







RESEARCH ARTICLE

Factors influencing implementation of digital cardiac rehabilitation: A qualitative analysis of health workers perspectives [version 1; peer review: 1 approved, 2 approved with reservations]

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Abstract

Background




Despite growing evidence for the effectiveness of digital cardiac rehabilitation (CR) uptake of this technology remains low. Understanding the factors that influence implementation of digital CR in clinical practice is a growing area of research. The aim of this nested qualitative study was to explore health worker perspectives on factors influencing implementation of a digital CR programme.


Methods

Using convenience sampling, semi-structured interviews were conducted with health workers, including health care professionals (nurses, dietitians, physiotherapists) and those in administrative and managerial roles who were involved in delivering and referring patients to Croí MySláinte, a 12-week digital CR intervention delivered

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Any reports and responses or comments on the

during the Coronavirus 2019 pandemic. The updated Consolidated Framework for Implementation Research (CFIR) guided data collection and framework analysis.

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article can be found at the end of the article.

Results

Interviews were conducted with 14 health workers. Factors influencing implementation of Croí MySláinte were multiple, with some operating independently and others in combination. They related to: (i) characteristics of individuals (e.g., senior leadership support, commitment and motivation of Health workers to meet patient needs, technical capability, workload and perceived fit with role); (ii) features of the programme (e.g., accessibility and convenience for patients, the digital platform, patient self-monitoring tools, the multidisciplinary team and core components); (iii) the external environment (e.g., partnership and connections between organisations, broadband and COVID-19); (iv) the internal environment (e.g., organisational culture, teamwork, resources including funding, digital infrastructure and staffing); and (v) the implementation process (e.g., engaging patients through provision of technical support).

Conclusion

The study findings suggest that factors influencing implementation of digital CR operate at multiple levels. Therefore, multi-level implementation strategies are required if the true potential of digital health in improving equitable cardiac rehabilitation access, participation and patient outcomes is to be realised.

Keywords

Cardiovascular disease; secondary prevention; cardiac rehabilitation; digital health; implementation science; Consolidated Framework for Implementation Research

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Introduction

Secondary prevention is an important strategy to reduce the burden of cardiovascular disease (CVD), which accounts for almost one third of all deaths globally^{1,2}. Comprehensive secondary prevention programmes, which include cardiac rehabilitation (CR), can reduce CVD mortality, recurrent CVD hospital admissions, and improve overall quality of life^{3,4}. However, CR is underutilised, with barriers including low referral rates, lack of access and limited capacity, among others^{5,6}. Notably, the majority of eligible patients do not meet guideline recommended lifestyle and risk factor targets^{7,8}. Digital cardiac rehabilitation (CR) interventions such as telemedicine, mobile health (smart phone apps, wearables, text messaging), web based applications and virtual reality are emerging as a promising solution to improve uptake and participation⁵. There is growing evidence to show similar efficacy on important endpoints such as LDL cholesterol, exercise capacity, and medication adherence, which are comparable to in-person, centre based rehabilitation^{9–11}.

Despite the potential benefits of digital CR interventions, their adoption into routine clinical practice has been slow and most do not reach large implementation scale^{12,13}. Even during the Coronavirus disease-2019 (COVID-19) pandemic, when technology was urgently needed and embraced, less sophisticated technologies such as the telephone were most widely used to deliver remote CR¹⁴. Barriers to the implementation of digital CR are complex and exist at the health system, patient and health workforce level¹⁵. Health workers play a pivotal role in bridging the gap between innovative solutions and patient care, ultimately influencing whether a new technology succeeds or fails^{16,17}. Therefore understanding their experiences is an important part of digital CR evaluation¹⁷. However, in comparison to patients, health worker related barriers and facilitators to digital CR¹⁸, have been less frequently described with one of the first systematic reviews in this field recently being published¹⁵. While this review included 20 studies, from 5 countries, the majority of studies were surveys (n=13) with the remainder (n= 7) focusing on implementation of home-based (n=4), hybrid (combined in person and home based or digitally enabled models, n=1) and virtually delivered interventions (n=2)¹⁵. Given that the effectiveness of digital interventions are highly dependent on context¹⁹, there remains a need to expand the number of implementation studies focusing on health workers perspectives of specific digital CR interventions. Insights into these perspectives are critical for optimising implementation strategies for digital CR, to enable scale up and translation into clinical practice.

Having already examined the clinical outcomes of “MySláinte” a digital CR intervention delivered during the COVID-19 pandemic²⁰, we conducted a nested qualitative study, to understand what factors influenced implementation of this programme from the perspective of health workers. The aims of this qualitative study were to a) conduct a post implementation evaluation of the barriers and facilitators to “MySláinte” and b) to identify potentially salient factors to inform the future implementation of digital CR. We use the term “health

workers” to describe the roles of both health care professional (HCPS) and those in administrative and managerial positions.

MySláinte (Gaelic for MyHealth) was developed by Croí, an Irish Heart and Stroke patient organisation in response to the need to provide patients with access to comprehensive CR during the COVID-19 pandemic. The process of developing MySláinte, together with the key intervention features and clinical outcomes have been previously reported²⁰. In brief, the core components included lifestyle modification, risk factor management, and psychosocial and behavioural change support. Patients received access to a bespoke web-based platform, a Fitbit™, a home blood pressure monitor, and were invited to attend weekly, online group-based supervised exercise sessions and educational workshops.

Methods

Study design

A nested qualitative design using semi-structured interviews was used to examine barriers and facilitators to the delivery of a digital CR intervention. The updated Consolidated Framework for Implementation Research (CFIR) was used to guide qualitative data collection and analysis. The CFIR is a comprehensive, meta-theoretical framework that is used to predict or explain the barriers and facilitators to implementation effectiveness, in health systems at multiple levels²¹. The CFIR contains 48 constructs and 19 sub-constructs across five domains: 1. Innovation, 2. Outer Setting, 3. Inner Setting, 4. Individuals, and 5. Implementation Process. **Table 1.** outlines how the CFIR was operationalised for this current study²¹. As one of the most highly cited frameworks in implementation science, the CFIR has been widely used in digital health research²².

Ethical approval was obtained from the Galway Clinical Research Ethics Committee (Ref. C.A 2689) on the 27th of August 2021. The study is reported in accordance with the Consolidated Criteria for Reporting Qualitative Research (COREQ) (Supplementary file 1: <https://osf.io/z9msx/>)²³.

Participants

Using convenience sampling, health workers with various roles and responsibilities for implementation and/or delivery of MySláinte were invited to participate in the study via email by the study partner Croí. Participants included health workers at Croí who delivered the programme (direct deliverers) and health workers from hospital cardiology and CR centres across five sites in the West of Ireland who referred their patients and/or conducted pre and post-programme assessments (indirect deliverers). We aimed to recruit a sample of 10–15 health workers. Sample size estimates were informed by the concept of information power²⁴ and by the number of potential participants available to recruit.

Data collection

Following informed written consent, which involved providing participants with a description of the research along with the participant information sheet, semi-structured interviews

Table 1. Operationalisation of CFIR.

CFIR Domain	Definition
Innovation	The Croí MySláinte programme. This domain includes factors related to innovation: design and core components; complexity (number of steps involved in delivery); relative advantages to current practice; evidence base; and the credibility of the HCP team at the source of the programme
Outer Setting	The broader extrinsic ecosystem, in which the Inner Setting exists. This domain includes factors related to policies and laws; critical incidents such as COVID-19; local technological conditions such as availability of broadband, and partnerships and connections between the Inner Setting organisations.
Inner Setting	The setting in which Croí MySláinte was implemented, including both Croí, the heart and stroke patient organisation that directly delivered the programme, and the various hospitals who referred patients and conducted pre- and post-programme assessments. This domain includes factors related to structural characteristics (staffing levels); available resources (funding); access to knowledge and information; compatibility with existing workflows; and tension for change.
Individuals	Roles and characteristics of individuals involved in implementing, delivering, and/or receiving the Croí MySláinte programme. This domain includes factors related to the health workers involved in direct and indirect programme delivery, high-level leaders (cardiologists and senior management), IT support, and family members and patients who received the programme. Characteristics relate to individual needs, capability, opportunity, and motivation.
Implementation Process	The activities and strategies used to implement Croí MySláinte. This domain includes factors related to forming a team, planning, engaging health workers and patients, and making programme adaptations.

were conducted online between October and December 2021. In acknowledging the lead investigator's (IG) positionality as a CVD nurse involved in the delivery of MySláinte, interviews were conducted by another study team member (LF). This helped to minimise potential power differentials during data collection, which may have occurred due to existing relationships between the lead investigator and health workers²⁵. The interview guide was informed by the CFIR and was refined through input from a Public and Patient Involvement (PPI) panel of HCPs (n=5), all with experience of delivering digital CR programmes (Supplementary file 2: <https://osf.io/z9msx/>). The interview guide was piloted in advance with members of the study team, and minor refinements were made prior to interview commencement.

Data analysis

Using NVivo RI software for data management, framework analysis²⁶ was performed using the CFIR as the *a priori* framework. To determine if modifications to the coding frame were required, open coding was conducted on a small sample of transcripts. Following this, a deductive approach was adopted to code barriers and facilitators using the framework. In addition, participant views on factors to help inform the future implementation of digital CR were captured using thematic analysis²⁷ and were mapped to the CFIR. Two investigators (IG and CK) independently coded two transcripts, checking for coding consistency and modifying CFIR definitions as necessary. The remainder of the data was analysed by the lead investigator (IG) and a third investigator (CR), a member the CFIR development group, provided expert input on CFIR construct definitions as required.

Results

Of the 15 health workers invited to participate, 14 (93%) responded. Interviews lasted on average 46 minutes (range

32-50 minutes). Participants included Croí HCPs (nurse prescriber, dietitian, physiotherapist) an administrator and chief executive officer (CEO) (n=5), and hospital cardiology and CR nurses (n=9). Characteristics of participants are outlined in [Table 2](#).

Factors influencing implementation of the MySláinte programme operated across the five CFIR domains: (1) Innovation; (2) Outer Setting; (3) Inner Setting; (4) Individuals; and (5) Implementation Process ([Figure 1](#)). Most factors acted simultaneously as barriers and facilitators, and while many acted independently in influencing implementation, some acted in combination. Through our analysis, we developed a matrix combining health workers perceived barriers and facilitators to implementation. Supported by sample quotes, this matrix also includes considerations to guide the future implementation of digital CR (Supplementary file 3: <https://osf.io/z9msx/>). The following section provides a narrative summary of the most commonly occurring factors and how they manifested across the five CFIR domains. HCP perspectives on considerations for future implementation efforts of digital CR are incorporated throughout.

Domain: Innovation

The design of the MySláinte programme acted as both a barrier and facilitator to implementation. Many of the programme features, which facilitated implementation, were compared favourably by Health workers to hospital-based CR programmes. Perceived advantages included increased accessibility and convenience for patients to attend, and while this was identified as particularly important during COVID-19, the need to deliver digital CR programmes beyond the pandemic was emphasised. Furthermore, health workers identified the advantages of having a multidisciplinary team (MDT) including a nurse prescriber and a dietitian, which is not routinely

Table 2. Baseline characteristics of participants.

	Participants (n=14) n (%)
Gender, female	12 (86%)
Professional role	
Clinical Nurse Specialist	6 (43%)
Clinical Nurse Manager	1 (7%)
Advanced Nurse Prescriber	1 (7%)
Cardiac Rehabilitation Co-ordinator (nurse)	2 (14%)
Physiotherapist	1 (7%)
Dietitian	1 (7%)
Administrator	1 (7%)
Chief Executive Officer	1 (7%)
Years working in health	
0-10	3 (21%)
11 to 20	5 (36%)
21 to 30	2 (14%)
30 or more	4 (28%)
Service type	
Community Cardiac Rehabilitation (Direct Deliverers)	5 (36%)
Hospital Cardiac Rehabilitation (Indirect Deliverers)	5 (36%)
Hospital Cardiology Department (Indirect Deliverers)	4 (28%)

available in many hospital-based CR programmes. Virtual care was described as being more individualised due to the use of self-monitoring tools, patients being in their own environment, and the ability to involve the family. All of these programme features were identified as important in engaging patients to participate and subsequently, achieving positive patient outcomes.

With virtual it just makes it more easily accessible. Also some people were carers, some didn't have transport. They were minding family, minding kids, minding partners so you know they could just do it from the comfort of their own home. (P11, Referrer)

The programme evidence base, together with the professionalism, reputation and credibility of the MySláinte team who developed the programme, were identified as positively influencing implementation. These factors helped to secure programme funding and importantly helped to engage patients to participate and Health workers to refer.

While we were hesitant about it being online, we were confident in Croí because of their experience and reputation for delivering high quality prevention programmes. (P7, Referrer)

Poor functionality of the online platform, together with an increased workload for Health workers, acted as barriers to implementation. For example, Health workers reported managing a larger volume of patients, having additional paperwork, and a general lack of compatibility between virtual and existing work practices, which added to the complexity of implementing the programme.

We had to rethink how you actually did everything because maybe one step in the real world could equal two or three or even four steps in the virtual world. (P9, Croí HCP)

Furthermore, referring Health workers identified challenges associated with supporting end of programme assessments.

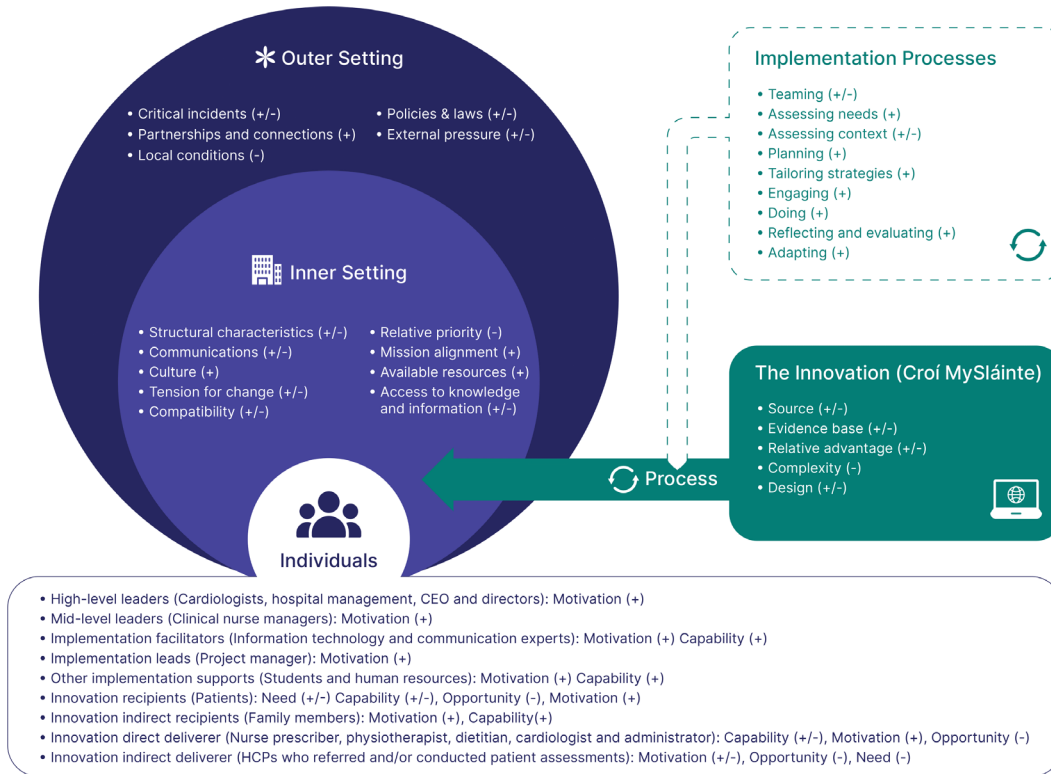


Figure 1. Factors influencing implementation of Croí MySláinte across multiple levels. Note: +, facilitators; -, barriers. Outer Setting = the extrinsic ecosystem, in which the Inner Setting exists; Inner Setting = the setting in which MySláinte was implemented; Individuals = roles and characteristics of those involved in implementing, delivering and/or receiving MySláinte; Innovation = the Croí MySláinte programme; Implementation Process = activities and strategies used to implement MySláinte.

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Having not been involved in direct programme delivery, these challenges related to a lack of familiarity with the patient, which was exacerbated by limited access to their clinical information.

Relative to hospital-based CR programmes, identified disadvantages included the inability to monitor patients in the absence of telemetry, and the impact of limited face-to-face contact on peer support and the patient relationship.

To me there's a huge void you know if there is no telemetry. I do think they need to be on telemetry to identify problems post event, heart blocks and new A-fibs and all of that. (P5, Referrer)

Domain: Outer setting

As a critical incident, the COVID-19 pandemic largely facilitated implementation of MySláinte. It created the momentum for change, increasing patient and HCP engagement in programme implementation.

I think the fact that COVID happened we were pushed to do things that we'd always wanted to do a bit quicker,

it forced us all online, even patients and made the uptake of these things easier. (P1, Croí HCP)

However, local conditions, specifically the lack of broadband was identified as a major barrier to implementation and a source of inequity in terms of patient access, with Health workers recommending that:

Broadband should be a fundamental right and nobody should be left behind in terms of the digital age. (P9, Croí HCP)

Strong partnerships and connections facilitated implementation, with referring Health workers speaking to the positive relationships that had developed between organisations (referring hospitals and Croí) through previous projects and how this helped to engage them and increase their confidence in referring to MySláinte. Information sharing and co-learning from other CR centres beyond those involved in the study also helped inform implementation efforts.

Our organisations had a good relationship ... we would have met face-to-face on a couple of different initiatives

that we did together so we kind of knew each other and that helped. (P8, Referrer)

Domain: Inner setting

The Inner Setting where Health workers worked (Croí and the referring hospitals) exerted both a positive and negative influence on implementation. Limited access to hospital-based CR services due to the COVID-19 pandemic and ensuring patient needs were met created the tension for change, which facilitated implementation. Related to this, MySláinte was seen as compatible with the organisations mission, culture and service priorities to address waiting lists for CR.

As an organisation our role is to respond to patients needs and our raison d'être for delivering this programme was to make sure that these patients received this vitally important care and support. (P14, Croí HCP)

It was desperately needed. The waiting lists for rehab, they're still really bad, but they were very bad back then because there was nothing happening and people were still having events. (P4, Croí HCP)

Access to available resources such as funding, the digital platform, and knowledge and information to deliver MySláinte facilitated implementation, and were highlighted as critical to future implementation efforts.

They need to come up with all the resources, I.T., manpower, funding, everything ... if you're establishing a program like this ... that planning has to be there before it is implemented. (P13, Croí HCP)

For referring Health workers, the existing work infrastructure acted as a barrier to implementation, with low staffing levels decreasing their opportunity to refer patients. Furthermore, referring patients to MySláinte became an additional task and less of a priority with the return of in person programmes.

We were short staffed as we were being redeployed and referring was time-consuming ... especially when we were starting back with our own groups again. (P10, Referrer)

Domain: Individuals

Individuals involved with implementing, delivering, and/or receiving MySláinte are outlined in [Figure 1](#). Health workers identified how the commitment and support from many individuals, ranging from high-level leaders (Cardiologists, Hospital Management, Nursing and CEO's) to implementation project managers, to IT support facilitated implementation.

Everybody just seemed to row in together you know and get things done that would have taken months previous to COVID, it just happened. (P5, Referrer)

While Health workers described barriers having to navigate new technology with limited training, they were highly motivated to deliver MySláinte. This was influenced by their knowledge and beliefs regarding the positive consequences

for patients, and their service (e.g., reduced waiting lists), and fit with their social/professional role and identity.

We all had the patient's best interests and we all wanted to do something and make a difference ... when we saw it was working ... their blood pressure improved, their cholesterol improved ... that gave us confidence. (P4, Croí HCP)

Time constraints impacted negatively on the opportunity to deliver the programme. Health workers reported that the process of using the technology, determining patient suitability (contacting patients, accessing medical information, risk stratification), coupled with increased administrative duties, was time consuming. Access to patient information through more integrated technology information systems and greater administrative support were identified as solutions to overcome these barriers.

Invest in the technology to ensure online delivery is more streamlined ... we need to be able to share information across organisations ... to ensure patient centred, integrated care. (P1, Croí HCP)

Health workers reported that while the programme responded to unmet patient needs regarding access to CR and peer support, there was a sense of uncertainty regarding who digital CR interventions are suitable for. This uncertainty related to the patients CVD risk profile and safety, their socio-demographics, and the potential to disenfranchise those with low digital literacy levels.

People mightn't necessarily have a smart phone, they mightn't have a laptop and those kind of digital inequalities and financial constraints can be an issue. (P3, Referrer)

Domain: Implementation process

The strategies used to implement MySláinte mainly acted as facilitators to delivery. Health workers highlighted how efforts to engage patients, through the provision of information and technical support, increased the patient's capability and confidence to participate.

Where people didn't have the necessary skills, but they had the technology, they actually went and trained them. (P14, Croí HCP)

Referring Health workers reported that they were effectively engaged through good relationships with Croí. There were multiple meetings, with demonstrations on the digital platform, and they felt their expectations and concerns were acknowledged. This was identified as an important factor to support future implementation.

If you're looking to innovate and support you need to try and engage as much as you can in advance and not just land something on people. And be sensitive to all these fears and anxieties that people will have. (P7, Referrer)

The commitment and motivation of the team, coupled with a project plan where roles and responsibilities were agreed in advance positively influenced the implementation process. Furthermore, through reflecting and evaluating, MySláinte was adapted iteratively in response to patient needs.

Some of the first education sessions we did we were like ... these are a bit long ... so we tried to make them more interactive ... we were constantly changing and tweaking it. (P14, Croí HCP)

Discussion

Using the CFIR, this study examined health worker perspectives of factors influencing implementation of MySláinte, a digital CR intervention delivered during the COVID-19 pandemic. Established areas of focus for implementation of digital health interventions (DHIs) include: intervention characteristics and technical factors, individuals (workforce and patients), the healthcare ecosystem and the broader extrinsic ecosystem within which they operate^{19,28}. Consistent with recent systematic review and scoping review evidence^{13,15,29}, we identified barriers and facilitators to implementation across all of these areas, including the implementation process which often receives insufficient attention in digital technology implementation frameworks¹⁶. To our knowledge, this is the first study to explore health worker perspectives of digital CR using the CFIR. While most factors influencing implementation of MySláinte operated independently, many also acted in combination. For example, strong partnerships and connections at the outer setting between organisations combined with the programme features (e.g., inclusion of the MDT and recommended CR core-components) and evidence base increased health worker confidence, and subsequent engagement in implementation. Consistent with previous studies^{16,22,29}, these findings demonstrate the dynamic inter-relationships that exists between factors. Therefore, understanding these inter-relationships is essential to optimising implementation of digital CR²².

The perceived usefulness of technology has been identified as one of the most common facilitators to implementation of DHIs among health workers^{13,29}. In keeping with these findings, the perceived value of MySláinte in providing patients with essential CR, whilst also addressing CR service waiting lists, motivated health workers to engage in implementation. Engagement was further enhanced by organisational leadership support and a culture of patient centeredness, both established predictors of implementation success^{21,22}. These findings reaffirm that implementation of DHIs is a social process which is influenced by the values, mind-set and engagement of individuals involved, including local champions^{16,30}. Health workers identified multiple benefits associated with MySláinte (e.g., increased accessibility and convenience for patients) which superseded in person CR programmes. However, health workers acknowledged that there was a trade-off between these benefits and perceived programme disadvantages, for example lack of peer support. In line with WHO recommendations, these findings emphasise the need for the “value” of digital CR to be clearly communicated, including benefits for

patients, health workers, and health systems as well as the rationale for why they are superior to the current standards of care^{17,31}.

The implementation of MySláinte required a significant shift in how health workers delivered CR care with new work practices and care pathways needing to be established. Not unique to MySláinte, the rapid transition to remote care during the COVID-19 pandemic necessitated the use of an existing platform Moodle, which was not appraised as optimal for CR delivery^{14,32}. This led to an increased workload, which added to the complexity of delivering CR care. Increased work and altered workflows are frequently cited barriers among health workers to DHI implementation²⁹, including those specific to CR¹⁵. To address these barriers, there is a need to involve health workers in all stages of the design, development and implementation of digital CR^{19,33,34}. Indeed, in a recent overview of systematic reviews of HCP barriers and facilitators to DHIs, involving health workers in DHI design was identified as a common facilitator to utilisation of DHIs across all 108 primary systematic reviews²⁹. Beyond the usability of the digital platform, health workers identified challenges regarding its interoperability in the context of a health system where information and communications technology (ICT) is not standardised or harmonised. Not limited to our study, interoperability of DHIs is a global problem^{19,34}, which requires implementation of national data interoperability standards in order to be addressed³⁵.

Similar to recent systematic review findings by Ferrel-Yui *et al.*¹⁵, workforce capacity issues including HCP-patient ratios and time to deliver in the context of the return to in-person programmes acted as barriers to implementation. Frederix *et al.*³⁶, argue that DHIs need to be blended into current practices, rather than being an “add on” to existing delivery models. Ultimately, implementation of digital CR requires dedicated resources, including staff who are equipped with skills and competencies in digital health delivery¹². Our findings show that limited experience and training in digital health was an obstacle to implementation with similar barriers reported internationally^{19,37}. These findings point to the need for greater integration of digital health competencies into the undergraduate and postgraduate curriculum as well as real-time, on the job training and support^{16,38}.

Health workers reported uncertainties regarding patient suitability for virtual care; these related to low digital literacy levels, limited access to technology and broadband, and the patient’s CVD risk profile. These findings are not surprising given that digital CR studies tend to focus on homogenous populations, where the majority of participants are male, and younger (<63 years)^{11,39}. To determine which patients may be best served by digital CRs, future research needs to be inclusive of oppressed and minoritized groups, e.g., people of colour, women, and the elderly. Furthermore, we believe these uncertainties could be addressed by conducting a rigorous assessment of patient needs, including their digital literacy and access to technology and broadband, in

advance of DHI deployment. This will ensure that adequate supports are in place to enhance participation¹⁹.

While there was widespread agreement that patients should be offered digital CR beyond the pandemic, referring health workers expressed safety concerns about delivering exercise remotely to high CVD risk patients. These safety concerns are mirrored internationally^{14,40}, and could be addressed by greater use of remote monitoring technologies and sharing of good practice for the use of digital CR in high-risk patients^{5,40}. Notwithstanding the importance of patient preference, health workers identified that hybrid CR, which combines in-person and remote components, could be a promising opportunity to broaden CR access⁴¹. However, essential to this approach is effective integration of care between digital CR and in-person CR, and further research is required to understand how to optimally achieve this.

We observed similarities between our findings and the recent study by Kenny *et al.*⁴² exploring patient experiences of MySláinte and a similar digital CR intervention. Specifically, health workers efforts to engage and support patients through developing interpersonal relationships, for example being more accessible and the provision of technical support, increased engagement. These findings suggest that DHIs do not necessarily compromise the patient-health worker relationship, a commonly held perception among health workers⁴³. Furthermore, health workers identified that limited opportunities for peer support negatively affected patient engagement. A challenge, which health workers suggested, could potentially be overcome through a hybrid CR delivery

model. Finally, health workers identified the importance of partner and family support in engaging patients to use the technology, a factor which is known to improve DHI use by patients^{15,42}.

Considerations for future implementation

Identifying strategies for effective implementation of digital health are a national and international priority^{19,44,45}. Based on our study findings, which included health workers views on factors to help inform future implementation, we developed a summary of key considerations to assist with future implementation efforts (see Table 3). Many of these considerations are consistent with solutions identified in the recent World Heart Foundation roadmap for digital health in cardiology¹⁹, thus emphasising the relevance of this roadmap for digital CR. Considerations include actions at multiple levels from the digital intervention, to the patient, the health worker, and the broader health system. Importantly, as barriers and facilitators to implementation of digital CR are interdependent, these considerations should not be viewed in isolation but rather as part of a whole systems approach to implementation. Currently, findings from this study are informing the development and implementation of a self-management, mHealth intervention for the secondary prevention of CVD⁴⁶.

Limitations

This study has some potential limitations. Due to funding, this study was conducted 6-months after patients had completed MySláinte, which may have impacted HCP recollection of their experiences of implementation. However, it is also likely that having this time offered an opportunity for reflection

Table 3. Key considerations for the future implementation of digital cardiac rehabilitation.

Level	Considerations for future implementation of digital cardiac rehabilitation
Digital Health Intervention	Digital health interventions should: <ul style="list-style-type: none"> • Incorporate evidence-based core components and be delivered using a standardised approach • Be delivered by a skilled inter-professional team including nurse prescribers • Be designed with end user involvement (Patients and health workers) • Be integrated with in-person programmes and offered as part of a hybrid approach to care
Patient	Patients should: <ul style="list-style-type: none"> • Be offered a choice of CR delivery options, including digital programmes • Be provided with access (equipment and broadband) and the necessary skills and supports to use technology, which includes involving the family
Health Workers	Health workers should be: <ul style="list-style-type: none"> • Equipped with the necessary skills and competencies to deliver digital CR • Provided with adequate resources including staff, administrative support, time and technological support • Engaged early in the implementation process to ensure barriers to implementation are addressed • Provided with clear guidance on how to appropriately risk stratify and monitor patients remotely
Health System	At a systems level there needs to be: <ul style="list-style-type: none"> • Approval and support by the organisational leadership team including Cardiologists • Compliance with general data protection regulations and other relevant regulatory standards • Long-term funding to develop technology that minimises workload whilst also ensuring that there is an adequate workforce to deliver • A focus on patient centred care, ensuring seamless integration of care across all CR delivery modalities • A robust digital infrastructure, with greater interoperability • A focus on developing implementation strategies, which address context specific barriers.

on implementation efforts and achievement of programme goals, thus enhancing the richness of the data collected. We recognise that the context of COVID-19 may have influenced HCP perspectives of DHIs and therefore, factors influencing implementation may not be as relevant in the post pandemic era. Furthermore, as this was a nested qualitative study of a digital CR intervention in one region, we acknowledge that our findings may differ to other digital CR interventions. Nonetheless, we found similarities in our results to international data on DHIs in CVD care and CR^{13,15,19}. Understanding health workers perspectives of digital CR is a growing area of research and therefore future research inclusive of other health workers (for example physicians and psychologists) is required. This study was part of a multi-method evaluation of MySláinte, and while previous research has examined clinical outcomes²⁰ and patient experiences⁴², there is also a need to consider cost effectiveness, an often neglected area in DHI research⁴⁷. Finally, while the aim of this study was to identify contextual factors influencing implementation of MySláinte, future research should align these factors to implementation outcomes (e.g., fidelity) to help determine which factors matter most.

Conclusion

With an increasing emphasis being placed on offering patients a range of CR options, successful implementation of DHIs is contingent upon a comprehensive understanding of the challenges and opportunities faced by health workers. Leveraging on the practical experiences of implementing a digital CR intervention during the COVID-19 pandemic, we identified a number of factors which may help inform future strategies to enable scale up and integration into clinical practice. Findings from this study highlight how factors influencing implementation of digital CR are interconnected. Therefore, multi-level implementation strategies are required if the true potential of digital health in improving equitable CR access, participation and patient outcomes is to be realised.

Ethics and consent

Ethical approval was obtained from the Galway Clinical Research Ethics Committee (Ref. C.A 2689) on the 27th of August 2021. Informed written consent, was obtained by

providing participants with a description of the research along with a participant information sheet.

Data availability statement

Study participants did not give consent for their data to be shared in a public repository. The information leaflet they received stated that their data would be anonymised and reported in aggregate. This was deemed necessary as the study is reporting on a qualitative study with a small number of participants, where they may be easily identified.

Extended data

Open science framework: Factors influencing implementation of digital cardiac rehabilitation: A qualitative analysis of health workers perspectives. DOI: <https://doi.org/10.17605/OSF.IO/Z9MSX>⁴⁸

This paper contains the following extended data:

- Supplementary file 1. Figure 1. Factors influencing implementation of Croí MySláinte across multiple levels
- Supplementary file 2. Interview topic guide
- Supplementary file 3. Summary of perceived barriers and facilitators to implementation of Croí MySláinte

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0)(<https://creativecommons.org/licenses/by/4.0/>).

Reporting guidelines

The study is reported in accordance with the Consolidated Criteria for Reporting Qualitative Research (COREQ)²³.

Acknowledgement

The authors wish to thank: the health workers who participated in this study at the Croí Heart & Stroke, the Galway Clinic and Bon Secours Hospital, Galway, Mayo and Sligo University Hospitals; and the public and patient involvement from health care professionals at the “Our Heart Our Minds” programme, Enniskillen, Co. Fermanagh

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<http://www.doi.org/10.17605/OSF.IO/Z9MSX>

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Ahmad M Osailan 

Prince Sattam Bin Abdulaziz University, University in Al-Kharj, Saudi Arabia

The article "Factors influencing implementation of digital cardiac rehabilitation: A qualitative analysis of health workers perspectives" offers valuable insights into the barriers and facilitators to implementing digital cardiac rehabilitation (CR) programs like MySláinte. While the study provides a strong basis for understanding the factors at play, there are a few areas where improvements could enhance the clarity and impact of the paper.

Introduction Clarity: The introduction gives a broad view of digital CR and the barriers to its adoption, but it would benefit from a more concise explanation of the MySláinte program. It lacks sufficient background on how the program operates, which is vital for readers unfamiliar with it. A more detailed explanation of its key features—such as how it integrates technology with healthcare—would better ground the reader for the analysis to follow.

Separation of Barriers and Facilitators: The results section discusses barriers and facilitators across multiple domains, sometimes muddling the analysis. Separating these into distinct sections or using tables to list the pure barriers and facilitators would make the discussion more digestible. Additionally, providing direct illustrative quotes alongside the barriers and facilitators in the table would allow for more engaging content and help emphasize the real-world impact, making the audience feel more connected and involved in the discussion.

Methodology The methodology is robust, but more detail on the specific roles and experiences of participants could enhance the credibility of the findings. For example, although it is mentioned that health workers from various roles were interviewed, discussing more about how their different perspectives (e.g., frontline workers vs. managerial staff) influenced their views on digital CR would make the analysis richer.

Deeper Analysis of Specific Challenges: While the paper touches upon critical challenges like digital infrastructure, workload, and training gaps, it could benefit from a more analysis of how these barriers were overcome or exacerbated during the MySláinte implementation. For example, more detailed examples of how specific barriers, like the lack of interoperability between systems,

played out in practice would help connect the findings more directly to actionable solutions.

Discussion: The discussion mixes barriers and facilitators in a way that could be more organized. Grouping the facilitators and obstacles into distinct paragraphs or sections could improve readability. Additionally, providing more information on the technological challenges faced by health workers, specifically the functionality of the Moodle platform used for the program, could give a clearer view of the specific technical limitations that impacted implementation.

Recommendations and Conclusion: The recommendations for future implementations are solid but could be strengthened by offering more specific, practical solutions to some identified problems. For instance, the need for "a robust digital infrastructure, with greater interoperability" is mentioned but could be expanded with examples of successful implementations from other contexts. In summary, the paper offers substantial contributions to understanding digital CR but could improve its impact through clearer structure and deeper engagement with its identified challenges. Adding more detail about the MySláinte program, separating barriers and facilitators, and providing practical recommendations would make the paper more effective and accessible.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Not applicable

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Cardiac Rehabilitation

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Reviewer Report 27 September 2024

<https://doi.org/10.21956/hrbopenres.15283.r41880>

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LaPrincess Brewer

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Grace Patrice Anyetei-Anum

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The manuscript titled, "**Factors influencing implementation of digital cardiac Rehabilitation: A qualitative analysis of health workers perspectives**" is an interesting manuscript examining the perspectives of health workers on factors influencing the implementation of a cardiac rehabilitation (CR) program. These factors include: i) characteristics of health workers, ii) features of the CR program, iii) the relationship of the external and internal environment on the delivery of the CR program and iv) the implementation process of the CR program. The authors' key finding was that factors affecting the implementation of digital CR are multi-layered; with a corresponding conclusion that to maximize beneficial use of digital CR, a well-rounded, multi-step approach is essential.

The strengths of the manuscript are in its use of the updated Consolidated Framework for Implementation Research (CFIR), a sound implementation science framework to direct qualitative data collection and analysis. Another strength of the paper is that it contributes to a growing body of knowledge on health workers perspectives on the use of digital CR – an area currently lacking in the literature. Overall, the paper has valuable insights that can be utilized to inform the implementation of digital CR in Europe and worldwide, potentially revolutionizing the field. This research also has the potential to significantly increase access to CR, particularly for underrepresented groups. Main concerns lie in the Introduction, Results and Discussion.

MAJOR REVISIONS:

Introduction

1. Although the authors cite previous work on the MySláinte interface in the introduction, it would be helpful for readers to gain more insight directly from this specific paper. As such, the authors should elaborate further on how the MySláinte app works to give readers a deeper understanding of their digital CR platform in the Methods section.

Results

1. The authors should separate the barriers and facilitators of the domains (innovation, outer setting, inner setting, individuals, implementation process) into tables with rows showcasing the pure barriers, pure facilitators or both, each with an illustrative quote.

Discussion

1. The authors should provide more details on how the existing platform Moodle works and how it is similar and different from MySláinte.
1. Authors should discuss barriers to the implementation of MySláinte in one paragraph and facilitators in another paragraph to enhance readability.
2. For Figure 1, the authors should provide more information on the factors listed in both the inner and outer setting directly. For example, how does policy and law directly/indirectly impact the implementation of digital CR?
3. In Table 3, the statement "A robust digital infrastructure, with greater interoperability" is

lofty and broad and needs more details.

MINOR REVISIONS

1. In Figure 1, the authors should further describe the meaning of (+) and (-). For example, facilitators only should be designated (+), barriers only (-) and both facilitators and barriers indicated by (+/-).
2. Authors should include the dates of the original trial, recruitment and data collection of the current study.
3. Authors should include reference (Adedinsewo et al. 2023[Ref -1]) for the sentence "...future research needs to be inclusive of oppressed and minoritized groups, e.g., people of colour, women, and the elderly."
4. Consider the following publications for references for digital CR and its implementation.
 1. Adedinsewo D, et al. (2023 [Ref-1]) Health Disparities, Clinical Trials, and the Digital Divide. *Mayo Clin Proc.* 2023 Dec. PMID: 38044003; PMCID: PMC10825871.
 2. Ravn MB, et al. Understanding Facilitators and Challenges to Care Transition in Cardiac Rehabilitation: Perspectives and Assumptions of Healthcare Professionals. *Glob Qual Nurs Res.* (2023 [Ref-2]) Dec. PMID: 38107551; PMCID: PMC10722928.
 3. Kim C, et al. A survey of the perceptions of barriers to and facilitators of cardiac rehabilitation in healthcare providers and policy stakeholders. *BMC Health Serv Res.* 2022 Aug. PMID: 35932056; PMCID: PMC9356496.
5. Given its recent release, recommend citing the more recent scientific statement on core components of CR:
 1. Brown TM, et al. 2024 (Ref - 4) Sep 24. Epub ahead of print. PMID: 39315436.

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4. Brown TM, Pack QR, Aberegg E, Brewer LC, et al.: Core Components of Cardiac Rehabilitation Programs: 2024 Update: A Scientific Statement From the American Heart Association and the American Association of Cardiovascular and Pulmonary Rehabilitation. *Circulation.* 2024. [PubMed Abstract](#) | [Publisher Full Text](#)

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Yes

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Cardiac rehabilitation, health equity, preventive cardiology

We confirm that we have read this submission and believe that we have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however we have significant reservations, as outlined above.

Reviewer Report 21 August 2024

<https://doi.org/10.21956/hrbopenres.15283.r41672>

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Nilay Shah

Northwestern University Feinberg School of Medicine, Chicago, IL, USA

In this manuscript, the authors present the findings of a qualitative analysis of the implementation of MySlainte, a digital cardiac rehabilitation program launched during the COVID-19 pandemic. The implementation evaluation follows the CFIR framework and focuses on health care professional perspectives of facilitators and barriers to implementation of the digital CR program. This analysis addresses an important and timely topic and the methodological approach is sound and grounded in a well-established framework in implementation science. The manuscript is clear and very well-written. Several comments are offered:

1. In the Introduction, it would be helpful to briefly detail the medical conditions for which cardiac rehabilitation is recommended.
2. The interpretation of the results would be facilitated by some greater detail of the health care professional roles. Though the HCP titles are provided, to understand how each interviewee interacts with the digital CR program, it would be important to understand how each person in the named roles specifically interacts with the digital CR program (for example, referring patients to CR, delivering the CR program, administering or managing the CR program, etc.)

3. In the Results – Innovation section, the authors refer to “poor functionality of the online platform.” Can the authors expand on this description, specifically regarding what aspects of the platform functioned poorly?
4. In the Results – Inner Setting section, the authors provide example quotes regarding “access to available resources... [that] facilitated implementation.” Did any of the interviewees provide additional detail about the work needed to implement the MySlainte program? This would materially aid the audience to understand the specific aspects or steps of implementation they might need to follow to adapt this CR approach
5. Although the authors do briefly address the context of the COVID-19 pandemic in the Discussion, this seems to be a considerable factor influencing the implementation of the digital CR program. I think their Discussion narrative would benefit from adding their interpretation and contextualization, specifically regarding what might people have to do to adapt the digital CR program outside of the COVID-19 pandemic context?

This comment is offered because of some of the participants’ responses alluded to an environment in which the deployment of the digital CR program was actually facilitated and accelerated by virtue of the simple necessity of doing so given the pandemic-related limitations for in-person CR (for example, in the Outer Setting section, one participants stated “I think the fact that COVID happened we were pushed to do things... quicker”).

Could the authors synthesize what aspects of the MySlainte intervention were specifically facilitators to the program given the COVID-19 pandemic outer setting? And, where such facilitators don’t exist (e.g., now in-person CR is allowed again), what might a digital CR program implementation staff have to do differently?

Is the work clearly and accurately presented and does it cite the current literature?

Yes

Is the study design appropriate and is the work technically sound?

Yes

Are sufficient details of methods and analysis provided to allow replication by others?

Yes

If applicable, is the statistical analysis and its interpretation appropriate?

Not applicable

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Cardiovascular disease prevention

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.
