Preparing for change: Reflections on technology design research in real-world healthcare contexts

AMIRHOSSEIN ASADI, School of Cybernetics, Australian National University, Australia
ELIZABETH T. WILLIAMS, School of Engineering, Australian National University, Australia

Where technology meets care, the intersection is rich with both promise and complexity. In this evolving landscape, research efforts in Human-Computer Interaction (HCI) and Human-Robot Interaction (HRI) are pivotal, particularly in real-world studies that require active user involvement and multidisciplinary collaboration. Such research often comes with practical and logistical challenges that are rarely discussed in traditional research publications. This paper reflects on these challenges through the lens of a PhD study that encompasses four distinct research phases and is guided by pragmatism and the Design Science Research (DSR) methodology. Through the experiences of both the PhD student and primary supervisor, we delve into the challenges and nuances of being an outsider, addressing recruitment difficulties, nurturing multidisciplinary collaboration, managing the complexities of healthcare research culture, balancing diverse views on ethics and risk, and maintaining flexibility and adaptability. We present recommendations based on our experiences for researchers conducting HCI/HRI research in healthcare.

CCS Concepts: • **Applied computing** → **Health informatics**; • **Human-centered computing** → Collaborative and social computing devices; **Field studies**; • **Hardware** → *Emerging tools and methodologies.*

Additional Key Words and Phrases: healthcare, design science research, in situ studies, safety-critical systems, outsider perspectives, reflective practice

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1 Introduction

Both Human-Computer Interaction (HCI) and Human-Robot Interaction (HRI) are increasingly being recognised as critical areas in the development of healthcare technologies and robotics applications, providing essential insights that inform the design and development of these systems [33, 39]. HCI experts enhance user interfaces and usability, crucial for meeting complex healthcare needs [3]. Similarly, HRI is becoming more important in healthcare as robotic systems are seen as solutions to challenges posed by the growing number of vulnerable populations, rising healthcare costs, and shortage of qualified healthcare professionals [33].

The HCI and HRI fields have a rich tradition of conducting research in real-world and situated contexts, often drawing on ethnographic and field research methodologies to better understand stakeholder needs and behaviours. Various studies highlight the need to continue and expand this real-world research (see, e.g., [6, 23, 35, 40]). Such *in situ*

Authors' Contact Information: Amirhossein Asadi, amir.asadi@anu.edu.au, School of Cybernetics, Australian National University, Canberra, ACT, Australia; Elizabeth T. Williams, School of Engineering, Australian National University, Canberra, ACT, Australia, elizabeth.williams@anu.edu.au.

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research is particularly important in healthcare, where poor design decisions can lead to technology non-adoption, or worse, have negative impacts on the quality of patient care. Real-world studies have been suggested as a means of enhancing the adoption of technologies designed for such contexts [27, 38, 39]. At the same time, this work can be very difficult to carry out in practice. Considerations around patient safety and care present challenges for how to carry out such research safely, ethically, and effectively.

To navigate these challenges, the field has increasingly recognised the importance of multidisciplinary collaboration (e.g. [3, 38]) and active user involvement (e.g. [37]). The effective development of healthcare technologies relies on multidisciplinary collaboration among clinicians, scientists, engineers, and human factors experts to tackle complex problems, keep pace with modern science, integrate diverse perspectives, and establish clinical guidelines [4, 7]. Similarly, active user involvement is deemed crucial, as it ensures that the design and evaluation processes are closely aligned with the actual needs and experiences of end users [21, 26].

Despite widespread recognition of real-world, multidisciplinary, and user-centred research in healthcare technology development, a significant gap remains in the practical implementation of these approaches. This gap could be attributed to the fact that most research reports present a polished final method, with little mention of the researchers' learning process [5]. Addressing this gap is necessary for bridging the divide between theory and practice. Previous works, such as the collection of case studies presented by Furniss et al. [15] and the works of Blandford et al. [5] and Valdez and Holden [41], have provided valuable insights into the challenges and strategies associated with conducting this type of research in healthcare settings, particularly focusing on how researchers interact with contextual nuances that shape such research.

In this experience report, we aim to contribute to this discourse by reflecting on our experience to date in getting a multidisciplinary, user-centred, "in-the-wild" HRI-focused research project off the ground. The project in question has been carried out within the context of a PhD study. It involved four data collection activities, utilising a mixed-methods approach that included quantitative surveys, interviews, and observations, all guided by the pragmatist paradigm and Design Science Research (DSR) methodology.

Through engagement in reflective practice, we explore the practical challenges and considerations that arose when attempting to conduct research in this evolving field, and identify practical mechanisms for planning for such challenges in future work. While our focus is on illuminating actions researchers can take to design robust research approaches for such contexts, this work also aims to identify potential mechanisms for fostering more supportive ecosystems for such research. Our overarching goal in this work is to contribute to the understanding and development of effective strategies for supporting healthcare technology research and the researchers engaged in the process.

2 Background and context

Before getting into the specific settings and foci of our research, we will first contextualise the research objective and methodological approach driving our research design, and provide some background information important for contextualising the contribution we present.

2.1 Research objective

The primary objective of this PhD research was to explore the socio-technical challenges encountered by designers and developers in the development and integration of collaborative AI-enabled systems and robots within healthcare settings. Our research focused on "clinician-facing technologies" [4], with the goal of creating a framework to assist designers and developers in navigating these challenges.

2.2 Research paradigm and research methodology

In this research, pragmatism was chosen as the foundational philosophical paradigm, as it best aligns with the PhD study's objectives and the healthcare setting. Pragmatism emphasizes the use of the most effective methods for investigating real-world issues, permitting the integration of multiple data sources and forms of knowledge to address research questions [29].

The DSR methodology was chosen to structure the research design for this study due to its compatibility with pragmatism [17]. DSR aims to resolve problems through innovative artefacts—objects made by humans to address problems—that contribute new knowledge to the field [17, 18]. DSR can be structured into three cycles: relevance, rigour, and design [17], as shown in Figure 1. Drawing from [17], the relevance cycle begins the process by identifying a problem or opportunity within an application domain that the DSR process aims to address. The rigour cycle draws on existing theoretical and methodological knowledge systems to support a rigorous design process (hence the cycle name). In DSR, different theories and knowledge systems can be combined to support artefact design, and in this cycle, researchers are encouraged to communicate such approaches back into the knowledge base to support the improvement of existing theories. Finally, the design cycle uses inputs from the relevance and rigour cycles to design, develop, and evaluate artefacts.

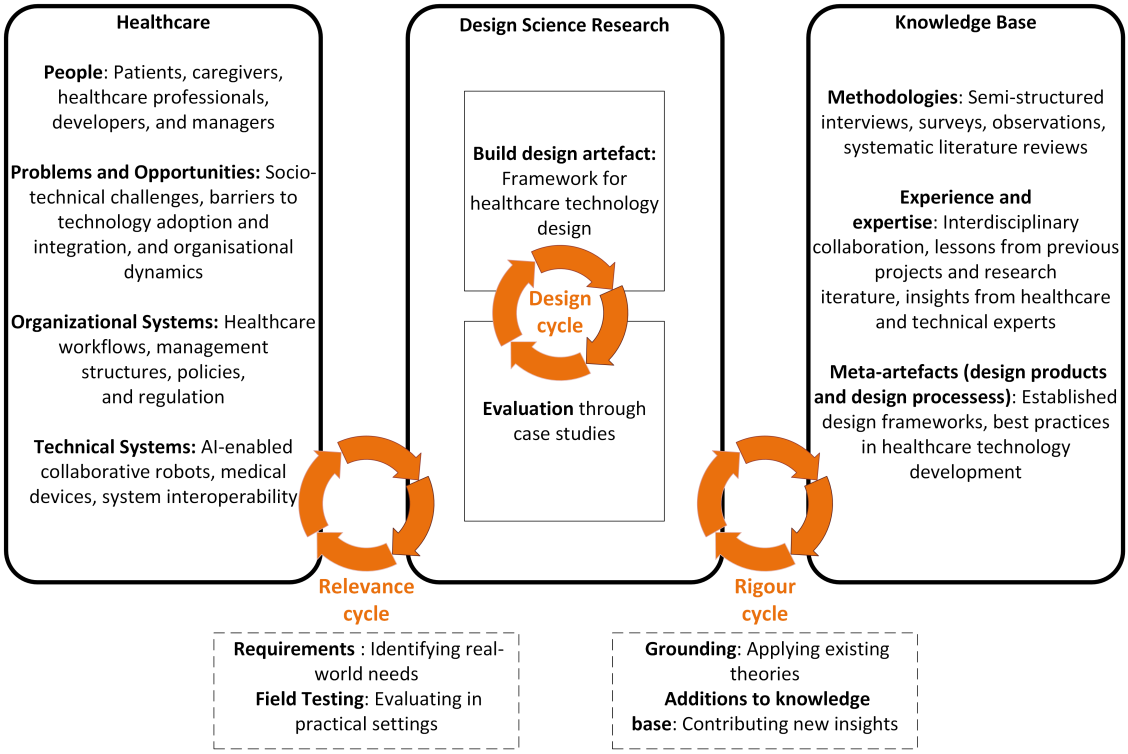

Fig. 1. The DSR framework as applied in our study, illustrating the relevance cycle (real-world requirements and field testing), the rigour cycle (grounding the study in theoretical frameworks and contributing insights), and the design cycle (involving the iterative development and evaluation of the framework). Adapted from [17].

The reflective stance of this paper is rooted in both the pragmatic paradigm and the DSR methodology. Pragmatism posits that human experience is crucial for understanding and developing knowledge [10, 19] (as cited by [1]), which is why we chose this stance to contribute to the knowledge around healthcare technology research by providing the practical insights gained from our own experiences. This also aligns with the DSR approach, where the rigour cycle connects research activities with the knowledge base [17]. This reflective stance allows us to add to the knowledge base by sharing our firsthand experiences and reflecting on them.

The perspectives of the authors strongly shape this output. To better contextualize the insights presented in this paper and illustrate how our perspectives have shaped the research, we next provide an overview of the authors' experiences and backgrounds.

2.3 Author perspectives

The PhD student and the first author of this paper was trained as an engineer with industry experience in robotics and medical device development. This expertise provided a strong foundation for understanding the engineering challenges associated with developing advanced healthcare technologies. However, during early field experiences, they became aware of the socio-technical challenges that often hinder the successful integration of these technologies into healthcare environments. Motivated by a desire to bridge the gap between technical innovation and real-world practical application, they embarked on this PhD project to explore these challenges more deeply.

Using the concept of insider-outsider from Dwyer and Buckle [11], where an insider shares characteristics, roles, or experiences with participants, and an outsider as one who does not, their stance is simultaneously that of an insider (as an engineer and designer of medical technologies), and outsider, as a non-native English speaker and international student conducting research in Australia, using qualitative and quantitative methods from the social sciences with limited exposure to from Masters training.

The supervisor and second author of this paper primarily provides an outsider perspective to this research. They were trained as a physicist and worked in academic environments with sometimes complex socio-technical dynamics and stringent safety requirements. They later engaged in research and education in multidisciplinary teams using qualitative and quantitative methods, and have served on a human research ethics committee. They have not previously conducted research or development work in the healthcare domain.

Our considerations throughout this project have been shaped by our interactions with others on the research team, which include a clinician practising intensive care medicine, a physiotherapist in a managerial role at the hospital where the research was conducted, and an academic working in robotics at an institution affiliated with the hospital. All our colleagues on this project have clinical roles in healthcare or have previously conducted research of this kind in care settings. They are not co-authors here, given that they bring an insider perspective to this work that is perhaps distinct from the perspective we aim to offer. We discuss how collaboration dynamics shaped our research below. First, though, we will present the nature of our research project, to provide context to that discussion.

3 Research project

3.1 Project phases

This research project was conducted in four phases. The study involved an initial exploratory phase, followed by three case studies examining specific applications and scenarios in greater depth. While the specific details, processes, and findings of each phase are beyond the scope of this paper, we will briefly outline the context and purpose of each phase.

- **Phase 1 - Exploratory phase**: Aligned with the DSR's problem identification phase, this broad phase aimed to understand the current landscape of healthcare technology development in Australia and its socio-technical dimensions. We conducted semi-structured interviews with developers, healthcare professionals, managers, and consultants for this phase.
- **Phase 2 - *A priori* acceptance study**: We conducted a quantitative survey to assess attitudes towards AI and robotics for intensive care applications among hospital staff, patients, and visitors.
- **Phase 3 - User and integration requirements study**: Semi-structured interviews and observations were used to gather user and integration requirements for an AI-enabled robotic system in intensive care, focusing on managers and healthcare professionals, including doctors and nurses.
- **Phase 4 - Evaluation of installed robotic system**: We evaluated the socio-technical aspects of integrating a robotic rehabilitation system into a hospital through semi-structured interviews and observations, targeting physiotherapists, allied health professionals, and managers.

Ethical approvals for this project were obtained as follows: Phase 1 by the Australian National University (ANU) Human Research Ethics Committee (HREC) (2021/832); Phase 2 by the ACT Health HREC (2023.LRE.00217) with subsequent ANU HREC approval (H/2024/0499); and Phases 3 and 4 by the ACT Health HREC (2024.LRE.00085) with subsequent ANU HREC approval (H/2024/0969).

4 Reflections and insights

In this work, we draw on the four phases of research as outlined above to reflect on how our research process has evolved in response to the diverse stakeholders and dynamics inherent to the real-world setting our research has focused on.

4.1 Being an outsider

The case studies of this project (phases 2, 3 and 4) were conducted in a field research manner, with the first author located at the hospital where our research was conducted. In the 2nd phase, the researcher had limited interaction with the clinical environment, as this phase primarily involved being stationed in the foyer of the hospital, inviting people to participate in completing the survey. However, the last two phases required direct connection with healthcare professionals and involved observing the operations within hospitals, including emergency situations, which were a significant part of the observations for phase 3.

The primary author felt distinctly like an outsider, as defined in Section 2.3, during these phases. This outsider status was particularly evident during the observations of intense and high-pressure hospital operations, where the researcher was not accustomed to the stress levels that healthcare professionals regularly navigate. This was partly due to the nature of the scenarios the researcher was observing; the work focused on observations of work conducted by part of the hospital's intensive care team, and stakes were high—indeed, potentially life-or-death for the patient. This feeling aligns with Moncur's observations [28] that research in sensitive, high-stakes settings like healthcare requires significant "emotional labour", which can amplify the sense of alienation for those unfamiliar with such environments.

The benefits of being an outsider included the ability to approach the research with a fresh perspective, asking questions and making observations that someone deeply embedded in the hospital environment might overlook. This outsider status allowed the researcher to maintain a level of objectivity, which is crucial in qualitative research, as it can lead to more critical and comprehensive analysis [30].

However, the challenges were significant as well—in line with the experiences of others conducting similar work [14, 34, 36]. The stress levels within the hospital, particularly during emergency situations, were unfamiliar and required the researcher to adapt quickly to an environment that demanded rapid decision-making and constant vigilance—conditions that are routine for healthcare professionals but overwhelming for someone not accustomed to them. This outsider status sometimes made it difficult to fully connect with the healthcare professionals during the interviews, as the researcher was not part of their world of experience, which could have potentially limited the depth of the data collected [2]. Additionally, the researcher's outsider status meant there were few support mechanisms in place to help the researcher cope with the stress introduced by the research—and in fact none beyond those provided as standard to other PhD students or informally through supervisory support and advice from those on the team more accustomed to working in clinical environments. Taking more care in understanding how healthcare providers prepare for work in high-stakes environments—and finding ways to access training and support prior to the commencement of field research—would have been highly beneficial. As argued by researchers in similar settings [9], support systems are essential to ensure the well-being of researchers, and proper preparation can significantly improve the researcher's ability to manage their role and emotional challenges in such high-stakes environments. This became clear only in retrospect.

4.2 Recruitment challenges

In the first phase of the research, we aimed to collect evidence characterising the research and development process for healthcare in Australia. Because the primary researchers did not have a strong and responsive network in the healthcare domain, participant recruitment was conducted primarily through advertisements on LinkedIn and other social media platforms. While this approach was effective in reaching a broad audience, it likely introduced a bias into the data collected.

Based on our reflections on the nature of the interview data we collected—particularly following our direct engagement with healthcare practitioners in later phases of research—the individuals who responded to these advertisements and expressed interest in participating in the research tended to exhibit techno-optimism in the sense that they were generally more familiar with and favourable towards technological advancements. In retrospect, we believe this is a function of the topic of research as presented in the advertisements we used (an example of which is provided in Fig. 2). We believe those without a positive predisposition towards technology were less likely to express interest in participating in technology-related research.

Recruiting participants for the subsequent phases of the research presented a different set of challenges, particularly given the specific context of the hospital where the studies were conducted. This hospital is a specialised rehabilitation facility, primarily serving patients who are undergoing recovery from serious illnesses, surgeries, or injuries. Patient demographics typically include older adults, individuals with chronic conditions, and those requiring long-term rehabilitation care.

Many of these patients are in poor health, which can make them less likely to participate in non-essential activities such as research surveys. As a result, our quantitative study did not attract as many participants as hoped, particularly among patients and visitors. Although the final sample size met the minimal threshold required for statistical analysis, it limited the broader applicability of our findings.

For the last two qualitative case studies, engaging healthcare professionals, whose schedules are often dominated by patient care and administrative responsibilities, required significant effort and flexibility. Many potential participants were willing to contribute, but finding suitable times for interviews was often difficult, especially with doctors and

Fig. 2. A recruitment advertisement used in the initial phase of our study, aimed at healthcare professionals and stakeholders involved in healthcare technology. The advertisement features an illustration created using DALL-E.

nurses. This challenge is echoed by Growth and Frykholm, who noted the difficulty of aligning research activities with the planned schedules of healthcare staff [16]. The intensity and unpredictability of clinical environments meant that planned interviews were sometimes postponed or cancelled, requiring the researcher to adapt and reschedule. Persistence— from both the participants and the researcher—shaped our participant pool as a result, and may have skewed findings in ways that are difficult to characterise.

4.3 Multidisciplinary collaboration

The latter three phases of this research were made possible by a 2-year multidisciplinary collaboration with experts from different disciplines. As noted above, our team for these research phases included both authors, the PhD student's co-supervisor, an intensive care specialist, and a department manager with a clinical background in physiotherapy and exercise physiology.

The intensive care specialist proposed the use of robots and AI in intensive care. Their experience working in clinical environments provided critical insights on how intensive care practices associated with our case study were carried out and what challenges clinical care teams faced that could be addressed by introducing robotic systems. This collaborator's contribution ensured that our research was aligned with real-world clinical needs, and our communications with clinical care stakeholders used the appropriate language and framing. The manager played a key role in organizing and facilitating data collection. They ensured we were able to reach the participant numbers and representation required for our research methods to be effective, and played a crucial role in ensuring that the views of those actively and routinely working with patients were represented in our data. The co-supervisor, whose expertise was in robotics, ensured we were aware of developments in HRI in healthcare and adjacent domain areas. They also ensured the language we used

to communicate with those working in HRI, engineering, and related fields was appropriate, and helped us identify audiences for our work to support the rigour cycle.

The benefits of working in a multidisciplinary team have therefore come in the form of recruiting participant groups we may not be able to reach otherwise, developing the skills needed (through collaboration) to address the multidisciplinary audiences our team needs to reach, and having a diversity of perspectives to draw on when challenges arose during our research. Having team members who understood the clinical environment, in particular, meant we could iterate more quickly and draw on approaches used in other disciplines to respond to challenges we faced in the hospital environment more effectively. This mirrors the experience reported by Growth and Frykholm, where close collaboration with a surgeon who actively contributed to their research was crucial for the project's success [16]. This is also consistent with Blandford *et al.*, who underscore that in the context of complex hospital organisations, having a clinician with a direct personal interest in the project can help set up studies that work for all stakeholders involved [5].

The benefits of working in a multidisciplinary team were only realised because of considerable work we put in from the start. Some of the work we did aligns with reports on the experiences of others (e.g. [16, 25]) in multi-disciplinary teams: (1) develop mutual understanding—particularly around key terms associated with our research, (2) agree on a way of working; (3) identify common ground in our interests; (4) identify ways of fulfilling disciplinary interests in mutually beneficial ways; and (5) find ways to navigate different disciplinary expectations (e.g. author order, key performance indicators) respectfully, with compromise in mind. In summary, we addressed the communication challenges many multi-disciplinary research projects are fraught with reasonably well within our team from the start because a subset of the team had done work in such contexts before and knew that frank discussions, held early and often, supported better outcomes for such projects.

In retrospect, we only did part of the work we needed to do to support the project and capitalise on the multi-disciplinary expertise of the team. In particular, we failed to adequately draw on the contextual knowledge of all researchers from the start. As a result, we often found ourselves drawing on this knowledge in the moment or after an incident requiring us to change our research approach had occurred. We address the specifics of this in more depth below in our discussion of the healthcare research culture.

4.4 Navigating healthcare research culture

Our attempts to recruit healthcare professionals exposed a broader issue within the research culture: a significant lack of interest in involvement in research activities, which research has shown is driven by barriers such as insufficient time and lack of organisational support [8]. Kemp et al., in the context of Australia [24], and Fradgley et al. in the context of Australia and New Zealand [12], highlight similar barriers, including limited recognition, organisational support, time, financial constraints, and opportunities for collaboration, which contribute to a weak research culture in these regions.

These barriers represent broader systemic challenges that, while not the focus of this study, are important for engineers and technology developers to be aware of when engaging in healthcare research. Initially, our assumptions were that more healthcare researchers and organizations would be willing to engage with research revolving around new technologies. However, as we delved deeper into the research, it became apparent that the constraints imposed by the existing research culture—such as limited time, resources, and support—significantly influence the capacity and willingness of healthcare professionals to participate in this type of research. Indeed, we found that willingness to engage in our work had more to do with the strength of the networks our clinical collaborators had access to than interest in the research itself. We found this despite choosing to do our work at a hospital affiliated with a university and designed to support research—and where incentives exist to encourage clinical staff to participate in projects like

ours. Understanding and designing for the constraints inherent to research in healthcare environments is, therefore, essential for tailoring approaches that align with the realities of the healthcare environment.

It is also important to acknowledge that healthcare professionals do not owe their time to research efforts. On reflection, we could have spent more time considering how to do this carefully and well for this project. Given the research focus of the institution, we may have assumed a greater interest than existed in those we hoped to recruit.

4.5 Accommodating diverse perceptions of ethics and risk

In any hospital setting, considerations of human research ethics and potential impact on patient care are paramount. In Australia, ethics review and approval processes for research involving human subjects are determined by the institution conducting the review, but such processes should conform to the guidelines offered in Section 5 of the National Statement [32]. These guidelines, and the institutional processes designed to implement them, are meant to support ethical research design. However, such review processes are typically linear, often focus on traditional experimental designs [36], and can make it difficult for the researcher to be responsive to challenges encountered in the field (see e.g. [13, 22, 31]). Additionally, Randell highlights that researchers need to carefully balance the rigid demands of ethics committees with the practicalities of conducting research in dynamic environments [34].

In our work, we used the following strategies to mitigate uncertainties in the ethics review process: (1) we used a survey instead of interviews to capture patient perspectives in phase 2, which gave them more power to decide whether or not to contribute but led to less depth in our findings, (2) we proposed diverse research methods in different phases of our project to mitigate uncertainties in risk perceptions shaping the ethics review process, (3) and we broke our research project into three separate low-risk ethics protocols to avoid having the ethics review process halt all aspects of the project, either due to the complexity of what we proposed, or due to perceived risks associated with a subset of the research we intended to do.

On reflection, our primary takeaway for HCI/HRI researchers conducting similar projects is the need to plan effectively for unknown differences in risk perception and management amongst humans and organisations involved in either conducting, assessing, or participating in the research. Based on our experience—both throughout the ethics review processes and while conducting the research—the risk perceptions and tolerances shaping ethics review processes may differ significantly from those that shape dynamics in the environment where the research is being conducted. For instance, observations of patients receiving care, however carefully planned, tended to result in diverse reactions both in the review process and in situ, possibly stemming from the impact of lived experience on perception. This aligns with existing research, which points out a disconnect between the protocols approved by research ethics boards and the practical realities researchers encounter when conducting HCI research in non-traditional environments [31].

Regarding our approach of breaking down the project into sub-phases of research, this strategy *may* have helped the committees understand our research—but we cannot directly evaluate this. It *did* require us to manage divergent requirements across the research phases, and also made the timeline for the different phases of research unpredictable, making it difficult for us to plan adequately each research phase. For future work, we would combine our proposals in a single review where feasible, but give ourselves flexibility in managing different risk tolerances and management approaches through careful methodological design. This would give us more space to respond to unexpected ethics committee perceptions and also adjust our research appropriately based on in-field observations of how research participants directly perceive and experience the risks of engaging in research.

Challenges we identified on both of these fronts could potentially be addressed as follows: (1) by choosing methodological approaches designed to be responsive (to the extent feasible) to different perceptions of risk, (2) by putting in

place training that helps researchers appropriately manage differences in communicated or experienced risk perceptions in the field and challenges that may arise as a result of such experiences, and (3) by being aware from the start of how such differences in risk perception can affect both the ethics review and research processes.

4.6 Embracing flexibility and adaptability

In navigating the complexities of our research, flexibility and adaptability were crucial. Throughout the project, we encountered instances where rigid adherence to our original research objective and plan would have limited our findings and led to missed opportunities for deeper exploration. This aligns with the advice of Hilligoss [20], who specifically cautions healthcare technology researchers to expect surprises, both positive and negative, and remain flexible in order to accommodate these unexpected developments.

The work we reflect on here supports this importance. The first major shift occurred after the exploratory interviews in phase 1. Initially, our research focused solely on the evaluation of healthcare technologies. However, these interviews highlighted that while evaluation is important, the healthcare technology field faces many challenges at earlier stages, including acceptance and implementation. This realisation prompted us to broaden our research focus.

Another example arose during the third phase, where we studied a robotic rehabilitation system. This was not part of our original plan, but emerged as a significant opportunity during discussions with hospital management, who had recently installed the system. Recognising the potential to examine real-world integration challenges, we strategically pivoted to include this case study.

However, this adaptability brought its own set of challenges. Shifting our focus required us to quickly develop a thorough understanding of the robotic rehabilitation system and its operational context. Additionally, we had to engage with a new set of stakeholders, adjust our data collection methods, and revise our ethics protocols to accommodate the new direction of our research. Such shifts can be particularly challenging for a PhD researcher, as they often require balancing the need for flexibility with the constraints of time, resources, and the original research scope defined at the outset of their studies.

5 Conclusion

While technology holds great promise for addressing many challenges in healthcare, conducting research in this domain is fraught with unique difficulties due to its inherent complexity and safety-critical nature. This paper has provided an in-depth reflection on our experiences navigating these challenges in a real-world research context.

We have highlighted several key challenges, including managing insider-outsider dynamics, overcoming obstacles in data collection and recruitment, and navigating the often complex research culture within healthcare. Additionally, we explored the need to accommodate diverse perspectives on ethics and risk, and examined both the advantages and challenges of working within multidisciplinary teams.

All of these challenges—and our proposed responses for managing them—emphasize the importance of maintaining flexibility and adaptability throughout the research life-cycle for projects conducted in real-world healthcare settings. Such environments are not possible to fully characterise and plan for in advance, so our hope is that the insights we have gleaned from our own research will offer valuable guidance for future researchers, helping them to better plan and execute healthcare technology research projects in similarly complex environments.

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