Investigating Technology Implementation in a Canadian Community Hospital

by

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Author's Declaration

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Statement of Contributions

Sana Allana was the sole author for Chapters 1, 5, and 6, which were written under the supervision of Dr. Catherine Burns and were not written for publication.

Exceptions to sole authorship of material are as follows:

Research presented in Chapters 2, 3, 4:

Luiza Dos Santos was a co-investigator on this study, and wrote the sections associated with FRAM research.

Abstract

The integration of technology into healthcare has witnessed significant advancements. However, the widespread adoption of such technologies may not be uniformly positive. While highest levels of adoption are typically found in densely populated urban areas, community healthcare facilities face challenges due to insufficient resources, like infrastructure, funding, and specialized staff, exacerbated by their remote locations. This is cause for concern as community hospitals account for 90% of all hospitals in Canada. This reveals a major opportunity to improve technology adoption and implementation at community hospitals, to aid their existing challenges, increase equity in healthcare, and improve generalizability of healthcare technologies.

This research aims to uncover the perceptions, expectations, cultural nuances, and barriers to technology adoption at a community-level hospital in Ontario, Canada. The study began with a contextual inquiry approach, incorporating semi-structured interviews and surveys. Data was collected from nine clinical and managerial staff members whose workflows were impacted by three pilot technology projects. The interviews aimed to explore staff expectations and experiences with how these pilot projects impacted their workflows, patient care, and the overall technology implementation process. The survey included demographic questions and items based on the Unified Theory of Acceptance and Use of Technology (UTAUT) model, designed to predict factors influencing technology acceptance. The pilot technologies included a discharge planning tool, a portable X-ray scanner, and a digital pathology tool.

A thematic analysis of the qualitative data was conducted, followed by affinity mapping to identify overarching themes. The Functional Resonance Analysis Method (FRAM) was also used to understand and model the impact of integrating the pilot technologies into preexisting, variable workflows. Finally, survey results were analyzed using frequency distributions to identify trends and triangulate findings.

Overall, most staff reported a high level of technology use in both their work and daily lives. They also acknowledged that technology breakdowns at the workplace were inevitable, often resulting in time-consuming, manual workarounds. As well, for all pilot projects, staff felt overburdened by the additional workload required to manage the pilots alongside their regular duties. However, despite these challenges, all staff expressed an appreciation for innovation and a strong willingness to try new tools to improve their work.

The discharge planning and X-ray scanner tools did not integrate well into existing workflows or provide additional value. Both tools performed inconsistently and failed to meet expectations for streamlining processes, leading to reluctance and distrust among staff. Additionally, change management

planning was insufficient for both tools, with staff experiencing abrupt workflow changes, limited training, and a lack of clarity on project timelines or statuses. As a result, neither tool was requested for purchase following pilot testing.

Conversely, staff decided to purchase the digital pathology tool, despite the disruptions to existing workflows, as the perceived benefits to both staff and patient care outweighed these challenges. Staff were excited about the tool's potential and engaged in close collaboration with the manufacturer and project team. Furthermore, change management was carefully planned, with a phased implementation approach. The pilot was also driven by strong advocacy from a pathologist, which ensured alignment with clinical needs.

Based on these findings, several recommendations were uncovered to improve the technology implementation process. First, the challenges with change management highlight the need for better resource allocation. This includes providing sufficient time for introducing new tools, clearly explaining the reasons for their selection, offering personalized training that covers tool usage, troubleshooting, and its impact on existing processes, and ensuring staff have the necessary bandwidth to manage change without disrupting daily operations. Second, communication channels should be improved. Startup companies should collaborate closely with the hospital during the development and testing phases to better understand staff needs and workflows, while also providing tailored support throughout the implementation process. Additionally, communication with hospital leadership must be strengthened to secure strong support, allocate resources effectively, and incorporate feedback on the challenges staff encounter, fostering a more collaborative environment that is better equipped to drive innovation. Finally, it is crucial to define and share specific success metrics for pilot projects. These metrics will help staff assess the technology's impact, make informed decisions about its use, evaluate the implementation process, identify lessons learned, and pinpoint areas for improvement, all of which can refine future technology adoption strategies.

Overall, technology implementation and adoption are influenced by a variety of factors, which are further compounded by the high workload, staffing shortages, and unpredictable environments commonly found in community hospitals. By addressing these recommendations, health organizations can enhance the adoption and effectiveness of new technologies, ultimately improving staff workflows and patient care.

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List of Abbreviations

ACE	Acute Care of the Elderly
AI	Artificial Intelligence
CI	Contextual Inquiry
CTU	Clinical Teaching Unit
EHR	Electronic Health Record
EMR	Electronic Medical Record
FRAM	Functional Resonance Analysis Method
GDP	Gross Domestic Product
GRH	Grand River Hospital
HF	Human Factors
HFE	Human Factors Engineering
HIT	Health Information Technology
ICU	Intensive Care Unit
IDT	Innovation Diffusion Theory
IT	Information Technology
KT	Knowledge Translation
OBIO	Ontario Bioscience Innovation Organization
PACS	Picture Archiving and Communication System
PRO	Patient-Reported Outcomes
RE	Resilience Engineering
RFP	Request For Purchase
ROI	Return on Investment
SEM	Structural Equation Modeling
STS	Socio-Technical Systems
TAM	Technology Acceptance Model
TRA	Theory of Reasoned Action
UTAUT	Unified Theory of Acceptance and Use of Technology Model

Chapter 1

Introduction

Technology integration into healthcare has witnessed significant advancements. Health Information Technology (HIT) has been shown to positively impact patient outcomes, efficiency of care, and reduce administrative errors [1]. However, according to the Canadian Health Policy Institute, only 3% of Canadian healthcare expenditure is allocated to health technology, placing Canada 60th out of the 72 countries involved in health technology spending [2]. This scarcity of funds correlates with low technology adoption rates [3]. Additionally, population density has been shown to affect health technology adoption, with the highest levels of adoption found in densely populated urban areas like Toronto, Vancouver, and Ottawa [3]. Conversely, rural and community healthcare facilities face challenges due to insufficient resources, like infrastructure, funding, and specialized staff, exacerbated by their remote locations [4]. This is cause for concern, as community hospitals make up 90% of all hospitals nationwide, 75% of hospitals in Ontario, the province with the highest population, and serve a population 2.64 times greater than teaching hospitals [5, 6].

The implementation and use of technology in healthcare face several limitations and challenges, with key barriers including limited capital, organizational and cultural obstacles, lack of training, and design limitations [7]. Furthermore, incorporating technology in healthcare can yield both positive outcomes as well as negative consequences, such as workflow disruptions, delays, diminished control, and increased staff stress [8]. Implementing new technology can also reduce system resilience due to the increased difficulty in performing cognitive functions, for instance. As technological advancements continue to evolve within healthcare settings, understanding their role within existing systems and how they interact with contextual factors is crucial for promoting effective integration.

Moreover, there is a notable gap in research specifically analyzing health technology adoption within community hospital settings, particularly concerning smaller, less mature technology companies. Existing studies often overlook the systematic perspective of human factors that can effectively assess the complex environments and diverse stakeholders involved in the unique context of community hospitals. This lack of focused research limits our understanding of how these technologies are integrated and adopted in such settings. This is further explained in section 2.7 of this report.

1.1 Objectives of the Thesis

In this paper, we analyze the challenges in implementing innovative technologies in community hospitals under the lens of Socio-Technical Systems (STS) theory, the Unified Theory of Acceptance and

Use of Technology (UTAUT) model, and Resilience Engineering (RE) concepts. Our goal is to understand the existing workflows and challenges faced by frontline workers, explore how the new technologies impacted their workflows, either enhancing or hindering their unit's capacity to deliver expected results, and examine staff perceptions and expectations of these innovations. Long term evaluation and broader hospital system analysis is not within the scope of this study. The results aim to identify barriers to technology implementation and provide recommendations for effectively integrating these and future technologies. Recommendations were structured using the Knowledge Translation (KT) framework in healthcare.

1.2 Structure of the thesis

The thesis is structured as follows:

Chapter 1: This chapter introduces the research topic, outlines the research objectives, describes the intended outcomes, and presents the overall structure of the thesis.

Chapter 2: This chapter provides an overview of the current healthcare landscape in Canada and explores how this context influences the introduction of new technologies. It includes a description of pilot projects and discusses key concepts related to human factors, including sociotechnical systems and resilience engineering. Additionally, relevant literature on health technology adoption, human factors in health technology adoption, and resilience engineering is reviewed.

Chapter 3: This chapter outlines the study design and methodology, detailing the methods used for participant recruitment, data collection, and data analysis. It also includes explanations for the chosen measures and their relevance to the research objectives.

Chapter 4: This chapter presents the findings of the study, including a thematic analysis, frequency distribution, and FRAM analysis, to highlight key insights gained from the research.

Chapter 5: In this chapter, the findings are triangulated, and overarching results are shared. It discusses how these results inform recommendations for community hospitals aimed at improving technology adoption and implementation. The strengths and limitations of the study are also examined.

Chapter 6: This final chapter synthesizes the study and its findings, connecting them back to the goals of the research. It discusses the implications of the results and identifies future areas for further investigation.

Chapter 2

Background

2.1 Healthcare Crisis in Canada

Canada's healthcare system stands out for its decentralized, publicly funded universal model known as Canadian Medicare. Administered by each province and territory, the system relies on federal funding distributed on a per capita basis. Originally established in 1957, and later strengthened by the Canada Health Act of 1984, it ensures national standards for essential medical services while still allowing for regional flexibility [9].

The federal government funds provincial and territorial health insurance programs, manages healthcare services for specific populations such as First Nations, regulates the safety and effectiveness of medical devices and health products, funds health research, and oversees public health initiatives on a national level. Meanwhile, provinces and territories are responsible for financing, organizing, and delivering healthcare, leading to differences in access and quality across the country [10]. Approximately 18% of Canada's population lives in rural or remote communities spread across 95% of the country's land. However, the distribution of healthcare resources does not reflect this need: only 13.6% of family doctors and fewer than 3% of specialists serve these areas [9].

These disparities have been further strained by Canada's growing population and the impact of the COVID-19 pandemic. Hospitals are over capacity, procedures are delayed, and healthcare providers are experiencing burnout [11]. In 2019, healthcare spending accounted for 11.5% of Canada's Gross Domestic Product (GDP), an increase of 1.2% from 2014, and nearly a quarter of all government expenditures [12]. Before COVID-19, government health spending was projected to increase annually by 4.6% to 6.4% from 2015 to 2030 [13]. However, by 2021, the federal debt-to-GDP ratio had increased by around 20% from 2019, and the aging population is expected to put further pressure on the system [14]. By 2040, the percentage of Canadians aged 65 and older will grow from 18.5% to 25%, likely reducing the available tax base to support new spending [15].

2.2 Health Technology Adoption in Canada

Recent years have seen significant advancements in health technology, with the COVID-19 pandemic playing a pivotal role in this progress. The pandemic underscored how technologies like telehealth can enhance access to care by removing geographical barriers, leading to a notable increase in

both usage and positive perceptions of these services [3]. Technological innovations in healthcare, fueled by processes such as streamlining, decision support, and automation, hold substantial promise for improving clinical practices related to diagnosis, treatment, and public health awareness. Collectively, these advancements have the potential to enhance the efficiency and objectivity of care, ultimately improving patient outcomes while reducing healthcare costs over time [16, 17]. However, despite these promising developments, the widespread adoption of such technologies has not been uniformly positive, leading to disparities in healthcare access. In Canada, despite a steady increase in health funding, technology adoption rates remain low [18]. According to the Canadian Health Policy Institute, only 3% of Canadian healthcare expenditure is allocated to health technology, placing Canada 60th out of the 72 countries involved in health technology spending [2].

Moreover, adoption rates vary by geographical region. Urban areas with high population densities, such as Toronto, Ottawa, and Vancouver, exhibit higher levels of health technology adoption, while rural and remote areas face challenges due to limited funding and inadequate IT infrastructure to support new tools [3, 19]. Interestingly, the demand for health technology is often more pronounced in rural and remote communities, where there is a notably higher utilization of technologies such as Electronic Medical Records (EMR) compared to urban areas [3]. In one study, the primary barriers to the adoption of new technologies in Canada, ranked from most common to least common, included: insufficient capital for equipment and maintenance, the need to hire technical support staff, concerns regarding the impact on patient information, the effort required to implement new tools, the necessity of training staff, equipment performance issues, and patient distrust in digital solutions [3, 20, 21].

2.3 Existing Problems at Community Hospitals

Community hospitals focus on delivering healthcare services to local communities, distinguishing them from traditional academic hospitals, which prioritize teaching and research [22]. Rural hospitals can serve as either community or academic facilities and are specifically located in rural or remote areas [23]. As mentioned, community hospitals represent the majority of hospitals nationwide and serve almost 3 times the amount of population in Canada in comparison to teaching hospitals [24]. Furthermore, community hospitals differ significantly from academic hospitals regarding patient demographics and organizational factors, typically serving a higher proportion of immigrants and older patients with poorer health, as well as experiencing limited access to specialized care [25, 26, 27].

Community hospitals also face significant challenges due to a lack of funding, which leads to staffing shortages, aging infrastructure, and limited research initiatives [25, 28]. Reduced funding is partly

due to Canada's health funding model, which allocates more resources based on the number of patients recruited for research studies [29]. However, since research is not a primary focus for community hospitals, healthcare professionals often lack the time to engage in research alongside their demanding clinical responsibilities [30]. Unlike academic hospitals, which allocate part of their operating budgets to developing and maintaining research infrastructure, as clinical reimbursement often does not cover the full costs of research, community hospitals generally lack the experience and resources needed for such activities [29]. These include participant recruitment, hiring and training dedicated research staff, and adhering to research ethics and regulatory standards, all of which can increase costs and require significant time commitments that community hospitals cannot easily accommodate [29, 31]. Consequently, more public funding and academic researchers are typically directed toward academic centers [32]. One study even noted that it can take up to 20 years for community hospitals to develop robust research programs [30].

This is problematic as community hospitals deliver most of the healthcare in Canada [5]. Their participation could provide more locally relevant insights and engage a greater number of research participants, thereby enhancing the applicability and generalizability of research findings [22]. This lack of research further exacerbates disparities in care, leaving most patients in community hospitals with reduced access to novel and innovative treatments that academic centers could provide [22].

2.4 Pilot Projects

The pilot process is designed to meet the healthcare needs of hospitals while aligning with the specific objectives of companies offering innovative solutions. The goal of these projects is to establish an integrated network for collaboration, adoption, and procurement of Canadian innovations. This framework allows Canadian businesses to test and refine their technologies in partnership with healthcare organizations, including home care facilities, hospitals, and private clinics, ultimately facilitating scaling through innovative procurement processes. Funding from organizations like CAN Health and the Ontario Bioscience Innovation Organization (OBIO) supports healthcare organizations in adopting technology solutions more sooner, prior to global expansion. This initiative aims to integrate innovative technologies into the health system and streamline procurement processes to achieve improved efficiency and cost savings [33, 34]. The information in this section is based on insights gathered from stakeholder interviews conducted with staff members from the Innovation and Research and Clinical Trials department at Grand River Hospital (GRH).

GRH's innovation approach emphasizes identifying technologies that address specific gaps in healthcare delivery, as determined through needs assessments to help prioritize solutions that align with

these needs. Companies looking to collaborate with GRH can initiate the process through various channels, such as submitting an innovation intake form via LinkedIn. Companies may reach out to GRH leadership at networking events, presenting their solutions and citing successful implementations at other hospitals. Additionally, clinical teams at GRH may identify problems and either seek out relevant technologies or express interest in existing solutions. If a clinical team sees promise in a product, they collaborate with directors and managers to establish success metrics, plan resources, and develop a project breakdown, including phased implementation and funding requirements.

Leadership, such as directors and clinical managers, play a crucial role in identifying needs and gaps and in deciding whether to pursue a project. Once a clinical team expresses interest in a product, the next step involves securing funding from various sources, such as CAN Health, OBIO, or the GRH Foundation. The pilot process involves detailed collaboration with clinical and management teams, assessing the solution's potential impact, and ensuring that all privacy, procurement, and IT requirements are met.

The selection of departments for testing depends on input from both the company and the clinical team. Companies may suggest the suitability of their solutions for specific departments, like surgery, while clinical teams evaluate multiple demos and choose the most promising option. Securing demo time itself can be challenging, requiring significant interest and buy-in from clinical staff.

Measuring the success of a project is multifaceted, involving metrics such as return on investment (ROI), clinical benefits, cost and time savings, and quality improvements. While change management plays a role in facilitating these projects, there is no standard set of success metrics, as each solution is unique. The hospital aims for substantial cost savings, typically 60-70%, but each project's impact is assessed based on its contribution to the clinical environment and the quintuple aim of healthcare. Although the hospital does not keep a static record of innovation projects or detailed statistics, they acknowledge that many projects take considerable time and may not proceed to full procurement. If a project fails, the likelihood of continuing collaboration with the same company is low, especially if the failure was due to vendor-related issues, such as system updates during trials or misaligned value propositions.

Once the pilot process is complete, if the hospital decides to invest in the tool, it must undergo a procurement process known as a Request for Purchase (RFP). Hospital staff often describe this process as tedious and time-consuming.

2.4.1 Startup Companies

The companies involved in this study are all Canadian healthcare technology startups, each with fewer than 50 employees. These companies are relatively young, with an average age of under 30 years, and a median age of 14 years [35, 36, 37]. Information related to individual company funding was not available.

2.4.1.1 Discharge Planning Tool

The first tool analyzed in this study was a machine learning-based discharge planning tool, which generated prediction reports listing patients by their discharge priority: high, medium, or low. A high priority indicated that the patient was likely ready for discharge, according to the tool's predictions [35]. The pilot project involved staff from the Acute Care of the Elderly (ACE) department and the Clinical Teaching Unit (CTU). Furthermore, this project was led by two clinical managers, one of whom was a registered nurse.

2.4.1.2 X-ray Scanner Device

The second tool evaluated was a portable X-ray scanner, capable of differentiating bone and soft tissue in a single exposure, allowing staff to generate three images at once [37]. The pilot project included staff from the medical imaging teams, focusing on chest X-rays from patients in the Intensive Care Unit (ICU). This project was led by two clinical managers, both of whom had prior experience as radiation technologists.

2.4.1.3 Digital Pathology Scanner

The third and final tool assessed in this study was a digital pathology device designed to scan and digitize pathology slides. This enables pathologists to review and analyze their slides digitally rather than using a traditional microscope [36]. The pilot project involved a select group of staff from the pathology department. This project was led by a clinical manager, who previously worked as a laboratory technician, as well as a medical director who is a practicing pathologist. This is the only tool out of the three that the hospital decided to continue with the RFP process.

2.5 The Role of Human Factors in Technology Adoption

Human Factors Engineering (HFE) is defined as "the scientific discipline concerned with understanding the interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance" [38]. This interdisciplinary field examines the physical, cognitive, and organizational

ergonomics of a Socio-Technical System (STS). Physical ergonomics focuses on human characteristics related to physical activity, while cognitive ergonomics addresses the mental processes that influence interactions between humans and other system components. Organizational ergonomics seeks to optimize the structure, policies, and processes within systems. Together, these perspectives offer a holistic approach to designing products and systems, considering how various elements within an STS interact and influence each other. This comprehensive view fosters the development of safe and sustainable work environments that acknowledge the needs of all stakeholders involved in the system [39].

STSs draw on concepts from general systems theory to design and analyze organizations by optimizing social and technical elements together. Socio-technical theory suggests that the technical and social components of a system are interdependent, influencing and shaping each other [40]. This theory rests on two fundamental principles. First, the interaction between social and technical factors determines whether a system performs successfully or fails. These interactions can involve straightforward, planned cause-and-effect relationships, as well as complex, unpredictable ones. Second, the theory emphasizes that focusing on optimizing only the social or the technical components can inadvertently create negative interactions, harming the system's overall performance. This means improving technology without considering its impact on people, or vice versa, can lead to inefficiencies and unintended consequences. Therefore, socio-technical theory emphasizes the importance of "joint optimization" of social and technical components to improve overall system effectiveness. It advocates designing systems that balance human needs with technological capabilities, enhancing its adaptability to both social and technological changes [41].

Health systems are often described as complex STSs, characterized by nonlinear, uncertain, and dynamic interactions [42]. These include fluctuating patient numbers, the need for personalized care, engagement from various stakeholders, and adherence to numerous legal regulations [43, 44, 45]. The intricate and often hidden connections within these systems make it difficult to fully control, predict, or understand their operations [45]. Therefore, planning and organizing health systems effectively requires a holistic approach [46]. Utilizing a discipline like HFE can offer essential concepts, methods, and tools to enhance the performance and quality of health systems, especially when changes like new technologies are introduced.

HFE aims to make tasks easier, safer, and more effective, with methods that are applicable throughout system development [38]. By adopting an STS approach, one can recognize the complexity of community health systems and understand how new technologies impact both technical and social functions, such as organizational culture and communication [47]. Viewing technology in isolation can lead

to unintended negative consequences on other subsystems, especially when social factors like attitudes and beliefs are overlooked [48]. Additionally, the organizational context, including governance and regulatory factors, can influence outcomes [47]. Applying HFE and an STS approach to technology adoption in community health systems helps to understand system components, their interactions, and the requirements for implementation [49]. In turn, this can help to identify barriers, ensuring that technology is effectively integrated and used by all stakeholders.

2.6 Resilient Healthcare

Resilience is defined as the ability for a system to adjust its operation before, during, and after significant disturbances, allowing adaptation and operation in anticipated and unanticipated circumstances [50]. Implementing new technology can also reduce system resilience due to the increased difficulty in performing cognitive functions, for instance. The changes introduced by new technologies challenge workers' abilities in sensemaking, event detection, problem-solving, decision-making, and others [51]. Marques et al. points out that technologies can positively impact the resilience abilities of healthcare services by improving monitoring, anticipating threats, enabling effective responses, and fostering a culture of learning from experiences [52]. The authors suggest further research on specific applications and processes, as well as more exploration of the interactions between technologies and contextual factors to better understand how new technologies can foster resilience in the healthcare domain.

Often, health system resilience is discussed in terms of acute events such as pandemics or natural disasters; however, there is a wide range of everyday challenges that health systems face to meet population health needs [53]. Such persistent and challenging conditions are an everyday reality of health systems. They include scarcity of resources, staff absenteeism, budgetary constraints, personnel tensions, and the politicization of health system management [54]. The capacity of health systems to continue to deliver good quality services in the face of these chronic challenges is called everyday resilience [55]. Building a resilient health system is not only about ensuring functioning under duress and faster recovery but also promoting better routine healthcare provision, social cohesion, and productivity during periods without exigent needs [56]. Thus, adaptation is the basis of Resilience Engineering (RE), which seeks to study how these adaptation capacities operate and how they can be supported in practice [57]. RE focuses on the ability of systems to cope with complexity under variable conditions [58].

Resilience Engineering has developed specific methods to represent and analyze system interdependencies and performance variability in complex domains. One method that has garnered significant attention in recent years is the Functional Resonance Analysis Method (FRAM) [59]. According

to Salehi et al., FRAM has been applied in different areas with promising results, the healthcare domain being the most explored. The authors argue that FRAM application in this domain may be associated with its nature: strong social characteristics, conditions of high variability, and scarce resources [42].

2.7 Knowledge Translation in Healthcare

Knowledge Translation (KT) in healthcare is a process that aims to enhance the usefulness and applicability of research to improve healthcare. It is a "dynamic and iterative process that includes synthesis, dissemination, exchange, and ethically sound application of knowledge to improve the health of Canadians, provide more effective health services and products and strengthen the health care system" [60]. The primary goal of KT is to ensure evidence-based research leads to actionable practices in healthcare environments, ultimately improving patient care and healthcare systems.

The synthesis of knowledge involves identifying problems, developing research questions, and reviewing relevant literature to build a solid evidence base. Dissemination refers to identifying and tailoring research content to suit the needs of the target audience, ensuring that the right people have access to useful and timely information. Exchange is the interaction between the user (e.g., healthcare practitioners, policymakers) and the researcher, where mutual learning occurs, and knowledge is co-produced. Finally, the ethically sound application of knowledge ensures that the knowledge is translated into practice in a way that adheres to ethical principles, legal frameworks, and norms [60, 61].

This concept is particularly relevant to this body of work, as it ties directly into change management and technology adoption. Understanding KT principles helps ensure that the integration of new technologies into healthcare systems is not only evidence-based but also contextually relevant, increasing its long-term sustainability. For these reasons, this framework will be considered within the recommendations portion of this thesis.

2.8 Related Work

This section will highlight related work relevant to this study. Regarding studies that did not leverage a human factors perspective, the successful adoption and implementation of health technologies were significantly influenced by organizational capacity, culture, stakeholder collaboration, and the presence of effective policies. Furthermore, from a human factors perspective, research indicates that usability, perceived usefulness, and organizational ergonomics significantly influence users' intentions to utilize health technologies. Overall, there is a pressing need for user-centered design and continuous stakeholder involvement to enhance the integration of these technologies into existing workflows.

2.8.1 Health Technology Adoption and Implementation

In a 2011 study, researchers evaluated the decade since the launch of the Canada Health Infoway's $1.6 billion initiative to establish a national interoperable electronic health record (EHR) system. This evaluation involved reviewing national reports and conducting structured interviews with 29 key stakeholders from various health organizations. The analysis identified key achievements such as funding, national standards, patient registries, and digital imaging. However, significant barriers to adoption were also noted, including the absence of a cohesive e-health policy, insufficient clinician involvement, a lack of compelling business cases for EHR use, a focus on national rather than regional interoperability, and a rigid implementation approach. The study recommends developing an e-health policy that employs a bottom-up approach prioritizing clinical needs, establishing a national investment policy for EHRs, and creating financial incentives linked to patient outcomes [62].

A Canadian study conducted in 2010 examined the relationship between a hospital's capacity to implement health technology and its use of quality improvement programs. Hospital administrators completed a cross-sectional questionnaire, and analysis using the Rasch model. This revealed that hospitals implementing a greater number of technologies are better equipped to adopt additional technologies. Different types of technologies also vary in their implementation processes, with electronic medical records (EMRs) being more challenging than diagnostic imaging, for example. Additionally, as hospitals develop their technological capabilities, they enhance their capacity to implement quality improvement initiatives. As well, a culture that emphasizes safety and collaboration further fosters the adoption of these initiatives. The findings suggest that hospitals need to assess their capabilities before selecting healthcare technologies, as varying levels of difficulty exist, and that both technology implementation and hospital culture are critical factors in the successful adoption of quality improvement programs [63].

A study conducted in 2014 aimed to identify factors influencing hospitals' decisions to adopt robotic technology, particularly for performing radical prostatectomies. Using data from hospitals from 2005 to 2009, the research found that hospitals were more likely to acquire robotic facilities if they were located in areas where other hospitals had already adopted robots, had more than 300 beds, or were teaching hospitals. Overall, the study concluded that local competition among hospitals for robotic technology contributed to its rapid adoption and that robotic facilities significantly enhanced surgical volumes for radical prostatectomy [64].

Another study conducted in 2024 aimed to identify the critical barriers impeding the implementation of 5G technology in hospitals in Western China. This research utilized the Delphi method and a quantitative analysis to uncover 14 barriers, with the "lack of policies on ethics, rights, and

responsibilities in core healthcare scenarios" identified as the most fundamental influencing factor. The study emphasizes the importance of collaboration among stakeholders to address the challenges in the evolving 5G medical landscape [65].

Lastly, a 2020 longitudinal qualitative study conducted in Norway examined the challenges of stakeholder management in implementing eHealth initiatives within community health care settings. This study involved 20 interviews with various stakeholders, including project managers, healthcare providers, and technology vendors. The findings highlighted the need to clarify relationships among stakeholders and establish effective communication channels in health technology implementation projects. Additionally, the study underscored the importance of early identification and involvement of stakeholders to ensure the success of health care projects [66].

2.8.2 Health Technology Adoption and Implementation using a Human Factors Approach

Much research has been conducted in the area of human factors related to health technology adoption and implementation. To start, in a 2017 review, researchers examined human factors (HF) research regarding the challenges of implementing health information technology (HIT) and its impact on usability and unintended consequences. Utilizing PubMed and Web of Science, they identified studies published in 2015 and 2016. The review emphasizes the importance of strengthening the evidence base for the benefits of HF research, enhancing knowledge translation in the implementation of HF approaches during the design, implementation, and evaluation of HIT, and improving transparency, governance, and enforcement of best practices throughout the technology system development life cycle [67].

A 2021 paper by Onur Asan and Avishek Choudhury notes that although artificial intelligence (AI) technology in healthcare has advanced, limited research has focused on designing and implementing AI models in real-world clinical settings using a user-centered design approach. This oversight means factors like AI's interaction effects, workflow impact, and patient outcomes are often neglected, particularly within broader STSs. The review analyzed 48 articles from human factors journals over the past decade, revealing a focus on usability, clinician perspectives, cognitive workload, and trust in AI. However, few studies ensured ecological validity or compared AI models against standard measures. The authors concluded that more work is needed to define AI's dynamic interaction within health systems [68].

Another study conducted in 2015 investigated the factors influencing healthcare professionals' intentions to use a mobile electronic health records (EMR) system by combining a questionnaire survey and analysis of system usage log files. Conducted over seven months in a university hospital, researchers surveyed 942 healthcare professionals using the UTAUT and the Technology Acceptance Model (TAM).

Structural equation modeling (SEM) was used to analyze the data from 449 participants. The findings revealed that performance expectancy significantly influenced users' attitude toward the system, which in turn affected their intention to use it. The study concludes that performance expectancy is a critical factor in the intention to use mobile EMR systems, suggesting that implementations should prioritize functions that enhance workflow and performance [69].

Next, a study conducted within hospitals associated with the Tehran University of Medical Sciences examined the organizational factors influencing physicians' adoption of EMRs. 330 physicians participated, and their attitudes towards EMR adoption were assessed using a conceptual path model based on the TAM and various organizational context variables. The data were analyzed using SPSS and SEM. Key findings revealed that perceived usefulness, perceived ease of use, management support, physician involvement, physician autonomy, and the doctor-patient relationship all had direct and significant impacts on physicians' attitudes towards EMR adoption. Interestingly, training was not found to significantly affect perceived usefulness or ease of use. The study concluded that organizational factors play a substantial role in shaping physicians' attitudes towards adopting EMRs, highlighting the need for health organizations and policymakers to focus on these factors [70].

A 2009 study investigated the acceptance and use of HIT in community health centers in Thailand. Researchers employed a modified UTAUT model to identify factors influencing health IT adoption, aiming to validate the model in the context of a developing country. Using a random sample of 1,607 community healthcare facilities selected from a total of 9,806, data was collected through a cross-sectional survey with a self-administered questionnaire. Results revealed that staff exhibited high levels of IT acceptance, strongly influenced by performance expectancy, effort expectancy, social influence, and voluntariness. Additionally, health IT use was found to be predicted by prior IT experiences, intention to use the system, and facilitating conditions [4].

Much research has also explored health technology implementation from an STS perspective. For example, a 2019 study investigated the use of Patient-Reported Outcomes (PROs) in clinical care, addressing the challenges and usability requirements for collecting and using PRO data through apps. Using an STS framework, researchers conducted semi-structured interviews with 18 patients and 9 healthcare professionals. The findings revealed that younger patients were interested in PRO apps for tracking active health issues, whereas older patients preferred passive data collection and direct communication with healthcare providers. All patients emphasized the importance of usability, bidirectional communication, and privacy transparency in PRO apps. Healthcare providers found PRO data valuable when tailored to specific patient groups and highlighted the necessity of integrating PRO data with electronic medical

records (EMRs). The study concluded that an STS model is effective for collecting feedback to guide the design and implementation of health information technology [49].

Lastly, a study completed in 2015 explored the implementation of an EMR system at a major national hospital, through an STS perspective. This study leveraged a case study approach that included document analysis, interviews, and observations. The research utilized qualitative thematic analysis grounded in Actor Network Theory (ANT). The findings revealed that the EMR functioned as a central 'actor' within a network of organizational stakeholders, influencing system acceptance and adoption. The study underscores the necessity of planning innovative information systems by addressing the needs of various stakeholders from the beginning, promoting commitment through participative approaches, defining new roles to support change, and assessing the system's impacts to unite stakeholders around shared goals. Ultimately, the research highlights crucial organizational, cultural, technological, and financial considerations for EMR implementation [71].

2.8.3 Technology Adoption and Implementation using FRAM

Several applications of FRAM can be found in the literature for different purposes, such as accident investigations, risk assessments, and process interventions, among others. FRAM also has been used to analyze technological transformations in complex systems. For instance, Ferreira & Cañas employed the FRAM to investigate the effects of foreseeable automation on human performance and behavior [72]. The primary goal was to identify new training needs for air traffic controllers considering anticipated automation scenarios. FRAM was instrumental in examining how the interactions between human operators and technology might change with the introduction of new automation features in air traffic control operations. The authors concluded that maintaining current skills and a deep understanding of system operations are crucial, as mismatches in cognitive load may result in performance degradation within the system. Additionally, they noted that FRAM provided valuable insights into the system without oversimplifying its complexities.

Ferreira & Praetorius applied FRAM to examine and design functional setups for potential complex maritime operational scenarios, particularly concerning highly automated ship operations [73]. They found that FRAM is effective in identifying critical coordination needs for future operations. Furthermore, they note that FRAM facilitates discussions on how changes may affect the system's ability to operate resiliently.

Henriqson et al. examined the use of FRAM modeling to understand and identify variability in integrated operations within the oil and gas industry by analyzing different operational cases [74]. They

discussed challenges related to integrating digital transformation in these systems. The study emphasizes that the operations investigated rely on human-machine interactions for resilient performance, with workers managing variabilities locally to ensure the continuity of safe operations. The findings indicate that FRAM could serve as a foundational framework for future studies aimed at enhancing resilience in integrated operations, especially as the industry continues to evolve with advancements in digital technologies.

Overall, this review revealed that while substantial research has been conducted in this area, there appears to be a gap in studies employing qualitative and mixed methods approaches, particularly those focusing on community hospitals in Canada and smaller startup companies.

Chapter 3

Study Methodology

This thesis employs a mixed methods approach to identify the current landscape, perceptions, expectations, and barriers to technology adoption and implementation at a community hospital in Ontario, Canada. This approach was chosen to ensure comprehensive data collection and analysis.

3.1 Setting

This study consisted of participants from Grand River Hospital (GRH). GRH is the largest healthcare provider in the Waterloo and Guelph-Wellington regions, offering care for more than 630,000 people. The community hospital operates across two campuses and three satellite locations [75]. GRH staff has more than 4,000 members, including 700 medical workers. Annually, GRH provides care for over 265,000 patients through its outpatient clinic (this includes the COVID clinic. If excluding, outpatient visits were 161,707) and performs over 7,500 surgeries. Additionally, almost 26,000 hospitalizations are recorded per year, in an infrastructure that comprises 681 beds [76]. GRH also provides specialized services such as cancer care, stroke, and complex continuing care.

3.2 Participants and Study Design

The recruitment of participants, data collection activities, and data analysis were conducted in accordance with research protocols approved by a Research Ethics Board (REB#46144). Following ethics approval, participant recruitment was conducted using two methods: a recruitment poster and email, both of which were drafted by the co-investigators and distributed by the local investigator. The poster was displayed throughout GRH, while the recruitment email was sent to team managers who had recently participated in pilot projects, with a request to share the study information with their staff. Both recruitment methods provided an overview of the study's purpose, contact details for the co-investigators, and a QR code linking to the survey, which was hosted on Qualtrics.

Upon accessing the survey, participants were presented with an information letter outlining the study's purpose, objectives, methodology, and estimated time commitment. The survey collected participants' consent via a yes/no question, as well as demographic information, details about the pilot project they were involved in, and survey responses measured using a Likert scale. Participants interested in an optional interview were asked to provide their email address. Survey results were accessible only to the co-investigators, ensuring confidentiality. Participants who provided an email address were

subsequently contacted by one of the co-investigators to arrange an interview, maintaining the anonymity of participants from the local investigator. All participants who completed the survey also expressed interest in participating in an interview.

Before beginning each interview, researchers obtained verbal consent from participants. Participants had the option to schedule interviews either in person or remotely. In-person interviews were conducted in a private room within GRH, while online interviews were held over Microsoft Teams. One researcher was responsible for asking questions, while the other tracked consent and took notes, including nonverbal cues such as facial expressions, hand gestures, and tone of voice. Each interview was audio recorded and transcribed using Microsoft Teams. The primary researchers were also in charge of cleaning and anonymizing the transcripts prior to data analysis.

Table 1: Participant Information

Demographics	Category	Number of participants
Age	20 - 30	1
	31 - 40	3
	41 - 50	1
	51 - 60	3
	61 - above	1
Gender Identity	Female	6
	Male	3
Experience in Profession (years)	1 - 10	4
	10 - 20	2
	21 - above	3
Category of Profession	Clinical management	6
	Non-management	3

The inclusion criteria for this study encompassed any staff member at GRH who participated in the pilot projects outlined in Table 2. These projects were recently completed and recommended for exploration by the local investigator. All pilot projects included in this study involved tools developed by Canadian start-up companies specializing in health technology. While the specific names of the technologies will not be disclosed, descriptive names will be used to provide context on the work performed

and illustrate how staff may have interacted with these tools. For each project, data was collected from both managerial and frontline staff. Due to low participation in the patient portal project, the results from that study were integrated into the overall findings rather than being presented separately.

Table 2: Pilot Project Information

Pilot Technology	Number of Participants	Departments Involved in the Pilot
Discharge planning tool	2	Outpatient (ACE and CTU)
Portable X-ray scanner	3	ICU (Radiology)
Digital pathology	3	Pathology
Patient portal	1	Oncology

3.3 Data Collection Methods

This study initially consisted of three methods for data collection, including surveys, field observations, and semi-structured interviews. However, due to reduced participation, a lack observational data was collected, and will not be considered within the results of this study.

A mixed methods approach was selected to combine qualitative and quantitative findings in the analysis, allowing for triangulation of results. Triangulation provides additional perspectives on the same phenomena, helps identify areas of discrepancy, addresses potential biases, and increases the overall validity of the findings [77].

Overall, this data will offer a comprehensive understanding of the daily work and mental models of the participants, encompassing their perceptions, expectations, challenges, and benefits associated with innovative technologies and their adoption.

3.3.1 Semi-Structured Interviews

Semi-structured interviews were chosen as the primary data collection method to incorporate a Contextual Inquiry (CI) approach into the study. CI synthesizes ethnographic research, field studies, and participatory design, and is utilized in literature to gather insights about user needs, as well as information regarding the user, their environment, and associated tasks [78, 79]. CI methods enabled the collection of data on clinical and managerial processes, values, workflows, and the ways in which these elements were impacted by or influenced the pilot projects. To maximize the information gathered, the interviews were

conducted in a semi-structured format. While an interview script was used, a semi-structured approach fostered a conversational style, allowing staff and researchers to engage in open dialogue and speak freely. This flexibility facilitated rapport-building and encouraged participants to elaborate on their experiences and perspectives.

The interview structure was designed to gain a comprehensive understanding of the pilot process. It began by asking staff to describe their current level of technology usage, their roles at GRH, and their daily workflows. This initial questioning provided a baseline understanding of their work environment, including the tools they use, their routine and non-routine processes, goals, challenges, and barriers. This approach also facilitated comparisons of how workflows evolved with the introduction of the pilot technologies while helping to build rapport with participants. Following this, participants were invited to share their perceptions and expectations regarding innovation both at GRH and within the broader healthcare landscape. They were encouraged to provide examples of technological innovations that resulted in both positive and negative experiences, which helped to uncover staff values and identify potential pitfalls associated with new technology. The final portion of the interview focused specifically on the pilot technology and process at GRH. Staff were prompted to walk through how the tools were introduced, any change management strategies that were implemented, how their workflows changed, the barriers they encountered, and their perspectives on whether these tools impacted patient care. This segment aimed to gain insights into how pilot projects are conducted at GRH and how these processes interact with staff's existing workflows, the tools they use, and other potentially involved stakeholders.

3.3.2 Surveys

The survey structure and questions were guided by the UTAUT model, which, as identified in the previous section of this report, is commonly used in similar studies. Developed by Venkatesh et al. in 2003, the UTAUT model synthesizes components from various established theories, including the Technology Acceptance Model (TAM), the Theory of Reasoned Action (TRA), and the Innovation Diffusion Theory (IDT) [80].

The TAM suggests that users' attitudes toward new technology significantly influence their intention to use it. Although TAM is the most widely adopted model for assessing technology acceptance, it is limited by a narrow range of variables that may impact acceptance [69]. In response to these limitations, the UTAUT model aims to create a more comprehensive framework that enhances our understanding of the factors influencing technology acceptance, thereby providing greater explanatory power [80]. The

UTAUT is also known to have 20-30% greater explanatory power than the TAM and is therefore more recommended for studies that analyze user acceptance [69].

The model identifies three key constructs that influence individuals' behavioral intention to use technology: Performance Expectancy, Effort Expectancy, and Social Influence. Facilitating Conditions is the only construct that directly influences use behavior, as its effect becomes nonsignificant after initial use [81]. Additionally, this model recognizes control variables, gender, age, experience, and voluntariness of use, that mediate the relationships between these constructs [80]. The relationships between these constructs and determinants are illustrated in Figure 1. Explanations for the constructs can be found in Table 3.

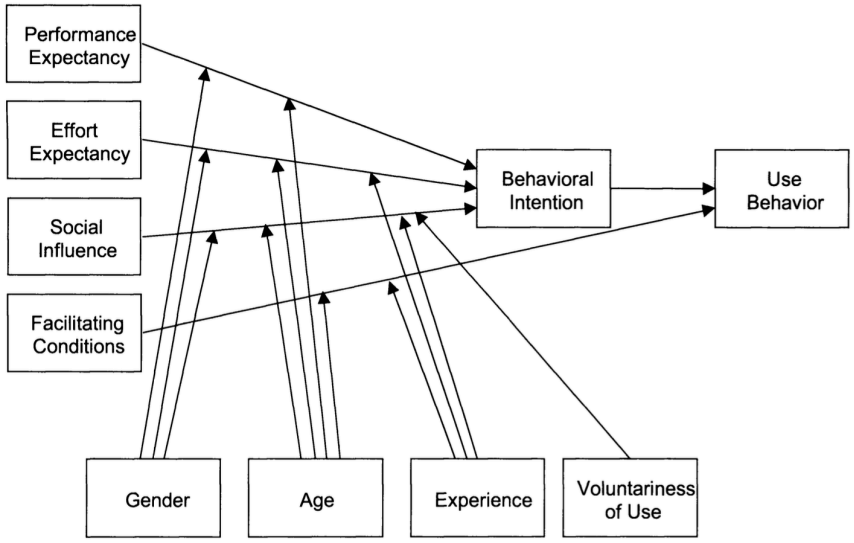


Figure 1: UTAUT Research Model [80]

Table 3: UTAUT Constructs [80]

UTAUT Construct	Definition
Performance Expectancy	Perceived benefits and effectiveness of using a technology
Effort Expectancy	Perceived ease of use
Social Influence	Impact of social factors and subjective norms
Facilitating Conditions	Perceived support and resources available for technology use

The model effectively leverages a systems perspective to understand the constructs that influence usage behavior, providing valuable insights for designing interventions and strategies aimed at enhancing the successful implementation and integration of new technologies across various contexts. This approach helps identify potential barriers and facilitators, guiding organizations in creating tailored solutions that foster user acceptance and optimize technology adoption.

3.4 Data Analysis Methodology

The data analysis methodology is organized into three sections: thematic analysis, frequency distribution, and FRAM analysis. Together, these findings will inform a set of recommendations aimed at facilitating the adoption and implementation of technology in a community hospital setting.

3.4.1 Thematic Coding and Analysis

To analyze the qualitative data, the de-identified interview transcripts were thematically coded independently by three researchers. The researchers then discussed their findings to compare and build consensus over any differences that emerged. Including three researchers helped ensure reliability by incorporating diverse perspectives and minimizing bias in the analysis [82]. The coding process followed grounded theory, which suggests conducting data collection and analysis in a parallel, iterative process. Grounded theory was used to ensure that the findings are rooted in the data collected, allowing for a more robust understanding of the themes and patterns that emerge from the interviews [83, 84]. The thematic coding was performed using Microsoft Word, while affinity mapping to determine broader themes was facilitated through Miro.

Thematic analysis was conducted using the procedure outlined by Braun and Clarke to identify overarching themes within the collected interview data, aiming for theoretical saturation [85, 86]. Theoretical saturation is defined as "the point at which gathering more data about a theoretical category reveals no new properties nor yields any further theoretical insights about the emerging grounded theory" [86]. While some researchers recommend specific sample sizes to achieve saturation in qualitative research, typically ranging from 12 to 70 interviews, many argue that determining saturation is ultimately a matter of judgment. This judgment is influenced by factors such as the research focus, available resources, and the quality of both the data and the sample [87, 88, 89, 90, 91].

Given this study's niche participant base and small sample size, determining whether true saturation was achieved is challenging. However, achieving theoretical saturation relies on judgment rather than an objective metric and can be supported by ensuring "groundedness" in data analysis and

representative sampling. As well, the term theoretical saturation may be better replaced with theoretical sufficiency, which refers to the point where categories sufficiently accommodate new data without requiring continued modifications [86]. Within the constraints of this study, this approach was adopted, and the data revealed repetitive and overlapping themes, suggesting a degree of thematic consistency.

3.4.2 Survey Analysis

The UTAUT model is typically analyzed statistically; however, due to the small sample size of nine participants, it was decided that the data would be better analyzed through frequency measures and a subjective approach. While this type of analysis cannot isolate which UTAUT construct contributes most or least to predicting use behavior and behavioral intention, it can help identify trends and triangulate these findings with the results from the thematic interview analysis. This approach allows for the thematic analysis to be further validated and provide more meaningful insights than a quantitative analysis that might not achieve statistical significance. This approach is also recommended for analyzing surveys with small sample sizes, particularly when using Likert scale responses [92, 93].

3.4.3 FRAM

As its name suggests, FRAM is a method used to build models of how work is done in complex sociotechnical systems [59]. FRAM does not examine system failures as a simple cause-and-effect relationship; FRAM focuses on understanding how activities can be coupled and how the combination of variability in these routine activities can result in unwanted and unexpected situations. For the functional resonance method, the failure or success of a system is the emergent result of variations in the functions of the system [42].

FRAM seeks to establish how variability in performance can affect situations positively or negatively [94]. In this way, FRAM follows four principles [95]:

1. Equivalence of success and failure: According to this principle, the performance of a system is associated with the adaptations and adjustments of the system to a given situation; thus, it is essential to understand how individuals, groups, and organizations regulate situations and how results emerge, regardless of whether they are acceptable or not. Failures should be interpreted as the other side of the adaptations necessary to deal with the complexity of the system under analysis.
2. Approximate adjustments: The conditions under which a system operates are constantly changing, so individuals, groups, and organizations need to adjust to these changes. Complex

systems are unpredictable, so work situations are always underspecified, and the variability that emerges through the adaptations conducted is normal and necessary for the functioning of the system.

3. Emergent results: The results of a system, regardless of whether they are acceptable or not, cannot be explored from a cause-and-effect perspective, as they are an emergent result of the interaction of variations that arise from the usual adjustments.
4. Functional resonance: According to this principle, the variations present in different functions can interact, reinforcing or even mitigating each other, i.e., they resonate. Exceeding the acceptable limits of variability, this resonance can cause unintended consequences in the system.

According to the FRAM vocabulary, the activities, or a set of activities necessary to produce the expected result in the system under investigation are called functions. A role can describe what a worker does (individually or collectively) to achieve a specific goal, what an organization does, or even what a technological system accomplishes. Thus, a function can be human, organizational, or technological [96]. A function is represented by six aspects [97]:

a. Input (I): What activates the function or is transformed, changed, or processed by the function itself.
b. Resources (R): What is consumed, required, or used to perform an activity (hardware, procedures, software, energy, and labor).
c. Time (T): Can be considered a special type of resource. Imposes time constraints or requirements on the role.
d. Control (C): Controls, monitors, or regulates the function so that its output converges to the desired result. Controls can be active functions or procedures and guidelines.
e. Precondition (P): States or conditions that must pre-exist for the function to occur. It is a necessary condition but not sufficient for activating the function.
f. Output: Corresponds to the result of the activity performed by the function. It can be a physical product or a change of state.

The construction of a model and the analysis of a system through FRAM develops in four stages listed below [42]:

1. Characterization of functions: The functions of the system are identified and described in terms of the six aspects mentioned above (input, output, precondition, resource, time, and control). The relationship between functions is defined as an upstream-downstream coupling and represents how the output of an upstream function affects a downstream function. FRAM indicates the existence of two types of functions: background and foreground. The first category corresponds to functions with only inputs and outputs considered constant in the analyzed timeframe. The second type, however, names the other functions with more than one active aspect.
2. Characterization of the variability of the functions: This step consists of describing the potential and actual variability in the output of each function from the identification of its possible sources. Such variability is a function of the variations present in the function itself, the environment in which the system is inscribed, and the coupling of functions. Therefore, the variability that occurs in the upstream functions impacts the performance of the downstream functions, and the propagation and combination of these variabilities can lead to the resonance effect, leading the system to unexpected and unwanted situations. However, the impact of variability is not only associated with variability in the inputs of a function but also with its ability to absorb these variations [96]. This variability is then analyzed in terms of some aspects, the main ones being time and precision.
3. Functional resonance analysis (aggregation of variability): At this point in the analysis, the real variabilities of functions under certain conditions are characterized, and paths of functional resonance are identified. This step shows how the variability of one function can influence the others and how the variability of two or more functions can interact and form an unstable situation. Analyzing these instantiations makes it possible to identify critical scenarios, human factors, risks, and variabilities related to the formation of unwanted situations [98]. The results of this step provide insight into system behavior and potential risks.
4. Analysis of results and development of variability management strategies: FRAM's fourth and final stage seeks to develop recommendations to maintain the results of activities within acceptable conditions. In this phase, the objective is to create barriers to the resonance and mitigation of variations.

Chapter 4

Results

This section describes the results from this study, consisting of findings from the thematic analysis, UTAUT survey, and FRAM analysis. The goal of this section is to analyze existing workflows, the challenges faced, perceptions of technology, and how new technologies have impacted staff capacity to deliver expected results.

4.1 Thematic Analysis

4.1.1 Experience Level with Technology and Pilot Projects

Table 4: Themes Related to Experience Level with Technology and Pilot Projects

Theme	Subtheme
Experience level with technology and pilot projects.	Staff have a high level of technology use.
	Team communicates with each other using technology.
	Staff frequently experience technology updates.
	Leadership has less experience managing pilot projects.

To start, most staff reported high levels of technology use in both their work and daily lives, with many expressing confidence in their technology skills. However, one participant noted that they would typically support pathologists on their team with troubleshooting and other technical support needs. Within their work environment, technology is widely utilized as a tool for communication cross functionally, between teams, and with provincial bodies to share metrics such as turnaround times. To add, all staff referenced using integrated technology systems to share patient health data, including tools such as Cerner and PACS (Picture Archiving and Communication System) for medical imaging. These tools played a crucial role in staff workflows, such as communicating procedural results, providing updates on staffing resources, and maintaining awareness of patient care plans.

"I usually check any emails from overnight if there were staffing concerns on any of my units, I'm texting, calling, emailing for any assistance through other managers, staffing, et cetera." – Discharge Planning Participant

"I mean we use the computer for everything and Cerner within the hospital for daily charting." – Digital Pathology Participant

Furthermore, all staff also mentioned they had previous experience in updating their technology through pilot projects, or software updates, with a few mentioning that was common practice in their work. However, for two projects, discharge planning and digital pathology, staff mentioned this was their first time leading a pilot project.

"In the laboratory, we are often changing technologies, putting in new instruments and validating them." – Digital Pathology Participant

"I'll be honest, this was my first like big innovation project here… I have feelings that this project was, I didn't know it at the time I know now, it's not usually how innovation or how research projects go, or new technology should be rolled out. So, this was very different in many ways than what is typical. But in the time during it I had no idea I was just doing what I do" – Discharge Planning Participant

4.1.2 Work Processes and Responsibilities

Table 5: Themes Related to Work Processes and Responsibilities

Theme	**Subtheme**
Work processes and responsibilities	Different departments operate differently.
	Work is highly collaborative.
	Staff leverages support from each other and cross functionally.
	Staff must follow specific safety and reporting protocols.

Workflows were described as variable, influenced by factors such as department type, time of day, procedural goals, resource availability, the physician in charge, and patient demographics. For instance, discharge planning in the Clinical Teaching Unit (CTU) was described as more proactive and streamlined.

This efficiency was attributed to the unit's staffing structure, where a dedicated doctor was assigned to the unit for an entire week, and to its financial model, which incentivized discharges by generating more revenue with each patient released. On the other hand, in the Acute Care of the Elderly (ACE) unit, discharge processes often take longer due to variability in physicians and their schedules. This variability increases the time needed to address discharge barriers, as it frequently requires additional discussions and coordination among team members. Patient characteristics also introduced variability. For example, in the medical imaging department, the choice of imaging technology depended on factors such as the patient's ability to be moved, size, and other clinical factors. This influenced things like how X-ray images were created and whether additional support would be required to capture the images.

"So, the clinical teaching unit CTU operates differently than any other medicine unit." – Discharge Planning Participant

"No exam's the same and no patient is the same… They could be like a bit bigger. They could be very angry, like they might have security with them. They might have police with them and it's up to you to figure out how you're going to do the exam" – X-Ray Scanner Participant

Work processes were described as highly collaborative, with all staff mentioning the use of cross-functional, team-based approaches to accomplish their tasks. Decisions and challenges, such as discharge planning or handling difficult patients, were typically addressed collaboratively during team huddles, where some participants reported feeling well-supported by their team. As well, managers regularly participated in cross-functional meetings, where staff from various clinical and non-clinical departments came together to address resource-related needs, including staffing, IT, and financial support.

"At 8:40 we have a bed meeting. So, for the whole hospital to see how many patients are in ED (Emergency Department), potential discharges, admissions, etcetera… We would go through each patient, potential discharges, barriers to discharge…" – Discharge Planning Participant

"Like I have spoken to my team lead… and we talk about it in our huddle meetings, like you're doing your best. If you feel like you know, always call for help if you need it so I try and do all that" – X-Ray Scanner Participant

Finally, in examining staff's day-to-day responsibilities, many referenced specific protocols and data reporting standards that govern their work processes. For instance, outpatient units adhere to defined patient flow protocols that dictate when and where patients can be sent within or outside the hospital. In

medical imaging, there are strict safety protocols regarding recommended radiation exposure levels for patients, while pathology follows a stringent set of rules for analyzing and preserving tissue samples. Additionally, both the medical imaging and pathology units emphasized their responsibility for reporting data to provincial bodies, including patient health metrics such as cancer case counts, as well as hospital performance indicators like turnaround times and wait times.

"If there were any concerns, so if the emergency department is at a certain level, we go into our service protocols and we send patients to hallways or do what we can to facilitate flow of patients through the hospital" – Discharge Planning Participant

"So, my role at Grand River is manager… ensuring that we're meeting our wait times required by the ministry. A lot of data reporting to the ministry" – X-Ray Scanner Participant

"So, we adopted the College of American Pathologists as our standard content. And so, we were the first jurisdiction in the whole province that actually got all their pathologists licensed and have use the standardized structure for reporting. All that data goes to CCO (Cancer Care Ontario) and we get a lot of business analytics from that. You know, we have our turnaround times, And so I feel very proud that we did that" – Digital Pathology Participant

4.1.3 Problems Within Current Workflows

Table 6: Themes Related to Problems Within Current Workflows

Theme	**Subtheme**
Problems within current workflows	Work is stressful and unpredictable
	Staff feel under resourced.
	Hospital technology can be improved.
	Workarounds are frequently needed and are hard to cope with.
	Communication can be inefficient and ineffective.

All staff reported that their work was often stressful and unpredictable. As mentioned, workflows were described to be variable, which made it challenging for staff to effectively plan their day as well as

prepare for anticipated problems. For example, in the pathology department, participants expressed feeling unprepared to face the growing patient population and increasing complexity of cases. Staff also reported several common challenges including technology breakdowns, staff shortages, lack of funding, and difficulties working with both patients and colleagues. Consequently, in conjunction with unpredictability, staff found their work to be mentally taxing and draining.

"The informal thing is I put out fires every day. That's really what it feels like my job is." – Discharge Planning Participant

"But I always say the hardest part of my job is all the computer stuff, like when something happens wrong on the computer, everything else kind of follows" – X-Ray Scanner Participant

Staff also felt under resourced in their day-to-day work. Managers frequently emphasized their priority of securing sufficient staffing and resources to support their teams throughout each shift. Some relied on cross-functional support or even assistance from outside of their hospital to meet resourcing needs. The COVID-19 pandemic was also noted as a major factor contributing to a reduced workforce and a more complex patient population. As a result, participants often faced increasing backlogs of cases, and the challenge of working with less experienced staff due to higher turnover rates. Funding was also a significant concern, particularly for the pathology department, which, unlike other departments, does not generate revenue. Limited funding made it difficult to prioritize patient care, manage workloads, reduce turnaround times, and update technology to keep pace with rising patient demands. A lack of funding also restricts their ability to share workloads outside of the hospital. The significant time, cost, and potential loss of materials associated with external consultations discourage staff from utilizing this workaround, further limiting their capacity to manage their workloads effectively.

"Lab does not generate revenue, so they have to pay for us and so if doctors over order or do inappropriate utilization, they're not paying for that test… so I go over budget and so I don't have control or influence over physician behavior or I do not have control or influence over patient volumes… you know it's higher than it was pre-COVID." – Digital Pathology Participant

"So that's where we've suffered a little bit because you know we've lost all our experienced technologists and so, you know they're learning, they're just fresh out of school." – Digital Pathology Participant

Additionally, many staff members expressed frustration with the limitations of their current technology. To start, some staff believed their technology limited their communication efficiency. One participant emphasized their team's frustration with their EMR system, describing it as a tedious method for documentation. Another pointed out that their team would benefit from a discharge status board, something they had seen in other hospitals, that displays discharge statuses, eliminating the need to repeatedly consult the discharge nurse for updates.

"Now what I hear very loud and clear from our clinicians is that they feel the electronic health record that we use is a barrier… because it's a lot of clicking and keystrokes and it's not as fast as being able to write something out on a paper or doing a verbal order or something like that." – Patient Portal Participant

"So, I just started in another hospital that had bed board where they can see all the discharges that are happening… all the admissions and where they're going and all that kind of thing in one system and we don't have that at Grand River. So, there's a lot of extra over communication that has to happen to make things flow, and it's not a very efficient system" – Discharge Planning Participant

Another source of frustration came from technology breakdowns. Staff described their technology to be unreliable as breakdowns would be frequent and often required manual and time-consuming workarounds that were not feasible on busier days. For example, breakdowns in the PACS imaging system prevented staff from electronically sharing imaging results with physicians, forcing them make repeated trips to the X-ray department. This also meant that patient IDs had to be entered manually, ultimately introducing inefficiencies as well as an increased likelihood of errors. Similar breakdowns were also identified in the pathology department.

"We have a system that we send our X rays to and then anyone in the hospital can go on that system and look at the X rays… this happened before, where that's gone down, so we can't send any X rays, but also, we can't update our list on our X ray machine to pull up any patients. So, we have to do everything manually and it takes a lot longer and it's so much easier to make mistakes if we put in one thing wrong manually" – X-Ray Scanner Participant

"This morning, we didn't have Wi-Fi, so as you can imagine my collectors that go out on the floor and take blood on patients, they're using laptops and so they can't see any orders, they're dark, they can't do anything" – Digital Pathology Participant

Finally, staff highlighted inefficient and ineffective communication workflows. In outpatient departments, staff needed to repeatedly check in with one another for updates on discharge decisions. Additionally, staff noted that doctors' notes were not shared or stored efficiently, often requiring them to sift through numerous pages of uniquely written notes to understand each patient's care plan. Furthermore, some staff members did not feel heard in decisions made by doctors. For instance, one participant described the frequent need to advocate for patients when doctors ordered unnecessary X-rays. They felt that their cross functional colleagues either didn't understand their role or trust their clinical judgment in these situations. This issue was further exacerbated by high staff turnover, requiring them to repeatedly explain their role, viewpoint and level of clinical knowledge each time this situation arose. A similar challenge was seen in pathology, where a participant reported that doctors frequently ordered lab services beyond budget limitations, despite repeated requests to hospital management for additional funding.

"Every doctor's note is written so differently… You have to read through 10 notes to figure out what the plan is for this patient. So, I think that's the challenging part" – Discharge Planning Participant

"It's hard for me to do my job sometimes when I get questioned a lot by a nurse or a doctor because they don't understand on my end what I'm trying to say. Like for example, let's say a hand X ray is ordered and a thumb X ray is ordered. Like the thumb shows up on a hand X ray, we don't need separate thumb pictures. That's unnecessary radiation, but sometimes when you try and speak to a nurse or doctor… we're fought on that a lot because they don't understand. They just want what's ordered to be done." – X-Ray Scanner Participant

4.1.4 Perceptions and Expectations of Innovation

Table 7: Themes Related to Perceptions and Expectations of Innovation

Theme	Subtheme
Perceptions and expectations of innovation	Staff feel a lack of control over the technology they use.
	There is a disconnect between the goals of hospital leadership and frontline challenges.
	Staff felt that pilots were top-down decisions and more beneficial for the startup company than for themselves or their patients.
	Staff are excited about technology advancements in healthcare and their industry.
	Staff actively seek out innovation opportunities.
	Staff values supporting local startups.

To begin, staff reported feeling a lack of control over the technologies they use for their work. Managers noted that once staff became aware of an upcoming pilot or technology update, they were less likely to voice their opinions, assuming the change would proceed regardless of their feedback. As a result, staff view technology as something they must adapt to using. For the two pilot projects that did not lead to purchase, staff expressed how they were waiting for the pilots to end but continued participating to fulfill research requirements. This highlights that staff feel compelled to comply with technology initiatives rather than genuinely support or influence them, reinforcing their sense of limited control in the technology they use.

"I think they did do some meetings and things to talk about why, but I don't think it was "Hey, should we bring this in?" It was already coming in... Even if somebody said, I don't think this is gonna be useful to then find out that it's coming anyways, it would not have been that helpful" – Discharge Planning Participant

"So right there, I would throw that [innovation project] out the window, but by being a study and we're trying to comply because you know it's a research thing. We went along with it" – X-Ray Scanner Participant

Another key perception was the evident disconnect between hospital goals and the challenges faced by frontline staff, resulting in differing views on the role of innovation. For instance, the discharge planning tool was introduced as a way to streamline the discharge processes and reduce patient length of stay. However, frontline staff were unaware of any issues related to length of stay and perceived the tool's introduction as a critique of their performance. One staff member even noted that efforts to reduce length of stay could disrupt workflows if they couldn't effectively manage the increased influx of patients. Staff indicated that their true challenges in discharge planning were related to communication workflows and dealing with non-clinical barriers, such as delays in waiting for imaging or allied health assessments. However, the innovation tool did not address these problems. A similar disconnect was observed in the medical imaging department, where an innovation tool was introduced to address a problem that staff did not believe existed, offering a solution they felt did not align with their actual needs. On the other hand, in the pathology department, where innovation efforts were driven from a bottom-up approach, frontline staff needed to advocate for the innovation tool and strategically communicate to hospital leadership on how it would benefit them and support their goal in becoming "world class".

"When we give them [their staff] this tool, you know… how we're going to try and discharge them faster and get patients out of here so you can get more patients right and… we do want our patients to go like I'm not trying to say we hold on to patients but… our staff do an incredible job and are busy everyday discharging patients when they can't. So, they already feel we're discharging people quicker, we're getting them out the door, we're getting new patients all the time. So, to then say here's a tool we're going to make it even faster for you, they'd be like we're already doing that." – Discharge Planning Participant

"[We] really didn't like the addition of the technology because we felt it was redundant like we already have imaging post processing that's similar to [X-ray scanner tool]... everything that the [X-ray scanner tool] was claiming to do, we could already do with our equipment, but we had to go through more steps with the [innovation tool] just to fulfill this experiment" – X-Ray Scanner Participant

"So, the one thing my CEO says we wanna be world class and that they were bringing in neurosurgery. So, I said, well, I can only do that by having digital pathology because we don't do neurosurgery… That was another way I managed to, you know, sometimes trying to get innovations adopted is by really listening to what your leaders are saying, right? Because if you do, you start using their language or you try and help them meet their goals, I found was also part of my strategy because I kept throwing well you

wanna be world class? Here it is… without digital pathology we can't have a neurosurgery program." – Digital Pathology Participant

This perception reinforced the belief that many pilot projects, such as the discharge planning and X-ray scanner tools, were top-down initiatives imposed by hospital leadership rather than being driven by the needs of frontline staff. Staff indicated that the purpose of these pilots were to validate the use of these tools for their benefit and to help the startup company test and improve its product using real hospital data. However, due to the lack of identified advantages for themselves or their patients, staff struggled to see how the pilots would provide that mutual benefit. Additionally, staff emphasized the need for the hospital to adopt a more thoughtful approach in selecting tools, ensuring that they genuinely address real challenges and effectively support day-to-day processes, rather than pursuing innovation for its own sake. Ultimately, frontline staff valued innovation more when they could see tangible benefits for their work or patient outcomes, rather than for the strategic goals of the hospital or startup companies.

"But like I said, they kept extending it because they [X-ray scanner company] didn't have enough cases and a lot of the cases in the beginning they weren't good. It's not what they were hoping for. They were hoping that their technology would be a lot better, whereas our machines are actually better right now" – X-Ray Scanner Participant

"Yep, they're a high priority, potentially ready to go, but the barrier for discharge is more social and they're going to be around. So, you know… if they were predicting accurately and the numbers weren't showing, like why weren't these people going... And then we thought we could always use it in predicting medical stability. It might then highlight, and we could drive work to then be able to work on those other barriers… but there's never been a way to capture, bring forward to senior leadership and say if we actually focused you know, potentially money or resources or anything towards addressing these things, we could make a difference in our length of stay potentially" – Discharge Planning Participant

"None of our doctors or none of our radiologists… I don't think ever mentioned like I wish we had three images out of a portable instead of one because I think the images we take on our portable machine right now, they're good… you see what you need to see… I don't know if anyone's ever expressed the need for it" – X-Ray Scanner Participant

"Then you know our strategic vision of our hospitals, are we gonna be world class and… I went to my CEO and I said all I need to do is to be able to be funded so I can do the ordinary things that I have to do extraordinarily well and I'm 98% world class and so part of it is we're trying to get all this innovation but at the same time I can't even do the ordinary things extraordinarily well. Just the basic things without big fancy bells and whistles, and then you can add on, you know" – Digital Pathology Participant

Overall, despite these challenges, staff expressed appreciation for innovation and a willingness to try new tools to enhance their work. They valued innovation, especially because they felt it was not common in their industry or community hospital settings. Many staff emphasized that innovation is essential for their work, particularly as they anticipate an increasing workload as time goes on. They were also excited about advancements in healthcare technology, frequently mentioning the potential of AI to streamline work processes, increase objectivity of care plans, and improve patient outcomes. Additionally, most staff were aware of technology projects occurring at other hospitals, and some even mentioned actively seeking out opportunities to adopt new practices into their own work. Finally, staff expressed their appreciation for collaborating with smaller, local startups to support their work. They valued the close proximity, which facilitated timely feedback and turnaround times, and appreciated the opportunity to play an active role in improving healthcare technology.

"Medicine doesn't get a lot of opportunities to try something new and be innovative… Like it's more typical to go to like surgery or oncology or something that follows patients… you do the typical same assessments, or you can put them on a program and go through. Medicine patients are all different. So, you know to have something in it, someone come to us and say like, medicine - these very complex challenging like all you know, we kind of have a care or we want to work with you like that actually was very positive." – Discharge Planning Participant

"Pathology is the one that has stuck. It's been the same Science for over 100 years… so even taking the pathway to digitize the glass slides, we can look at it on a computer monitor instead of under a microscope. We are going to be able to use different software to look at those cells and use AI… to help our pathologists or potentially maybe even it can be a screening tool... and maybe we can decompress some of that workload on our pathologist and just have our pathologists looking at clinically significant cases. So, it's kind of exciting, it's this world of unknown and uncertainty and very exciting." – Digital Pathology Participant

4.1.5 Experiences With the Innovation Tool

Table 8: Themes Related to Experiences with the Innovation Tool

Theme	Subtheme
Experience with the innovation tool	A lack of system integration makes it difficult to update existing workflows.
	Unresolved technical issues reduce trust in the tool and manufacturing company
	The technologies impeded robust and reliable workflows for staff.
	Staff faced resistance from others who were dissatisfied by the tool.
	A lack of perceived value and unmet expectations hindered engagement in the project.

To start, a lack of EMR integration made updating existing workflows challenging. Staff rely heavily on technology, particularly their EMR systems, for their daily tasks, so the lack of integration made it difficult to use the discharge planning and X-ray scanner tools effectively. Incorporating these tools required extra effort, causing staff to become more wary and, at times, forgetful about using them consistently. For example, the discharge planning tool only provided its prediction once daily, in the morning, and did not account for updates made in the EMR, such as changes to care plans or clinical factors. This made staff wary of trusting its predictions as it did not incorporate updated patient data. Additionally, the tool would provide its discharge predictions through email. This was problematic because frontline staff rarely use email in their daily routines and they often forgot to check it before discharge huddles, preventing them from using the tool's predictions altogether. In the imaging department, the lack of integration required manual workarounds, such as inputting patient IDs and clinical details. This process was not only tedious but also increased the risk of errors. The lack of integration also required both teams to face privacy and IT-related barriers that required complex workarounds, sometimes taking months to resolve or adding extra steps to go around. Overall, a lack of integration makes it difficult to adopt new technologies.

"It was not integrated into our existing software. So that was an initial flag, right. So, we already have a digital software and a digital plate and now I'm having to introduce a new second digital plate and a second tablet for everything to be entered on. So, while it was a great concept and idea, it didn't have enough value for the added work and added potential for error" – X-Ray Scanner Participant

"We were told it could not be integrated into Cerner, so that's why we went to this thing where a list would be sent to these emails... So, one is like, it was like learning or remembering to check … like it was on my list but let's be honest I get enough emails a day… I learned it! I'm not that ancient, but you know to go to this other unfamiliar area, so that was a learning curve to do that. And two, we had to sign up each person we wanted to have access to it. So, it is patient information right… so privacy had requested, we can't just add everyone, and to get someone access to this mailbox, we'd have to e-mail either [discharge planning company staff], or [IT staff] … but hospital staff move around, right? Maybe they're on vacation and we have someone covering. Well do you add someone who's covering? It's for one day or do I just take on that responsibility? It was on a person to bring that list to rounds… so anytime I feel like you rely on a single person there's a possibility of days to get missed or something right" – Discharge Planning Participant

Next, unresolved technical issues reduced staff trust in both the tools and the startup companies. Although staff understood that the tools being piloted were in less mature phases, technical problems that affected patient care significantly reduced their confidence in the tools' usefulness, especially if the company could not resolve them. For instance, the discharge planning tool predicted that some patients were not ready for discharge due to abnormal clinical factors. However, staff knew these factors were typical for such complex patients, leading them to believe that the AI could not reliably assess medical stability for all cases. Despite providing feedback for this, this issue remained unresolved by the startup company. For medical imaging, the X-ray scanner required a higher dose of radiation to operate. Even then, it often malfunctioned or needed repeated imaging, exposing patients to even more radiation. This made some staff uncomfortable and wary of using the tool due to its unpredictability and potential harm for patients. Despite providing feedback to the startup company, these issues remained unresolved, making staff feel unheard and hesitant to rely on the company. On the other hand, staff highly praised the startup company behind the digital pathology tool. Even though they also encountered technical issues, the company worked closely with staff to address and resolve the problems, which fostered a sense of trust and collaboration.

"We also talked about in those rounds or afterwards potentially if it was a low priority and medium priority, well, they went anyways, right? … And again, early on or through many months of taking a look at those ones and then being able to provide feedback to [discharge planning company] you know we discharged 2 low priority patients today and then being able to explain why… You know if they are just looking at numbers… we know some types of patients, renal patients will always have low blood pressure. So, in machine learning's eyes this person will never be medically stable, but they've reached a

stability to be like they're medically stable enough for us, a human being able to identify we're OK at this level … and we discharge them that way and it's safe because we have supports where we're discharging them to" – Discharge Planning Participant

"My biggest issue was the ethics of this because [X-ray scanner company] required a little higher dose of radiation to provide an image than our equipment. Now, who was informing the patient? … We're using more radiation for a poor-quality image with [X-ray scanner company], right. Sometimes we have to repeat it, which is extra dose for the patient too… we try not to X-ray people extra because it's radiations cumulative… They [X-ray scanner company] replaced the module, but with a similar one and it was, it really wasn't much of an improvement. The intensivists that were looking at it and ICU were not happy with the quality of the images" – X-Ray Scanner Participant

"It was great working with [digital pathology company]. They were fantastic partners in the work that we've done. Their scanner is great. Their software, you know, they made it work, but they're not mature in that software" – Digital Pathology Participant

Each tool analyzed in this study disrupted staff's established workflows in various ways. For instance, the discharge planning tool's lack of EMR integration required staff to retrieve prediction reports from their email accounts, print them out, and bring them to their huddles, an extra task alongside their usual census report available in their EMR. The census report was also color-coded, whereas the prediction report was not, adding another step for staff to color-code it themselves in order to use the report effectively. For medical imaging, incorporating the pilot tool introduced delays into existing workflows and required reliance on technology that did not meet their current standards, such as having a smaller screen size, taking longer to produce images, requiring additional radiation for patients, and a shorter battery life. Finally, in pathology, staff emphasized that their existing workflows, though more manual and labor-intensive, had been consistent and reliable for many years. The new tool required significant adjustments, such as reconfiguring the physical layout of their work environment, purchasing high-quality monitors to view digital slides, and adding extra steps to their workflows, including digitizing and analyzing slides through their computer rather than a microscope. Overall, all staff needed to make adjustments to introduce the pilot tools into their workflow.

"But the reason why is because, for [X-ray scanner tool] you got to connect a little, it almost looked like an iPad to our existing portable machine and it was very small, to the point where doctors would come and they would ask like, can you make this any bigger? They couldn't really, they had to like, squint and

bend down to see if their lines or tubes were in the right spot. And that was hard for us too, because you wanna make sure that you got everything on too" – X-Ray Scanner Participant

"The other part of it is with that list, again talking early on, is we originally were kind of told things like maybe be color-coded or you know like the high priorities for discharge maybe would be in green or red... But the list itself was quite plain… there was no way to kind of highlight or bring to attention or that… So, there was that but yes but some work around. We did, you know my staff were good about like me saying like you have to print it, and we did learn about someone taking ownership of like putting it in red on the board. These are the high priority ones." – Discharge Planning Participant

"So, I had to free up some space and I had to move my technologist into another area, and I had to move pathologists, you know, to another part of the building and, oh my gosh, it was just brutal. They just, you know, it's not like I asked them to move to Timbuktu like it was just like, it's just the two minute walk, you know, same roof and different aged building. Uh, so that was a very negative effect. You know, and again, like I said, some people just don't want change" – Digital Pathology Participant

In addition to technical issues, staff encountered resistance from colleagues who were dissatisfied with the tool when attempting to implement it into their workflows. While most staff reported a general willingness to try new technology, managers noted that some doctors did not try the tools at all. In fact, some doctors from the pathology department chose to retire during the pilot project to avoid transitioning to a digital workflow. In the CTU, participants encountered pushback from doctors regarding the discharge planning tool, as they questioned the validity of the tool's predictions. Discharge decisions and care plans were typically within the doctors' authority, and they did not perceive value in using a tool to guide these processes. Additionally, because doctors managed larger patient bases, they would have needed to print multiple priority reports, and they were unwilling to add this extra step to their workflows. Similarly, doctors and other staff expressed frustration with the X-ray scanner, mentioning that the images were too small for accurate assessments and took too long to develop. Overall, these negative sentiments left pilot staff feeling awkward when promoting the tool and apprehensive about asking staff to change their routines for technology they did not like.

"It did slow down our workflow. I know a few of the intensivists when they called for a stat portable and they needed an X-ray very quickly on a very ill or crashing patient in the ICU and we went with this [X-ray scanner] and the physician was like, this is terrible. Like, why isn't it bringing it up quick enough? The

image is very poor compared to our images, so they weren't happy with that either... So yeah, impeded their workflows, intensivists weren't happy about it and the whole process was significantly longer than the current one with our current X ray machines" – X-Ray Scanner Participant

"So, the CTU, the clinical, the team members there didn't feel this was actually helpful and the doctors were like why is a piece of paper need to tell me that I'm going to discharge someone? I found staff on CTU would be like why? Like this isn't adding anything. We've discharged a bunch of medium or low priority patients. So, this list is inaccurate or that… So could we call down to medical imaging to get that chest X-ray done or something to speed it up, but like I said, our doctors already do that inherently. So that was always the bit of the hesitation perhaps or the reduced attitude or value seen, value added to CTU" – Discharge Planning Participant

"I think, two of the pathologists who were close to retirement basically have retired saying, they're not prepared to move to digital pathology, which was the same experience that [another hospital] had." – Digital Pathology Participant

Finally, a lack of perceived value further fueled these negative sentiments, ultimately reducing engagement in the pilot projects. Staff implied that they were willing to update their workflows if the changes were worthwhile; meaning the technology had to positively impact patient care, streamline their work, or offer a new benefit that did not already exist. Without a clear benefit, staff did not see value in putting effort into adopting or implementing these tools. For example, both the discharge planning and X-ray scanner tools were introduced with the promise of streamlining workflows. However, staff did not believe these were significant problems compared to the more pressing challenges they faced, and neither tool lived up to such expectations based on its performance and capabilities. For instance, the discharge planning tool failed to incorporate updated EMR data and did not address non-medical barriers to discharge. Staff emphasized that they were already aware of a patient's medical stability, which rendered the tool's information redundant and unhelpful to plan discharge. Consequently, the tool did not increase the number of discharges or fulfill expectations for a more streamlined discharge decision process. Regarding the X-ray scanner, while the tool showed promise as an innovative solution to streamline the imaging process, its inadequate performance prevented it from meeting expectations. As mentioned, the X-ray images produced by this tool were significantly smaller, resulting in almost a 75% reduction in size compared to the standard portable X-ray imaging technology that doctors were accustomed to. Additionally, the tool took too long to develop images and frequently malfunctioned, necessitating repeated

imaging. These issues not only hindered staff from effectively utilizing the tool's output but also increased radiation exposure for patients, ultimately diminishing the perceived value and interest of integrating the tool into their workflows. On the other hand, although teams encountered technical issues, altered workflows, and a negative culture during the implementation of the digital pathology tool, the advantages it offered, such as easier handling and sharing of digital slides, made the challenges worthwhile. Interviewees from this department highlighted the long-term benefits of continued use, including improved management of staff shortages, enhanced workload sharing across hospitals, reduced turnaround times, and the potential for remote work. These advantages addressed several issues that the department faced prior to implementation. Ultimately, staff recognized numerous benefits from using the digital pathology tool, which amplified their commitment to the pilot project.

"I do know that it was a top-down project that was sort of brought in from leadership and saying, hey, we should try this versus somebody finding it and saying this was helpful in another hospital or we think this, we know what our problem is, discharges and we think this is a solution… I think the staff would have probably had other ideas if they were asked, how can we discharge patients more efficiently… I just don't think it was helpful information, finding out that somebody is high priority for discharge isn't really useful information. They already know that information usually. It didn't provide anything new that they wouldn't have already known." – Discharge Planning Participant

"It was just extra work in several facets that didn't show enough of an improvement to make it seem like there extra steps were needed, right? Like I think if you could say, you know my end result was like, wow, that's amazing right then sometimes you go OK, that might not be too bad to do that extra step, right? Because I get this. Wow. But when you don't get the wow and then you have the extra steps, there's a lot of resistance, right?" – X-Ray Scanner Participant

"Imagine this new generation that probably did some online school, imagine being able to work from home? They've never, [GRH Doctor] would never have thought of being able to work from home. This will become a reality. He could work in Greece if he wanted to, right? Like so, it's just gonna open up so many great opportunities for the pathologists. And so, one of the things that they are always doing for very complicated cases is requiring consults. So sometimes they can consult on site, but it's very frequent that they have to have the slides packed up and we're couriering them wherever. Imagine the freedom if we could share our screen and we could have an immediate consult. That's great innovation. The fact that we can make diagnostic improvements in real time and potentially save a patient in a more cost-effective

manner. And if the slide gets broken, it's glass. So, it's gone, right? But because we have a digital image, we'll resend it, right? It's exciting." – Digital Pathology Participant

4.1.6 Experiences With the Pilot Project

Table 9: Themes Related to Experiences with the Pilot Project

Theme	Subtheme
Experience with the pilot project	Pilot projects for the unpurchased tools lacked planning and organization.
	Pilot projects are not well resourced
	Pilot projects lack effective communication workflows
	Staff felt that their feedback was not always valued.

To start, the pilot projects for the unpurchased tools were characterized by a lack of planning and organization. The discharge planning and X-ray scanner pilots were notably disorganized, mismanaged, and implemented abruptly, in stark contrast to the digital pathology pilot, which was well-planned and phased for better integration. For instance, staff noted that the CTU rarely engages in discharge discussions as part of their workflows, primarily due to the consistent presence of doctors, who had the authority to quickly resolve discharge barriers. As a result, the tool did not align with or fit into their existing processes. Better planning with staff from that department could have addressed this issue and allowed for implementation where it would actually be needed. A staff member also acknowledged that this was their first experience leading a pilot and that they had not anticipated the significant time and effort required for effective planning. Staff emphasized that conducting a workflow analysis with key stakeholders, establishing clear roles and responsibilities, and planning a phased implementation instead of having abrupt changes would have offered more support in introducing and adjusting to the new tool. To add, training was not provided to staff on how to use the pilot technology, as the tool seemed easy to use, and their busy schedules did not align to provide training for everyone. These issues were also observed with the X-ray scanner pilot project. In contrast, staff involved in the digital pathology pilot described conducting research on and consulting with other hospitals that had successfully digitized manual workflows as well as engaging early with key stakeholders, including doctors and frontline staff. They mapped out the implementation process to understand both current and future states, adopted a phased approach to introducing the technology, and provided personalized training to a subset of staff based on their experience level and role. These

actions ultimately helped staff better prepare for the upcoming changes and provided them with the flexibility needed to adjust to the new tool within their existing workflows.

"I know, especially by the second time people were very negative about it, but I'm not sure how it was sold the first time, so I think people are very wary if you come in and say this is gonna change everything or this is the next big thing. Instead, more of hey, this could give small improvements to your work day or … ask staff like what are your pain points throughout the day? What do you think would be helpful and how can we help you?" – Discharge Planning Participant

"And so [GRH Manager] and I mapped things out. I just got those great big sticky notes. So, we initially started with just drawing it out like this is current state. What does future state look like? What are we gonna need? Who's our stakeholders? How do we handle the change management? You know, some of these peers, they're not gonna be interested in learning this new technology... What's going to happen is the newer generation of pathologists, they're not gonna come here unless there's digital pathology. How do we make sure we engage the pathologists… making sure they feel like they are part of this as opposed to having it done to them… and that recognizing we need to do a phased approach so that they get comfortable with the tool. So, let's say we give them 20 cases on Monday to this one pathologist, and maybe we just digitize three of them. But we're also going to give you your glass slides. We're going to give you your training wheels so you can just start getting comfortable." – Digital Pathology Participant

Next, the pilot projects faced challenges due to a lack of resources. Staff expressed a strong desire for dedicated resources to support change management, such as project managers, IT support, funding and time for training. To start, staff members who led these projects reported feeling overworked, short-staffed, and unappreciated for their efforts, as they struggled to balance the demands of the pilots with their existing work responsibilities. All projects resulted in delays to their workflows and took longer to implement than anticipated. As well, the discharge planning and X-ray scanner tools were implemented alongside other pilot projects that were either recently completed, running concurrently, or anticipated in the near future. As a result, staff were either still adjusting to or anticipating additional changes to their workflow, further compounding their workload. Next, a lack of IT support created significant delays for all projects, as some had teams had to wait several months for the IT department to address various issues, including privacy barriers, technology integration challenges, and equipment malfunctions. Technical support was also provided by the startup companies; however, for the discharge planning and X-ray scanner tools, the level of support declined as the projects progressed. Finally, project leaders expressed a strong desire for more

dedicated training time, as this was lacking across all pilots. Staff often had to rely on one another to learn how to use the tools effectively, depending on who had time with the tool based on their shift schedules. To add, staff from the medical imaging department noted that they were accustomed to having training documentation, such as instruction manuals or videos, for the tools they used. The absence of such resources for the X-ray scanner made troubleshooting difficult and diminished their confidence in using the tool, which contrasted with the digital pathology pilot. They emphasized that they would have appreciated more support from the startup company.

"And they tried some other projects at the same time throughout it… There were other innovations happening at the same time, so I think staff did feel too, that there were other things that this wouldn't be the only solution going forward. So, people knew that this if this didn't work, they would try other things in the future" – Discharge Planning Participant

"I wish more of us got, first of all formal training because it was different from what we usually use… I had to ask like my coworker, like I had to walk with them and get them to show me how to use it. So, I wish the reps maybe stayed longer. I know that was probably hard, but I wish they stayed longer and all of us got more formal training. I wish maybe they even sent out a package like walking through how to do certain things." – X-Ray Scanner Participant

"It took us almost a year to test... we had to make sure that we got the supports and making sure that we have the IT supports in place for using new technologies and software. Yeah, we had to wait until they had capacity in order to implement this system. So, we ended up spending good six months waiting for that for the support to be in place to push this project forward. I don't have the capacity to do it myself. I don't have the skill set, but if we have the appropriate people working on the project, it can be a relatively easy implementation." – Digital Pathology Participant

Effective communication workflows were lacking in the pilot projects. Staff reported instances of miscommunication between themselves and the startups companies for the discharge planning and X-ray scanner tools. Both teams expressed uncertainty regarding the timing and purpose of software updates, leaving them uninformed about important changes. Additionally, the team implementing the X-ray scanner faced challenges in understanding project timelines, as they were frequently given incorrect dates, making the project difficult to plan around. These projects were further complicated by other concurrent technology implementations, which resulted in changes to the teams managing the pilots and increased the

workload required to onboard new members. Finally, the most significant communication issue that affected all teams was ineffective communication with hospital management. Staff from the unpurchased pilot projects emphasized their lack of understanding regarding the rationale behind the implementation of these tools, which hindered their ability to recognize the true needs driving these initiatives. These teams also reported being unaware of when projects concluded, as they received no updates from hospital management. Additionally, they lacked access to metrics that could have helped them objectively assess how the tools performed compared to other pilot projects, which would have provided valuable insights and feedback for future initiatives.

"I also had issues with the length of the study. At first, we were told that there would be here for two weeks. Then, after those two weeks were coming to a close, they told us another two weeks. Why didn't they tell us right up front and be open and say, look, we need 100 cases or 200 cases, you know, and we'll stay as long as we need. Everybody was, like, hoping they'd get out of there in 2 weeks and it's like another two weeks and another two weeks." – X-Ray Scanner Participant

"I do think Grand River does like to just try all things a little bit here and there like oh, we've got some space for a few weeks. Let's try this new program. But I think there's challenges with sometimes tracking different projects of like knowing if it's a success or not. Sometimes it's just somebody has an idea, and they run with it and then how do we measure if it worked or not?" – Discharge Planning Participant

Finally, staff felt that their feedback was not always valued by hospital leadership and the startup companies. Both the discharge planning and pathology teams expressed that despite communicating their daily challenges to hospital leadership, issues often went unaddressed. The pathology team emphasized the need for their strategic advocacy for the digital pathology tool, underscoring its value and alignment with the hospital's broader goals and vision. They asserted that more effort was needed from the hospital to fully embrace a collaborative environment, advocating for the adoption of "innovative procurement" practices. This approach would ensure that innovation projects are implemented in environments where they can be effectively evaluated, valued, and deliver meaningful benefits for all stakeholders involved. Finally, all teams reported facing resistance when attempting to engage in open discussions about innovation, as their feedback was often met with negative reactions. For instance, the discharge planning team struggled to communicate flaws in the tool to both hospital leadership and the startup company, often feeling the need to justify their lack of reliance on the discharge prediction. This led to a sense of feeling

blamed for the tool's shortcomings, which further diminished the perceived value of their feedback and increased animosity in their relationships.

"…So really trying to find a good system of trying to adopt innovative procurement and it's a collaboration… how we build that infrastructure of collaboration and innovative procurement. And I don't think we make much use of that, but the like I said, the environment doesn't foster that. But I think things are changing out of necessity" – Digital Pathology Participant

"In certain higher-level meetings… there were some vice presidents looking at numbers about accuracy or efficiency of this that I had to spend a lot of time explaining, like why it wasn't working for us or why we weren't seeing huge benefits from it. And having to explain ourselves away every time and feeling like we had not done enough. Yeah, it's sour. Like, you know, you get tired of doing that piece and being like my staff are doing everything they can. Please listen to us. So, I felt at some point it turned where we weren't heard, and it was just on us to make it work or see the value in it or we're not trying hard enough to get like with this product. So, I think if there was a change in the future about that piece and truly being able to say yes or no or feedback being valued, that would be important and not having to like to justify again and again that we've tried absolutely everything. It then became like… we had to try and prove we've done everything. It's the product that's not working for us" – Discharge Planning Participant

4.2 UTAUT Survey Results

The results of the UTAUT survey will be discussed in this section. As mentioned, the results were analyzed through frequency distributions. Results are displayed visually in graphs to enable comparison between pilot projects. The sample sizes for each tool are three for the X-ray scanner, two for the discharge planning tool, and three for the digital pathology tool.

4.2.1 Performance Expectancy

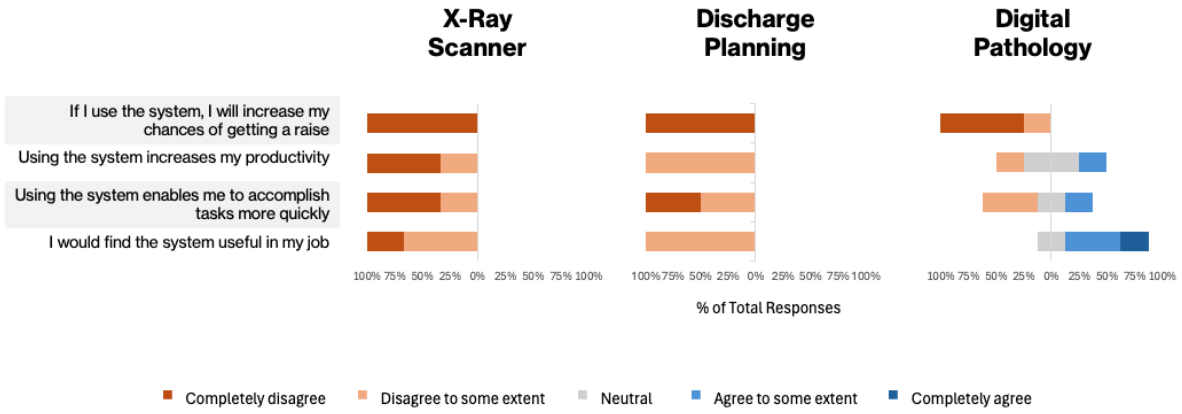


Figure 2: Performance Expectancy Survey Results

Performance expectancy refers to the perceived benefit and effectiveness of using the innovation tool. As shown in Figure 2, the performance expectancy for the X-ray scanner and discharge planning tools was considerably lower compared to the digital pathology tool. This trend is consistent with the results of the thematic analysis, where staff recognized greater value in the digital pathology tool for enhancing their quality of work and patient care, addressing problems they faced in their day-to-day work. In contrast, the X-ray scanner and discharge planning tools were deemed unnecessary or even detrimental to patient care, further explaining the differences in performance expectancy among these tools.

4.2.2 Effort Expectancy

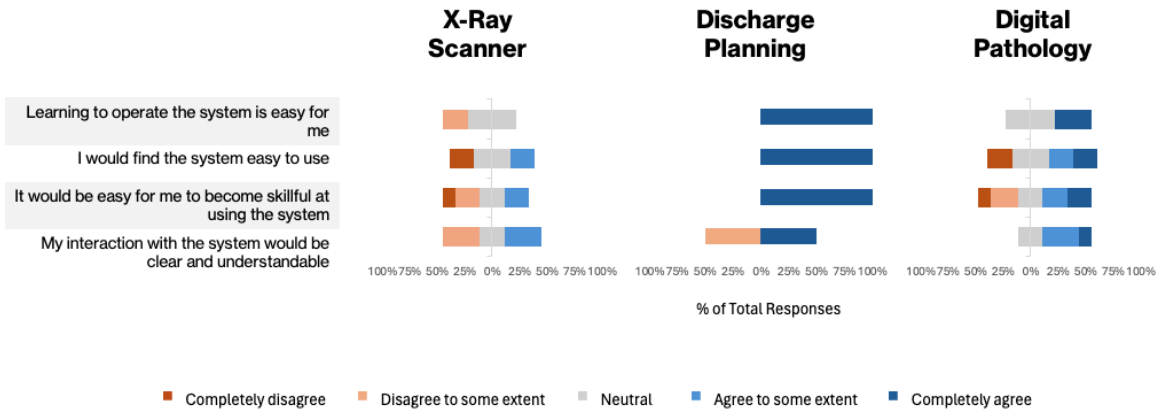


Figure 3: Effort Expectancy Survey Results

Effort expectancy refers to how easy staff perceive it is to use the innovation tool. As illustrated, the overall distribution appears neutral for the X-ray scanner and digital pathology tools, but largely agreeable for discharge planning. It is important to note that for the discharge planning tool, both participants were managerial staff, while for the X-ray scanner and digital pathology, a mix of frontline and managerial staff are included. Overall, these findings align with the thematic analysis. For the X-ray scanner and discharge planning tool, managerial staff did not see value in providing training as they were perceived as straightforward to use. However, this led to a reduced ability to integrate these tools into their workflows, as shown for the X-ray scanner responses. On the other hand, training was provided for digital pathology and represents a significant shift from an otherwise manual workflow. While mainly neutral, digital pathology has a higher number of positive responses in comparison to the X-ray scanner to exemplify this.

4.2.3 Social Influence

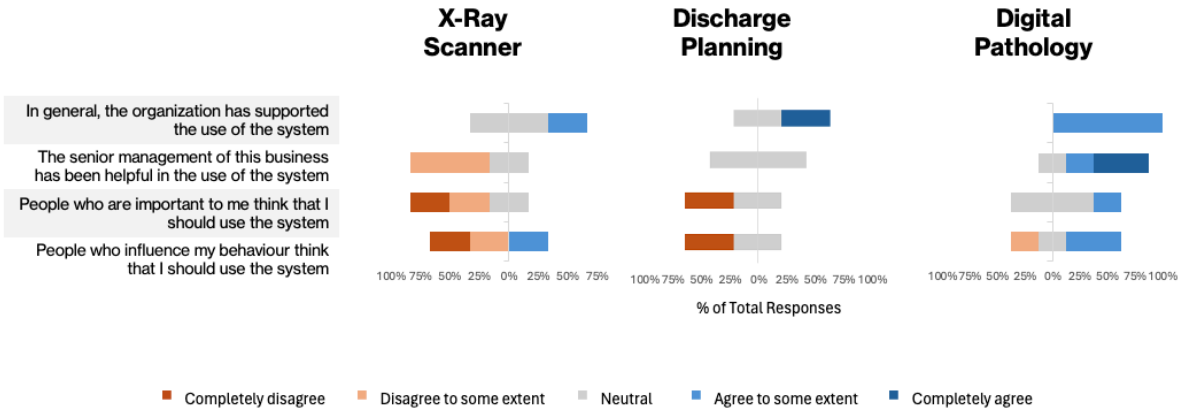


Figure 4: Social Influence Survey Results

Social influence captures the effect of social pressures and norms on adopting the innovation tools. The thematic analysis revealed that staff experienced resistance from colleagues, especially doctors, when it came to using the X-ray scanner and discharge planning tools. In contrast, the digital pathology pilot benefited from having a clinical partner who was also a pathologist, a key frontline staff as well as influential person on a care team. This partnership significantly reduced the resistance encountered, differing from the opposition felt for the other tools. The results of the survey exemplify these findings.

4.2.4 Facilitating Conditions

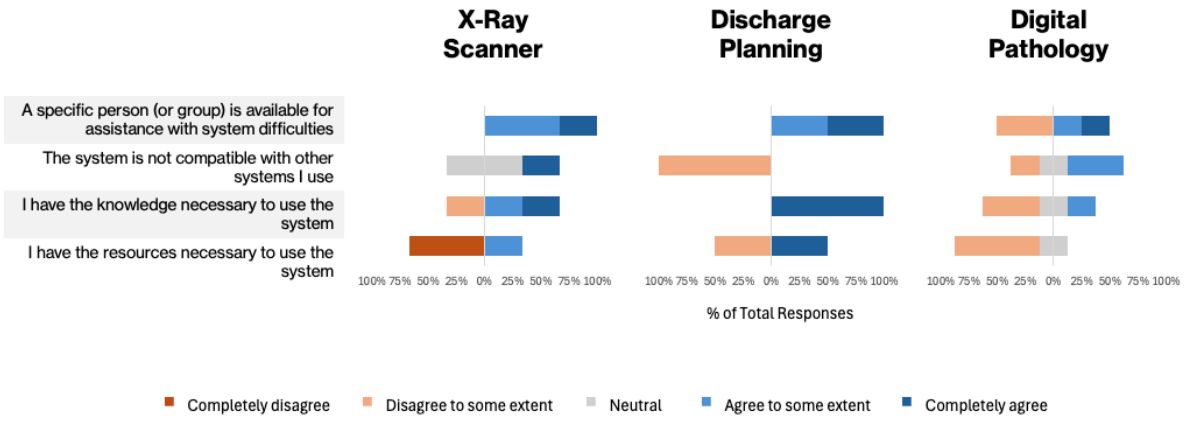


Figure 5: Facilitating Conditions Survey Results

Facilitating conditions pertain to the perceived support and resources available for using the innovation tool. For the X-ray scanner, frontline staff relied on each other for training and lacked confidence in their troubleshooting skills, which aligns with the responses for the first and third questions. In contrast, for discharge planning, which only consisted of responses from managerial staff, they found the tool as easy to use, which aligns with the complete agreeance on questions one and three. However, for both, the tools were not compatible with existing systems, and teams lacked IT support as well as support from the developing company, supporting the responses for questions two and four.

In contrast, digital pathology represented a complete shift in the laboratory staff's workflows, which had remained largely unchanged for many years. This makes the tool more difficult to use, but its thoughtful change management plan made it easier to integrate than the other tools. The thematic analysis revealed that the pathology team felt supported by the developer company. However, it was also noted that the company's relative immaturity may explain the uncertainty among staff regarding their perception of having the necessary tools to effectively use the technology. Additionally, the disproportionate ratio of experienced workforce to patient backlog, as highlighted in the thematic analysis, may have contributed to these concerns as well.

4.3 FRAM

In this section, we report the main findings of the analysis by focusing on the discussion of the process in terms of their usual work-as-done and how the new technology interacts with their routines as well as impacts the process outcomes. While the sample size was limited for this project, the participants include representatives with different levels of involvement in the processes. Reports by participants regarding the process and the issues faced were consistent.

4.3.1 Discharge Planning Tool

Through the FRAM analysis, it is observed that discharge is a process driven by many factors, requiring different sources of patient information provided by all the agents involved in their care process. Therefore, when information is not clear or not available in the EMR, the decision about the discharge may be delayed. As pointed out by participants, physicians' notes are not standardized, making them hard to understand. Moreover, when the physician is not present in the discharge discussion, other healthcare workers do not feel confident and comfortable in making decisions, adding more delays to the process. Finally, one of the main barriers reported and observed to discharge is related to the availability of resources to support medical decisions and to assure patients' safety and health. As previously mentioned, discharge is a multidimensional decision; healthcare workers need to ensure that patients are in the right health conditions to leave the hospital as well as they will have the right support to maintain and improve these conditions after their discharge. For instance, a patient's discharge may be pending an x-ray, a psychological evaluation, or even the availability of a spot in a long-term care facility. The lack of these resources may impede patients' discharge.

The analysis shows that the new technology does not strongly relate to any of these barriers, at least not in its current state. The list of patients classified according to their potential to be discharged may not be available when necessary. In the prospective case where the list provided by the tool replaces their regular list of patients, the discharge process would suffer delays, impacting the whole unit workflow.

The AI provides a classification of the patients according to their potential to be discharged so that a patient may be classified as a low, medium, or high priority for a discharge. They attempt to use this information to prioritize the discussion during discharge huddles. However, participants point out that they inherently know this piece of information, rendering the prioritization provided by the AI useless. Besides, the tool does not account for more nuanced aspects of a patient's health, such as psychological state, mobility, or preexisting health conditions that may impact their stability parameters. The absence of these factors in the predictions made healthcare workers skeptical of its functionality to inform decisions. In

instances when the physician is absent in the discharge discussion and staff rely on the predictions, a premature discharge could be made, or a patient could be unnecessarily kept in the unit. Therefore, the system's outcomes (patient discharged) would also be imprecise.

Finally, as the technology was not properly integrated into their information systems or adapted to their needs, the prioritization list was hard to access and lacked important patient information, not being able to replace their regular census and therefore adding more steps in the workflow including some workarounds to improve the usability of the list, like color-coding patients according to their priority classification.

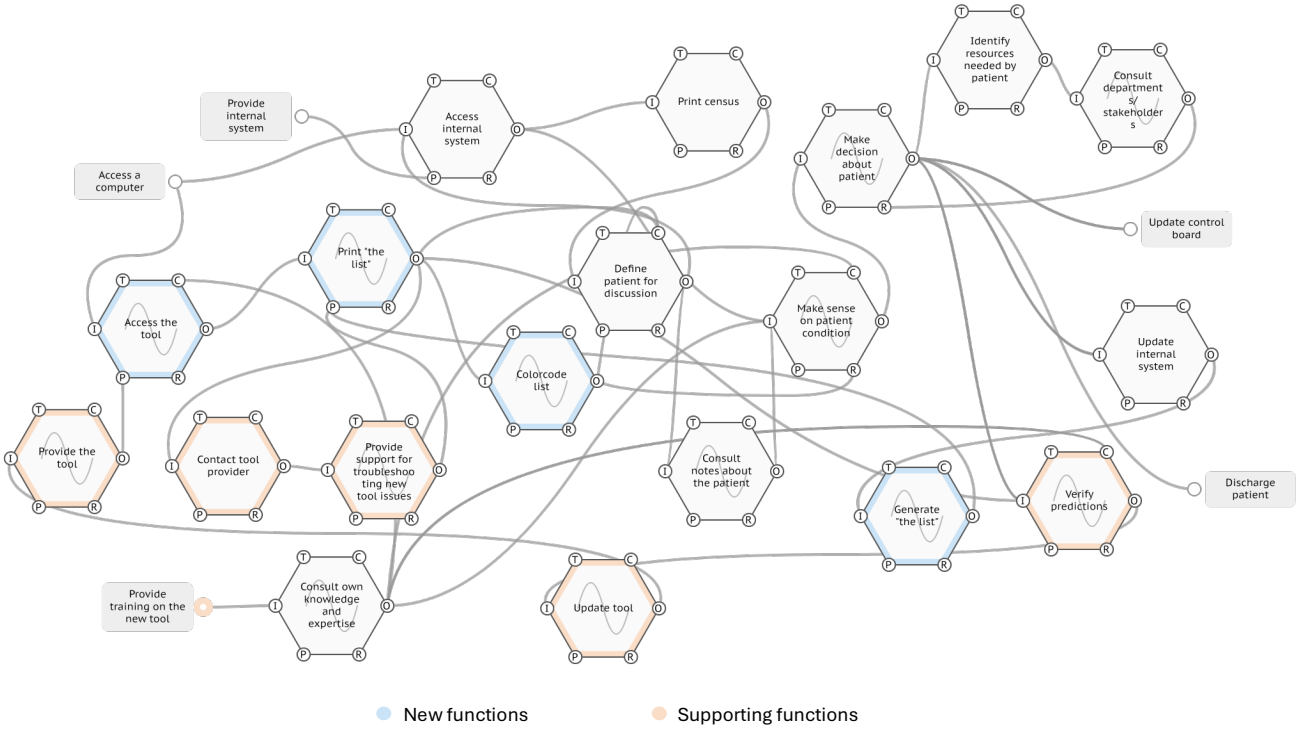


Figure 6: FRAM Model for Discharge Planning

Table 10: Potential Variability for Discharge Planning

Function	Output	Output Variability Regarding Timing		Output Variability Regarding Precision	
		Range	Description	Range	Description
Make decision about the patient	Decision "Discharge patient" Decision "Discharge pending" Decision "Keep patient"	Too late	The final decision about the patient is made by a doctor who may not be present during the discussion, delaying the decision and next steps	Imprecise	If the doctor is not present in the discussion and staff relies on the tool's predictions, the decision may be imprecise
Access the tool	Tool open	Omission	Due to the lack of knowledge on where the tool is available, staff may not be able to access it	Precise	Output is stable regarding precision along the process time frame
Print the "list"	List of prioritized patients List not available	Omission	Due to divergencies between the organization of the process and the processing time of the tool, the list may not be available when requested	Imprecise Acceptable	The tool does not account for more nuanced aspects of patients' health, making prioritization inaccurate in some situations The list does not provide all the necessary patient information, so the original census also has to be printed
Make sense of the patient's condition	Patient evaluation	On time	This function consumes relatively little time in the general time frame	Imprecise	If the doctor is not present in the discussion, staff believes that the evaluation may be imprecise
Generate the "list"	The list	On time	This function consumes relatively little time in the general time frame	Imprecise	The tool does not account for more nuanced aspects of patients' health, making prioritization inaccurate in some situations
Consult departments/stakeholders	Resources needed by the patient	Omission	Resources needed by the patient may not be available in the expected time frame, making the expected discharge impossible	Acceptable	Discharge is driven by many factors. Therefore, they needed to ensure that patient will have adequate support before and after leaving the hospital
Provide support for troubleshooting new tool issues	List available	Too late	As they depended on outside support to fix issues regarding list availability, it may not become available when necessary	Precise	Output is stable regarding precision along the process time frame
Consult notes about the patient	Information about the patient's clinical, psychological, and social condition	Omission	Patients' notes are not standardized; therefore, relevant information may be missing	Imprecise	Patients' notes are not standardized, making hard to interpret and use them to inform decisions
Consult own knowledge and expertise	Knowledge and experience with the tool Knowledge and experience in discharge Knowledge of the patient's condition	Omission	As there was not much training and several changes during implementation, workers may not be sure how and when to access and use the tool	Imprecise	As there was not much training and several changes during implementation, workers may not be sure how and when to access and use the tool
Provide the tool	The tool	On time	This function consumes relatively little time in the general time frame	Imprecise	As the feedback provided was not fully taken into account, the tool's algorithm was not compatible with the work situation
Color-code list	List color-coded	Too late	The color code of the list to make it more usable introduces delays in the process	Precise	Output is stable regarding precision along the process time frame
Verify predictions	Information on the tool's accuracy	On time	This function consumes relatively little time in the general time frame	Imprecise	Predictions are sometimes inaccurate
Update tool	Changes/improvements on the tool	Too late Omission	Requested improvements were never made or were made too late, damaging the perception of the tool	Imprecise	As the feedback provided was not fully considered, updates made did not benefit the work/predictions

4.3.2 X-Ray Scanner Device

In their regular workflow, the main challenges are related to connectivity and organizational culture. As all systems depend on an internet connection to communicate with each other and transfer information, when the internet connection is down, the worklist needs to be manually transferred from the internal information system to their portable imaging equipment. In this situation, information is subject to errors, and the image may be attributed to the wrong patient, and correction cannot be easily made by department workers, requiring contact with the sector in charge of providing support to the information systems and delaying next steps in the process, like reporting and sending the results to the ordering physicians. Regarding cultural aspects, participants report a feeling of disregard for their knowledge and experience by other professionals, such as physicians and nurses, resulting in them taking unnecessary x-rays.

The introduction of the new device did not target any specific issue; however, it aimed to provide more information through the generation of multiple diagnostic images at once.

The technology displayed malfunctions and required more time to generate the images than their regular machine. The images often showed ghosts or lines, which made them improper for diagnosis. Thus, technologists had to reject the image and set up the machine again in order to try to obtain a better quality image. However, there are reports of training being insufficient, making workers unsure of how to proceed when faced with these situations and having as the only solution search for the assistance of a coworker. The occurrence of this situation may compromise the provision of a satisfactory image in a timely manner, leaving physicians without the right support to inform their decisions in time-sensitive cases. This instance also affected the interaction between imaging department personnel and physicians, who displayed annoyance in the presence of the technology. Part of this discontent may also be attributed to the small size of the device display (75% smaller than their regular portable), which made visual inspection difficult and impacted their decision-making process.

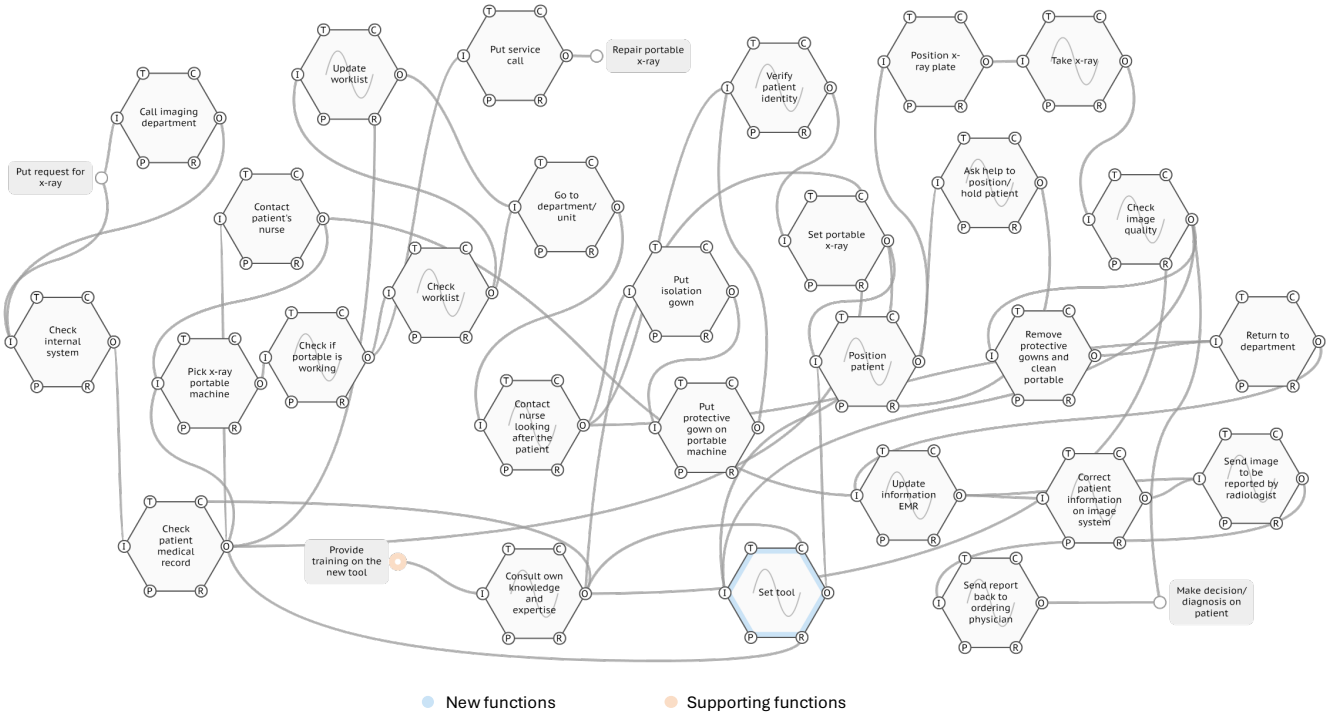


Figure 7: FRAM Model for Portable Imaging

Table 11: Potential Variability for Portable Imaging

Function	Output	Output Variability Regarding Timing		Output Variability Regarding Precision	
		Range	Description	Range	Description
Check worklist	Complete list of requests for portable x-ray Incomplete list of requests for portable x-ray	On time	This function consumes relatively little time in the general time frame	Imprecise	Due to internet connection problems, the worklist may not be updated on the portable. This requires manually updating the list
Update worklist	List of requests for portable x-ray updated	Too late	Because of internet connection issues, the worklist may be updated manually, introducing delays in the process	Imprecise	Because of internet connection issues, the worklist may be updated manually, introducing errors in patient information
Check if the portable is working	Working portable x-ray Malfunctioning portable x-ray	On time	This function consumes relatively little time in the general time frame	Imprecise	The portable may not be working properly. Therefore, they put a service call and pick another portable
Contact nurse looking after the patient	Portable imaging is viable Portable imaging not viable	On time	This function consumes relatively little time in the general time frame	Imprecise	Portable imaging has limitations; hence, it is not always viable. In this case, the patient must be directed to the imaging department
Verify patient identity	Patient's identity verified	On time	This function consumes relatively little time in the general time frame	Acceptable	In case information was manually entered into the system, divergencies may be found and corrected later in the process
Set portable x-ray	Portable machine set	On time	This function consumes relatively little time in the general time frame	Precise	Output is stable regarding precision along the process time frame
Set tool	Tool set	Too late	The manual process may introduce delays, especially considering the small screen size	Imprecise	The device runs a separate software, i.e., it is not integrated with their other information systems. Therefore, patient information and technical factors must be entered manually. The wrong patient or the wrong technical factors may be entered, impacting how the image is processed or post-processed
Position patient	Patient positioned	On time	This function consumes relatively little time in the general time frame	Acceptable Imprecise	Patients may not be able to communicate/help in the procedure due to being unconscious, on a ventilator, or having a disability. If the patient does not hold still, the quality of the image can be compromised. If necessary, they request help with positioning
Ask help to position/hold patient	Help to position the patient	Omission	Depending on the situation, especially on night shifts, help may not be available. Therefore, the technologist has to position the patient by themselves	Precise	Output is stable regarding precision along the process time frame
Take x-ray	X-ray	Too early Too late	The tool takes x-rays without them pressing any button, which does not allow them to verify that everything is in order before taking the x-ray The tool may also take too long to provide an image when compared to their regular portable (minutes vs seconds), impacting the diagnostic in more time-sensitive situations	Imprecise	The tool would often show lines or ghosts over the image
Check image quality	Image quality is acceptable Image quality is not acceptable	On time	This function consumes relatively little time in the general time frame	Acceptable Imprecise	The image has to be diagnostic enough. If the image is not satisfactory, reorganize the setup and take a new one
Update information EMR	Patient record updated	Too late	If the internet connection is down, the image cannot be uploaded, delaying the process	Imprecise	Because of internet connection issues, this and other steps may be executed manually, introducing errors in patient information. Images may be assigned to the wrong patient, requiring correction
Correct patient information on image system	Image and patient information corrected	Too late	The correction is made by another sector. Therefore, it requires contacting other actors, which may introduce delays in the process	Precise	Output is stable regarding precision along the process time frame
Send image to be reported by a radiologist	Image sent to radiologist	Too late	As the system depends on an online connection, when the internet is down, the images cannot be uploaded and sent	Precise	Output is stable regarding precision along the process time frame
Send report back to ordering physician.	Report sent to ordering physician	Too late	As the system depends on online connection, when the internet is down, the images cannot be uploaded and sent	Precise	Output is stable regarding precision along the process time frame
Consult own knowledge and expertise	Knowledge and experience with the tool Knowledge and experience in portable imaging	Omission	As training and documentation were limited, workers may not have the required knowledge to use the tool, especially in cases of unusual behavior. In this case, they may request for help	Imprecise	As training and documentation were limited, workers may not be sure how to use the tool, especially in cases of unusual behavior

4.3.3 Digital Pathology Tool

One of the main issues identified through the analysis is the consultation process. When pathologists believe that a case requires additional analysis, they resort to consultation with pathologists in other hospitals in the province. In this case, slides are sent by courier, generating more financial costs to process. However, there are reports of slides being lost or broken by the courier company. This situation can delay the diagnosis process, and if there are no more blocks or slides at the laboratory, additional analysis will not be impossible, hindering the possibility of a more robust diagnosis.

Another important situation reported by participants is related to the shortage of labor in the sector, which in the medium and long term will make hiring more difficult, affecting their turnaround time. Currently, many of the laboratory assistants have few years of experience, and they are described as "fresh" and are still learning the required skills. This lack of experience and skills is reflected in the quality of the slides produced by them and, consequently, the quality of the analysis.

These two situations are directly addressed by the implementation of the digital pathology analysis, improving the system's capacity to achieve the desired outcomes. The new technology will eliminate the handling of the physical slides during the analysis since pathologists will be provided with "digital slides". Therefore, they will be able to do online consultations, saving time and preserving the integrity of the original slides. Additionally, there will be the opportunity for remote or hybrid work, expanding hiring opportunities.

Currently, the mentioned "freshness" of the assistants poses a challenge in the use of digital pathology since the scanning process tends to exacerbate slide imperfections. However, skills have a natural tendency to improve with practice, and lab leadership already anticipates an initial moment of higher turnaround times and rework during the full implementation process.

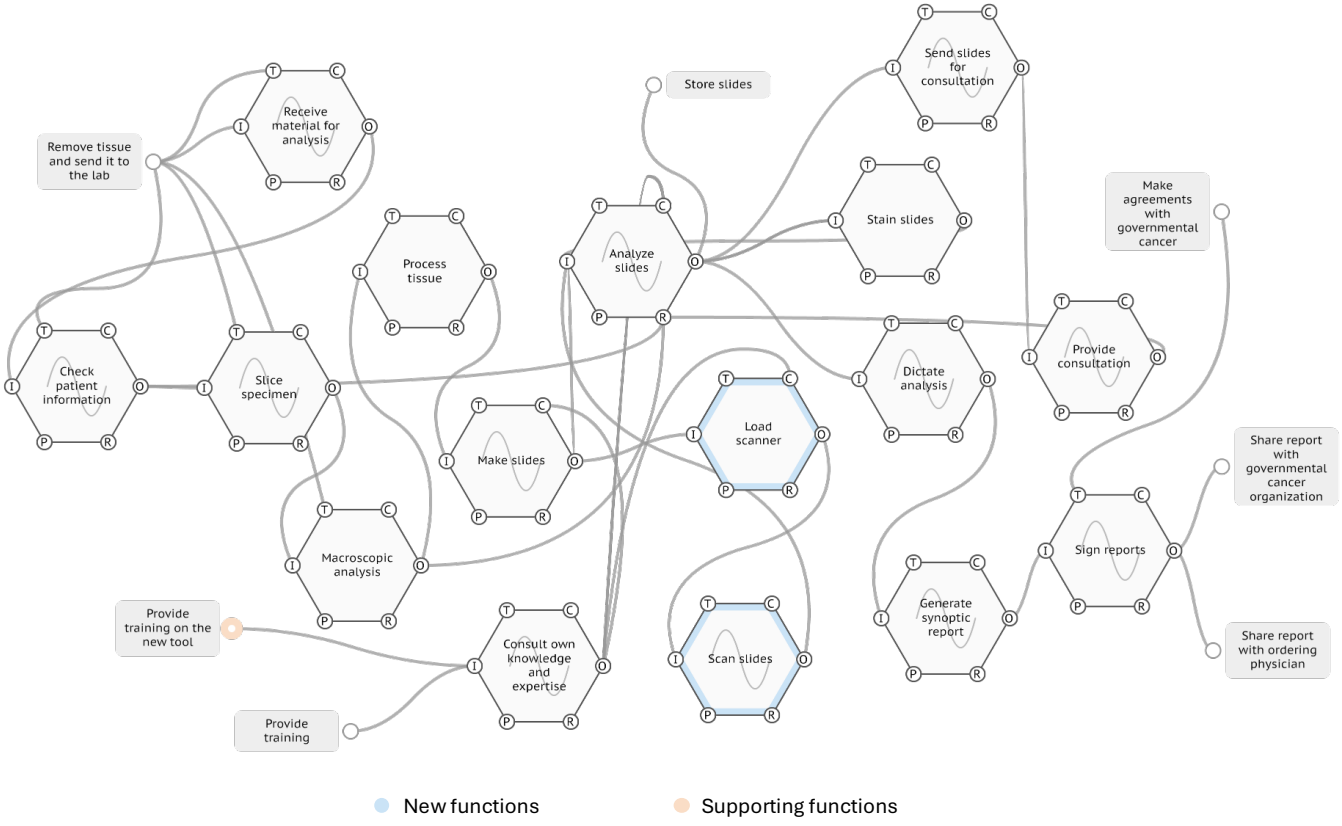


Figure 8: FRAM Model for Digital Pathology

Table 12: Potential Variability for Digital Pathology

Function	Output	Output Variability Regarding Timing		Output Variability Regarding Precision	
		Range	Description	Range	Description
Receive material for analysis	Specimen received	Too late	If the specimen is not processed in 60min, the quality of the tissue is compromised	Precise	Output is stable regarding precision along the process time frame
Check patient information	Specimen verified	Too late	If the specimen is not processed in 60min, the quality of the tissue is compromised	Precise	Output is stable regarding precision along the process time frame
Slice specimen	Tissue slices	Too late	If the specimen is not processed in 60min, the quality of the tissue is compromised	Precise	Output is stable regarding precision along the process time frame
Make slides	Slides	On time	This function consumes little time in the general time frame	Imprecise Acceptable	Due to the lack of experience of some techs, the quality of slides sometimes is not good, requiring more attempts to produce the slides
Analyze slides	Diagnosis and recommendations	Too late	Due to a lack of workforce, cases need to be prioritized. Therefore, the time to provide an analysis is not standardized and may be longer for low-priority cases	Acceptable Imprecise	Additional analysis and consultation may be required to provide a more complete diagnosis
Scan slides	Digital slides	On time	This function consumes relatively little time in the general time frame	Acceptable	Due to the lack of experience of some techs, the quality of slides is sometimes not good, affecting the quality of the images
Dictate analysis	Diagnosis and recommendations dictated	On time	This function consumes relatively little time in the general time frame	Acceptable	In case additional consultation is impossible, a more precise diagnosis is unavailable
Generate synoptic report	Synoptic report	On time	This function consumes relatively little time in the general time frame	Acceptable	In case additional consultation is impossible, a more precise diagnosis is unavailable
Send slides for consultation	Slides sent to other pathologists	Too late Omission	Sending the slides introduces delays in the analysis process. Besides, slides may be lost by the courier company	Imprecise	If not properly handled by courier, the slides may be damaged since they are made of glass
Provide consultation	Other pathologists' diagnosis and recommendations	Too late Omission	Sending the slides introduces delays in the analysis process. Besides, slides may be lost by the courier company, making consultation impossible	Precise	Output is stable regarding precision along the process time frame
Sign reports	Reports signed	On time	This function consumes relatively little time in the general time frame	Acceptable	In case additional consultation is impossible, a more precise diagnosis is unavailable to support decisions

The three cases of implementation described portray the use of different technologies in different departments and at different periods. Each process displays a different degree of complexity according to its context and goals. Therefore, we ground our analysis on the effects of the introduction of technologies in the workflow in terms of their impacts on systems outcomes. Table 13 summarizes the effects of the innovative technologies on the processes and their outcomes.

Table 13: Effects on Process and Outcomes of The New Technologies

Innovation Technology	Implementation location	Relation to workflow	Effects on process and outcomes
Portable Imaging device	Imaging department/ICU	The device did not address preexistent need	Delays in intermediate steps and results Rework Lack of adequate support to inform medical decisions Patient misidentification errors
Discharge Planning AI	Teaching unit and Acute Care of the Elderly unit	The device did not address any preexistent need	Additional steps on the workflow (higher workload and new roles) Decisions supported by misleading information Lower patient flow efficiency
Digital Pathology scanner and analysis	Pathology laboratory	The technology directly addressed preexistent issues in the workflow	Lower analysis time when consultation is required More capacity to provide a complete diagnosis Better preservation of the analyzed material Delays and rework (temporarily)

Chapter 5

Discussion

Overall, this study aimed to analyze the challenges in implementing innovative technologies in community hospitals through the lens of STS theory, the UTAUT model, and RE concepts. The thematic analysis and FRAM revealed existing workflows, the challenges faced by frontline workers, and the impacts of new technologies on staff workflows. Additionally, the thematic analysis and UTAUT survey provided valuable insights into staff perceptions and expectations regarding these innovations.

The data analyses reveal significant disparities in the implementation, perception, and utility of the three pilot technologies. Across all analyses, the digital pathology tool emerged as the most effective and closely aligned with staff needs. In contrast, the discharge planning tool and X-ray scanner device failed to address workflow requirements or deliver meaningful improvements. Consequently, the digital pathology tool was the only technology recommended for purchase by GRH staff.

To start, the thematic analysis revealed that despite staff confidence in their technology skills and eagerness for health technology innovation, they faced significant challenges in integrating new technologies into their workflows. Unpredictable and stressful workdays, coupled with feelings of being under-resourced, necessitated workarounds to manage unreliable technology and inefficient communication processes. Additionally, staff reported feeling unheard regarding the issues impacting their workflows, making it difficult to embrace new technological innovations, especially when these tools failed to address their existing problems or added unnecessary complexity to their tasks.

A recurring theme in all three analyses is the importance of aligning new technologies with pre-existing challenges or needs. The digital pathology system successfully addressed critical issues such as labor shortages, inefficiencies in slide consultations, and physical slide preservation. Its ability to facilitate remote consultations and reduce turnaround times directly impacted workflow outcomes, gaining strong staff support. In contrast, the discharge planning tool and X-ray scanner device lacked alignment with existing needs. For example, the FRAM analysis noted that the discharge planning tool provided redundant information, adding steps to workflows without addressing core barriers to discharge, such as resource availability and communication inefficiencies. Similarly, the X-ray scanner's design shortcomings, such as the small display size and frequent malfunctions, introduced workflow disruptions, adding to the existing technology struggles staff already faced.

Another recurring theme across the UTAUT and thematic analysis was the importance of system and workflow integration. A lack of change management, planning, and effective communication channels

hindered staff's ability to adapt to new technologies, requiring healthcare workers to adjust to unfamiliar systems and processes. Inadequate staff training further impeded workflow efficiency, as staff struggled to navigate these challenges, feeling uncertain about their ability to troubleshoot issues, lacking sufficient support resources, and burdened by competing responsibilities. As highlighted by the FRAM analysis, without integration into existing technology systems like Cerner or adequate support for workflow integration (e.g., from IT or external vendors), significant barriers emerged. This was evident with both the discharge planning tool and X-ray scanner, as staff often resorted to workarounds to incorporate these tools into their workflows. Additionally, if the technology had limitations, such as poor design or slow performance, it could disrupt operations, reduce efficiency, and increase errors, particularly when the tools failed to align with workflow needs. The discharge planning tool and X-ray scanner, for instance, introduced delays, rework, and inefficiencies without offering clear advantages. The X-ray scanner, in particular, raised patient safety concerns due to repeated imaging and radiation exposure. In contrast, the digital pathology system had a positive impact on outcomes by reducing consultation delays and improving the preservation of diagnostic materials. Despite presenting a steep learning curve, the digital pathology tool benefited from structured training programs, phased implementation, and a collaborative relationship with its developer, which facilitated smoother integration into workflows.

The importance of staff perception and engagement in the pilot project was highly emphasized by both the thematic analysis and the UTAUT survey. Staff expressed enthusiasm and optimism about the digital pathology tool, citing its alignment with their needs and its potential benefits. In contrast, without a clear understanding of how the discharge planning tool and X-ray scanner tools would benefit them, staff perceived these innovations as top-down decisions made by hospital leadership that prioritized institutional goals over their individual needs. Poorly managed feedback loops further compounded the issue, leaving staff feeling undervalued, unfairly blamed for the tools' shortcomings, and voiceless in decisions that affected their work. This environment ultimately fostered resistance to new tools, as staff sought solutions that genuinely addressed their challenges rather than complicating their workflows further.

Overall, this triangulation reveals that successful technology implementation relies on addressing genuine workflow needs, providing robust support and training, and fostering frontline engagement. The digital pathology tool serves as a model for innovative procurement, while the challenges faced by the discharge planning tool and X-ray scanner underscore the risks of introducing solutions without sufficient alignment, planning, and feedback mechanisms.

5.1 Recommendations

Based on these findings, several recommendations have been formulated to enhance future pilot projects. Overall, community hospitals are recommended to adopt participatory approaches to innovation, prioritize integration with existing systems, and ensure robust change management strategies to maximize the impact of new technologies.

5.1.1 Increase Collaboration Between Hospital Leadership and Staff in Earlier Stages

To start, the findings revealed several gaps in understanding between hospital leadership and the staff involved in the pilot projects. Strengthening communication channels will be vital for securing mutual support, effectively allocating resources, and incorporating feedback on the real challenges and barriers staff encounter. This will ensure that leadership understands the concerns and insights of frontline workers, while staff gain a clearer understanding of the goals and expectations from the leadership. By fostering these collaborative networks, hospital leadership can help staff feel more involved and valued, which will enhance the likelihood of successful implementation and adoption of new practices. These efforts align with the principles of knowledge translation by ensuring that evidence and expertise flow both ways, creating a dynamic exchange of information that supports both decision-making and the practical realities of the pilot projects [60].

Technologies that explicitly tackle existing problems and support workers' abilities to manage them, or at least that do not amplify issues and undermine workers' coping capacities, should be favored, and potential problems created by the new technologies should be anticipated and openly acknowledged. Therefore, frontline workers and local managers should be involved as early as possible in the implementation process to avoid unnecessary problems that may undermine the adoption. Aligning with concepts of participatory design, involving relevant end-users in the design process can empower them, increase their sense of ownership over changes, and improve the likelihood of open acceptance [99]. This approach contrasts with the negative culture associated with the pilots in this study, as it fosters collaboration and reduces resistance to change.

Crawford et al. point out that among the factors that impact technology adoption, end-user buy-in is critical [100]. However, buy-in can be undermined when end-user expertise is not utilized. Participants recognized that new projects are frequently managed from the top down and that contributions from the bottom up can add significant advantages toward expediting system changes [100]. Braithwaite et al. highlight the importance of a bottom-up approach to problems in complex systems [101]. There is a great need to look at the frontline, allowing the design of appropriate solutions within the context presented [43,

102]. In addition, changes tend to be more accepted when people are involved in the decisions that affect them [43].

5.1.2 Increase Collaboration Between Startup Company and Staff in Earlier Stages

Communication channels with startup companies can also be improved. Companies should collaborate closely with the hospital during the development and testing phases to understand staff's unique needs and workflows, providing tailored support throughout the implementation process. It is important to ensure that the new technologies meet the specific needs and requirements of the activities they are intended to facilitate in order to guarantee that they serve their intended purpose effectively and provide real improvements in the workflow. Frontline workers should be involved in identifying these requirements to ensure that the technologies are technically compatible with their work environment and, hence, potentially effective in real-world scenarios. This will allow device manufacturers to identify possible opportunities and problems in using the new technology with the engagement of its prospective users. According to Hollnagel et al., when implementing solutions in complex systems, it is important to always consider how they fit into the existing systems to ensure that they are appropriate and functional for the intended workplace [103].

By involving frontline staff early in the process, startup companies can take advantage of an integrated knowledge translation approach to ensure that the innovations are not only evidence-based but also contextually relevant, addressing the real challenges faced by healthcare workers. In turn, this enhances the likelihood of successful adoption and sustainable use of new technologies in everyday practice [60].

5.1.3 Prioritize Change Management Efforts

As outlined by the findings of this study, staff faced significant challenges with change management, emphasizing the need to allocate sufficient time for the introduction of new tools, clarify the reasons for their selection, and provide personalized training that covers their use, troubleshooting, and impact on existing processes. According to the KT framework, proper dissemination of information is key to ensuring that all stakeholders are well-informed and prepared for the transition [60]. Disseminating relevant information about the new tools and their intended impact on individual workflows is critical to reducing resistance and increasing buy-in [104]. Providing proper support at all stages of the transition, such as training, additional equipment, and strong technical support, can help shorten this period and mitigate its effects [74].

As discussed, health systems are complex with intricate relationships between entities. Thus, no procedure or task can be changed in isolation and periods of increased variability are expected, translating into higher turnaround times and more rework [103]. Any transformation impacts the already in-place mechanisms and challenges workers' knowledge and expectations of the systems. Therefore, change management should not be addressed as a discrete change but as a continuous transition. This will ensure that technologies are implemented in a context that fosters change, facilitating its adoption process.

Leadership must ensure sufficient bandwidth is available before initiating a project, including the allocation of dedicated resources to manage change without disrupting daily operations. These resources should include staff, change management training, IT support, and adequate time between the pilot and other ongoing initiatives. This allows staff to engage in comprehensive change management practices, such as workflow analysis, risk assessment, training, logistical planning, feedback collection, and performance monitoring, all of which can facilitate a smoother implementation process for all stakeholders involved.

Additionally, amidst workers' already unpredictable schedules and growing workloads, introducing additional sources of uncertainty raises the likelihood of negative perceptions toward pilot projects. To improve acceptance, time should be dedicated to carefully planning pilot project logistics. This includes establishing clear timelines, identifying involved staff, and defining distinct roles and responsibilities. When staff have a better understanding of the changes affecting their work, they can anticipate and prepare rather than feeling as though projects are being layered onto an already heavy workload.

Finally, it is important to define and share specific success metrics for the pilot projects to help staff assess the technology's impact and make objective decisions about its use. Conducting a thorough review after the pilot will allow staff to evaluate the implementation process, identify lessons learned, and highlight areas for improvement, which can refine future technology adoption strategies and keep staff informed about the status of the pilot project once it concludes. This will also foster a stronger sense of collaboration between hospital leadership and the staff involved in the pilot projects, empowering staff to feel like key participants in the changes affecting them [60].

5.2 Strengths & Limitations

This study had several strengths and limitations that may have influenced the results. One of the key strengths was the analysis of firsthand experiences from staff at a community hospital. The use of semi-structured interviews allowed the researchers to collect rich, qualitative data, capturing unique perspectives from healthcare workers who are often underserved and overworked in Canada. Additionally, the study employed a unique data collection and analysis methodology, setting it apart from existing research and

advancing understanding in a niche area. This novel approach enhances the research landscape and opens new avenues for further exploration.

This study has several limitations to consider. First, the findings may lack generalizability, as data was collected from a single hospital, which could limit the applicability of the results to other healthcare settings. Additionally, each project in this study involved a startup company, which may present unique challenges and considerations that differ from those faced by larger, more established organizations. The study also relied on self-reported, retrospective data, making it susceptible to biases such as recall bias and social desirability bias, which may have impacted the accuracy of participants' responses. Moreover, interview data was collected after the completion of the innovation projects and from participants with novice experience using the technologies, which could have influenced their responses, especially given that they already knew the outcome of the pilot. Furthermore, interviews were not conducted with the startup companies involved, omitting their perspective on how the technologies were designed, implemented, and supported on their side, including any knowledge translation strategies they had in place. Finally, the relatively small sample size may have limited the diversity of perspectives captured, potentially reducing the robustness of the conclusions drawn.

Chapter 6

Conclusion

In the healthcare sector, innovative technology has the potential to significantly enhance the quality of care for patients and streamline the workflow for healthcare professionals. By leveraging technology, healthcare systems can improve patient outcomes, increase efficiency, and reduce the likelihood of errors in medical processes. However, it is crucial to approach technology implementation in hospital settings with a targeted strategy that addresses specific existing challenges. It is important to recognize that successful integration of technology in healthcare settings requires an understanding of the system's unique needs and complexities. The introduction of technological transformations requires a learning process regarding the system, and an approach that recognizes the variability and uncertainty of the systems. It is important to understand how innovative technologies interact with the system in all its dimensions, technological, social, and organizational, as well as its the impact on its outcomes.

Our study focused on the dynamics of specific processes, but a similar discussion is both possible and relevant at a broader level. Technology acceptance is shaped by the interplay of decisions made at various levels within an organization. However, external domains beyond the organization also influence how technologies are implemented, experienced, and perceived by end users. Future research could examine how interactions among these internal and external actors impact the implementation of innovative technologies, providing a deeper understanding of the contextual factors that enable successful adoption. This includes engaging with and understanding the perspectives of technology manufacturers, hospital leadership, and policymakers responsible for initiating such projects. Additionally, it may be valuable to compare these findings with those from research or academic healthcare facilities to identify key differences and determine which barriers are unique to community hospitals.

In conclusion, the implementation of technology in community hospitals are influenced by various factors, further exacerbated by their already existing unique challenges. By addressing the outlined recommendations, organizations can enhance collaboration among all stakeholders: hospital leadership, manufacturers, and frontline staff. These efforts will cultivate a culture of innovation, increasing project engagement, supporting effective planning, and ensuring that the goals and needs of all parties are met. Ultimately, this can facilitate the successful adoption of new technologies and potentially lead to improved staff workflows and better patient care outcomes.

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Appendix A

Ethics Approval

UNIVERSITY OF WATERLOO

Notification of Ethics Clearance to Conduct Research with Human Participants

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Principal Investigator: Catherine Burns

Co-Investigator: Sana Allana

Co-Investigator: Luiza Dos Santos

Co-Investigator: Carla Girolametto (Grand River Hospital)

File #: 46144

Title: Innovation and Technology Acceptance in Community Hospitals: A Human Factors Based Investigation

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The Human Research Ethics Board is pleased to inform you this study has been reviewed and given ethics clearance.

Initial Approval Date: 02/28/24 (m/d/y)

University of Waterloo Research Ethics Boards are composed in accordance with, and carry out their functions and operate in a manner consistent with, the institution's guidelines for research with human participants, the Tri-Council Policy Statement for the Ethical Conduct for Research Involving Humans (TCPS2 2022), the Ontario Personal Health Information Protection Act (PHIPA), and all laws and regulations of the province of Ontario (as applicable). Additionally, CREB operates in a manner consistent with the International Conference for Harmonization of Technical Requirements for Pharmaceuticals for Human Use (ICH) Guidance E6(R2): Good Clinical Practice , the International Organization for Standardization of Good Clinical Practices (GCP) as set out by ISO 14155 - Clinical investigation of medical devices for human subjects, Part C, Division 5 of the Food and Drug Regulations, Part 4 of the Natural Health Products Regulations, Part 3 of the Medical Devices Regulations. Both Boards are registered with the U.S. Department of Health and Human Services under the Federal Wide Assurance, FWA00021410, and IRB registration number IRB00002419 (HREB) and IRB00007409 (CREB).

Expiry Date: 03/01/25 (m/d/y)

Multi-year research must be renewed at least once every 12 months unless a more frequent review has otherwise been specified. Studies will only be renewed if the renewal report is received and approved before the expiry date. Failure to submit renewal reports will result in the investigators being notified ethics clearance has been suspended and Research Finance being notified the ethics clearance is no longer valid.

Level of review: Delegated Review

Signed on behalf of the Human Research Ethics Board



Heather Root, Senior Manager, Ethics, heather.root@uwaterloo.ca, 519-888-4567, ext. 41469

This above-named study is to be conducted in accordance with the submitted application and the most recently approved versions of all supporting materials.

Documents reviewed and received ethics clearance for use in the study and/or received for information:

Appendix B

Recruitment Materials

Recruitment Poster

SEEKING PARTICIPANTS FOR A STUDY

Innovation and Technology Acceptance in Community Hospitals: A Human Factors Based Investigation

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB #46144).

Who can participate?

Clinical and IT/decision support staff who used/have been using innovative technology in their workflow

The study consists of a 5 minutes survey, with a optional 45 minutes interview and/or observation session

Please access the link in the QR Code to learn more about the study and answer the survey.

UNIVERSITY OF WATERLOO
FACULTY OF ENGINEERING

Office of Innovation & Research
Grand River Hospital

PLEASE RECYCLE TEMPLATE 057

Recruitment Email

Dear _____ (Colleague Name),

GRH is conducting a study in collaboration with the Department of Systems Design Engineering at the University of Waterloo. This research aims to uncover the perceptions, expectations, cultural nuances, and barriers to innovation and innovative technology adoption at GRH by analyzing the staff participation in innovation projects that were previously conducted at GRH. This study will involve a survey, a one-on-one semi-structured interview and survey, an observational session and survey, or all three.

You are being contacted because you participated as a GRH staff member in the support of one or more of our innovation projects.

If you are interested in hearing more about this research and how you can participate, **please directly reply to this email to the students from the University of Waterloo** (Sana Allana, s2allana@uwaterloo.ca, and Luiza dos Santos, l3dossan@uwaterloo.ca), informing your title and the projects you have been supporting at GRH. They will contact you to discuss the study and the next steps for participation.

Your information will be anonymized by the students and stored in a secure/password-protected Excel spreadsheet. Participant names will not be shared by the two students, and only the two students will have access to a spreadsheet linking the participant's name to a unique participant ID.

You are under no obligation to participate in this study and a decision not to participate will not affect your employment in any way.

The study was approved for both GRH and a University of Waterloo Research Ethics Board.

The attached information letter offers more explanations about the study.

Thank you in advance for your consideration,

Carla Girolametto

Carla Girolametto, MA, MSc, CCRP |
Director of Innovation, Research, and Clinical Trials
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http://www.grhosp.on.ca/research

OFFICE OF INNOVATION & RESEARCH
GRAND RIVER HOSPITAL

"There are no failures in science, rather there are experiments whose outcome you did not anticipate" Carolyn Bertozzi, Chemistry Nobel Prize Winner 2022

Appendix C

Information Letter

Study Title: Innovation and Technology Acceptance in Community Hospitals: A Human Factors Based Investigation

Principal Investigator:
Catherine Burns
catherine.burns@uwaterloo.ca
Department of Systems Design Engineering
Faculty of Engineering
University of Waterloo, Canada

Local Investigator:
Carla Girolametto
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Office of Innovation and Research
Grand River Hospital, Canada

Student Investigators:
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Luiza Dos Santos
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Department of Systems Design Engineering
Faculty of Engineering
University of Waterloo, Canada

To help you make an informed decision regarding your participation, this letter will explain what the study is about, the possible risks and benefits, and your rights as a research participant. If you do not understand something in the letter, please ask the principal or one of the student investigators before agreeing to participate in the study. You will be given a copy of this information-consent letter if you choose to participate in the study for your records. You may wish to save a copy of this letter for your records.

Study Overview

You are invited in a research study conducted by Sana Allana and Luiza Dos Santos, under the supervision of Catherine Burns in the Systems Design Engineering Department at the University of Waterloo and in collaboration Grand River Hospital with Carla Girolametto as the local investigator. The purpose of this study is to uncover the perceptions, expectations, cultural nuances, and barriers to technology adoption at GRH (Grand River Hospital), a community-level hospital in Waterloo. The study is for master's and PhD theses.

The Study

The study will involve a survey and semi-structured interview and/or observational session. The interview and observational sessions are estimated to last 45 minutes each, and the survey is expected to take 7 minutes to complete. Participants may choose to take part in just the survey, an interview and survey, an observational session and survey, or all three. We aim to conduct interviews and observations with 5 staff members and administer surveys to 10 staff members from each of the clinical and IT/Decision Support departments that have worked with the new technologies introduced at GRH.

If you provide consent to participate, you will be asked questions about your demographics and professional designation (age, gender, education, occupation, years of experience, and experience level with the technology). We will use this information to contextualize the findings (e.g., a more experienced worker may find it easier to manage a situation because they have experienced it before; however, a novice may have a different perception).

For the interview, participants will be asked questions about their workflow (before and after technologies implementation) and reflect on the different demands of their work to uncover routine and nonroutine aspects of the processes. We also aim to gain an understanding of their perceptions and feelings towards innovation, and their predictions of how it would improve or challenge their workflow. We will also question workers' perceptions of the implementation process.

During the observational session, participants will be observed while interacting with the novel tools. Here, you will be asked to think aloud as you interact with the tool. This will not be a test of your knowledge, intelligence, or performance but rather an opportunity to discover design and usability issues with the tool and implementation process. At this phase, please be aware that as observations are happening in the workplace, anonymity will be limited; your co-workers may learn that you are participating in a research study.

For the survey, participants will be asked Likert-scale questions which are intended to measure one's level of technology acceptance. The survey questions can be found in literature and is modelled after the UTAUT or Unified Theory of Acceptance and Use of Technology model. Technology acceptance is measured using the constructs: performance expectancy, effort expectancy, attitude toward using technology, social influence, facilitating conditions, self-efficacy, anxiety, and behavioral intention.

Interview / Observation Meeting

If you agree to proceed with the interview and observational sessions of the study, you will be invited to meet either virtually on a virtual meeting platform or at Grand River Hospital at an agreed-upon date and time, whichever is more convenient for you. Grand River Hospital has given permission for the researchers to set up a time that has been negotiated according to staff availability and with prior discussion with their respective

managers/directors. If you choose to meet online instead, our preferred platform is Microsoft Teams, which has implemented technical, administrative, and physical safeguards to protect the information from loss, misuse, and unauthorized access, disclosure, alteration, or destruction. Interviews will be conducted in a private office at GRH or online. We would also be happy to accommodate a meeting outside of work hours if you would prefer.

With your permission, interviews will be audio recorded to facilitate data analysis. We advise participants to refrain from unnecessarily disclosing personal information during the recordings, make use of Teams' backgrounds to protect any information that could be visible around them if applicable, and wear headphones or isolate themselves in a separate room to prevent other people from overhearing their conversation during the interview.

With your permission and acknowledgement of others in the area, parts of the observational sessions may be audio recorded and/or pictures may be taken of the technology. We advise participants to refrain from unnecessarily disclosing personal information during the recordings If researchers advertently see or capture personal health information during the observations, this information will be deleted and will not be included in the transcripts of audio recordings. We understand that, at times, the work environment may not be appropriate for such recordings and will always confirm with the participant and others around for permission before doing so.

The Survey

If you would like to proceed with the survey, you can access the link through the recruitment poster, recruitment email, or by sending an email to Sana and/or Luiza. In every case, you will access a link to an online platform called Qualtrics. This platform has implemented technical, administrative, and physical safeguards to protect the information from loss, misuse, and unauthorized access, disclosure, alteration, or destruction.

Your Participation

Participation in this study is voluntary. Your decision to participate will not impact your employment standing. You may decline to answer any questions presented by the researcher. Furthermore, you may decide to withdraw from this study at any time without any negative consequences.

Risks

There are no known or anticipated risks to you as a participant in this study.

Benefits to the Study

The study aims to bridge the gap between the development of innovative technologies in healthcare and the acceptance, implementation, and subsequent adoption of these tools

into the workflow of target users, particularly in community-level hospitals. The design requirements and guidance obtained will be valuable for informing researchers, system designers, and developers of innovative healthcare technologies. Additionally, this information will benefit hospital administrators responsible for planning subsequent implementation processes of new tools.

Data Confidentiality and Security

Your identity will be confidential, it will not appear in any thesis or report resulting from this study. However, it is important to remember that no internet transmission is ever fully secure or error free. We do not collect or use internet protocol (IP) addresses or other information which could link your participation to your computer or electronic device.

A list that links participant names and email addresses with participant IDs will be kept separately from the study data, in a locked spreadsheet, to ensure the study data does not have any personal identifiers. Data collected during this study will be retained for a minimum of 7 years in OneDrive storage provided by the University of Waterloo. However, with your permission, anonymous quotations from the interviews and/or observational sessions may be used in future scientific publications. Once all the data collected from this project have been analyzed thoroughly, results may be shared with the research community through seminars, conferences, presentations, dissertations, and/or journal articles. The recommendations and findings of this study will also be complied into a report using accessible language and will be shared with Grand River Hospital to address the issues that motivated the study.

If you wish to withdraw your data at any time, please contact s2allana@uwaterloo.ca, l3dossantos@uwaterloo.ca or catherine.burns@uwaterloo.ca. You may decline responding to any questions you prefer not to answer. Note that it may not be possible to withdraw your data once the results of the study are published in a publication or dissertation as all identifying information will be removed from the data. If you consent to participate in the study, it does not mean that you waive any legal rights you may have under the law, nor does it mean that you are releasing the investigators, institutions and/or sponsors from their legal and professional responsibilities.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB # 46144). If you have questions for the Board, contact the Office of Research Ethics, toll-free at 1-833-643-2379 (Canada and USA), 1-519-888-4440, or reb@uwaterloo.ca.

If you are interested in receiving more information regarding this study, a summary of its results, or if you have any questions or concerns, please contact Sana Allana, Luiza Dos Santos, or Catherine Burns at the email addresses listed above.

We look forward to speaking with you and thank you in advance for your assistance in this project.

Appendix D

Oral Consent Form

Interview Verbal Consent Script and Documentation Form

Study Title: Innovation and Technology Acceptance in Community Hospitals: A Human Factors Based Investigation

As mentioned in the information letter, the purpose of this interview is to understand the workflow (before and after technologies implementation), perceptions and feelings towards innovation, the technology implementation process, and the predictions of how innovation technology would improve or challenge the participants' workflow. With your permission, interviews will also be audio recorded to facilitate data analysis. We advise participants to refrain from unnecessarily disclosing personal information during the recordings, make use of Teams' backgrounds to protect any information that could be visible around them if applicable, and wear headphones or isolate themselves in a separate room to prevent other people from overhearing their conversation during the interview.

You may decline responding to any questions you prefer not to answer. Note that it may not be possible to withdraw your data once the results of the study are published in a publication or dissertation as all identifying information will be removed from the data. By providing your consent, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Board (REB # 46144). If you have questions for the Board, contact the Office of Research Ethics, toll-free at 1-833-643-2379 (Canada and USA), 1-519-888-4440, or reb@uwaterloo.ca.

Have you had a chance to read the information letter?

Do you have any questions?

As a reminder, participation is voluntary, and you may end the interview session by advising me of your decision at any time. If you have questions for the Research Ethics Board, contact information for the Office of Research Ethics is listed on the information letter that you received prior to this session. For all other questions about the study, you may contact Sana Allana at s2allana@uwaterloo.ca, or Luiza Dos Santos at l3dossantos@uwaterloo.ca. You may also contact Professor Catherine Burns at catherine.burns@uwaterloo.ca.

With full knowledge of all the foregoing, do you agree of your own free will, to consent in participating in this interview knowing that you can withdraw at any point with no consequences to you?
[ ] YES [ ] NO

Do you give permission for your interview to be audio-recorded to ensure accurate transcription and analysis?
[ ] YES [ ] NO

Do you agree to the use of anonymous quotations in any paper or publication resulting from this research?
[ ] YES [ ] NO

(If yes to the above questions, please read the following response to the researcher):

I, (name), agree of my own free will to participate in this interview session today (date) at (time).

Appendix E

Study Materials

Semi-structured Interview

Interview questions: Clinical Staff:

[XXXXX] will be replaced with the new medical tool that staff uses / used for their department.

1. What is your current level of technology use within your daily life? Can you provide any examples?
2. Can you please describe your role at Grand River Hospital?
    a. How long have you worked in this role?
    b. How long have you been working at GRH?
3. Can you walk me through your day to day, highlighting your task associated with the use of [XXXXX].
    a. What are your day to day goals?
    b. What are the tools or technology is involved?
    c. Do you work with other departments or disciplines at the hospital?
    d. Are there any formal protocols (Standard Operating Procedures, others) within this work?
        i. If so, do they encompass the important aspects of the workflow?
        ii. Are they updated?
    e. Do you identify any barriers or difficulties to your work? Can you provide any examples?
        i. Like software, communication, culture, knowledge/training
        ii. How do you deal with these barriers (workarounds)?
        iii. What kind of improvements could be made to avoid these barriers?
4. What are your expectations about new technology innovation at GRH? Do you perceive it to be helpful? Why or why not?
    a. Can give an example of something new that has helped your workflow (or the work of others?)
    b. Can they think of projects that were explored but were not that helpful?
5. How was the implementation process for [XXXXX]?
    a. Before implementation, was the clinical staff consulted?
        i. Regarding the need for the tool?
        ii. Was there a workflow analysis to understand how [XXXXX] will be implemented, and how it fits in the workflow?
        iii. Did you receive any training before [XXXXX] implementation?
            1. If so, how? For how long?
            2. If not, do you think training would have been helpful? Why?
    b. Have you had previous experience with a similar type of tool?
        i. If so, which ones? And how similar or different they are?
    c. What do you think could be improved in the technology implementation process?
6. Did [XXXX] improve your workflow? Why or why not?
    a. Do you prefer to use [XXXXX] or avoid it?
7. Did you perceive some potential problems or barriers with the use of this tool? Why?
    a. Is there someone to whom you can easily report these issues? Who would that be?
8. What difference, if at all, do you think [XXXXX] is making to patients? Why or why not?
9. Is there anything else you would like to add?

Survey

Performance expectancy

U6: I would find the system useful in my job.

RA1: Using the system enables me to accomplish tasks more quickly

RA5: Using the system increases my productivity.

OE7: If I use the system, I will increase my chances of getting a raise

Effort expectancy

EOU3: My interaction with the system would be clear and understandable

EOU5: It would be easy for me to become skillful at using the system

EOU6: I would find the system easy to use.

EU4: Learning to operate the system is easy for me.

Social influence

SN1: People who influence my behavior think that I should use the system.

SN2: People who are important to me think that I should use the system.

SF2: The senior management of this business has been helpful in the use of the system

SF4: In general, the organization has supported the use of the system.

Facilitating conditions

PBC2: I have the resources necessary to use the system.

PBC3: I have the knowledge necessary to use the system.

PBC5: The system is not compatible with other systems I use.

FC3: A specific person (or group) is available for assistance with system difficulties.

Appendix F

Thematic Analysis




Work processes & responsibilities
Staff must follow specific safety and reporting protocols
Different departments operate differently
Work is highly collaborative
Staff leverages support from each other and cross functionally
Clinical staffing is top priority
Follows specific safety and patient flow protocols
Manager looks after staff needs
Follows specific safety and patient flow protocols
Manager looks after staff and technology operations across imaging
Deals with safety management
Manager looks after staff operations across labs
Pathology tissue must be stored for long time
Managers look after staff resources in their day to day
Quality of slide is crucial for a good analysis
It is manager's responsibility to support & motivate staff to use new technology
Maintaining the quality of the slide is meticulous and dependent on time
Clinical staffing is top priority
Follows protocols for data reporting (wait times) to ministry
Looks after staff and their needs
All cancer reports are shared to provincial health organizations for analytics
Order of work depends on proximity of office and layout
Discharge planning takes into account non-medical barriers as well
Some hospital units make money with more discharge, and some do not
Different departments have different priorities for patient flow
Staff structure changes depending on time of day
Discharge is impaired by social issues and lack of resources -L
Each unit is unique with its own work organization -L
Discharge process is variable by hospital unit / floor
X-ray procedure may vary depending on patient needs/characteristics
Various goals for imaging depending on staff / patient workflow
Breakdowns in technology affects departments differently
Portable x rays image depends on clinical factors inputted by staff
X rays provide doctors more visibility and validation in their work
Portable x rays image depends on clinical factors of patient
There is a variable process in pathology to aid diagnosis
Only sick or immobile patients use portable x rays
Discharge process becomes variable by doctors
Tech must deal with difficult patients
Doctors have final say in patient care plan
Ease of use for the portable x ray varies based on patient characteristics
Recognizes discharge barriers through intuition and past experiences
Values cross functional alignment on decisions
Discharge decisions are made as a team
Added new role to improve communication efficiency for discharges
Manager works outside of hospital too
Imaging team support each other to discuss patients and barriers in work
Leverages support from cross functional teams
Team & department huddles to plan patients and barriers in work
Leverages physical support from cross functional staff and strategies to orient patients
Values cross functional work to ensure solution is best for the hospital rather than in silo
Leverages support from hospital IT to resolve technical issues
Values cross functional collaboration to solve problems
Leverage support from other hospitals
Prefers hybrid work rather than completely remote for collaboration
Managers work cross functionally
Understanding barriers to discharge is important
Managers work cross functionally
Doctors allow staff to understand barriers to discharge
Imaging works cross functionally as its results are used at various points of patient journey
Allied health confirms functional barriers for discharge
Works closely with surgical department
Meetings take up most of their day
Consistent meetings is a barrier in their workflow


Problems within current workflows
Work is stressful and unpredictable
Work is unpredictable
Feels their job is unpredictable and stressful
Work is unpredictable and stressful
Tech is responsible for getting consent despite patient barriers and difficulties
Tech is responsible for getting clear image despite patient barriers and difficulties
The everyday work is described as complex -L
Feels uncertain about discharge decisions without doctors
Needs reassurance and to mentally prepare for work
Feels mentally drained by unpredictable work problems
Despite notifications, checks for updates in their tracking software
Hospital work is inevitably stressful
Staff feel under resourced
Would like to be in a proactive rather than reactive state in work
Doctor excessively order lab services when finances are not available
Feels responsible for the barriers in their work
Feels a lack of control over doctors' decisions which negatively impact lab services
Feels unprepared to deal with unnatural healthcare shortages & increased hospital workload/complexity
Workforce decreased due to Covid
Feels pressured due to increasing workload / backlog
Covid increased patient volume and complexity of diseases
More funding is not the solution for a lack of labour
Covid put pressure on lab operations with increased workload
Has lack of experienced techs which affected their quality of slides
Experiencing a shortage of labour
Lab is not prioritized financially because it does not generate revenue
Experiencing backlog and high workload
Pathology equipment is expensive, even to maintain
Population has grown a lot, negatively impacting hospital resources and capacity
Lack of funding makes it difficult to prioritize patients & turn around times
Workload increases turn around time for patients
Experiences lack of finances to meet patient demands
Covid instigated change and desire for innovation
Feels pressured to follow orders from Premier's Office
Covid changed work norms to be remote for radiology department
Provincial health system does not provide adequate support for increased patient base/complexity
Hospital technology can be improved
Finds it challenging to keep technology up to date with changing patient populations
Portable x ray machines are not reliable
Feels technology breakdown is inevitable
Hospital X ray machines are not reliable
PACS-integrated technology is not reliable with technical difficulties, preventing communication of results
Unreliable technology impacts all lab staff and work processes
Feels technology issues are inevitable
Fear of over-reliance on new technology in case it breaks down
Breakdowns in integrated systems renders staff unable to work and communicate results
Anticipates issues with new tool to come up through trial and error
Unreliable technology makes work more difficult and stressful
EMR is a barrier in clinical work
Documentation without EMR is easier
Believes other hospitals are more advanced in their technology
Workarounds are frequently needed and are hard to cope with
Tech failure workarounds delay work, which is infeasible on busy days
System failures result in manual work which is not reliable and prone to error
Patient overflow prevents workaround of moving patients when machines fail
Lots of effort to get technology to start working again
Needs walk back and forth to x ray room/refers to inefficient and increases stress when PACS system collapses
Workaround for large workload cycle: get cancellations outside of GRH, but is infeasible due to cause and barriers of mail delivery
If portable x ray cannot be used, patient must go to x ray department
Communication is ineffective
Their real problem was people assignment -L
Feels like cross functional staff do not trust their clinical judgement
Doctors are set in their ways
Doctor's orders may not always be the best decision
Double checks with staff to ensure there is a need for the x-ray order
Need to verify x ray order and patient barcode prior to procedure
Advocates for staff and patients
Advocates for patients if they are receiving excess radiation
Would like to implement technology to make objective decisions that staff typically complain about, rather than a person
Communication is inefficient
Would like to have discharge information readily available rather than needing to ask someone
Communication workflows between staff is not efficient
Would like to implement technology to relay information, rather than a person
High staff turnover makes it difficult to consistently explain themselves and their responsibilities
Dealing with staff who do not understand their role is a challenge


Perceptions of Innovation
Staff values supporting local startups.
Close proximity of company and hospital facilitated continuous support from them
Supporting local innovation avoids supply chain issues
Values supporting smaller companies
Hospital wants to support a local company
Staff feel a lack of control in the technology they use
Feels that staff are less likely to voice their opinion if the tool is owned regardless
Staff feel a lack of control in the technology they use
Lack of participation of front-end workers in the decisions regarding the changes being made -L
Feeling out of control creates resistance and frustration -A
Felt excited to work with tech company who could adapt technology to their needs
Disconnect between hospital goals and frontline challenges
Leadership believes AI is the solution to existing problems, but this isn't true
Feels problems are unheard by hospital leadership in their decision-making and priorities
Leadership thought they were filling a need with innovation tool
Leadership expected greater uptake for the innovation tool
Pilot was done in departments with expected capacity and interest by leadership
Believes hospital priorities should focus more on existing problems rather than innovation
Their current workflow faces more pressing issues -L
Hospital needs to work on finding where innovation can best fit
Hospital resources are not being used to solve the real problem at hand
Needed to strategically communicate with hospital leadership, aligning with their goals and needs to advocate for tool
Staff needed to prove tool's benefit to hospital leadership before testing
Committee must agree to take on pilot projects
Innovation should allow for open conversation, not judgement when things go wrong
Unable to express true needs and problems in discharge process to hospital leadership
Hospital vision does not align with amount of funding provided
New technologies are introduced as top-down decisions
Staff did not believe tool resolved a real need, only hospital leadership did
No frontline staff asked for a tool like this, nor were they consulted
The decision on the implementation was made at the blunt end of the organization -L
Staff believes technology implementation is top-down decision
Pilot was a top down decision
Staff believes hospital leadership likes to try new tools
Staff are excited about technology in their industry
Values innovation as this is not common in their industry
Values innovation to resolve problems within their industry
Innovation is typically explored in well-resourced areas/populations
Feels positive about innovation as its not common in their industry
Staff appreciates new technology
Believes innovation is necessary for their field of work
Indigenous communities face social & IT barriers for innovation/adopt on of new tools
Working with other hospitals to encourage adopting same tool to help build network
Passionate to build network to improve innovation tool's capabilities
Pilot project gave team a sense of ownership
Staff are excited about technology advancements in healthcare
Sees potential for technology/AI to further improve healthcare
Curious to learn more about AI
AI can increase objectivity of diagnosis
AI can improve treatment planning efficiency
Sees AI as a solution for documentation
AI would be useful to collect & make use of data, not for direct patient care
Believes dictation/AI tool would be easy to implement
AI can help with physician workload and efficiency
Sees AI as a solution for tedious tasks
Thought AI could be improved (need more resources, provided reasoning) to make the tool more useful
Appreciates innovation where gaps exist in patient care
Staff actively seek out innovation opportunities
You need to actively seek out information & the right people for a successful project
Actively networks to learn more about innovative tools and opportunities for improvement
Staff actively seeks out new technology releases
Appreciates and seeks out innovation
Works with diverse, international community leaders to help them adopt innovative tools
Awareness of technology at other hospitals
Awareness of pilots in other hospitals
Awareness of what this company is working on
Values innovation that prioritizes preventative care
Actively finds ways to leverage data driven approach to improve quality of care
Staff felt that testing the tool was more beneficial for the manufacturing company
Tool did not positively impact staff or patients
Pilot helped innovation company
Frequent back and forth communication between GRH and tech company
Believes innovation tool was more harmful to patients
Provided feedback on company on how to improve the tool
Frequent communication with innovation company to troubleshoot errors
New technology needs to make a positive impact on patients
Purpose of pilot was to verify validity of the tool for the company's benefit
GRH tested the tool and provided feedback to manufacturing company
Tool did not positively impact patients
Pilot was beneficial to company as they were able to get real hospital data
Company visited during client testing to collect staff feedback on their preferences and how tool was used
Tool's poor performance required patients to receive repeated x-rays
Pilot was beneficial to the hospital as they were able to test a tool before purchasing
Hospital staff would request help and company would troubleshoot
Innovation tool is expected to positively impacts patients with timely care
Company only visited at start of innovation project
Unsure about why tool was introduced
Innovation tool is expected to positively impacts patients with quality care
A purpose of pilot was to verify validity/accuracy of the tool
Staff were not aware of what the tool was before it was implemented
Innovation tool will positively impact doctors
Needed to prove their efforts irregardless of how old performed
Staff did not understand how the tool worked, how predictions were made
Portable x-ray made workflow faster for doctors
The pilot aimed to validate tool's predictions -L
Limited information skews expectations -A
Worried that the tool would make them do worse in their job, underprioritizing patients
Prior to pilot, needed to verify the innovative tool can work in the hospital infrastructure
Negative sentiments when staff feels as though they are missing information -A
Knowing the discharge planning priority is redundant information
Purpose of pilot was for doctors to evaluate if the tool was working
Current technology already met the need for the innovation tool
Manufacturing company updated their tool in response to feedback provided by GRH


Experience with Innovation tool
A lack of integration makes it difficult to update existing workflows
Some staff do not use emails in their day to day
Lack of integration into Corner made the tool difficult to fit into workflows
Corner integration was not effective
Team needed to remember to use the tool
Lack of integration made the tool hard to use -L
Tool had updated vaccine info, but do not have all information from EHR
Innovation tools need to fit into existing technology systems
Lack of integration into Corner made work manual, error prone
Innovative technology connected with EMR
Lack of EMR integration was a barrier for tool
Lack of EMR integration required manual entry for staff
Privacy barriers prevented use of the tool
Privacy barrier workaround's were ineffective and increased workload
The production logic of the units impacts the uptake of new technologies -L
Unresolved technical issues reduce trust in the tool and manufacturing company.
Inaccurate predictions from the tool made staff more wary of using it
Staff reverted back to original technology when innovation tool did not work
Tool did not perform consistently in sending emails
Staff provided feedback to the innovation company but the company could not always solve the problem
Negative sentiments when innovation tech does not align with previous knowledge -A
Believes technology is to blame for poor job performance rather than staff
Tool's output was not useful / inconsistent in quality
Tool would behave unexpectedly, leaving staff confused and wary of using it
Errors from the tool delayed workflow
Innovation tool was recording records that were worse than the existing technology
Felt that technology was not mature and in beta phase
Lack of trust in tool providing discharging decisions
Rigorous rough technology was in beta results, as using relationship with company, made it work
They were suspicious of tools capacities and role -L
Invalidated counterfeit solutions to avoid workflow disruption with printing and storing
High level of trust in physicians to adhere to new tools in innovation technology -A
EMR integration was planned as a future update
There are limits to data-driven tools that leverage user inputted data
Patients must wait more as a result of technical difficulties
Does not make AI costly to predict medical toxicity for complex patients
New technology should be reliable and durable
Significant emphasis placed on identifying atypical situations -A
Functional problems prolonged work process -A
Staff faced resistance from others who were dissatisfied by the tool.
Some staff did not want to try the innovation tool at all
Staff were in agreeance for dislike of tool
Team wanted innovation project to end
Doctors did not like discharge planning tool
Doctors did not like discharge planning tool due to their paternic structure
Doctors are not willing to change their workflows, resulting in more work for nurses to use the tool
Doctors did not like the tool leading discharge discussions as this is something they do
Tool did not fit into doctors' workflows in they changing patient type across hospital
Doctors did not like the innovative tool
Senior doctors don't like change and are not willing to update their workflow
Experts negative perception of new technology at first
Staff created a negative culture when one used using tool in workflow
Felt pressure from doctors surrounding the use of the tool in critical times
People are tired of pilots
Felt apprehension about asking their staff to change their routine
Technologies impeded robust and reliable workflows.
Innovation tool could change how work is done, which will affect case loads
Argues sees innovation that can make systems more efficient and effective
The technology was something completely new -L
Technically are used to manual work, systematizing is a novel technology is very overbearing
Innovation tool added additional work / responsibilities into workflows
Discharge planning tool was novel to staff members
Innovation tool required an update to the physical layout of work
The tool required additional steps in the workflow -L
It is difficult and time consuming to update existing workflows
Innovation tool will significantly alter existing workflows
Hesitation to tools needed to mesh existing workflows to avoid being a burden
Barriers in update existing workflow age, low technology skill, and human memory
Innovation tool does not have exact regulatory protocols yet
Innovation tool impeded existing workflows
People are used to the established way of doing the things -L
Tool will be replacing something in current workflow
Innovation tool added extra steps to existing workflows
Implementation of new technology is difficult
Sees existing workflow as more robust and reliable
Innovation tool added steps to workflow
Lack of innovation in pathology for many years
Sees potential for innovation tool to make remote/hybrid work possible
Innovation tool required additional tools like a monitor and dictaphe
Doctors are used to their existing workflows for many years, making change difficult
Staff preferred original workflow as it includes plans not to they usually and accustomed to formers
Innovation tool required additional tools like a monitor and dictaphe
Consistency should have been research on the environment of use
New technology should support staff in making their job easier and faster
Felt that the company was trying target staff to replace their workflow with their tool
Innovation tool had poor battery life
Portable x rays makes work portable and flexible
Company felt their technology was superior
Innovation tool's screen size was much smaller than existing technology
Manufacturing company did not design tool to match their workflow
New technology must meet their unique needs and requirements of work
Innovation tool made the process slower
The tool had design and reliability issues making hard to see in the make decisions -L
The tool doesn't account for many nuanced aspects of the decisions being made -L
New technology should not cause delays in workflows
Technological design failed to align with user needs -A
Innovation tool did not meet standards and protocols for imaging.
Innovation tool is expected to make the diagnostic process faster
Small screen size of innovation tool made doctor's work harder
Innovation tool is expected to reduce turn around times
Tool design did not meet work requirements
A lack of perceived value hinders engagement in the project
Staff are willing to use new technology and upgrade their workflow
Believes new tool is future for the field
Staff are willing to use new technology if its worth it
Feels excited for the workflow improvements in diagnostic innovation tool will bring
They are open to new technologies -L
Saw no potential for improvement in innovation tool
Evidence of positive impact creates positive perception -A
The tool did not add value to their workflow
Implemented technology that had more but its payoff made it worth it
New technology needs to add value to existing workflows
Staff are willing to use new technology if its worth it and utilizes cons
No perceived value for the tool
Believes new tool will help labour shortage issue
Staff do not like EMR as they don't see understand its benefits
New tool makes workload sharing for consultations possible and more reliable
Lack of perceived value creates resistance to change
New technology will allow hospitals to work together
Lack of engagement leads to project failures
Staff did not believe innovation project would be successful
Lack of perceived need as to why staff need to be willing to updating their workflow
Lack of need leads to lack of uptake
Lack of perceived need by hospital staff leads to lower staff engagement
Innovation project failed if the need is already resolved
They didn't perceive any value added to the process -L
Tool was a patient portal to share their health status
Lack of perceived need for the innovation tool
Pilot would not be possible without funding
Excited about potential for innovation technology to further improve
Sees potential for innovation tool to further support other workflows
Lack of funding is a barrier in innovation and adoption
Just knowing the discharge planning priority is not helpful
People need to understand how the tool will benefit them


Experience with pilot project
Pilot projects lack planning and organization
Multiple attempts to integrate the technology and unmet expectations negatively impacted its perception.
Pilot projects are not well resourced
Project outcomes were not discussed.
Technology implementation was abrupt, rather than phased.
Pilot projects lack effective communication workflows
Staff felt that their feedback was not always valued.
More training and workflow analyses could have been done with end users.