

A Web-based Enabler for Rehabilitation Care at Home: Cardiac Rehabilitation and More

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Abstract

Cardiovascular diseases pose a significant health challenge worldwide, affecting millions of individuals. A key component of recovery is cardiac rehabilitation (CR), which involves a combination of exercise, education, and lifestyle changes. Despite the established benefits of CR, patient adherence and completion rates are low. Factors such as cost and distance (i.e., having to drive, or travel for long distances to attend a clinic) often deter patients from participating and pursuing CR towards completion. To address these issues, we attempt to answer the following research question: How might a digital health solution be developed to improve access to cardiac rehabilitation? Using design science research methodologies, we have developed a web-based prototype as an attempt to answer the above research question. Our solution has a clinician-facing interface and a patient-facing interface. Our solution enables patients accessing personalized exercise plans and educational resources from the comfort of their home. The solution enables clinicians to supervise patients and monitor their progress. We have concluded one round of co-design. The initial need for this CR solution was highlighted by a senior clinician, which served as our starting point. We undertook a 6-week project to create a prototype to serve the needs presented by the clinician. The prototype was then presented to the senior clinician for assessment. The qualitative feedback received suggests that our web-based framework has wider applications beyond CR and could be adapted to general rehabilitation care. Furthermore, our framework could be customized to provide patient education on various hospital procedures and processes. This paper documents our progress thus far. We highlight the results at the conclusion of our first co-design phase, and the potential of our solution is emphasized.

Keywords: Cardiac rehabilitation, digital health, web-based prototype, Design Science Research Method (DSRM), Co-design.

1. Introduction

Cardiovascular diseases (CVDs) impact millions of people and exert a significant strain on healthcare systems worldwide. For example, in Australia, CVDs collectively affect about 5.2% of the population, which is around 1.3 million individuals (ABS, 2022). These ailments account for an alarming 25% of all fatalities in the nation (AIHW, 2023). The situation worldwide is just as serious, with CVDs standing as the primary cause of death, contributing to 32% of all deaths worldwide (WHO, 2021). This prevalence of CVDs calls for the urgent need for effective prevention, management, and rehabilitation strategies.

Cardiac rehabilitation (CR) is a crucial element in the ongoing care for those with CVDs. It includes exercise programs, management of risk factors, and emotional support, aimed at improving patient recovery and life quality. However, despite its established advantages, CR is not fully utilized, with less than half of eligible patients participating (Beatty et al., 2023). Factors such as distance, work obligations, and difficulty of transportation lead to this low compliance. As a result, it is important to investigate new strategies to improve accessibility and participation in CR.

With the aim of addressing some of the issues with CR, arises our research question: How might a digital health solution be developed to improve access to cardiac rehabilitation? This question is not only relevant but also crucial in addressing the shortcomings in CR delivery.

Utilizing design science research methodologies (Hevner et al., 2010; Hevner & Wickramasinghe, 2018; Peffers et al., 2007), we created a prototype for a web-

based solution that has the potential to enhance CR delivery. Our solution presents a framework that has a patient-facing interface and a clinician-facing interface. The clinician-facing interface is designed to combine and upload exercise plans and other educational resources personalized to patients. These can be accessed by the respective patients from the comfort of their home through the patient-facing interface. Moreover, the patients can provide feedback on the resources and their progress. This feedback and patient progress can in return be tracked by respective clinicians through the clinician-facing interfacing. Our initial qualitative assessment of this solution weighing on perspectives of a senior clinician shows that the potential influence of this solution goes beyond CR delivery. The feedback received indicates that our web-based solution could be adapted for broader rehabilitation care. In addition, our system can be tailored to offer educational resources to patients about different hospital protocols and procedures. This paper reports our progress thus far. We highlight the outcomes at the end of our initial co-design stage, and the potential of our solution is emphasized.

2. Review of some platforms available for at-home CR delivery

Few solutions have already been developed to deliver at-home cardiac rehabilitation. Some of them have been developed to a commercial scale. Some such solutions are identified and reviewed in this section for insights.

The Australian eHealth Research Centre, in partnership with Queensland Health, has developed an online cardiac rehabilitation platform known as Cardihab™ (CSIRO, 2019). This platform, which includes a web portal for clinicians and a smartphone app for patients, allows for remote access to cardiac rehabilitation tools. This means patients can participate in rehab from their homes, reducing the need for regular outpatient clinic visits. Cardihab™ provides key elements of cardiac rehab, such as education, behavior change, and psychological counseling, tailored to the patient's clinical needs. Clinicians can remotely access patient data through a web portal, improving communication and outcomes. Cardihab™ was commercialized in 2017 after securing venture capital and has shown health outcomes that are comparable or superior to traditional rehabilitation programs (CSIRO, 2019).

Carda Health (CardaHealth, 2023) provides a virtual cardiac rehab program that can be accessed from home. It offers treatments that are similar to those provided by in-person cardiac rehab programs. Patients can participate in exercises and receive support

remotely, making it a convenient choice for home-based cardiac rehabilitation (CardaHealth, 2023).

During the COVID-19 pandemic, innovative approaches to cardiac rehabilitation have been developed, including hybrid models (Dalal et al., 2021). These models blend virtual and in-person elements, offering patients more choice and potentially increasing the uptake of cardiac rehab. While these are not specific commercial tools, hybrid models provide flexibility and adaptability for patients seeking home-based rehab (Dalal et al., 2021).

However, it is crucial to understand the limitations and gaps in the existing solutions. Some of these limitations and gaps include:

Firstly, while home-based tools like Cardihab™ and Carda Health offer convenience, some patients may struggle to engage consistently. Factors such as technological literacy, motivation, and adherence can affect the effectiveness of these tools. Therefore, there is a need for interventions that address these engagement barriers to improve long-term outcomes (Dalal et al., 2021).

Secondly, commercial tools may not adequately consider cultural diversity (Cardihab, 2022). Patients from diverse backgrounds may have different preferences, beliefs, and health practices. A lack of culturally tailored content is a weakness that could potentially affect patient engagement and outcomes. Therefore, it would be beneficial to adopt more culturally sensitive approaches in cardiac rehab tools and have platforms that are easily adaptable to culturally sensitive and new material.

Thirdly, despite the potential of remote tools, geographic disparities remain (Cardihab, 2022). Patients in rural or underserved areas may face challenges accessing reliable internet or mobile networks, in addition to transportation difficulties. Therefore, it is important to focus on equitable access to cardiac rehab, perhaps with a multimodal approach that includes downloadable text resources and phone consultations, in addition to videos.

Fourthly, while tools focus on physical aspects, they often neglect psychosocial support. Emotional well-being, anxiety, and depression play significant roles in recovery (Dalal et al., 2021). Existing tools may lack comprehensive strategies for addressing these aspects. Therefore, it is important to adopt holistic approaches that integrate additional services such as mental health support. More importantly, it is beneficial to have platforms that are easily adaptable to facilitate any additional services.

Lastly, cost implications are a significant barrier. Although home-based cardiac rehab is more cost-effective compared to traditional center-based programs (Dalal et al., 2021), there are still cost implications.

Some patients may struggle with out-of-pocket expenses related to technology, subscriptions, or equipment. Therefore, it is important to minimize financial barriers and promote affordability.

Driven by these gaps, we were motivated to develop a web-based prototype for at-home cardiac rehab that could potentially offer more robustness and flexibility in terms of factors such as ease-of-use, cultural sensitivity, ease-of-access, and affordability.

3. Theoretical grounding

3.1. Design Science Research Methodology

This study is centered around the creation of an artifact, adhering to the principles of Design Science Research Methodology (DSRM) as outlined by (Baskerville et al., 2018).

DSRM is a systematic approach for the conception, design, development, and evaluation of artifacts, with the aim of optimizing their desirability to fulfill stakeholder requirements. The methodology typically encompasses six stages: (1) Identifying and understanding the problem; (2) Establishing solution objectives; (3) The design and development phase; (4) Demonstration; (5) Evaluation; and (6) Communication. Each of the initial five stages can incorporate research, which is aimed at comprehending and resolving any issues to enhance the desirability of the artifacts. For further details, seminal publications by (Hevner et al., 2010; Hevner & Wickramasinghe, 2018; Peffers et al., 2007), are recommended.

In essence, DSRM merges creativity, practicality, and academic rigor to generate practical solutions for real-world problems. It enables researchers to collaborate with stakeholders, produce artifacts, and make significant contributions to both theoretical and practical fields.

3.2. Theory of Task Technology Fit

The assessment of the artifact designed in this study, i.e., the web-based solution for delivering at-home cardiac rehabilitation, was grounded in the theory of Task Technology Fit (TTF) proposed by (Goodhue & Thompson, 1995). TTF is a widely recognized approach for determining the suitability of artifacts, particularly those rooted in information systems. The theory of TTF posits that IT systems are more likely to be usable, desirable, and have a significant impact if their capabilities align with the tasks that users need to perform (Goodhue & Thompson, 1995). Consequently, the semi-structured interviews conducted for the assessment of our artifact were guided by this theory.

4. Methodology

The methodology used in this study, which is inspired by DSRM, is illustrated in Figure 1. Provided in Table 1 is a list of the participants involved in the design process. The subsequent subsections are dedicated to detailing the different phases of the design process.

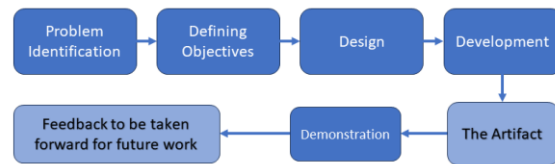


Figure 1. Methodology (inspired by DSRM) followed in this study (the text is legible, please zoom in to read).

Table 1. The research team that conducted this study.

Researcher's code	Description about the participant	Role in the project
C1	Senior Clinician (Doctor)	Clinician consultant
A1	Professor in Digital Health	Principal Investigator
R1	Research Fellow in Computer Science	Associate Investigator
R2	Research Fellow in Computer Science	Associate Investigator

4.1. Phase of Problem Identification

During the problem identification phase, researchers A1 and R1 held a meeting with C1 to discuss the requirements for a digital health solution to enhance the delivery of cardiac rehabilitation. C1 highlighted the significance of cardiac rehabilitation and shared some experimental digital health solutions that have been implemented at his hospital to facilitate during the COVID-19 period. These solutions were designed to educate and guide patients about specific hospital procedures they would undergo. Drawing from these trials, C1 stressed the need for similar solutions in the field of cardiac rehabilitation. This conversation served as a source of inspiration for our work. The discussion culminated in a list of strengths, weaknesses, opportunities, and threats (SWOT) associated with digital health solutions for cardiac rehabilitation. This SWOT analysis is presented in Figure 2.

4.2. Phase of Defining Objectives

After the successful execution of the problem identification phase, A1 managed to secure a seed grant intended for a concentrated 6-week mini project. The decision was made to allocate this funding towards the design and development of a prototype for a digital health solution, specifically tailored for cardiac rehabilitation. This crucial phase was spearheaded by researchers R1 and R2, who planned and set achievable objectives to be accomplished within the 6-week timeframe. These carefully crafted objectives are detailed in Figure 3. Figure 3 is provided later under the Results section.

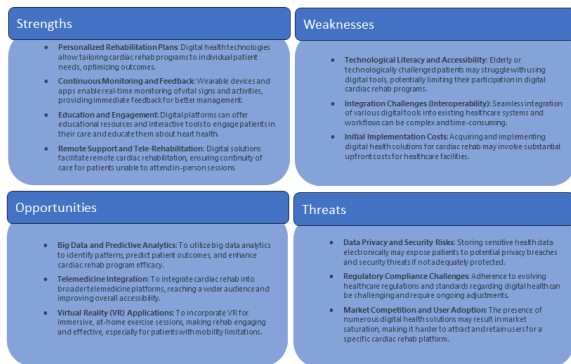


Figure 2. Analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT) for digital health solutions in cardiac rehabilitation—the outcome of the phase of ‘Problem Identification’ (the text is legible, please zoom in to read).

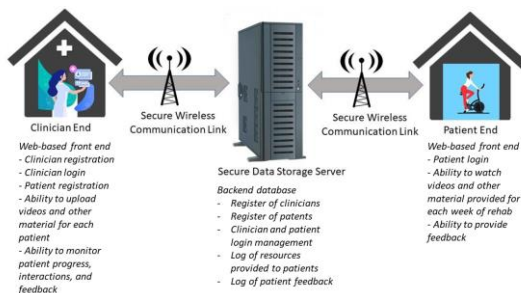


Figure 3. Objectives and deliverables planned for the 6-week project—the outcome of the phase of ‘Defining Objectives’ (the text is legible, please zoom to read).

4.3. Phase of Designing

A consensus was reached on the design elements depicted in Figure 3. The design was to include:

(a) A web-based frontend interface specifically tailored for clinicians, providing them with a user-friendly platform to interact with the system;

(b) A separate web-based frontend interface designed for patients, ensuring they have a seamless and intuitive experience; and

(c) A robust database backend, constructed with the capacity to gather and store as much data as possible, thereby facilitating comprehensive analysis and insights.

During this design phase of the project, R1, in close consultation with A1, crafted skeletal illustrations for each of the segments of the planned solution. These illustrations served as preliminary visual representations of the proposed design, providing a tangible blueprint for the team to work from. Examples of these skeletal illustrations, which offer a glimpse into the early stages of the design process, are provided in Figures 4 and 5.

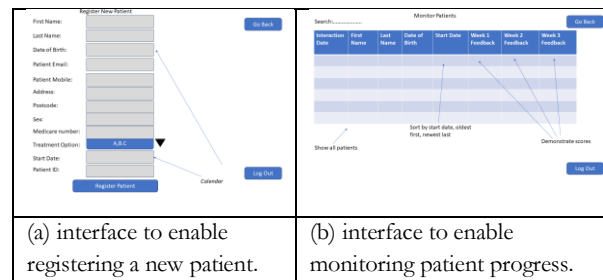


Figure 4. Some initial designs sketched to guide the clinician-facing interface (the text is legible, please zoom in to read).



Figure 5. A design sketched for the patient-facing interface to display videos (the text is legible, please zoom in to read).

4.4. Phase of Development

During this phase, development work was undertaken guided by the designs sketched in the previous phase. R2 was responsible for crafting the web-based front ends. Utilizing HTML, R2 transformed the designs from the previous phase into functional web-based front-end interfaces. It was agreed to keep the interfaces free from clutter, i.e., large fonts, no more than a handful of options to click on, contrasting colors

between fonts and backgrounds. These simple and decluttered design features were inspired by some of our previous design experiences with smartphone and web applications (Dang et al., 2023; Thodis et al., 2023; Ulapane et al., 2023a, 2023b; Ulapane, Forkan, et al., 2024; Ulapane, Wickramasinghe, et al., 2024). These interfaces were designed with both clinicians and patients in mind, to help us ensure an intuitive and seamless user experience. In the end, two interfaces were designed—one for clinicians, and the other for patients. Snapshots of these interfaces are provided later under the Results section.

While R2 was developing the web-based front-end interfaces, R1 focused on the development of the necessary database backends. This involved creating a robust and secure data storage solution to handle the data generated by the system. In addition to this, R1 also developed PHP interfaces. These interfaces were crucial in enabling key communication processes, such as the registration and login procedures for both clinicians and patients.

Upon completion of the development work, the frontend and backend components were seamlessly integrated to form a cohesive system. The resulting website—a culmination of careful planning and diligent development—was then hosted on a private hosting platform, ready for use.

4.5. The Artifact

The outcome of the ‘Phase of Development’ was an intricate and multifaceted website, which served as the artifact. As mentioned before, this website was designed with a dual interface—one end catering to clinicians and the other dedicated to patients—all underpinned by a robust backend database.

The clinician-facing interface was designed to empower healthcare professionals with several capabilities. It provided a platform for clinicians to register themselves and their patients, thereby creating a unique digital identity for each user. Furthermore, it served as a conduit for clinicians to disseminate educational and therapeutic material to their patients. This interface also offered a comprehensive view of each patient’s progress, allowing clinicians to monitor their journey and receive valuable feedback.

On the other side there comes the patient-facing interface. This was designed with a focus on user-friendliness and accessibility. Our principles of simple and decluttered design (Dang et al., 2023; Thodis et al., 2023; Ulapane et al., 2023a, 2023b; Ulapane, Forkan, et al., 2024; Ulapane, Wickramasinghe, et al., 2024) were especially helpful when designing for patients. Patients could log in using their unique credentials, ensuring data privacy and security. Once logged in, they had access to

a wealth of material provided by their clinicians. This interface was not just a passive recipient of information but also allowed patients to actively participate in their healthcare journey by providing feedback.

To give a visual representation of this artifact, screenshots are provided in Figures 6 to 10 that come under the Results section. These figures provide a glimpse into the simple and decluttered design and the functionality of the website, showcasing the seamless integration of the clinician-facing and patient-facing ends with the backend database. This artifact, therefore, stands as a testament to the successful completion of the ‘Development’ phase of this project.

4.6. Phase of Demonstration and Assessment

The assessment of the artifact was conducted in two distinct phases: an internal assessment and an external assessment.

During the internal assessment phase, a meeting was convened by A1 (the professor in Digital Health who spearheaded the project), and R1 (Research Fellow). This meeting was held with C1 (the senior clinician who partnered at the beginning of the project). A1 and R1 presented the progress made detailing the advancements since their initial meeting with C1. Following this, R1 showcased the artifact to C1, demonstrating both the clinician-facing and patient-facing interfaces, as well as the underlying databases.

C1 was then invited to provide feedback, marking the internal assessment of the artifact. Prior to giving feedback, C1 was guided to adhere to the principles of Task Technology Fit (TTF). This involved asking C1 to comment on the task characteristics of cardiac rehab clinicians, the technology characteristics of the artifact, and the degree to which the artifact could support the tasks of cardiac rehab clinicians. The conversation was open and free flowing, with transcripts being recorded for future reference. C1 provided valuable feedback, emphasizing the potential of the solution to extend beyond cardiac rehab and support other healthcare services. The feedback from C1 is discussed in detail in the Results section.

The external assessment phase involved a meeting with an external expert in health. The website was demonstrated to the expert. Similar to the guidance provided to C1 during the internal assessment, the external expert was also encouraged to provide feedback based on the principles of TTF. The feedback was duly recorded. Moreover, the external expert expressed interest in potential enhancements that could be incorporated into the solution in the future. These suggestions were documented as a wish list of potential additions to the solution. This wish list is presented in Figure 11 in the Results section.

4.7. Feedback to be Taken Forward for Future Work

The phase of ‘Demonstration and Assessment’ yielded significant results, most notably the constructive feedback from C1 during the internal assessment, and the comprehensive wish list outlined in Figure 11. As said earlier, the wish list was formulated based on insightful feedback from the external health expert consulted during the external assessment. Both the feedback and the wish list contribute to the enhancement of the cardiac rehab solution, transforming it into a more robust system. Such an enriched solution could generate valuable insights and provide personalized care, extending its benefits beyond cardiac rehabilitation to encompass other healthcare services as well.

5. Results

5.1. The Web-based Solution

Figures 6 through 10 offer visual representations of the web-based solution that has been designed and developed. These figures with their captions are largely intuitive and have been presented without additional explanations to maintain clarity.

Welcome to cardiac rehab admin page.



Figure 6. The welcome page to both clinicians and patients—the two buttons can be clicked, and the users are connected to their respective pages.

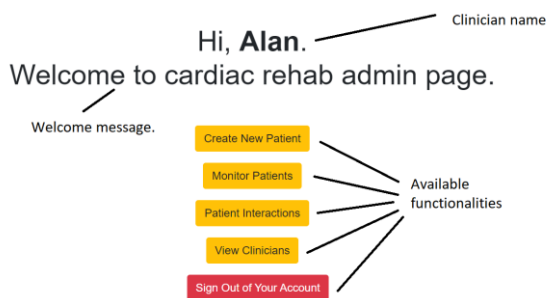


Figure 7. The main page inside the clinician’s portal—the marked buttons can be clicked, and the users are connected to the respective pages (the text is legible, please zoom in to read).

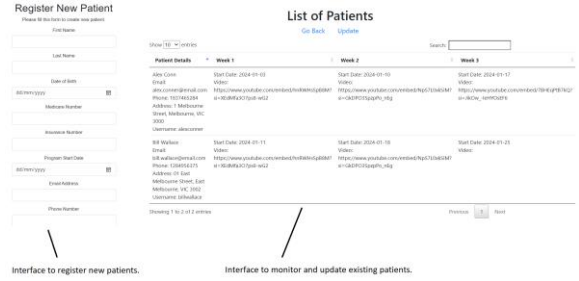


Figure 8. Some interfaces inside the clinician’s portal (the text is legible, please zoom in to read).

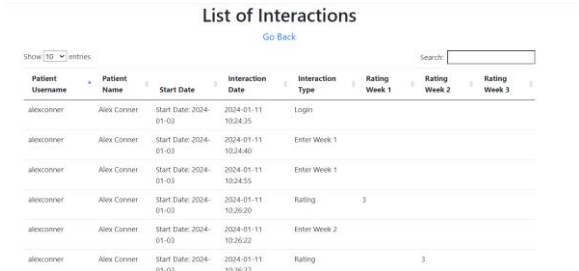


Figure 9. The interface in the clinician’s portal to monitor patient progress and interactions (the text is legible, please zoom in to read).



Figure 10. Some interfaces inside the patient’s portal (the text is legible, please zoom in to read).

5.2. Outcomes from the Internal Assessment

The feedback from the senior clinician (C1) on the developed web-based cardiac rehab solution was largely positive, with C1 expressing a favorable impression regarding the system. However, the feedback also highlighted several critical areas that require further consideration and development.

5.2.1. Interoperability and Integration. C1 raised concerns about the platform’s compatibility with existing hospital systems, particularly considering recent cybersecurity issues. Specifically, C1 asked, “What is this [the web-based solution] built on? Obviously, that will have implications for integration into what we have [at our hospital] because, you know, because of the new cybersecurity issues, everything is now locked down. So, we are really struggling to interact with anything outside...” This highlights the persisting issues with cybersecurity and the need for a universal healthcare platform that can seamlessly

interact with various hospital systems while maintaining robust security measures.

5.2.2. Versatility and Scalability. C1 recognized the potential of the solution to be adapted for various healthcare services beyond cardiac rehab, stating, “This has got potential in making it as generic as possible and cardiac rehab is [just] one project...” This implies that the solution can be designed with scalability in mind, ensuring it can be effectively tailored to different healthcare contexts.

5.2.3. Health Literacy and Patient Engagement. C1 appreciated the inclusion of video instructions in the solution, highlighting the importance of diverse information dissemination modes in healthcare. C1 noted, “This is good, the video instructions. That’s the one thing that I was actually very interested in because if you focus this as a health literacy improvement effort, because we have real difficulties for people to understand and patient(s) might have anxiety...” This suggests that the platform could be further developed to enhance patient engagement, possibly through the incorporation of additional multimedia content or interactive features. These may not necessarily be limited to cardiac rehab, but they could be regarding any healthcare service that is required.

In conclusion, while the web-based cardiac rehab solution has been positively received, the feedback from C1 provides valuable insights into areas where further development could enhance the effectiveness and usability of the solution. These areas include interoperability and integration, versatility and scalability, and health literacy improvement and patient engagement. Addressing such issues will be crucial in ensuring the solution’s successful implementation and its potential impact on healthcare delivery.

5.3. Outcomes from the External Assessment

The external health expert, who was consulted for this external assessment, enthusiastically suggested several additional features that could enhance the system. These proposed enhancements were documented as a wish list, categorized under the following headings: Health Data, Patient Information, Wellness Tracking, Messaging System, and Accessibility Features. The complete wish list is depicted in Figure 11.

Wish list of data and notifications to be handled in future developments

<p>Health Data:</p> <ul style="list-style-type: none"> - Medications - Blood Pressure - Heart Rate - Blood Glucose - Diet Log - Exercise Log - Comorbidities 	<p>Patient Information:</p> <ul style="list-style-type: none"> - Age - Weight - Height - BMI - Waist circumference - Hip circumference - Sex - Ethnicity - Pets - Environmental / pollution details 	<p>Wellness Tracking:</p> <ul style="list-style-type: none"> - Mood - Weather - Symptoms - Feedback <p>Messaging System:</p> <ul style="list-style-type: none"> - Motivational Messages - Reminders (To-Do List) - Reminders (Not-to-Do List) 	<p>Accessibility Features:</p> <ul style="list-style-type: none"> - Solution Available in Different Languages - Weather-Specific Advice - Behavioural Support - Follow up and significant life events – avatar
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Figure 11. The wish list of data, notifications and additional features to be handled in future work (the text is legible, please zoom in to read).

6. Discussion

6.1. Research Problem

Cardiovascular diseases pose a significant health challenge worldwide, affecting millions of individuals. A key component of recovery is cardiac rehabilitation (CR), which involves a combination of exercise, education, and lifestyle changes. Despite the established benefits of CR, patient adherence and completion rates are low. Factors such as cost, and distance to travel to clinic often deter patients from participating and pursuing CR towards completion. Given that premise, the research question we attempted to answer is: How might a digital health solution be developed to improve access to cardiac rehabilitation?

6.2. Summary of the Developed Solution

Using design science research methodologies, we developed a web-based prototype to address the research question. Our solution has a clinician-facing interface and a patient-facing interface, underpinned by a robust backend database. The clinician-facing interface provides a platform for clinicians to register themselves and their patients, disseminate educational and therapeutic material, and monitor patient progress. The patient-facing interface, designed with a focus on decluttered design, user-friendliness, and accessibility, allows patients to access material provided by their clinicians and actively participate in their healthcare journey by providing feedback, all while enjoying the comfort and privacy of their home.

6.3. Contribution to Theory

Our work contributes to the theory of design science research methodologies in healthcare. We add to the literature that demonstrates how these methodologies can be applied to develop a digital health solution that addresses a significant health challenge. Our principles of simple and decluttered design were

especially helpful when designing for patients, contributing to the theory of user-friendly design in healthcare applications.

Of equal significance, we have conducted co-design at two levels, i.e., 1) with clinician users, and 2) with patient and their family users. In our internal assessment, the senior clinician (C1) represents a clinician user. In our external assessment, the health expert consulted, while being a university academic, can also be considered a representative for patients and family members. Our sample size for this assessment was obviously small—one participant in each category, as this was the conclusion of our very first co-design cycle. Despite that, the point to note is that the same model of assessment can be replicated in further codesign rounds with more participants. For healthcare, this is significant given that users are not heterogenous, and clinical users and patient users have different needs, levels of health and tech literacy and time availability. Thus, our use of DSRM in this way is a unique theoretical contribution.

6.4. Contribution Practice

Our solution contributes to practice by providing a digital platform for cardiac rehabilitation that can be accessed from the comfort of a patient's home. This could potentially increase patient adherence and completion rates for CR. Furthermore, our solution could be adapted to general rehabilitation care and other healthcare services and be customized to provide patient education on various hospital procedures and processes.

6.5. Limitations of the Study

The feedback from the senior clinician (C1) highlighted several critical areas that require further consideration and development. These include the platform's compatibility with existing hospital systems, particularly considering recent cybersecurity issues, and the need for a universal healthcare platform that can seamlessly interact with various hospital systems while maintaining robust security measures. The solution also needs to be designed with scalability in mind, ensuring it can be effectively tailored to different healthcare contexts.

6.6. Directions for Future Work

Future work will focus on addressing the limitations identified in the study. This includes enhancing the interoperability and integration of the solution with existing hospital systems, improving its versatility and scalability, and further developing the

platform to enhance patient engagement, possibly through the incorporation of additional multimedia content or interactive features. The external health expert's wish list, which includes enhancements in Health Data, Patient Information, Wellness Tracking, Messaging System, and Accessibility Features, will also guide the future development of the solution.

7. Conclusions

This study was driven by the worldwide health burden of cardiovascular diseases and the pivotal role of cardiac rehabilitation (CR) in the recovery process. Despite the proven benefits of CR, we emphasized the problem of adherence and completion rates remaining suboptimal due to barriers such as cost, and the difficulty faced by cardiac patients in driving or traveling to clinic.

Our response to this challenge was the development of a web-based prototype, designed to bridge the gap between patients and CR. The dual-interface solution we proposed caters to both clinicians and patients and offers a platform for the delivery and monitoring of CR and facilitates active patient participation in their healthcare journey from home.

The theoretical contribution of our work lies in its application of design science research methodologies in healthcare, and the practical contribution is the potential enhancement of patient adherence and completion rates for CR. The solution's adaptability for other healthcare services and its potential for customization further extend its practical implications.

However, our study is not without its limitations. Feedback received during assessment of the solution emphasized the need for compatibility with existing hospital systems, robust cybersecurity measures, and scalability across different healthcare contexts. Future work should be aimed at addressing such limitations. There are some persisting gaps at present that inhibit the desired enhancements in interoperability, versatility, scalability, and patient engagement. Addressing these hindrances needs collective effort from multiple stakeholders involving technology, healthcare, regulatory, security, financing stakeholders and more. The wish list provided by the external health expert during our external assessment, encompassing areas like Health Data, Patient Information, Wellness Tracking, Messaging Systems, and Accessibility Features, will serve as a roadmap for future development.

Our study in conclusion offers a promising platform, or an architecture, for improving access to CR, and many other healthcare services. Despite the challenges ahead, the potential of our solution to transform healthcare delivery is immense. We remain

committed to collaborating and advancing this crucial work.

Given the pressing challenges facing healthcare delivery today, notably, escalating costs, pressure to provide high quality care to all while being location independent, workforce shortages, aging population and longer life expectancy, we contend that our cardiac rehab digital health solution address a key and significant healthcare challenge and fills and important void supporting superior cardiac care.

8. Acknowledgement

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