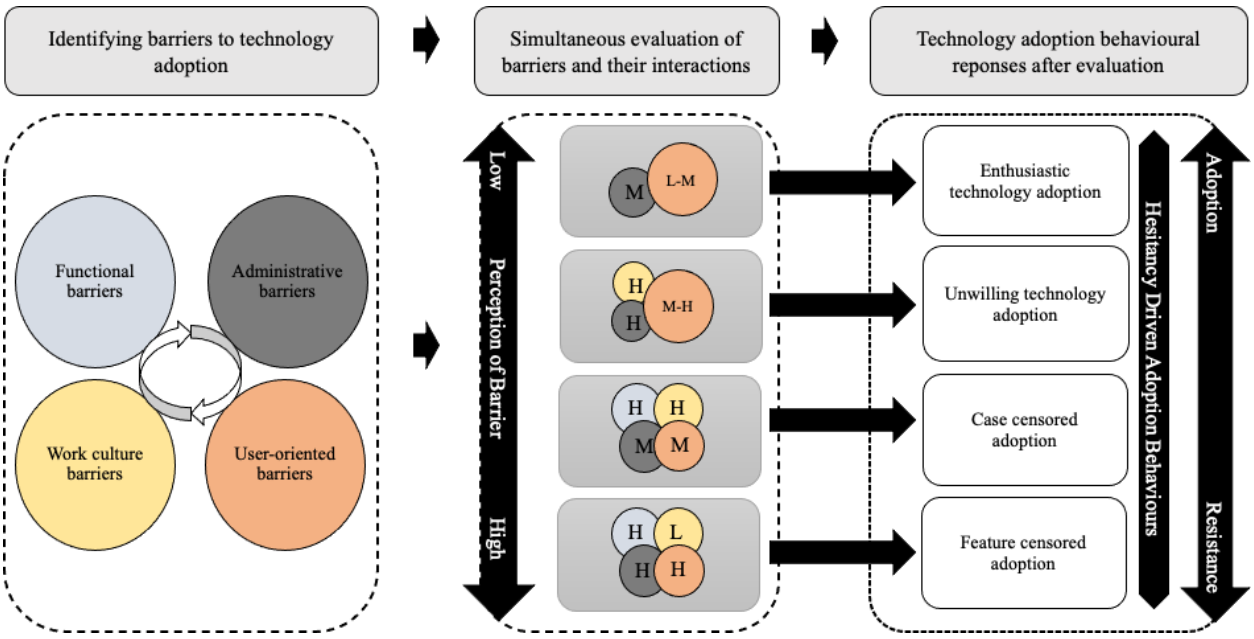

Figure 3. Framework for evaluating barriers to adoption and hesitancy behaviours

5 Discussion and Conclusion

The purpose of this study was to understand the adoption and resistance of innovation among healthcare professionals. We were guided by two research questions in this journey. RQ1 sought to understand key factors influencing the adoption of healthcare technological innovations, and RQ2 sought to uncover how these barriers impacted adoption behaviour in a contingency framework. To this end, we not only uncovered several barriers to adoption that impact innovation adoption in healthcare, but we also demonstrated that contingent adoption is possible under high barrier situations. Furthermore, these adoptions may be censored or uncensored in nature, thus highlighting the need to conceptualize resistance and adoption behaviours that fall between complete adoption and non-adoption. We also delved into how different barriers interact with each other to create these behaviours. We presented a contingency framework to access these behaviours and map which barriers need to be addressed that cause the behaviour. The study is particularly important in the context of the 'new normal' that is emerging due to the COVID-19 pandemic. We add to that body of knowledge by providing precise barriers and behavioral outcomes to introduction of surgical innovations (Somashekar et al., 2021; Quaranto et al., 2021).

5.1 Theoretical Implications

The findings of this study contribute to the literature in three key ways. First, the study augments an evolving body of literature investigating the adoption of technological innovation by healthcare professionals, particularly surgeons whose adoption behaviour is of great interest because of their importance in healthcare (Anderson et al., 2012; Perl et al., 2021). Whereas prior research investigated enablers and their influence on adoption (Escarce, 1996; Wilson, 2006), our findings explored the complex nature of interrelated barriers and their influence on adoption behaviours. This reinforces the importance of considering healthcare innovations as complex

multi-stakeholder systems comprising patients, healthcare professionals, and hospitals (Shah et al., 2021).

Second, the findings render support to our initial arguments that investigating only barriers to use cannot fully explain resistance or adoption intentions when considering complex radical innovations. In this respect, the current study extends IRT, which predicts barriers and risks leading to rejection or postponement of the adoption (Heidenreich & Spieth, 2013) by showing that barriers are not mutually exclusive or independent of each other. Our results show that, even under heavy usage barriers and risks – in which resistance is expected according to IRT – most surgeons still chose to adopt the technology either out of concern for stakeholders, such as patients, hospitals, and future surgeons or due to contextual reasons beyond their control. This indicated a need to consider both attitudinal and barrier perspectives simultaneously. Therefore, we have introduced technological adoption hesitancy as a concept to define the continuum between complete adoption and resistance. This establishes a bridge between the bodies of literature working on understanding adoption behaviours at one end and resistance behaviours on the other. Specifically, we conceptualize two types of hesitancy-driven adoption – censored and uncensored. Furthermore, innovation resistance among healthcare professionals is a concept that has received only sparse treatment, with hardly any research investigating adoption and resistance behaviours among surgeons. The theory has seen its primary use in consumer-level innovation studies, such as mobile ticketing (Chen et al., 2022), mobile payment (Migliore et al., 2022), and drone delivery. Due to the same contextual setting (consumer-level innovations), the contribution to theoretical knowledge has been limited, with the majority of studies being restricted to application studies that utilize quantitative methods to test the theoretical lens. However, we add to the theoretical lens by adopting an exploratory qualitative design and conceptualizing new barriers and adoption behaviours that, although specific to the surgical context, may also hold implications for adopting other complex innovation systems.

Third, our results show that the interrelationships and intensity of the perception of barriers elicit certain kinds of behaviour. IRT captures the extremity of this (complete resistance or non-usage). However, the interactive nature of these barriers produces in-between barriers. This is depicted in the proposed contingency framework for healthcare technology innovation adoption. Furthermore, our results delve into, for example, the presence of technological barriers that usually lead to censored adoption. This means that innovations that allow censored adoption may see some degree of adoption instead of resistance. However, in the absence of existing studies investigating the phenomenon, studies are needed to explicate the factors involved. Furthermore, we observed that certain barriers could interact with other barriers. For instance, poor perception of task-related skills can lead to censored adoption. However, having unfavourable technological or risk barriers can transform the response into resistance. Thus, barriers should be investigated as an interconnected system of factors rather than mutually exclusive antecedents of resistance, as has been carried out by most quantitative empirical studies on IRT (Kaur et al., 2020; Laukkanen et al., 2007; Leong et al., 2020). The contingency framework developed from pattern-matching responses may be used as a reference by future researchers to investigate their research questions and formulate hypotheses that will provide quantitative validation.

5.2 Managerial implications

Our study presents implications for three key stakeholders: (a) surgeons; (b) healthcare technology companies; and (c) hospital administration. First, for surgeons, the framework provides a bird's eye view of the barriers they may perceive and how they interact with each

other. When confronted with new technologies, they may assess their perceived barriers. This will facilitate a better conversation and negotiation with technology companies and administration about the design and use of technology.

Second, for healthcare technology companies, the barriers highlighted in our results show that hesitancy-driven censored adoption behaviours can exist. Here, it may be possible to encourage censored or even uncensored adoption by working on the barriers and risks perceived by healthcare professionals. For instance, knowing that the technology, with its low usage barriers, can help patients has encouraged censored adoption of the innovation on a voluntary basis. The marketing of healthcare technologies can be designed to communicate the ability to turn off features when not needed. The marketing message for complex healthcare technologies, such as 3D recording, can be structured to communicate how using the technology, despite its risks, can help relevant stakeholders, such as future surgeons and patients. This provides actionable insights into product or service research and development and encourages innovators to modularize their features.

In some cases, especially with the technology compatible with freemium or add-on revenue models, censored adoption can be encouraged first based on those features perceived as low barriers. That is to say, a list of features generally considered suitable by consumers may be innovated and rolled out first for a fixed fee. The remaining features, which some users perceive as barriers, may be rolled out as add-ons for users with no such perception. Our results suggest that empowering the user to select those features they are happy to use is a good way to move them from resistance to censored adoption, at the very least.

Third, for the hospital administration, we note that low task-related skills and a high perception of other barriers can lead to rejection unless mandated by the hospital. However, mandating usage may not be in the best interest of the surgeons, hospitals, or patients. Several surgeons were nervous about being recorded and feared the technology could become an auditing tool. This demonstrates that hospitals should only consider employing such radical technologies after consulting the healthcare professionals mandated to use them. Moreover, the results provide insights into how more experienced surgeons with high task-related competency are the best targets for these communications because they are inclined to ignore other barriers associated with the innovation in favour of the benefits. Thus, assessing task-related skills and offering voluntary adoption opportunities to such surgeons could be a good way to launch the adoption process. This would enable the creation of administrative and cultural processes to reduce administrative barriers over time. Furthermore, providing a choice of cases or features would encourage a certain level of adoption.

5.3 Limitations and future research directions

As with all research, our results have some limitations. First, although we tried to adopt the necessary steps to ensure wide heterogeneity in the data, it must be noted that most of the data are from Sweden. Therefore, any generalization of the results must be made with caution. Particularly, we believe two factors could hinder the generalizability of the studies. First, Sweden has a public healthcare infrastructure where doctors are less likely to face legal action as compared to countries like the United States of America, where healthcare is privatized. Second, the Swedish culture ranks one of the highest in embracing innovations. Therefore, the barriers are likely to play differently in countries that are less open to change. However, surgeons around the world, are likely to express functional and user barriers similarly as they are related to the

skill of the surgeon and the usability of technology rather than the administration or culture which are likely to be country dependent. Second, our results are advanced with the assumption that censored adoption is better than resistance or no adoption at all. This assumption primarily applies to complex multi-stakeholder systems and may not be appropriate for some innovations that cannot accommodate censored adoption.

We encourage future researchers in this area to build on our results. For instance, quantitative empirical work is needed to validate further the interconnected nature of the barriers proposed in this study. Our research opens avenues for the scale development of hesitancy-driven adoption behaviours, including censored and uncensored adoption under conditions of resistance.

References

Anderson, J. E., Chang, D. C., Parsons, J. K., & Talamini, M. A. (2012). The First National Examination of Outcomes and Trends in Robotic Surgery in the United States. *Journal of the American College of Surgeons*, *215*(1), 107–114. https://doi.org/10.1016/j.jamcollsurg.2012.02.005

Barbash, G. I., Friedman, B., Glied, S. A., & Steiner, C. A. (2014). Factors Associated With Adoption of Robotic Surgical Technology in US Hospitals and Relationship to Radical Prostatectomy Procedure Volume. *Annals of Surgery*, *259*(1), 1–6. https://doi.org/10.1097/SLA.0b013e3182a5c8b8

Bateman, J., & Cleaton, N. (2021). Managing patients using telerheumatology: Lessons from a pandemic. *Best Practice & Research Clinical Rheumatology*, *35*(1), 101662. https://doi.org/10.1016/j.berh.2021.101662

Bird, M., McGillion, M., Chambers, E. M., Dix, J., Fajardo, C. J., Gilmour, M., Levesque, K., Lim, A., Mierdel, S., Ouellette, C., Polanski, A. N., Reaume, S. V., Whitmore, C., & Carter, N. (2021). A generative co-design framework for healthcare innovation: development and application of an end-user engagement framework. *Research Involvement and Engagement*. https://doi.org/10.1186/s40900-021-00252-7

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brooke-Sumner, C., Petersen-Williams, P., Kruger, J., Mahomed, H., & Myers, B. (2019). 'Doing more with less': a qualitative investigation of perceptions of South African health service managers on implementation of health innovations. *Health Policy and Planning*, *34*(2), 132–140. https://doi.org/10.1093/heapol/czz017

Chen, C. C., Chang, C. H., & Hsiao, K. L. (2022). Exploring the factors of using mobile ticketing applications: Perspectives from innovation resistance theory. *Journal of Retailing and Consumer Services*, *67*, 102974. https://doi.org/10.1016/J.JRETCONSER.2022.102974

Dam, L., Roy, D., Atkin, D. J., & Rogers, D. (2018). Applying an Integrative Technology Adoption Paradigm to Health App Adoption and Use. *Journal of Broadcasting & Electronic Media*, *62*(4), 654–672. https://doi.org/10.1080/08838151.2018.1519568

El Bahrawy, M., & Alió, J. L. (2015). Excimer laser 6th generation: state of the art and refractive surgical outcomes. *Eye and Vision*, *2*(1), 6. https://doi.org/10.1186/s40662-015-0015-5

Elledge, R., & Jones, J. (2021). Character failings in the surgeon fallen from grace: a thematic analysis of disciplinary hearings against surgeons 2016–2020. *Journal of Medical Ethics*. https://doi.org/10.1136/medethics-2020-106809

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107–115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Escarce, JoséJ. (1996). Externalities in hospitals and physician adoption of a new surgical technology: An exploratory analysis. *Journal of Health Economics*, *15*(6), 715–734. https://doi.org/10.1016/S0167-6296(96)00501-2

Escobar-Rodríguez, T., & Romero-Alonso, M. (2014). The acceptance of information technology innovations in hospitals: differences between early and late adopters. *Behaviour & Information Technology*, *33*(11), 1231–1243. https://doi.org/10.1080/0144929X.2013.810779

Fishbein, M. (1980). A theory of reasoned action: some applications and implications. *Nebraska Symposium on Motivation. Nebraska Symposium on Motivation*.

Fishbein, M., & Ajzen, I. (2011). *Predicting and changing behavior: The reasoned action approach*. Taylor & Francis.

Fosch-Villaronga, E., Khanna, P., Drukarch, H., & Custers, B. (2022). The Role of Humans in Surgery Automation: Exploring the Influence of Automation on Human–Robot Interaction and Responsibility in Surgery Innovation. *International Journal of Social Robotics*, 1–18. https://doi.org/10.1007/S12369-022-00875-0/FIGURES/2

Ganguly, A., Kumar, C., Saxena, G., & Talukdar, A. (2020). Firms' Reputation for Innovation: Role of Marketing Capability, Innovation Capability, and Knowledge Sharing. *Journal of Information & Knowledge Management*, *19*(02). https://doi.org/10.1142/S0219649220500045

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2013). Seeking Qualitative Rigor in Inductive Research. *Organizational Research Methods*, *16*(1), 15–31. https://doi.org/10.1177/1094428112452151

Heidenreich, S., & Spieth, P. (2013). Why Innovations Fail — The Case of Passive and Active Resistance. *International Journal of Innovation Management*, *17*(05), 1350021. https://doi.org/10.1142/S1363919613500217

Herzlinger, R. E. (2006). Why innovation in health care is so hard. In *Harvard Business Review*.

Kamalaldin, A., Linde, L., Sjödin, D., & Parida, V. (2020). Transforming provider-customer relationships in digital servitization: A relational view on digitalization. *Industrial Marketing Management*, *89*, 306–325. https://doi.org/10.1016/j.indmarman.2020.02.004

Kaur, P., Dhir, A., Singh, N., Sahu, G., & Almotairi, M. (2020). An innovation resistance theory perspective on mobile payment solutions. *Journal of Retailing and Consumer Services*, *55*, 102059. https://doi.org/10.1016/j.jretconser.2020.102059

Kerr, A., Smith, M., Reid, L., & Baillie, L. (2018). Adoption of Stroke Rehabilitation Technologies by the User Community: Qualitative Study. *JMIR Rehabilitation and Assistive Technologies*, *5*(2), e15. https://doi.org/10.2196/rehab.9219

Keyworth, C., Hart, J., Thoong, H., Ferguson, J., & Tully, M. (2017). A Technological Innovation to Reduce Prescribing Errors Based on Implementation Intentions: The Acceptability and Feasibility of MyPrescribe. *JMIR Human Factors*, *4*(3), e17. https://doi.org/10.2196/humanfactors.7153

Laukkanen, T., Sinkkonen, S., Kivijärvi, M., & Laukkanen, P. (2007). Innovation resistance among mature consumers. *Journal of Consumer Marketing*, *24*(7), 419–427. https://doi.org/10.1108/07363760710834834

Lazard, A. J., Brennen, J. S., Troutman Adams, E., & Love, B. (2020). Cues for Increasing Social Presence for Mobile Health App Adoption. *Journal of Health Communication*, *25*(2), 136–149. https://doi.org/10.1080/10810730.2020.1719241

Leong, L.-Y., Hew, T.-S., Ooi, K.-B., & Wei, J. (2020). Predicting mobile wallet resistance: A two-staged structural equation modeling-artificial neural network approach. *International Journal of Information Management*, *51*, 102047. https://doi.org/10.1016/j.ijinfomgt.2019.102047

Li, J.-P. O., Liu, H., Ting, D. S. J., Jeon, S., Chan, R. V. P., Kim, J. E., Sim, D. A., Thomas, P. B. M., Lin, H., Chen, Y., Sakomoto, T., Loewenstein, A., Lam, D. S. C., Pasquale, L. R., Wong, T. Y., Lam, L. A., & Ting, D. S. W. (2021). Digital technology, tele-medicine and artificial intelligence in ophthalmology: A global perspective. *Progress in Retinal and Eye Research*, *82*, 100900. https://doi.org/10.1016/j.preteyeres.2020.100900

Loftus, T. J., Filiberto, A. C., Balch, J., Ayzengart, A. L., Tighe, P. J., Rashidi, P., Bihorac, A., & Upchurch, G. R. (2020). Intelligent, Autonomous Machines in Surgery. *Journal of Surgical Research*, *253*, 92–99. https://doi.org/10.1016/j.jss.2020.03.046

Low, S. T. H., Sakhardande, P. G., Lai, Y. F., Long, A. D. S., & Kaur-Gill, S. (2021). Attitudes and Perceptions Toward Healthcare Technology Adoption Among Older Adults in Singapore: A Qualitative Study. *Frontiers in Public Health*, *9*. https://doi.org/10.3389/fpubh.2021.588590

Madden, T. J., Ellen, P. S., & Ajzen, I. (1992). A Comparison of the Theory of Planned Behavior and the Theory of Reasoned Action. *Personality and Social Psychology Bulletin*, *18*(1), 3–9. https://doi.org/10.1177/0146167292181001

Manohar, S., Mittal, A., & Marwah, S. (2019). Service innovation, corporate reputation and word-of-mouth in the banking sector. *Benchmarking: An International Journal*, *27*(1), 406–429. https://doi.org/10.1108/BIJ-05-2019-0217

Menchik, D. A. (2020). Moving from Adoption to Use: Physicians' Mixed Commitments in Deciding to Use Robotic Technologies. *Work and Occupations*, *47*(3), 314–347. https://doi.org/10.1177/0730888420919792

Migliore, G., Wagner, R., Cechella, F. S., & Liébana-Cabanillas, F. (2022). Antecedents to the Adoption of Mobile Payment in China and Italy: an Integration of UTAUT2 and Innovation Resistance Theory. *Information Systems Frontiers 2022*, *1*, 1–24. https://doi.org/10.1007/S10796-021-10237-2

Muaddi, H., Hafid, M. El, Choi, W. J., Lillie, E., de Mestral, C., Nathens, A., Stukel, T. A., & Karanicolas, P. J. (2021). Clinical Outcomes of Robotic Surgery Compared to Conventional Surgical Approaches (Laparoscopic or Open). *Annals of Surgery*, *273*(3), 467–473. https://doi.org/10.1097/SLA.0000000000003915

Neuner, J. M., See, W. A., Pezzin, L. E., Tarima, S., & Nattinger, A. B. (2012). The Association of Robotic Surgical Technology and Hospital Prostatectomy volumes. *Cancer*, *118*(2), 371–377. https://doi.org/10.1002/cncr.26271

Palanica, A., & Fossat, Y. (2020). COVID-19 has inspired global healthcare innovation. *Canadian Journal of Public Health*, *111*(5), 645–648. https://doi.org/10.17269/s41997-020-00406-2

Patrício, L., Grenha Teixeira, J., & Vink, J. (2019). A service design approach to healthcare innovation: from decision-making to sense-making and institutional change. *AMS Review*, *9*(1–2), 115–120. https://doi.org/10.1007/s13162-019-00138-8

Perl, J. R., Sheth, K. R., Shea, K. G., & Wall, J. (2021). Hospital Value Committees: The Role of the Surgeon in New Technology Adoption. *Surgical Innovation*, *28*(4), 401–402. https://doi.org/10.1177/15533506211031094

Quaranto, B. R., Lamb, M., Traversone, J., Hu, J., Lukan, J., Cooper, C., & Schwaitzberg, S. (2021). Development of an interactive remote basic surgical skills mini-curriculum for medical students during the covid-19 pandemic. *Surgical Innovation*, 28(2), 220-225.

Ram, S. (1987). A model of innovation resistance. *Advances in Consumer Research*.

Ram, S., & Sheth, J. N. (1989). Consumer Resistance to Innovations: The Marketing Problem and its solutions. *Journal of Consumer Marketing*, *6*(2), 5–14. https://doi.org/10.1108/EUM0000000002542

Reed, P., Conrad, D. A., Hernandez, S. E., Watts, C., & Marcus-Smith, M. (2012). Innovation in patient-centered care: lessons from a qualitative study of innovative health care organizations in Washington State. *BMC Family Practice*, *13*(1), 120. https://doi.org/10.1186/1471-2296-13-120

Rusinko, C. (2020). IT responses to Covid-19: rapid innovation and strategic resilience in healthcare. *Information Systems Management*, *37*(4), 332–338. https://doi.org/10.1080/10580530.2020.1820637

Saun, T. J., Zuo, K. J., & Grantcharov, T. P. (2019). Video Technologies for Recording Open Surgery: A Systematic Review. *Surgical Innovation*, *26*(5), 599–612. https://doi.org/10.1177/1553350619853099

Serag, A., Ion-Margineanu, A., Qureshi, H., McMillan, R., Saint Martin, M.-J., Diamond, J., O'Reilly, P., & Hamilton, P. (2019). Translational AI and Deep Learning in Diagnostic Pathology. *Frontiers in Medicine*, p. *6*. https://doi.org/10.3389/fmed.2019.00185

Shah, A. A., Bandari, J., Pelzman, D., Davies, B. J., & Jacobs, B. L. (2021). Diffusion and adoption of the surgical robot in urology. *Translational Andrology and Urology*, *10*(5), 2151–2157. https://doi.org/10.21037/tau.2019.11.33

Shaikh, A. A., Alharthi, M. D., & Alamoudi, H. O. (2020). Examining key drivers of consumer experience with (non-financial) digital services—An exploratory study. *Journal of Retailing and Consumer Services*, p. *55*, 102073. https://doi.org/10.1016/j.jretconser.2020.102073

Somashekhar, S. P., Acharya, R., Manjiri, S., Talwar, S., Ashwin, K. R., & Rohit Kumar, C. (2021). Adaptations and safety modifications to perform safe minimal access surgery (Minimally invasive surgery: Laparoscopy and Robotic) during the COVID-19 pandemic. *Surgical Innovation,* 28(1), 123-133.

Talwar, S., Dhir, A., Kaur, P., & Mäntymäki, M. (2020). Barriers toward purchasing from online travel agencies. *International Journal of Hospitality Management*. https://doi.org/10.1016/j.ijhm.2020.102593

Talwar, S., Talwar, M., Kaur, P., & Dhir, A. (2020). Consumers' Resistance to Digital Innovations: A Systematic Review and Framework Development. *Australasian Marketing Journal*, *28*(4), 286–299. https://doi.org/10.1016/j.ausmj.2020.06.014

Van Velthoven, M. H., & Cordon, C. (2019). Sustainable Adoption of Digital Health Innovations: Perspectives From a Stakeholder Workshop. *Journal of Medical Internet Research*, *21*(3). https://doi.org/10.2196/11922

Venkatesh, V., Thong, J. Y. L., & Xu, X. (2012). Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology. *MIS Quarterly*, *36*(1), 157–178. https://doi.org/10.2307/41410412

Volkov, M., Hashimoto, D. A., Rosman, G., Meireles, O. R., & Rus, D. (2017). Machine learning and coresets for automated real-time video segmentation of laparoscopic and robot-assisted surgery. *2017 IEEE International Conference on Robotics and Automation (ICRA)*, 754–759. https://doi.org/10.1109/ICRA.2017.7989093

Wamble, D. E., Ciarametaro, M., & Dubois, R. (2019). The Effect of Medical Technology Innovations on Patient Outcomes, 1990-2015: Results of a Physician Survey. *Journal of Managed Care & Specialty Pharmacy*, *25*(1), 66–71. https://doi.org/10.18553/jmcp.2018.18083

Wilson, C. B. (2006). Adoption of new surgical technology. *BMJ*, *332*(7533), 112–114. https://doi.org/10.1136/bmj.332.7533.112

Yee-Loong Chong, A., Liu, M. J., Luo, J., & Keng-Boon, O. (2015). Predicting RFID adoption in healthcare supply chain from the perspectives of users. *International Journal of Production Economics*, *159*, 66–75. https://doi.org/10.1016/j.ijpe.2014.09.034

Yu, C.-S. (2016). Consumer's Resistance to Using Mobile Banking: Evidence from Thailand and Taiwan. *International Journal of Electronic Commerce Studies*, *7*(1), 21–38. https://doi.org/10.7903/ijecs.1375