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**eHealth Interventions to Support Self-Management
in People with Musculoskeletal Disorders:
'eHealth: It's TIME'**

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List of Abbreviations

BCT	Behaviour Change Techniques
CeHReS	Center for eHealth Research
CFIR	Consolidated Framework for Implementation Research
CONSORT-EHEALTH	Consolidated Standards of Reporting Trials of Electronic and Mobile HEalth Applications and onLine TeleHealth)
COREQ	Consolidated Criteria for Reporting Qualitative Research
CPMT	Chartered Physiotherapists in Musculoskeletal Therapy
CREC	Clinical Research Ethics Committee
DIRUM	Database of Instruments for Resource Use Measurement
ED	Emergency Department
eHEALS	The eHealth Literacy Scale
ERIC	Expert Recommendations for Implementing Change
EQUATOR	Enhancing the Quality and Transparency of Health Research
GP	General Practitioner
GUIDED	GUIDance for the rEporting of intervention Development framework
HIQA	Health Information and Quality Authority

HSE	Health Service Executive
ICF	International Classification of Functioning, Disability and Health
ICMJE	International Committee of Medical Journal Editors
IQR	Interquartile range
ISCP	Irish Society of Chartered Physiotherapists
JB1	Joanna Briggs Institute
MSD	Musculoskeletal Disorder
MSK	Musculoskeletal
MRC	Medical Research Council
NCD	Non-Communicable Diseases
NICE	National Institute for Health and Care Excellence
UN	United Nations
OECD	Organisation for Economic Co-operation and Development
PEEP	Pain Education Empowerment Program
PMSD	Person with Musculoskeletal Disorder
PPI	Patient and Public Involvement
PSD	Persuasive System Design
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PT	Physiotherapist
PSEQ	Pain Self-Efficacy Scale
PRISMS	Practical Reviews in Self-Management Support

RCT	Randomised Controlled Trial
RTA	Reflexive Thematic Analysis
SDG	Sustainable Development Goal
TIDieR	Template for Intervention Description and Replication
WCAG	Web Content Accessibility Guidelines
WHO	World Health Organisation

Declaration

This is to certify that the work I am submitting is my own and has not been submitted for another degree, either at University College Cork or elsewhere. All external references and sources are clearly acknowledged and identified within the contents. I have read and understood the regulations of University College Cork concerning plagiarism and intellectual property.

A handwritten signature in dark ink, appearing to read 'Noel', is written over a faint, light blue rectangular stamp.

Signed:

Date: 30/10/24

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2. **Kelly M**, Fullen B, Martin D, McMahon S, McVeigh JG **eHealth Interventions to Support Self-Management in People with Musculoskeletal Disorders: ‘eHealth: It’s TIME’** - A Scoping Review. *Phys Ther*. 2022 (Chapter 2)
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3. **Kelly M**, Fullen B, Martin D, Bradley C, McVeigh JG eHealth Interventions to Support Self-Management: Perceptions and experiences of People with Musculoskeletal Disorders and Physiotherapists - 'eHealth: It's TIME': A Qualitative Study. *Physiother Theory Pract* 2022 (Chapter 3)
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4. **Kelly M**, Fullen BM, Martin D, Bradley C, O’Mahony B, McVeigh JG Design and development of an **eHealth** intervention to support self-management in those with musculoskeletal disorders - ‘**eHealth: It’s TIME**’: a study protocol [version 2; peer review: approved]. *HRB Open Res* 2023 (Chapter 4 Protocol)
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5. **Kelly M**, Fullen BM, Martin D, Bradley C, O’Riain E, McVeigh JG Design and Development of an **eHealth** Intervention to Support Self-Management in People with Musculoskeletal Disorders: ‘**eHealth: It’s TIME**’ *Clin Rehabil* 2024 (Chapter 4)

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Peer Reviewed Non-thesis Related Publications

1. **Kelly M**, Higgins A, Murphy A, McCreesh K. A telephone assessment and advice service within an ED physiotherapy clinic: a single-site quality improvement cohort study. Arch Physiother. 2021 Feb 8;11(1):4.

DOI: [10.1186/s40945-020-00098-4](https://doi.org/10.1186/s40945-020-00098-4).

2. Sulaiman AA-S, **Kelly M**, O'Connor M, Eva-Bamiou D, Pavlou M. Dual tasking interferes with dynamic balance in young and old healthy adults. Physiotherapy Practice and Research. 2021;41:155-62.

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Thesis Related Presentations

Platform Presentations

2025

1. **Kelly M**, Fullen B, Martin D, Bradley C, O'Riain E, McVeigh JG. Design and development of an eHealth intervention to support self-management in people with musculoskeletal disorders - 'eHealth: It's TIME'. ISCP Annual Conference April 5th, 2025. Oral presentation.

2023

2. **Kelly M**, Fullen B, Martin D, Bradley C, O'Riain E, McVeigh JG. Design and development of an eHealth intervention to support self-management in people

with musculoskeletal disorders - 'eHealth: It's TIME': a study protocol. ISCP Virtual Conference Oct 13th, 2023. Oral presentation.

3. **Kelly M**, Fullen B, Martin D, Bradley C, McVeigh JG. eHealth Interventions to Support Self-Management: Perceptions and experiences of People with Musculoskeletal Disorders and Physiotherapists - 'eHealth: It's TIME': A Qualitative Study. WCPT Congress Dubai June 3rd, 2023, Poster with a 3-minute Oral Presentation

2022

4. **Kelly M**, Fullen B, Martin D, Bradley C, McVeigh JG. eHealth Interventions to Support Self-Management: Perceptions and experiences of People with Musculoskeletal Disorders and Physiotherapists - 'eHealth: It's TIME': A Qualitative Study. ISCP Virtual Conference Oct 14th, 2022, Oral Presentation
5. **Kelly M**, Fullen B, Martin D, McMahon S, McVeigh JG. eHealth Interventions to Support Self-Management in People with Musculoskeletal Disorders: 'eHealth: It's TIME' - A Scoping Review. VR4REHAB Conference 2022 "It's the patient, stupid!", Inspyrium, Netherlands, June 23rd-24th 2022, Oral Presentation, in-person attendance

2021

6. **Kelly M**, Fullen B, Martin D, McMahon S, McVeigh JG. eHealth Interventions to Support Self-Management in those with Musculoskeletal Disorders: 'eHealth: It's TIME': A Scoping Review. ISCP Conference October 15th, 2021, Online, Oral presentation.

7. **Kelly M**, Fullen B, Martin D, McMahon S, McVeigh JG. eHealth Interventions to Support Self-Management in those with Musculoskeletal Disorders: 'eHealth: It's TIME': A Scoping Review. Oral presentation to clinical colleagues within North Lee and South Lee (CHO 4), and within Mercy University Hospital and South Infirmary Victoria University Hospital (South/Southwest Hospital Group)

Poster Presentations

2023

8. **Kelly M**, Fullen B, Martin D, Bradley C, O'Riain E, McVeigh JG. Design and development of an eHealth intervention to support self-management in people with musculoskeletal disorders - 'eHealth: It's TIME': a study protocol. 13th Congress of the European Pain Federation EFIC, Budapest, 22nd September 2023. Poster Presentation (Fullen B).
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11. **Kelly M**, Fullen B, Martin D, Bradley C, McVeigh JG. eHealth Interventions to Support Self-Management: Perceptions and experiences of People with Musculoskeletal Disorders and Physiotherapists - 'eHealth: It's TIME': A Qualitative Study. UCC College of Medicine and Health Research Conference Sept 22nd, 2022, Poster Presentation
12. **Kelly M**, Fullen B, Martin D, McMahon S, McVeigh JG. eHealth Interventions to Support Self-Management in People with Musculoskeletal Disorders: 'eHealth: It's TIME' - A Scoping Review. 12th Congress of the European Pain Federation EFIC, Dublin, 27th – 30th April 2022. Online, Poster presentation.

2021

13. **Kelly M**, Fullen B, Martin D, McMahon S, McVeigh JG. eHealth Interventions to Support Self-Management in those with Musculoskeletal Disorders: 'eHealth: It's TIME': A Scoping Review Protocol. IASP World Congress, June 29th, 2021, Online, Poster presentation

2020

14. **Kelly M**, Fullen B, Martin D, McMahon S, McVeigh JG. eHealth Interventions to Support Self-Management in those with Musculoskeletal Disorders: 'eHealth: It's TIME': A Scoping Review Protocol. Irish Pain Society Annual Scientific Meeting, October 10th, 2020, Online, Poster Presentation

Non-thesis Related Presentations

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Public Engagement

1. Radio interview on Back Pain with PJ Coogan/Opinion line on 96FM 29/6/22

(<https://shows.acast.com/corks-96-fm-opinion-line/backache-so-much-we-know-is-wrong>)

2. Chronic Pain Ireland Webinar participation: Future access to quality online care:

What does this look like? To mark Pain Awareness Month and World

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Thesis Abstract

Background and Aims

Musculoskeletal disorders (MSDs) are a leading cause of disability worldwide, significantly impacting individuals' quality of life and contributing to substantial healthcare costs. Despite the high demand for rehabilitation services, access to appropriate care remains limited, leading to what is termed the musculoskeletal (MSK) care gap. To address this gap, self-management support has been identified as a key element of modern healthcare reform. The increasing use of eHealth presents a promising opportunity to facilitate self-management interventions for people with MSDs. However, these interventions are often poorly understood, partly due to fragmentation and inadequate reporting in the existing literature. Moreover, the rapid adoption of eHealth interventions during the COVID-19 pandemic highlights the need to reassess the barriers and facilitators to eHealth-mediated self-management support. Furthermore, many interventions lack a user-centred design and are not grounded in strong theoretical frameworks. Therefore, the overall aim of this thesis is to enhance eHealth-mediated self-management support by mapping the available evidence and describing intervention characteristics, exploring the perspectives of people with MSDs and physiotherapists, and co-designing a user-centred, theory-based eHealth-mediated self-management support follow-up prototype for people with MSDs.

Methods

First, a comprehensive systematic scoping review was conducted to map the available evidence base and describe the characteristics of existing eHealth interventions. Second, a qualitative interview study was undertaken to explore the perspectives of people with MSDs and MSK physiotherapists on eHealth-mediated self-management support. Building on these findings, a mixed-methods, three-step co-design and development study was conducted. In Step 1, intervention features and content were created, with two focus groups reviewing prioritised eHealth intervention elements. Step 2 involved heuristic testing using Nielsen's 10 heuristic principles. Finally, Step 3 incorporated qualitative think-aloud interviews and the System Usability Scale as part of usability testing.

Results

The scoping review highlighted considerable variation in eHealth-mediated self-management support interventions, identifying gaps in specific eHealth modalities, MSK diagnoses, and healthcare utilisation data. Using the Practical Reviews in Self-Management Support (PRISMS) taxonomy, eHealth-mediated self-management support interventions were characterised as complex, multicomponent interventions. The qualitative interview study found that eHealth-mediated self-management support interventions were broadly acceptable for people with MSDs and MSK physiotherapists. However, both groups felt they should be reserved for follow-up purposes due to concerns about assessment, diagnosis and establishing a therapeutic relationship. Based on these results, a new eHealth-mediated self-management support follow-up prototype was co-developed with people with

MSDs. The four main intervention components, namely an information library, goal tracking, a support forum, and a 'contact your physiotherapist' feature, were approved by people with MSDs and aligned with recognised theoretical frameworks.

Conclusion

This thesis has made a significant contribution to the evidence base on eHealth-mediated self-management support. It has identified gaps in the existing literature and described the characteristics of existing interventions, likely enhancing the understanding of these complex, multi-component interventions and facilitating their successful implementation. This research has also established perceived barriers and facilitators to eHealth-mediated self-management support in MSK physiotherapy services in Ireland. These findings contribute to the development of new knowledge, guiding the design of tailored implementation strategies. Furthermore, these findings were further refined through the co-design and development of an eHealth-mediated follow-up self-management support prototype for people with MSDs, underpinned by recognised theoretical frameworks. Future research will focus on testing the feasibility of this prototype in clinical practice with a diverse population.

Chapter 1

Introduction

1.1 Chapter overview

This chapter provides a comprehensive overview of the literature that informed this research. It opens with a discussion of musculoskeletal disorders (MSDs) as a global public health issue and how a current mismatch between demand for and supply of rehabilitation services has created a musculoskeletal (MSK) care gap. The chapter then briefly discusses global calls for healthcare reforms to address this burden, with a more detailed focus on the Irish context. Next, it explores the concept of self-management support as a core principle of these planned healthcare reforms, followed by an overview of eHealth, with a particular focus on eHealth-mediated self-management support. The chapter concludes by identifying key research gaps, outlining the aims and objectives of this thesis, and presenting the theoretical frameworks that underpin the research.

1.2 Musculoskeletal disorders (MSDs): a major public health issue

MSDs encompass more than 150 diverse conditions affecting joints, muscles, bones, and connective tissues (1-3), with low back pain, osteoarthritis and neck pain being among the most common (4). While some of these conditions present with acute onset and short duration, a significantly larger proportion of these disorders reoccur or become chronic (5). Chronic pain, defined as pain lasting or reoccurring for more than three months (6), along with loss of function, are the primary mechanisms through which MSDs lead to disability, work loss, and reduced participation in society, making them a major global health issue (1, 4).

As a consequence of these physical limitations, individuals living with chronic MSDs - who are the target population for this research - often experience significant

emotional distress, including anger, anxiety, depression, and frustration (7). This distress is usually exacerbated by stigmatisation (8), social isolation (9), and a loss of identity as they relinquish personal values and social roles (10). These combined factors have a significant negative impact on the quality of life for individuals living with MSDs (11). To reflect the type of population typically encountered in Irish MSK primary care services – the intended setting for the intervention – individuals with pain of specific pathological origin (e.g. infection or malignancy), those who were pregnant, or those who had undergone surgery within the previous six months were excluded.

Globally, MSDs, a group of non-communicable diseases (NCDs), represent a significant public health burden and are a leading cause of disability, accounting for 149 million years lived with disability worldwide (12, 13). This burden is driven by their high prevalence, long duration, and frequent coexistence with other serious health conditions, such as cardiovascular disease (4). In 2019, the Global Burden of Disease estimated that 1.71 billion people worldwide had an MSD, making them one of the most common health conditions globally (12, 14). The prevalence of MSDs has increased by 62% from 1990 to 2019 (12), a trend that is expected to continue due to population ageing, the rising prevalence of other NCDs, and modifiable risk factors such as obesity and low physical activity levels (15).

Beyond their impact on disability, MSDs also impose a significant socioeconomic burden due to both direct and indirect costs (11). Direct costs include healthcare expenses such as drugs, GP attendances, hospital referrals/admissions, physiotherapy, and surgery, with MSDs ranking among the top five conditions in terms of healthcare expenditure, based on data from the 38 member states of the

Organisation for Economic Co-operation and Development (OECD) (15-17). Indirect costs include those related to absenteeism (i.e., sick leave), reduced productivity caused by ill health while at work (i.e., presenteeism), loss of employment, or early retirement due to MSDs (11). Within the European Union, MSDs represent the most costly work-related health problem, affecting about 45 million workers (18). Given the increasing prevalence and economic consequences of MSDs, addressing the rehabilitation needs of people with these conditions is crucial.

1.3 Musculoskeletal (MSK) care gap

MSDs are the leading contributor to the global demand for rehabilitation across the lifespan (12). Rehabilitation comprises a set of essential interventions designed to optimise the physical, mental, and social functioning of individuals with MSDs (19). The International Classification of Functioning, Disability and Health (ICF), developed by the World Health Organisation (WHO), offers a biopsychosocial framework for understanding health in a multidimensional way, addressing impairments in body structures and functions, activity limitations, participation restrictions, and the influence of environment and personal factors (20). MSK physiotherapists play a crucial role in this process, helping to reduce pain (21) and disability (22, 23). However, despite the critical need for these services, access to MSK physiotherapy-led rehabilitation remains limited, with extensive waiting lists reported in many countries (24-28). These delays may result in detrimental clinical outcomes such as increased pain, disability, reduced quality of life, and psychological symptoms (29). In addition, they may lead to adverse health systems and economic consequences, including higher healthcare utilisation, longer sick leave, and reduced care efficiency

(29). This highlights a significant MSK care gap and underscores the importance of addressing this issue to ensure timely and effective rehabilitation for individuals with MSDs.

The WHO has acknowledged this care disparity through its “Rehabilitation 2030: A Call for Action” initiative (30), highlighting the urgent need for greater access to high-quality rehabilitation services. This initiative is closely aligned with the United Nations (UN) Sustainable Development Goal (SDG) 3, which aims to ensure “good health and well-being” for all (31, 32).

1.4 Addressing the global burden of MSDs

To address the global burden of MSDs and improve access to care, the WHO has called for a paradigm shift from health systems focused on acute episodes of care to people-centred, integrated health services (33). Countries such as the US (34), Australia (35), the UK (36), and Ireland (37) strive to implement such reforms (37). Since this project is situated in Ireland, examining the Irish healthcare system is vital.

1.4.1 The Irish healthcare system and MSD care

The Irish healthcare system operates under a two-tier ‘public-private’ model, with approximately equal reliance on both sectors (38, 39). Unlike many European countries, such as the UK, which introduced universal healthcare in the early twentieth century, Ireland did not adopt a similar system (40). As a result, Ireland relies heavily on both public and private sectors to meet its healthcare needs. Public services are overseen by the Health Service Executive (HSE), while various providers deliver private healthcare (41).

People with MSDs typically access care through both primary and secondary care pathways. In primary care, general practitioners (GPs) are the first point of contact, providing initial diagnosis and management. GPs also act as gatekeepers, referring patients to other primary care services, such as physiotherapy and secondary care specialists, including neurosurgeons, orthopaedic surgeons, pain management consultants and rheumatologists (39). However, limited access to GPs is one reason why approximately 25% of emergency department (ED) attendances are related to MSDs, many of which are non-urgent (42-44).

Public healthcare services in Ireland are often associated with long waiting times (38). In primary care, physiotherapy services are stretched, with over 50,000 waiting for treatment, and approx. 17,000 waiting for over a year (45). In secondary care, adult orthopaedic services, a common referral destination for MSDs (46), currently have the longest adult waiting times, with 64,997 people on the list as of September 2024, including 10,115 waiting longer than one year (47). Factors contributing to these delays include reduced staffing due to economic restrictions within the HSE, primarily caused by vacancies from maternity leave or resignations (48). Due to budget overspending, the most recent recruitment pause occurred from October 2023 to mid-July 2024 (49). Additionally, Ireland faces a shortage of physiotherapists, with the supply being 30% lower than the EU-28 average (50). Other factors contributing to long wait times include service curtailments due to the COVID-19 pandemic (39), seasonal ED crowding (51, 52), and the rising demand and complexity of care (53).

In response to these challenges, Sláintecare, Ireland's ambitious 10-year health reform plan, aims to transform health and social care by enhancing

community-based services and reducing reliance on acute hospital care (39). A key focus of the plan is the implementation of integrated care models to manage chronic conditions, such as MSDs better (54). Self-management support is a crucial element of modern healthcare reform (55) and is consistently recommended for managing MSDs (56). The concept is also a core principle of the Sláintecare model (57).

1.5 Self-management and self-management support

1.5.1 What is self-management/self-management support?

Self-management and self-management support are integral aspects of high-quality rehabilitation for people with MSDs (58-60). However, these concepts lack consensus in their definition (61), as evidenced by the varied nature of self-management interventions and diverse outcome measures. This ambiguity poses a significant barrier to meaningful knowledge synthesis and successful implementation (61), with the improvement of self-management support identified as a key research priority (62).

The term self-management was first introduced in paediatric asthma by the behavioural psychologist Thomas Creer in 1976 (63). Influenced by Bandura's early work on self-efficacy, which refers to an individual's belief in their ability to execute the behaviours required to achieve a specific outcome successfully (64), Creer and his colleagues were the first to suggest that patients should actively participate in their treatment (65). Since then, this term has been widely adopted, with some researchers even proposing that, due to the increasing prevalence of long-term conditions, self-management should be incorporated into the very definition of

health: ‘the ability to adapt and self-manage in the face of social, physical, and emotional challenges’ (66).

There are numerous definitions of self-management (61). One commonly encountered definition in many MSD studies (67-69) is Barlow et al.’s (70): ‘the individual’s ability to manage symptoms, treatment, physical and psychological consequences and lifestyle changes inherent in living with a chronic condition’. The US Institute of Medicine’s definition is also frequently encountered (71): ‘Self-management is defined as the tasks that individuals must undertake to live with one or more chronic conditions. These tasks include having the confidence to deal with medical management, role management, and emotional management of their conditions.’

While both definitions give equal importance to medical, social, and emotional tasks in self-management, it has been suggested that using the word ‘must’ in the latter definition places more responsibility on the individual (71). Although self-management does not mean ‘going it alone’ (72), many people with MSDs report feeling abandoned when they are discharged from the healthcare services (73).

Given the tension in the self-management agenda between the rhetoric of patient empowerment and the actual experiences of those living with MSDs (71), and drawing on critical scholarly works (65, 70, 74, 75), this PhD defines self-management support as follows:

Self-management is a *complex* intervention involving patient education and behaviour modification. It is designed to equip people with the skills to manage the physical, emotional, and social challenges of their

condition. It requires a collaborative approach, with healthcare professionals delivering ongoing support.

Complex interventions involve multiple topic areas and components that interact over time as the participants move back and forth between intervention processes and day-to-day life (76).

1.5.2 Frameworks for self-management support

Several self-management support frameworks have been developed to enhance the understanding of self-management support interventions and their components as complex interventions. In 2002, Barlow et al. (70) conducted a review of self-management approaches and identified a diverse range of self-management components, which were non-mutually exclusive. These were broadly categorised as providing information, symptom management, drug management, psychosocial consequences, social support, lifestyle (including exercise), communication and other self-management strategies such as goal setting, career planning and accessing support services (70).

Fischer et al. (77) expanded on this work by incorporating a broader perspective that includes various levels of influence, such as the individual, social environment, and physical and policy environments. In doing so, the following vital resources and supports for self-management were identified: individualised assessment, skills enhancement, collaborative goal setting, access to resources, follow-up and support, and continuity of quality clinical care. A UK-based health and social care charity, the King's Fund, also made significant progress in characterising

self-management support interventions and their components (75). The critical elements of effective supported self-management were identified as follows (78): 1) a combination of personalised information, including action plans, information prescriptions, and structured education and training, and 2) access to specialist advice from trained healthcare professionals and volunteers or through online or face-to-face peer support as needed.

One criticism of the frameworks above is that none provide a comprehensive and universal practical taxonomy of self-management support components (75). This issue also applies to Michie et al.'s 93-item taxonomy of behaviour change techniques (BCT) (79), developed to characterise the active components of behaviour change interventions. While useful, the BCT framework does not encompass the broader services necessary for delivering effective self-management support, such as regular clinical review and provision of easy access (75). Self-management support typically equips people with long-term conditions with the general knowledge, skills and confidence to manage all aspects of their condition – a process known as patient activation (80) – rather than solely focusing on client interactions (81).

To address the need for a taxonomy that outlines potential components of self-management support, enhances the understanding of self-management practices, improves intervention reporting, and promotes a common language among stakeholders, Pearce et al. (75) developed a comprehensive taxonomy. Derived from over 100 systematic reviews of self-management support, the Practical Reviews in Self-Management Support (PRISMS) taxonomy proposes a 14-item classification system of the components of self-management support interventions (**Table 1**).

The PRISMS taxonomy has been utilised in evidence syntheses for other conditions (82, 83); however, to date, no review in the MSD literature has specifically outlined the components of self-management support using the PRISMS taxonomy. This is a barrier to identifying critical features associated with effective and ineffective interventions and successful implementation.

Table 1: The Practical Reviews in Self-Management Support (PRISMS) Taxonomy (75)

Component	Description
A1 Information about condition and /or its management	Providing people with information and guidance on their condition or on general aspects and principles of managing their condition, including physiology, medication, prognosis, and emotional and psychosocial factors
A2 Information about available resources	Providing people with information (e.g., verbal, written, visual) on topics such as financial benefits, sources of social or peer support, and charitable organizations.
A3 Provision of/agreement on specific clinical action plans	Written instructions, prepared with or by a healthcare professional, tailored to the individual, their condition, and its severity, to help them manage their condition.
A4 Regular clinical review	A regular, scheduled review of the individual, their condition, and their self-management, conducted by a healthcare professional.
A5 Monitoring of condition with feedback	Monitoring symptoms, behaviours, or objective measures, either by the patient or others, with results reported to the patient. The patient interprets the data and takes action, potentially with professional support. Professionals can also review the data and provide feedback to assist in self-management.
A6 Practical support with adherence (behavioural)	Providing practical assistance to help a person adhere to behaviour change activities.
A7 Provision of equipment	Providing equipment to enable, assist, or promote self-monitoring and self-management of the long-term condition
A8 Provision of easy access to advice or support when needed	Flexible access to and timely advice from health services for any urgent or non-urgent questions or concerns.
A9 Training/rehearsal to communicate with health-care professionals	Teaching of communication skills and techniques to improve relationships, express their needs more effectively, and enhance shared decision-making with healthcare professionals. Additionally, providing support and mentoring to help them practice and apply these skills.
A10 Training/ rehearsal for everyday activities	Teaching of skills to support their daily activities and/or assisting them in practicing the skills they have learned.
A11 Training/ rehearsal for practical self-management activities	Teaching of specific practical skills to manage their condition, and/or supporting them in practicing these skills.
A12 Training/ rehearsal for psychological strategies	Teaching of psychological strategies to better manage the impact of their condition, and/or supporting them in practicing these skills. May include: problem-solving, relaxation techniques, reframing, distraction, cognitive restructuring, goal setting, and action planning (involving detailed performance or outcome planning, and is not necessarily focused solely on health behaviours)
A13 Social support	Facilitating social support, where individuals feel cared for and supported by their social network. May involve: befriending, peer support, peer mentoring, and group socialising.
A14 Lifestyle advice and support	Offering practical guidance on health and lifestyle, including managing life stressors, diet, physical activity, smoking cessation, and alcohol use (excluding training in psychological strategies; see A12)

1.5.3 Self-management support in policy

Since this project is in Ireland, it is helpful to consider the Irish self-management support policy (84), published in 2017, which acts as a workstream of the Integrated Care Programme for the Prevention and Management of Chronic Disease. This framework, informed by the PRISMS review (84, 85), identifies core components of self-management support as education, practical support for physical care, psychological strategies, social support and action plans for use in deterioration in conditions. Self-management support provided before this framework was noted to be inadequate due to variability across geographical areas and a lack of support for self-management in areas such as providing care plans and information on how to manage their condition (84).

The framework recommends technology for self-management support where evidence supports its effectiveness (84). However, one challenge highlighted in the literature is the population-based nature of evaluations. Studies are often conducted with motivated individuals in selected settings and may not generalise to diverse or underserved populations. A more significant challenge is the lack of head-to-head studies comparing various technologies (86).

One strength of the Irish policy is its detailed implementation and evaluation plan (87). However, a significant weakness of this framework is the narrow range of conditions it includes, namely asthma, chronic obstructive pulmonary disease, diabetes, and cardiovascular disease (84). Notably, only two policy documents included chronic MSDs (88, 89), highlighting a widespread failure to recognise MSDs as long-term conditions requiring access to integrated care similar to other chronic

diseases. This oversight is a consistent feature in policies worldwide and may partly explain the inadequate management of these conditions globally (3, 15, 90).

While policy outlines the importance of self-management support, it is also essential to consider the broader evidence base for self-management interventions in MSK care, which is discussed in the following section.

1.5.4 Self-management support evidence

Beyond policy frameworks, self-management support is consistently recommended in clinical guidelines for MSDs (56, 59, 91, 92). Furthermore, self-management support interventions have been found to produce small positive effects on pain and disability (93-98), with one systematic review in people with chronic low back pain reporting a moderate effect on pain and a small to moderate effect on disability (99). These interventions have also demonstrated positive effects on broader patient-reported outcomes such as quality of life, self-efficacy, and disease-related knowledge or control across various chronic conditions, including MSDs (85, 100).

While effects are generally modest in magnitude, they are consistent across studies, with pooled results from meta-analyses showing small benefits on pain and function — though confidence intervals are often wide (101). A key limitation in interpreting the evidence is the variability in intervention content and definitions (85, 97), which complicates comparisons between studies and may contribute to the overall grading of the evidence as limited. Nevertheless, there are strong and consistent recommendations for the use of self-management as a first-line treatment option for MSDs, even in the context of this limited evidence base (101).

1.5.5 Self-management support in practice

Poor quality MSK healthcare is considered a significant contributing factor to the burden of MSDs (58). Despite these consistent guideline recommendations (92, 102-109), many physiotherapists worldwide fail to provide this crucial component of rehabilitation (110). There are many possible explanations for this evidence-to-practice gap, with MSK care often characterised as a ‘super wicked problem’ (60). This issue is socially complex and multifaceted and lacks a definitive solution. The prevalent ‘we can fix and cure you’ approach is a significant barrier to the self-management support model (111). Physiotherapists are often perceived as providers of ‘cures’ through passive treatments such as manual therapy, which are seen as ‘fixes’. Moreover, given the ever-increasing prevalence of MSDs (12, 15), lengthy waiting lists (45), and workforce shortages (50), regular face-to-face contact is unfeasible.

eHealth has been proposed as a mode of delivery for self-management support, with the potential to improve the value of care provided (112). It enables clinicians to transition from their traditional role as “fixers”, providing hands-on care, to acting as coaches who facilitate self-management — a shift that aligns with guideline recommendations for MSDs (56). As a delivery method, eHealth may offer practical advantages, such as enabling more regular contact and enhancing self-management support through remote clinical review. This approach could increase treatment durability within our overstretched healthcare systems. Nevertheless, caution is required to ensure eHealth implementation does not potentiate low-value, inefficient, ineffective, or unwanted care (113). While promising, the effectiveness of

eHealth as a delivery mechanism for self-management support remains an evolving area of research — explored further in the sections that follow.

1.6 eHealth

1.6.1 eHealth definitions

Many definitions of electronic health, or eHealth, exist (114). The WHO broadly defines eHealth “as the cost-effective and secure use of information and communications technologies in support of health and health-related fields” (115). An eHealth modality is defined as a specific type of technology used within healthcare (114).

Examples of eHealth modalities include:

- Mobile phone applications: mobile-based or mobile-enhanced programs that deliver health-related services
- Internet-based interventions
- Interactive voice response: Systems using a phone’s touch-tone keypad to respond to automated scripts
- Telephone support: interventions with telephone support from health practitioners
- Virtual reality: a 3-dimensional computer-generated environment the individual can explore, interact with, and manipulate
- Telephone-based: intervention delivered via telephone calls
- Videoconferencing: high-quality real-time video and audio connection via online internet networks).

For more detailed definitions, see **Appendix 1**.

1.6.2 The potential of eHealth

In May 2024, the Department of Health launched the Digital Health Framework for Ireland (2024-2030), highlighting eHealth's potential to transform how people interact with healthcare services (116). This framework conceptualises eHealth not as a clinical intervention in itself, but as a mode of delivering or enhancing care – including the delivery of self-management support. This potential is partly driven by rising global smartphone ownership rates (117). Empowering patients to be active partners in their care is a central focus of the framework and is viewed as a key mechanism to promote self-management (116).

Although national policy initiatives like Digital for Care 2030 signal a stronger commitment to digital health, the implementation of eHealth across Ireland's health system — including MSK care — has been relatively fragmented and slow to date (116). The first HSE-developed app specifically for MSK care — designed to support the hip and knee osteoarthritis care pathway using a blended approach — was launched in late 2024 (118). However, this specific care pathway has not yet been rolled out nationally (119). Across both public and private clinical settings, the use of eHealth to support the self-management of MSDs appears to remain inconsistent and largely ad hoc. MSK physiotherapists may use basic digital tools — such as step counters or commercially available mobile apps — to support home exercise programmes (120). While telehealth was rapidly adopted during the COVID-19 pandemic (121), its uptake has since declined. Some services continue to offer video

or telephone consultations; however, integration into routine practice remains limited and inconsistent (122).

eHealth modalities have the potential to enhance the accessibility of healthcare services, allowing individuals to receive care and support from the comfort of their own homes. eHealth may also improve cost-efficiency by reducing the need for travel and direct clinician involvement (123). In addition, these modalities may improve treatment durability by enabling ongoing support and reinforcement of skills even after formal care has ended (123). The COVID-19 pandemic, often described as a "black swan" event (124-126), appears to have significantly accelerated the temporary adoption of eHealth modalities in routine practice (127). However, much of the existing literature on eHealth predates the COVID-19 pandemic, and the full long-term impact of eHealth remains to be understood.

While eHealth shows great promise, several challenges must be addressed to unlock its full potential. Further evidence is needed to establish its efficacy and ensure patient safety fully (128). Additionally, the assumption that eHealth reduces costs and improves access remains inconclusive (129, 130), with mixed results from the few MSK studies evaluating cost-utility (131, 132). Many studies also have methodological limitations that, if addressed, could significantly strengthen the evidence base (130). Moreover, most research excludes individuals with low digital literacy levels or without internet access and often focuses on younger, white populations (133). This raises concerns about both equity and generalisability. If eHealth interventions are not designed inclusively, digital exclusion could exacerbate existing inequality and inequity in healthcare (134). A recent systematic review

demonstrated that while internet-based eHealth self-management can benefit certain social groups, it may disadvantage others who have historically experienced health inequality and injustice (135). This is particularly relevant given that MSK pain and disability disproportionately affect areas of economic deprivation and minor ethnic groups (136). Despite these challenges, eHealth remains a highly promising tool that, with careful consideration and inclusive design, could help bridge gaps in healthcare access and reduce health inequalities. By addressing these barriers, eHealth has the potential to make healthcare more equitable and accessible for all (134).

1.6.3 eHealth-mediated self-management support

eHealth has been proposed as a means to promote and enable self-management. However, some suggest it may inadvertently increase dependence on healthcare professionals rather than fostering self-management (137). Paradoxically, while patients may gain access to more clinical information, empowering them in one sense, their reliance on professional expertise can grow (137). For example, healthcare professionals have reported that patients often expect more regular contact, such as phone calls, for reassurance and guidance (137). This increased dependence may stem from patients seeking validation or clarity about the information they access.

Despite these concerns, eHealth has the potential to contribute to several of the PRISMS taxonomy components, which can be organised into the following categories (82):

- Provision of information and patient education
- Remote monitoring with feedback and action plans
- eHealth-enabled clinical review
- Support for adherence (e.g., lifestyle intervention adherence)
- Psychological support
- Lifestyle interventions (e.g., exercise, weight management)

eHealth-mediated self-management support interventions are an emerging area of research, though much of the literature to date is fragmented, relating to either a specific MSD, such as back pain (138), or a specific eHealth subgroup, such as mobile phone applications (139). This heterogeneity presents a barrier to eHealth's successful and sustainable adaptation into routine clinical practice.

1.6.4 Perspectives on eHealth-mediated self-management support

Achieving optimal uptake of eHealth interventions remains a challenge (140). This is partly due to barriers for people with MSDs and healthcare professionals, such as costs, digital literacy, high existing workloads, intervention design, reimbursement, and resistance to change (141, 142). However, the applicability of these barriers in the local context of MSK physiotherapy services in Ireland remains unclear. To address this, a comprehensive understanding of end-user perspectives towards eHealth-mediated self-management support is required. This insight is crucial for designing inclusive, effective, and efficient interventions (143) and is an essential step toward developing tailored implementation strategies for this local context (144).

A systematic review of qualitative studies conducted before the COVID-19 pandemic offers valuable insights into eHealth's acceptability, challenges, and facilitators for self-management among individuals with chronic MSDs (143). Key facilitators included patient empowerment and convenience, while significant barriers included difficulties in establishing a patient-therapist relationship, technological obstacles, and limited digital literacy (143). Given the significantly accelerated adoption of eHealth modalities in routine practice due to the COVID-19 pandemic (124), an updated exploration of perspectives from individuals with MSDs and physiotherapists on eHealth is needed to guide future implementation and enhance uptake and sustainability beyond the pandemic.

While research has been published on patients' experiences (145) and physiotherapists' perspectives (112, 146) regarding eHealth since the COVID-19 pandemic, much of it focuses primarily on eHealth-facilitated clinical reviews, representing only one component of eHealth-mediated self-management support. The attitudes and experiences of individuals with MSDs and MSK physiotherapists toward a comprehensive understanding of eHealth-mediated self-management support as a complex intervention remain largely unexplored. Additionally, since these studies (112, 145, 146) were conducted during the initial COVID-19 lockdowns when eHealth was a necessity rather than a choice, the potential for bias is apparent. Pre-COVID-19 research suggests that individuals with MSDs viewed eHealth options as more suitable as a supplement than a replacement for face-to-face care (147).

1.6.5 Gaps in existing eHealth-mediated self-management support interventions

While research evaluating eHealth-mediated self-management support interventions in Ireland remains limited, a growing body of international studies has explored their potential over the past decade (123, 138, 139, 148-155). Although these studies are often fragmented by specific MSDs (138) or eHealth subgroups (139), reviews and meta-analyses have found moderate-quality evidence suggesting that these interventions are effective for pain and function for people with MSDs (69, 156-158). However, the benefits are typically short-term (69), with modest effects (156), and the long-term efficacy has yet to be confirmed (157). Considering these mixed and inconclusive findings, several limitations and challenges have been identified, particularly around user involvement and the theoretical foundation of eHealth interventions. These issues will be discussed in more detail below.

1.6.5.1 User involvement

A considerable number of reviews have noted the limited involvement of people with MSDs (123, 139, 148-150, 154, 159, 160) and the inadequate or complete absence of healthcare professional involvement (139, 151, 153-155, 159, 161-163) in the design and development processes of eHealth-mediated self-management support interventions. This lack of user involvement is at odds with the fundamental concept of self-management support, which positions people with MSDs as active partners in their care (75). This methodological gap is also considered a significant factor contributing to initial and sustained engagement challenges, likely limiting the overall impact of these interventions (164-166).

It has been suggested that the development of many current eHealth-mediated self-management support interventions has been driven more by technological advancements than by actual user needs (154, 167-169). To address this, reviews recommend involving users throughout the entire design and development process to ensure the focus is on user needs, enhancing knowledge of usability (148, 159, 160, 170), improving user satisfaction (123, 150, 171), and better understanding of user needs (123, 148, 149, 160, 171).

1.6.5.2 Theoretical foundation

Designing eHealth-mediated self-management support interventions to change health behaviours is complex, requiring a robust theoretical foundation to increase their effectiveness (172). However, many interventions are not well-described (79, 173), with insufficient detail on how individual components are linked to the named theoretical constructs and how this may impact outcomes (173, 174).

This inadequate reporting represents a barrier to implementation (79, 175-177), prompting numerous calls to improve the quality of reporting eHealth intervention development processes with content mapping against recognised taxonomies (173, 177, 178). Developed explicitly for self-management support interventions, the PRISMS taxonomy (75) facilitates the identification of broad intervention components deliverable via eHealth, such as remote monitoring with feedback and action plans and adherence support and lifestyle interventions (82, 179). Michie et al.'s (79) BCT taxonomy is recommended (177) for describing distinct behaviour change techniques such as action planning, goal-setting, and self-monitoring (137, 180, 181).

There is growing support for combining BCTs with persuasive system design (PSD) principles, such as nudges or prompts (175, 182), to enhance eHealth-mediated behavioural change. Onias-Kukkonen's PSD model (183), which builds on Fogg's earlier research (184), aims to influence users' attitudes and behaviours (183) and can be tailored to user profiles to motivate and trigger health behaviour changes in technology design (183, 185, 186). However, a scoping review of eHealth behaviour change research across the last 20 years (187) highlighted further reporting issues, noting that the PSD framework is often underreported (175). Other significant gaps include the mismatch between PSD principles and the theoretical foundations of interventions (188) and the need for more guidelines on integrating behaviour change theory with PSD principles (176).

When claims are made about the effectiveness or therapeutic value of eHealth-mediated self-management support interventions without addressing or identifying their theoretical foundation, existing evidence, or intervention content, there is a significant risk of misleading people with MSD and the therapists involved in their care (113, 155, 189). This oversight could potentially cause more harm than benefit (161), exacerbating issues related to low-value care (113).

1.7 Summary of research gaps which this thesis aimed to address

Firstly, eHealth-mediated self-management support interventions are an emerging research area. The literature to date is fragmented, often focusing on either a specific musculoskeletal condition, such as back pain (138), or a particular eHealth modality, such as mobile phone applications (139). This fragmentation limits the understanding of eHealth-mediated self-management support interventions, representing a

significant critical knowledge gap (190). Since robust evidence is lacking, this gap hinders the successful and sustainable integration of eHealth into routine clinical practice. Additionally, while the PRISMS taxonomy has been used in evidence syntheses for other conditions (82, 83), no review in the MSD literature has specifically detailed the components of self-management support using the PRISMS taxonomy. This gap limits the characterisation, understanding, and implementation of these often complex, multi-component interventions (75).

Secondly, understanding end-users' experiences, needs, and preferences are vital early steps in a user-centred development process (191). However, there is a paucity of research outlining the views of people with MSDs and MSK physiotherapists towards eHealth-mediated self-management support as a complex intervention, particularly since the COVID-19 pandemic. This knowledge is important for developing tailored implementation strategies for the MSK physiotherapy services in Ireland (144).

Thirdly, despite strong and consistent recommendations to adopt a user-centred design approach (169, 192, 193), the actual implementation of end-user involvement remains limited. Moreover, inadequate reporting of the theoretical foundations of eHealth-mediated self-management support interventions presents an additional challenge. Specifically, there is often insufficient detail on how individual components are linked to the named theoretical constructs and how this connection may influence outcomes (173, 174). The lack of applied examples demonstrating real-world implementation may contribute to this issue. Providing such examples could help address these methodological gaps (194).

1.8 Overall aim and research objectives

In light of the research gaps outlined above, the overall aim of this PhD thesis, titled **‘eHealth: It’s TIME’**, was to contribute to the evidence by enhancing eHealth-mediated self-management support for people with MSDs. To achieve this overall aim, three separate studies were conducted, each with specific objectives:

- Study 1 (Chapter 2)
 - Research objectives:
 - To map the available evidence base on eHealth modalities, musculoskeletal diagnosis, and outcomes.
 - To chart intervention characteristics, such as intervention provider, duration, and frequency, together with information on outcomes descriptively described as improved, unchanged, or worse.
- Study 2 (Chapter 3)
 - Research objective
 - To explore the perceptions of people with MSDs and physiotherapists toward eHealth-mediated self-management support.
- Study 3 (Chapter 4)
 - Research objective
 - To co-design and develop a user-centred, theory-based eHealth-mediated self-management support follow-up prototype for people with MSDs

1.9 Methodological frameworks

This PhD project, 'eHealth: It's TIME', was guided by two frameworks: the CeHReS (Center for eHealth Research) Roadmap (195, 196) and the Medical Research Council (MRC) framework for the development and evaluation of complex interventions (76). While both frameworks relate to intervention development, the CeHReS Roadmap focuses specifically on eHealth (176, 197), providing practical guidance for a user-centred approach that prioritises user needs and values (198). In contrast, the MRC framework is applied more broadly to complex interventions, with a strong emphasis on the integration of theory (76, 198). Applying both of these frameworks ensures a more comprehensive approach to developing eHealth interventions. **Figure 1** presents an overview of the work undertaken in this thesis, mapped to both the CeHReS Roadmap and the MRC framework.

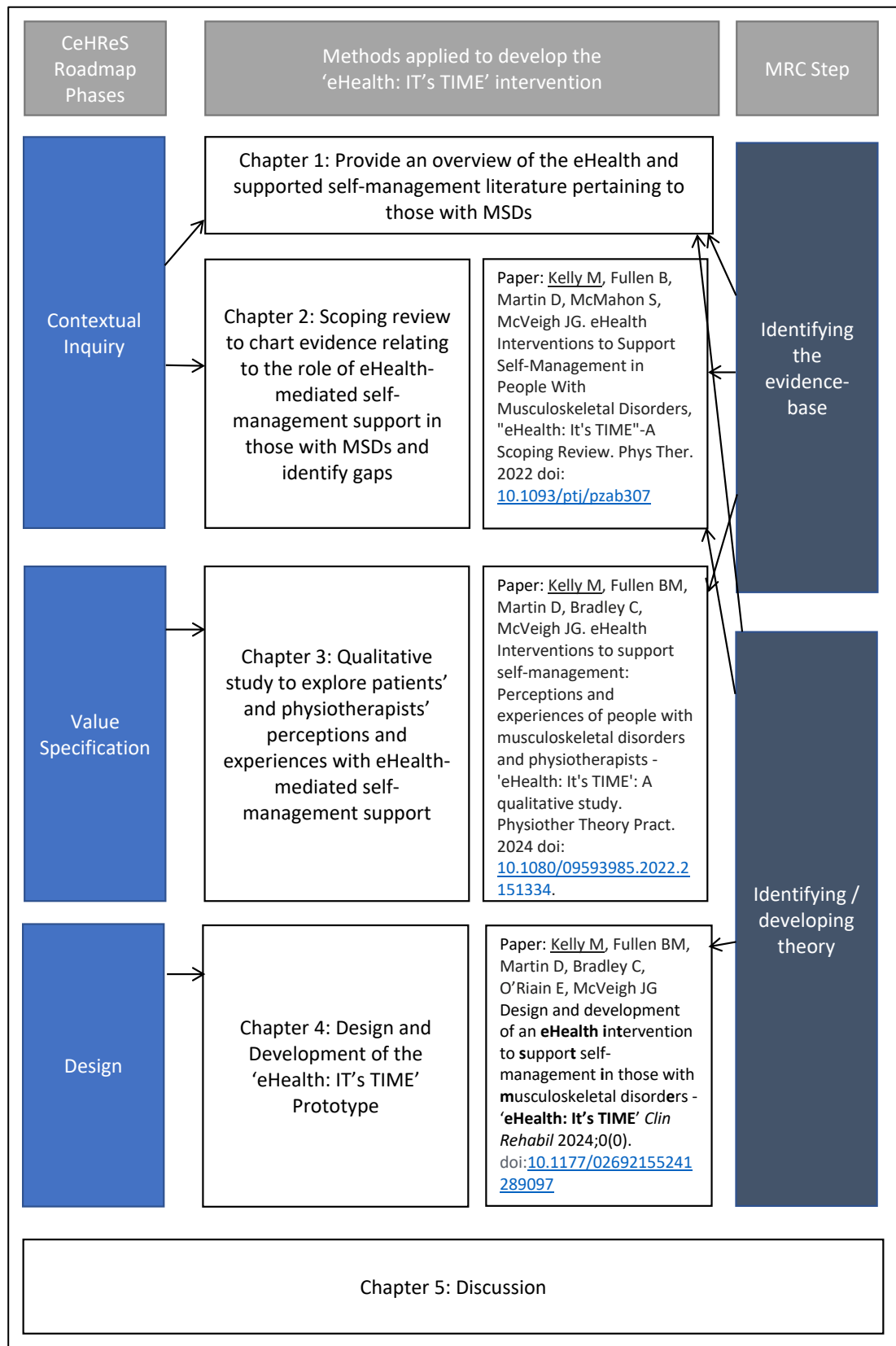


Figure 1: Thesis Overview

1.9.1 The CeHReS (Center for eHealth Research) Roadmap

The CeHRes Roadmap, developed by the Center for eHealth and Disease Management (195), provides a comprehensive guideline for the development, implementation, and evaluation of eHealth technologies (196). It is arguably the most prominent and widely utilised (199) and is founded on five core principles, which are also acknowledged in other eHealth development studies (200):

- **User-Centred:** eHealth development should follow a user-centred process, involving stakeholders both actively and systematically throughout the development process (201-204). For reference, “User-Centred Design” and “Human-Centred Design” are synonymous (199). Although some argue that user-centred design may reduce a person to merely a user of technology (199), this thesis adopts the term due to its broader acceptance in the technology market (205). This approach is believed to enhance patient engagement (206, 207), increase adoption rates (208-210), and improve patient satisfaction (206).
- **Integration into Healthcare:** eHealth should be integrated into existing healthcare systems, requiring changes in service delivery (211-213).
- **Interconnection of Development and Implementation:** The development and implementation of eHealth should be interconnected, with implementation considered from the outset due to its complexity (214, 215).
- **Persuasive Design:** eHealth interventions should be grounded in persuasive design principles, which can facilitate behaviour and attitude changes through technology (183).

- **Ongoing Evaluation:** Continuous formative evaluation is crucial in eHealth development to allow for iterative improvement based on feedback (201, 216-218).

The framework includes five interconnected phases for the eHealth development process: contextual inquiry, value specification, design, operationalisation, and summative evaluation (**Figure 2**).

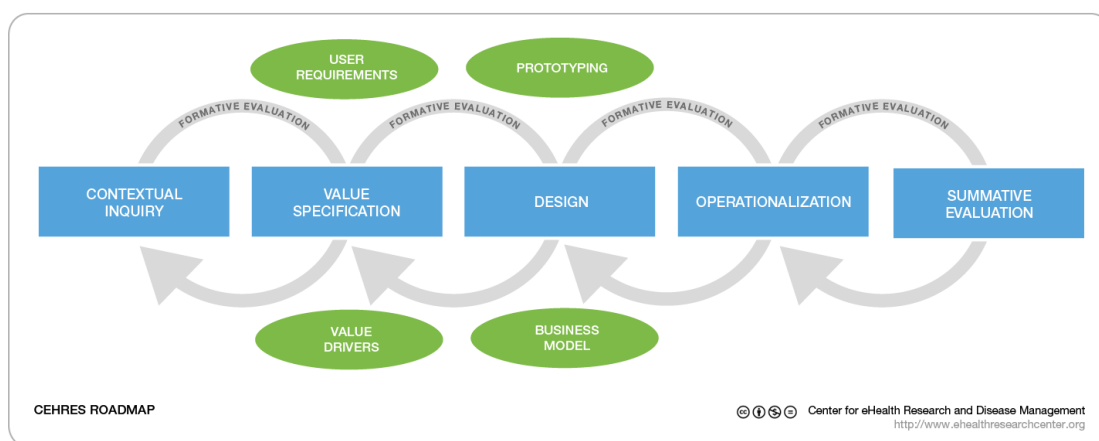


Figure 2: The CeHRes Roadmap (the Centre for eHealth Research Roadmap)

Source: @van Gemert-Pijnen et al (195). Originally published in the *Journal of Medical Internet Research* (<https://www.jmir.org/2011/4/e111/>), 13.12.2011. This is an open-access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/2.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work, first published in the *Journal of Medical Internet Research*, is properly cited. The complete bibliographic information, a link to the original publication on <http://www.jmir.org/>, as well as this copyright and license information must be included.

The CeHRes Roadmap has been utilised for eHealth development in numerous settings (197, 204, 219, 220) and complex contexts (195), such as MSK healthcare. While this framework (195, 196) provides valuable guidance, it is not intended as a rigid, step-by-step prescription for eHealth development (200, 217). This flexibility,

however, can create uncertainty about how best to execute a user-centred design process to suit different aims, phases, and settings (176, 197, 221), which may contribute to its underutilisation. Although there is no optimal step-by-step approach to developing eHealth interventions, combining multiple methods is recommended to strengthen findings and enhance generalisability (176). While various techniques can be combined, mixed methods are the most commonly applied approach (197). This thesis, 'eHealth: It's TIME', focuses on the design and development (rather than the implementation or evaluation) of an eHealth intervention, explicitly addressing the first three phases of the Roadmap: contextual inquiry, value specification and design. The initial contextual inquiry phase, detailed in Chapters 1 and 2, sets the stage for understanding user needs and context. Subsequent phases – value specification and design – are explored in Chapters 3 and 4. Adopting a mixed methods approach enables a comprehensive understanding of user needs and contextual factors while supporting an iterative design.

1.9.1.1 Contextual inquiry

Chapters 1 and 2 contributed to the contextual inquiry phase by providing a comprehensive understanding of existing eHealth-mediated self-management support interventions (222). As utilised in these chapters, literature reviews are among the most common methods in this phase (176) because they help map the current landscape, identify gaps, and establish a foundational knowledge base for developing new eHealth interventions.

Chapter 1 identified critical issues such as the fragmentation of research, inadequate integration of theoretical frameworks, and the need for improved user-

centred design, with a lack of knowledge on end-users' attitudes towards eHealth-mediated self-management support since the COVID-19 pandemic. Chapter 2 (Study 1) (179) expanded on this by mapping seven different eHealth modality types to identify internet-based interventions and mobile phone applications as two of the most commonly evaluated. Furthermore, it characterised the existing eHealth interventions, utilising the PRISMS taxonomy and confirmed gaps relating to user-centred design and theoretical foundations across 63 different eHealth interventions.

1.9.1.2 Value Specification

During the value specification phase (Chapter 3, Study 2 (223)), semi-structured telephone interviews were conducted with key stakeholders (i.e., people with MSDs and MSK physiotherapists) to identify and prioritise their values and determine the eHealth intervention's intended benefits. Interviews are one of the most common methods used for this phase (176). Based on the findings from Chapters 2 (179) and 3 (223), a list of proposed elements for the eHealth intervention prototype was formulated to address these needs and requirements (see **Appendix 2**).

1.9.1.3 Design

In line with the main objectives of this phase (196), Chapter 4 (Study 3 (224)) involved the iterative development of several prototypes (paper, click-through, and mid-fidelity prototypes), followed by heuristic and usability testing using mixed methods. Theoretical frameworks were incorporated by mapping intervention components to the PRISMS taxonomy (75), BCT taxonomy (79), and the PSD model (183).

Chapter 4 (Study 3 (224)) employed methods commonly used in this phase (176), such as focus groups, heuristic evaluations, usability interviews, and questionnaires.

1.9.2 Medical Research Council (MRC) Framework

The UK MRC first introduced its framework for developing and evaluating complex interventions in 2000 (225), with revisions published in 2006 (76, 226). Although updated guidance was published in 2021 (227), this PhD project, which commenced in 2019, is informed by the guidance available at that time (76) (**Figure 3**). As this thesis relates to the design and development of a complex eHealth-mediated self-management support intervention, the focus is on this framework's 'development' phase.

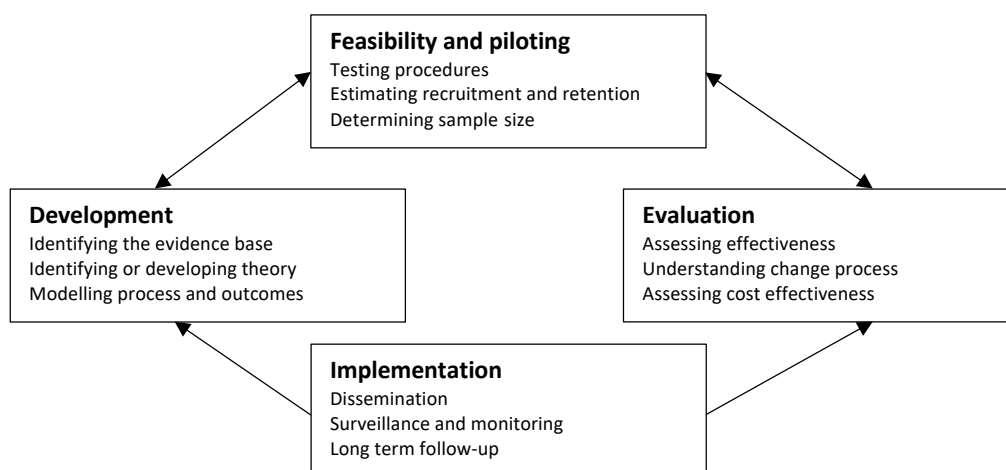


Figure 3: The Medical Research Council (MRC) framework for developing and evaluating complex interventions

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1.9.2.1 Development phase

This thesis explored two core components of the development phase: ‘identifying the evidence base’ and ‘identifying and developing theory’.

1.9.2.1.1 Identifying the evidence base

The first component is similar to the contextual inquiry phase of the CeHRes Roadmap (195) and involves identifying existing knowledge about similar interventions and the methods used to evaluate them (76). As demonstrated in **Figure 1**, Chapters 1, 2 (Study 1 (179)), and 3 (Study 2 (224)) address this component by providing an overview of the current literature on eHealth-mediated self-management support, identifying critical gaps and highlighting the barriers and facilitators to adopting these interventions.

1.9.2.1.2 Identifying/developing theory

A strength of the MRC framework’s Development phase (76), compared to the CeHRes Roadmap (195), is its emphasis on identifying or developing theory from the outset. In a recent scoping review (176), limited use of BCT theory was noted, and it was acknowledged that the CeHRes Roadmap does not explicitly encourage the incorporation of theoretical frameworks (176).

As illustrated in **Figure 1**, Chapters 1, 2 (Study 1 (179)), and 4 (Study 3 (224)) correspond to this component by providing an overview of relevant theoretical frameworks, characterising existing eHealth-mediated self-management support interventions using the PRISMS taxonomy (75), and mapping prototype intervention components to established theoretical frameworks.

Chapter 2

Paper 1: Scoping Review Article

**eHealth Interventions to Support Self-Management in those
with Musculoskeletal Disorders:**

‘eHealth: It’s TIME’: A Scoping Review

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2.1 Abstract

Objective: eHealth-mediated interventions have been proposed as one option to support self-management in those with musculoskeletal disorders (MSDs). This scoping review aimed to chart the evidence regarding eHealth modalities, musculoskeletal diagnosis, and outcomes of eHealth-mediated self-management support interventions in persons with MSDs and identify any gaps within the literature.

Methods: Six electronic databases (MEDLINE, CINAHL, PsycINFO, Embase, Scopus and the Cochrane Database of Systematic Reviews), seven grey literature sources (e.g., OpenGrey) and reference and citation lists of included studies were searched from database inception to July 2020. Published studies of adult participants with a MSD utilizing an eHealth intervention to support self-management were included. Studies were limited to those published in English. Two reviewers independently screened all studies. Data was extracted by one reviewer and reviewed by another reviewer.

Results: After screening 3377 titles and abstracts followed by 176 full-texts, 87 studies fulfilled the eligibility criteria. The majority were published in the last five years (n=48; 55%), with almost one-third originating in the USA (n=28; 32%). The most common eHealth modality type was internet-based (n=22; 35%) with almost one half (n=41; 47%) of the included studies involving participants with widespread musculoskeletal symptoms. The most commonly reported outcomes related to body functions (i.e. pain intensity) (n=67; 45%), closely followed by activities and

participation (i.e. function) (n=65; 44%) with environmental factors (i.e. healthcare utilisation) the least commonly reported (n=17; 20%).

Conclusions: There is considerable variation within the eHealth-mediated self-management support intervention literature. Research is needed on the role of eHealth-mediated self-management support interventions across a broad range of MSDs to guide clinical practice.

Impact Statement: This scoping review has identified gaps in the literature relating to specific eHealth modalities, musculoskeletal diagnoses and healthcare utilisation data which should guide future research.

Keywords: Digital health, eHealth, Musculoskeletal pain, Review, Self-management

2.2 Introduction

The profound burden of disease associated with musculoskeletal disorders (MSDs) is well established. Accounting for one-fifth of the world's total 'years lived with disability' (228), MSDs such as knee osteoarthritis and back pain also represent a significant economic cost (3). This global burden is expected to rise in the coming decades due to an increase in related factors such as obesity, population growth, and aging (229). Healthcare systems worldwide face the challenge of how to manage the rising demand, within limited resources.

Against this background, eHealth has attracted considerable interest as a possible solution. Definitions of eHealth are many and varied (114); in this paper, an eHealth modality is defined as any specific technology that is applied in the context of healthcare (114). Examples include internet-based interventions, telephone-supported (interventions with telephone support from health practitioners), interactive voice response (the use of a phone's touch-tone keypad to provide responses to automated scripts), virtual reality (a three-dimensional computer-generated environment that the individual can explore, interact with, and manipulate), and mobile phone applications (mobile-based or mobile-enhanced programs) that deliver health-related services. Telehealth is an example of eHealth (230) and with respect to telehealth, this scoping review focuses on 'real-time' telehealth (videoconferencing and telephone-based interventions) (231) (More detailed definitions are available in **Appendix 1**).

eHealth modalities have the potential to improve the availability of healthcare services, helping patients to access services and support from their own home. Furthermore, eHealth modalities may provide more cost-effective treatment

options, reducing the requirement for travel and direct healthcare professional involvement; however, the extent of actual cost savings remains unclear (123). Such modalities also have the potential to improve treatment durability, as patients can obtain support and reinforcement of skills after formal treatment has ceased (123). The COVID-19 pandemic, viewed as a “black swan” moment (124-126), appears to have been a significant catalyst for the temporary implementation of eHealth modalities into routine practice. However, much of the literature on eHealth predates the COVID-19 pandemic and is very fragmented, with existing systematic reviews mainly involving those with a chronic MSD (150, 232) and often limited to a specific eHealth subgroup such as internet-based (150) or mobile phone applications (232).

Self-management strategies for people with MSDs are complex interventions that involve patient education and behaviour modification and are designed to encourage people to take an active self-management role to improve health outcomes (74). Effective self-management interventions have been identified as a priority implementation area for healthcare services (233). Supported self-management, aims to empower people to take an active role in managing their condition and health behaviours, collaboratively with their healthcare professional (234). Supported self-management is an important step toward better healthcare provision, which results in positive outcomes including reduced pain and improved self-efficacy (235). eHealth may be used to promote and enable self-management support on a large scale, however, uptake may be limited to those with knowledge and access to appropriate technology and hence may exacerbate healthcare

inequality (236). Another concern is that eHealth modalities may increase dependence on healthcare professionals (137).

Self-management and its support, comprise a wide range of potential activities and interventions, with no single component identified as being more important than another (85). Taylor et al (85) suggest that the detail and quality of reporting of complex self-management interventions was a barrier to understanding their effective components and wider implementation (85), which contributed to the development of the Practical Review in Self-Management Support (PRISMS) taxonomy (75). This taxonomy identified 14 separate elements, which are considered important for self-management support by patients and caregivers (237) (e.g. information provision and patient education; remote monitoring with feedback and action plans) (82). eHealth has the potential to contribute to many of these components.

The PRISMS taxonomy has previously been used in evidence syntheses for other conditions (82, 83), however, there has not been a review in the MSD literature that outlines components of self-management support with reference to the PRISMS taxonomy.

Given the variety of eHealth options, and the varied nature of self-management interventions, this review aimed to provide a broad overview of the evidence for eHealth-mediated self-management support interventions using scoping review methodology. This methodology is recommended when mapping literature that is predicted to be large and heterogeneous (238). In order to characterise the available literature and identify any gaps or limitations, this scoping review had the following objectives: (1) to map the available evidence base on

eHealth modalities, musculoskeletal diagnosis and outcomes; and (2) to chart intervention characteristics, such as intervention provider, duration and frequency, together with information on outcomes described as improved, unchanged or worse.

2.3 Methods

2.3.1 Scoping Review

This scoping review followed the Joanna Briggs Institute (JBI) methodology for Scoping Reviews (238) and reported findings utilising the elements provided in the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (239). Our protocol was registered with the Open Science Framework (<https://osf.io/29rd6>) and published (240). Since our full methods are available in our protocol, they are outlined briefly below.

2.3.2 Data sources and searches

For MEDLINE (via EBSCO), a three-step search strategy was utilised as outlined in the protocol (240). One reviewer (MK) developed the search strategy, with assistance from two professional librarians. A comprehensive electronic search of MEDLINE (EBSCO), CINAHL (EBSCO), PsycINFO (EBSCO), Embase, Scopus and the Cochrane Database of Systematic Reviews databases were searched from inception to July 2020. Studies were limited to those published in English. The main literature search was supplemented by utilizing the Canadian Agency for Drugs and Technology Gray Matters approach (241) with Google Scholar, Health Technology Assessment agencies (Canada, Australia, Ireland, UK and USA) along with OpenGrey searched for grey literature. Additionally, screening of citation and reference lists of included

studies was conducted to identify other potential studies that met the inclusion criteria.

2.3.3 Study selection

Literature search results were screened using Covidence online software (<http://www.covidence.org>). Titles and abstracts were screened by two review authors (MK and SMcM) independently against the eligibility criteria (**Appendix 3**). Any disagreements were resolved by consensus or by decision of a third reviewer (JMcV). Studies that met the inclusion criteria were then retrieved in full and assessed in detail against the eligibility criteria by two review authors (MK and SMcM) independently. Any conflicts were resolved by consensus or a third reviewer (JMcV).

2.3.4 Data extraction

Data extraction was conducted using a standardised data extraction form, which was developed a priori, based on the JBI data extraction tool (238) and the template for Intervention Description and Replication (TIDieR) checklist (242). Data charted is synthesised in **Tables 2 – 5** and **Appendix 4**. Data was charted for all studies by the lead author (MK) and checked by another author for accuracy, with any discrepancies resolved by consultation.

2.3.5 Data synthesis and analysis

Quantitative and qualitative data are presented in tabular format and synthesised narratively, prioritising information reporting on distribution of studies by eHealth

modality, musculoskeletal diagnosis and quantitative and qualitative outcomes. We mapped the interventions in included studies to the components of the PRISMS taxonomy of self-management support (75). Quantitative outcomes are presented in line with the International Classification of Functioning, Disability and Health framework (20), with overall study results categorised descriptively (rather than analytically) as 'improved', 'unchanged', 'worse' or 'mixed'. This categorisation was based on the results presented by the study authors without further interpretation of the results due to the nature of the review being undertaken. Due to updated scoping review methodology recommendations (238), a qualitative thematic analysis was not performed, which was a deviation from the scoping review protocol (240).

Role of the Funding Source: The Irish Society of Chartered Physiotherapists (ISCP) played no role in the design, conduct or reporting of this review.

2.4 Results

As presented in the PRISMA flow diagram (**Figure 4**) (239), from 3,377 unique citations, 87 full-text studies were included.

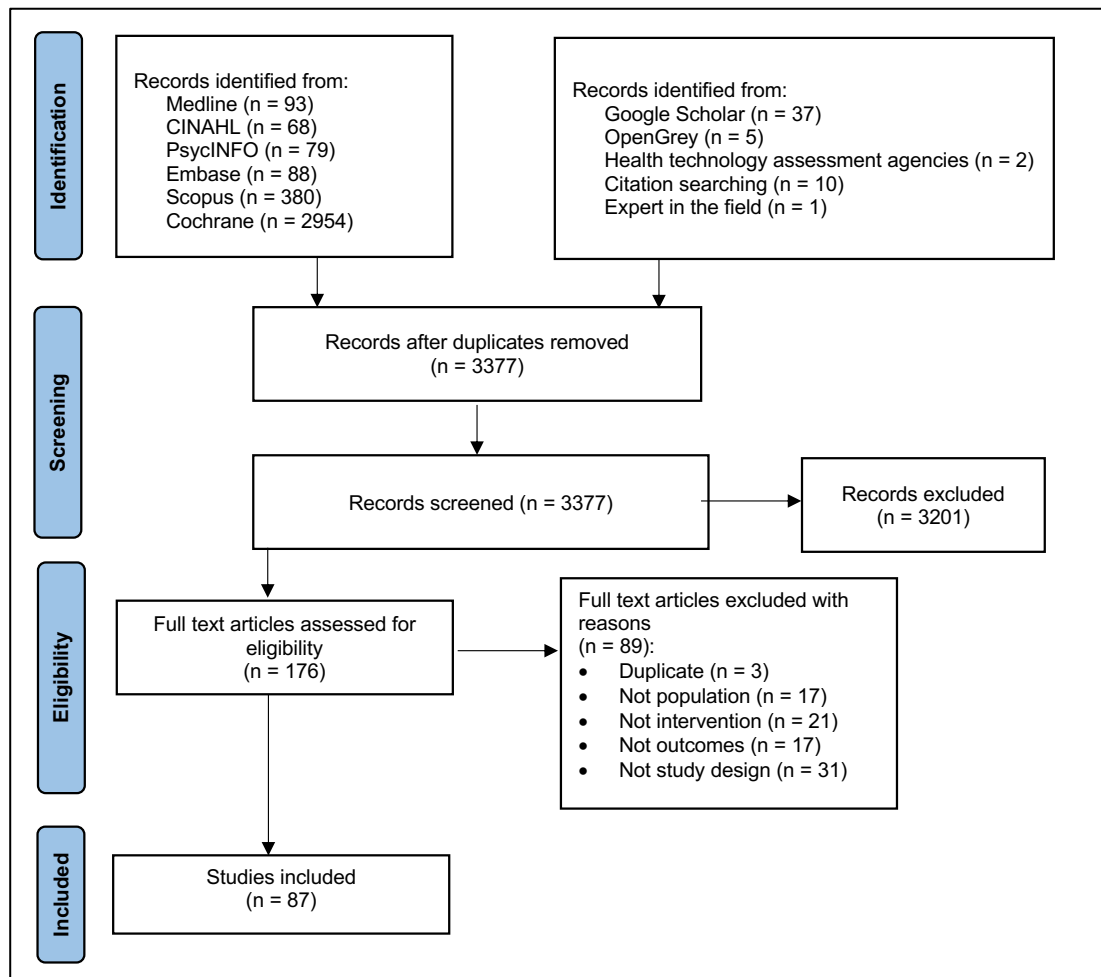


Figure 4: PRISMA Flow Diagram

2.4.1 Description of studies

A summary of the 87 studies included in this review is provided in **Table 2** and **Appendix 4** (categorised by eHealth modality).

Table 2: Characteristics of the studies included in scoping review

Characteristics	Studies (N = 87)
Study design	
Randomized Controlled Trial	60
Randomized non-inferiority trial	2
Observational	10
Qualitative	8
Mixed methods	7
Origin of Study	
USA	28
Australia	16
Sweden	11
UK	6
Norway	5
Germany	5
Netherlands	4
China	3
Nigeria	2
Switzerland	2
Austria	1
Canada	1
India	1
Italy	1
South Korea	1
Year of Publication	
2016 - 2020	49
2011 - 2015	26
2006 - 2010	5
Prior	7
Musculoskeletal Diagnosis	
Widespread musculoskeletal conditions ^a	41
Back Pain	27
Osteoarthritis	12
Knee pain	5
Neck pain	2
Duration of symptoms	
Chronic (>12 weeks)	79
Acute (<12 weeks)	4
Unspecified	3
^a Indicates pain at multiple sites	

The most common study designs were randomised controlled trials (RCTs) (n=60; 69%). Non-RCTs consisted of observational (n=10; 12%), qualitative (n=8; 9%), mixed methods (n=7; 8%) and randomised non-inferiority trials (n=2; 2%). The majority of qualitative and mixed methods studies (n=12; 80%) utilised interviews for data collection.

The included studies were conducted in 15 countries, including the USA (n=28; 32%), Australia (n=16; 18%) and Sweden (n=11; 13%). Most studies were published in the last 5 years (n=48; 55%). The mean age-range of participants reported across studies was 27.3 to 75 years. Only three studies had participants with a mean age greater than 65 (243-245).

2.4.2 eHealth modality type

Twenty-four studies reported the same eHealth modality: hence, 63 interventions were outlined (**Table 3**). The most common eHealth modality type was internet based (n=22; 35%) with the least common single modality, virtual reality (n=1; 2%). Almost one fifth of interventions identified (n= 12; 19%) reporting utilising more than one eHealth modality with the most common combination, internet based with telephone support (n=8; 13%). The majority of interventions utilised a combination of face-to-face (i.e. in-person) and eHealth modality format (n=35; 56%).

Table 3: Overall Characteristics of eHealth-mediated self-management support interventions

Variable	Intervention Count (n = 63)
eHealth-modality type	
Internet-based	22
Telephone-based	15
Mobile phone application	8
Internet based with telephone-support	8
Interactive voice response	3
Video teleconferencing	2
Mobile phone application with telephone-support	1
Interactive voice response with telephone-support	1
Internet based with video conferencing	1
Interactive voice response with telephone-support & internet-based	1
Virtual reality	1
Format	
Mixture of face-to-face & eHealth	35
eHealth only	28
Components of the interventions mapped to PRISMS taxonomy	
Adherence support & lifestyle interventions	59
Information provision & patient education	58
Remote monitoring with feedback & action plans	53
Training & rehearsal of psychological strategies	41
eHealth-facilitated clinical review	42
Type of provider	
Multiple providers	17
Other*	10
Psychologist/Graduate psychology students	12
Physiotherapist	9
N/A - eHealth modality fully automated	11
Nurse	2
Health coach	2
Location of intervention	
Multiple locations	34
Patients home	28
Outpatient	1
Frequency	
Mixed	29
Weekly	18
More than once per week	5
Daily	5
Unstructured – Degree of frequency not specified	3
Monthly	2
More than once per day	1
Duration	
Six – eight weeks	18
Nine – twenty weeks	16
Six months – one year	14
Three – five weeks	7
Mixed	5

Two years	1
One time access	1
Unspecified	1
Intervention Development	
Use of framework/theory	48
Co-designed with patient	14
*Other providers: Health counselor, facilitator, psychiatrist, therapist, research staff, exercise physiologist, orthopedic specialist, physician)	

2.4.3 Musculoskeletal diagnosis

There were five groups of musculoskeletal diagnoses identified. The most frequent diagnosis was widespread musculoskeletal conditions (n=41; 47%) (**Table 2**); followed by back pain (n=27; 31%) with the least common diagnosis, neck pain (n=2; 2%). The majority of studies related to chronic or persistent presentations (n=79; 91%).

2.4.4 Study outcomes and results

Characteristics of the quantitative study outcomes are presented in **Table 4**. Sixty-seven studies (45%) assessed outcomes relating to body functions (i.e., pain, anxiety, depression etc), while sixty-five studies (44%) assessed outcomes relating to activities and participation (i.e. function). The least common outcomes reported related to environmental factors such as medication and healthcare utilisation (n=17; 20%). The overall study outcomes were reported solely based on the findings reported by the studies authors' findings and were not subjected to any form of critical analysis. These results were categorised descriptively as 'improved', 'unchanged' or 'worse'. When studies reported a combination of improved, unchanged and/or worse outcomes, they were categorised as 'mixed' results. Based

on this method of categorisation, 149 outcomes were reported, of which 50% (n=75) improved, 1% (n=2) worsened, 21% (n=30) had no change and 28% (n=42) had mixed results. Of the 75 outcome categories that were improved, 30 (40%) were related to body functions, 38 (51%) were related to activities and participation while 7 (9%) were related to environmental factors.

Table 4: Summary of quantitative study outcomes*

Common Outcomes	Description	Number of studies	Number of studies in which outcome improved
Body Functions	Pain intensity, pain interference, anxiety, depression, sleep, self-efficacy	67	30
Activities & Participation	Stress management, walking, function, employment	65	38
Environmental factors	Medication, health care utilization	17	7
*Based on the International Classification of Functioning, Disability and Health framework			

Appendix 4 includes the findings from eight qualitative and seven mixed methods studies. The majority of these studies (n=12; 80%) utilised interviews for data collection. It is difficult to summarise findings into meaningful categories given the variety of eHealth-mediated self-management support interventions. Two studies reported good satisfaction (246, 247), three studies reported good acceptability (248-250), and two studies reported that participants with MSDs found the eHealth-mediated self-management support interventions to be beneficial (251, 252).

2.4.5 eHealth-mediated self-management support intervention characteristics

eHealth modalities were overseen by a variety of providers (**Table 3**). The most common category was 'multiple providers' (n=17; 27%). The most common identifiable group of providers was psychologists or graduate psychology students (n=12; 19%), with the same number of interventions fully automated with no provider involvement (n=12; 19%). The least common was health coach (n=1, 2%). The majority of interventions involved mixed frequencies ranging from three times per day to monthly (n=29; 46%) with the least common frequency reported was more than once per day (n=1; 2%). The majority of interventions lasted between six and eight weeks (n=18; 29%) while the least common durations reported included one-time access, two years and unspecified (n=1; 2% each). Almost half of the included studies (n=29; 46%) reported post-treatment data only. The majority of eHealth-mediated self-management support interventions involved multiple locations such as a combination of outpatient with persons' home (n=34; 54%), with the outpatient setting being the least common location reported (n=1; 2%).

Adherence support and lifestyle interventions were the most common components of the PRISMS taxonomy identified (n=59; 94%), while training & rehearsal of psychological strategies was the least common (n=41; 65%). The majority of the eHealth-mediated self-management support interventions were complex interventions with multiple components; only two studies (3%) contained two or less PRISMS taxonomy components (253, 254).

With respect to intervention development, 76% (n=48) indicated the use of theories or frameworks. These included cognitive behavioural theory, acceptance and commitment theory, social cognitive theory and the transtheoretical model of

behaviour change. Almost a quarter of interventions (n=14; 22%) involved patients in the design of the intervention.

An overview of identified eHealth modality types with corresponding musculoskeletal diagnosis, outcomes and intervention characteristics is provided in **Table 5**. The majority of studies evaluating internet-based interventions have been conducted in those with widespread musculoskeletal symptoms (n=19; 63%), while the majority of telephone-based interventions have been assessed in populations with back pain (n=9; 45%) and osteoarthritis (n=8; 40%). Of the ten studies included in this review relating to mobile phone applications, six (60%) were evaluated in those with back pain.

Table 5: Tabular presentation of scoping review outcomes

eHealth modality type (intervention count = 63)	Internet-based (n=22)	Telephone based (n=15)	Modality + telephone support (n=11)	Mobile phone application (n=8)	IVR (n=3)	Video conferencing (n=2)	VR (n=1)	Internet-based with video conferencing (n=1)
MSK diagnosis (n=87)	MSK conditions (n= 19) Back pain (n=7) OA (n=4)	Back pain (n=9) OA (n=8) Knee pain (n=1) Neck pain (n=1) MSK conditions (n=1)	MSK conditions (n= 13) Back pain (n=5)	Back pain (n=6) MSK conditions (n= 2) Knee pain (n=1) Neck pain (n=1)	MSK conditions (n= 3) Back pain (n=1)	MSK conditions (n=1) Knee pain (n=1)	MSK conditions (n=1)	Knee pain (n=2)
Quantitative study outcomes (n=149)	Body functions (n=23) Activities & Participation (n=22) Environmental factors (n= 4)	Body functions (n=13) Activities & Participation (n=15) Environmental factors (n=5)	Body functions (n=15) Activities & Participation (n=13) Environmental factors (n=4)	Body functions (n=9) Activities & Participation (n=8) Environmental factors (n=2)	Body functions (n=3) Activities & Participation (n=3) Environmental factors (n=1)	Body functions (n=2) Activities & Participation (n=2)	Body functions (n=1) Activities & Participation (n=1)	Body functions (n=1) Activities & Participation (n=1) Environmental factors (n=1)
Intervention provider (n=63)	N/A - eHealth modality fully automated (n=9) Multiple (n=5) Psychologist/ Graduate psychology students (=5) Nurse (n= 1) PT (n=1)	Multiple (n=7) Other (n=4) PT (n=3) Nurse (n=1)	Psychologist/ Graduate psychology students (=6) Multiple (n=2) Health coach (n= 1) PT (n=1) Other (n=1)	N/A - eHealth modality fully automated (n=2) Multiple (n=2) PT (n=2) Other (n=2)	Other (n=2) Multiple (n=1)	Psychologist/ Graduate psychology students (=1) PT (n=1)	N/A - eHealth modality fully automated (n=1)	PT (n=1)

	Other (n=1)							
Duration (n=63)	6-8 weeks (n=6)	6 months – 1 year (n=7)	6-8 weeks (n=6)	9-20 weeks (n=3)	Mixed (n=2)	6-8 weeks (n=1)	3-5 weeks (n=1)	9-20 weeks (n=1)
	9-20 weeks (n=6)	Mixed (n=3)	9-20 weeks (n=2)	6-8 weeks (n=2)	9-20 weeks (n=1)	9-20 weeks (n=1)		
	3-5 weeks (n=5)	6-8 weeks (n=2)	6 months – 1 year (n=3)	3-5 weeks (n=2)				
	6 months – 1 year (n=2)	9-20 weeks (n=1)		Unspecified (n=1)				
	Mixed (n=2)	Two years (n=1)						
	One time access Unspecified (n=1)	Unspecified (n=1)						
Frequency	Weekly (n=9)	Mixed (n=11)	Mixed (n=8)	Mixed (n=2)	Mixed (n=3)	Weekly (n=2)	Daily (n=1)	Mixed (n=1)
	Mixed (n=8)	Monthly (n=2)	Weekly (n=3)	Unstructured (n=2)				
	More than once/week (n=2)	Unstructured (n=1)		More than once/week (n=2)				
	Daily (n=1)	More than once/week (n=1)		Daily (n=2)				
	Unstructured (n=1)							
	More than once per day (n=1)							
Outcomes improved, worse, unchanged or mixed	Body functions Mixed (n=15)	Body functions Mixed (n=5)	Body functions Mixed (n=6)	Body functions Mixed (n=2)	Body functions Improved (n=3)	Body functions Improved (n=1)	Body functions Mixed (n=1)	Body functions Improved (n=1)
	Improved (n=5)	Improved (n=5)	Improved (n=8)	Improved (n=7)				
	Unchanged (n=3)	Unchanged (n=3)	Unchanged (n=1)		Activities & Participation Improved (n=3)	Activities & Participation Improved (n=1)	Activities & Participation Improved (n=1)	Activities & Participation Improved (n=1)
	Activities & Participation Improved (n=9)	Activities & Participation Improved (n=9)	Activities & Participation Improved (n=8)	Activities & Participation Improved (n=6)	Environmental factors Improved (n=1)	Environmental factors Improved (n=1)	Environmental factors Improved (n=1)	Environmental factors Improved (n=1)
	Unchanged (n=9)	Unchanged (n=2)	Unchanged (n=4)	Unchanged (n=1)				
	Mixed (n=3)	Mixed (n=4)	Mixed (n=1)	Mixed (n=1)				
	Worse (n=1)							
	Environmental factors Improved (n=2)	Environmental factors Improved (n=1)	Environmental factors Improved (n=2)	Environmental factors Improved (n=2)				
	Unchanged (n=1)	Unchanged (n=3)	Mixed (n=1)					
	Mixed (n=1)	Worse (n=1)	Unchanged (n=1)					
Abbreviations IVR, interactive voice response; MSK, musculoskeletal; PT, physiotherapist; VR, virtual reality								

2.5 Discussion

This scoping review mapped the available evidence on eHealth-mediated self-management support interventions for those with MSDs with regards to eHealth modalities, musculoskeletal diagnosis, and outcomes. To our knowledge, this is the first review comprehensively charting seven different eHealth modalities and their various combinations with respect to self-management support. In total, 87 studies of considerable variation in eHealth modality, outcomes assessed, and results obtained fulfilled the inclusion criteria. eHealth-mediated self-management support interventions are an emerging area of practice in musculoskeletal disease with the majority of the studies published in the last 5 years. COVID-19 may accelerate this further (124), with reported increases in eHealth use in Switzerland and Australia, as a result of the pandemic ranging from 44.6-60% (112, 255). However, these figures contrast sharply with findings reported by Werneke et al. (256) indicating an overall eHealth usage rate of 6%. Furthermore, despite increased use of eHealth reported in certain settings, physiotherapists may not plan to continue to provide eHealth modalities after the pandemic (255).

Internet-based interventions were the most common eHealth modality encountered, in keeping with previous reviews (123, 152), with the most common intervention delivery format a combination of eHealth and face-to-face. It should be noted that during the COVID-19 pandemic, allied health clinicians managing those with MSDs rapidly introduced video conferencing and telephone into their clinical practice (112, 255); not internet-based interventions. This is likely related to the fact that more people have access to smartphones than desktop personal computers (69), and not all internet-based interventions are accessible via

smartphones (257). Other reasons may be the cost of developing and implementing internet-based self-management support interventions from an organisational perspective, along with issues around reimbursement that healthcare services across many countries receive for eHealth interventions (258). In response to the COVID-19 pandemic, advocacy from professional bodies supported the reimbursement of telephone and video teleconferencing services by numerous funding bodies (259, 260) which paved the way for the recent rapid introduction of these eHealth modalities into practice in some settings (112, 255). While this move was necessary during the pandemic for many healthcare providers, as it was the only option for patients to receive musculoskeletal healthcare (231), it is worth noting that video teleconferencing was identified in only two included studies (245, 261), and hence, requires further investigation. The first-hand experience of video teleconferencing and telephone that many clinicians and patients with MSDs now have, will certainly shift views, either positively or negatively (231). Given the lack of user (i.e. patients with MSDs) involvement in eHealth intervention design noted within this review and criticised repeatedly in the literature (192, 262), it is of paramount importance that future research adopts a co-design model involving various stakeholders (e.g. patients with MSDs, clinicians, software developers, researchers) to ensure the success and long-term sustainability of eHealth as a method for service delivery (201).

Almost half of the included studies (n=41; 47%) involved participants with widespread musculoskeletal symptoms such as neck and back pain (263) or fibromyalgia (264-266) or chronic pain (261, 267-290). This is not surprising given that research indicates that most people reporting musculoskeletal pain describe multisite pain, with single-site pain relatively rare (291). Furthermore, the more

widespread the symptoms, the greater the impact on health and functioning (291). An important point to highlight is that telephone and video teleconferencing consultations were being utilised during the pandemic to manage a myriad of MSDs such as tendinopathy, joint and muscle strains, despite very limited evidence of efficacy to support eHealth-mediated self-management support for these presentations (112); the majority of the telephone-based studies identified within this review were pertaining to those with back pain and osteoarthritis. More recently, a retrospective observational design study published by Werneke et al. (256) reports that telehealth was administered equally across numerous musculoskeletal regions with unadjusted physical function change similar for those using and not using telehealth. However, the authors urge caution in the interpretation of physical function change due to the study design. This together with the gap identified in this scoping review highlights the urgent need for high-quality research to develop and evaluate eHealth-mediated self-management support interventions for the broad range of MSDs managed by healthcare systems, to provide better guidance for clinical practice (112). Only 5% of included studies involved individuals with an acute presentation (<12 weeks), which is similar to other reviews (292, 293) on self-management interventions. As a result, the effectiveness of self-management support interventions in this cohort remains unknown, despite the recognised importance of early self-management in those with MSDs (105). This gap within the literature may be partly related to the nature of MSDs, with recent onset low back pain for example, resolving quickly (294), often with minimal intervention (295). However, approx. 26% do not recover within three to six months (296), with research indicating that treatments are rarely effective at returning them to a pain-free life

(297). It is likely that any eHealth-mediated self-management support intervention for those with acute MSDs would require different advice and support to that offered to those with chronic MSDs, in line with clinical guidelines (105).

While research indicates that self-management support has a positive impact on healthcare utilisation in conditions such as asthma (83) and cardiovascular disorders (298), there is a paucity of literature available on this outcome with regards to MSDs. The eHealth-mediated self-management support intervention duration was relatively short, despite improved treatment durability considered one potential advantage of eHealth modalities. Another limitation of the eHealth-mediated self-management support interventions identified within this scoping review is the lack of follow-up with almost half of studies reporting posttreatment data only, a finding replicated in a review by Garg et al. (138).

The outcomes of the interventions used in the studies included in the review were descriptively categorised as improved, unchanged or worse, based solely on the study authors' conclusions. The strength of the evidence underpinning the authors' findings was not subjected to critical analysis, and as a result, conclusions regarding the effectiveness of eHealth-mediated self-management support interventions for those with MSDs cannot be drawn. The aim of this scoping review was to review the breadth of the current literature and present the gaps that exist with scoping review methodology not the most valid approach to evaluate effectiveness (299).

2.5.1 Study Limitations

A number of limitations pertaining to this scoping review need to be acknowledged. This review includes English language papers only and hence, potentially relevant

evidence from other language may have been overlooked. Materials from sources such as guidelines, websites, or book chapters were not included. This may have introduced potential bias into the results. Finally, scoping reviews are inherently limited because the focus is to provide breadth rather than depth of evidence on a particular topic (238). Hence, conclusions cannot be drawn regarding the most effective eHealth-mediated self-management support intervention for those with MSDs. However, this method was appropriate given the variety of options that eHealth includes and the varied nature of self-management interventions.

2.5.2 Future Implications

Accessibility and sustainability are key challenges facing musculoskeletal healthcare services, challenges which have been further exacerbated by COVID-19. Robust evidence to support eHealth-mediated self-management is critical if these interventions are to be successfully adopted post-COVID-19. At present, it is challenging to synthesis and interpret eHealth-mediated self-management support interventions given the different methodological approaches and outcome measurements utilised among the included studies. To ameliorate this, researchers should adopt standard eHealth reporting guidelines (300). This scoping review identified two studies evaluating the role of video conferencing in supporting self-management; an eHealth modality which was rapidly introduced into routine clinical practice in response to the COVID-19 pandemic. It is imperative that future research adopts a co-design model when evaluating the role of video conferencing and other eHealth modalities in supporting self-management. The majority of eHealth modalities were evaluated in populations with chronic pain, back

pain and osteoarthritis. To provide better guidance for clinical practice, high quality research is also required for the broad range of MSDs managed by healthcare systems. Lastly, future studies should also evaluate the impact of these interventions on health-care utilisation (138), and increase the length of follow-up.

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Systematic Review Registration

The protocol was registered with the Open Science Framework (<https://osf.io/29rd6>) and published (240).

Disclosures and Presentations

The authors completed the ICMJE Form for Disclosure of Potential Conflicts of Interest and reported no conflicts of interest. Part of this study was presented at the National Irish Society of Chartered Physiotherapists Conference (virtual), October 15, 2021.

Chapter 3

Paper 2: Qualitative Study

eHealth Interventions to Support Self-Management: Perceptions and Experiences of
People with Musculoskeletal Disorders and Physiotherapists –

'eHealth: It's TIME': A Qualitative Study

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3.1 Abstract

Background: There is increasing interest in the potential role of eHealth interventions to support self-management in people with musculoskeletal disorders (MSDs). The COVID-19 pandemic appears to have been a significant catalyst for the implementation of eHealth modalities into routine practice, providing a unique opportunity for real-world evaluation of this underutilised method of delivering physiotherapy.

Objective: To explore the perceptions of eHealth-mediated supported self-management from the perspective of people with MSDs and physiotherapists who work in this clinical area.

Methods: A qualitative interpretive descriptive approach was used. Semi-structured telephone interviews with 13 musculoskeletal physiotherapists and 13 people with musculoskeletal disorders were undertaken. Transcripts were analysed using reflexive thematic analysis.

Results: Three main themes were identified: 1) Flexibility within a blended care model, 2) eHealth as a facilitator of self-management support, and 3) Technology: Getting it right. Participants expressed concerns about assessment and diagnosis, establishing a therapeutic relationship and felt eHealth should be reserved for follow-up purposes. There was a consistent view expressed that eHealth could facilitate aspects of self-management support. A lack of resources and suboptimal user experience remains a challenge.

Conclusions: eHealth-mediated self-management support interventions were broadly acceptably, predominately as a follow-up option.

Keywords: eHealth; self-management; qualitative research; musculoskeletal pain; intervention development

3.2 Introduction

Musculoskeletal disorders (MSDs) such as knee osteoarthritis and back pain are some of the leading causes of years lived with disability worldwide (301). MSDs pose a considerable burden for individuals and society as they are associated with pain, disability, time lost from work and reduced quality of life (302). Physiotherapy is viewed as a fundamental element in the management of MSDs, reducing pain and optimising function (303). However, access to publicly funded physiotherapy services is limited in many countries such as Canada, the UK and Australia, with extensive waiting lists reported (29). Access to physiotherapy has been further exacerbated by the COVID-19 pandemic (304).

Self-management is a treatment approach that encourages the individual to take a more proactive role in the management of their condition (75) and is widely recognised and recommended for MSDs (105, 303). Self-management is not the sole responsibility of the individual living with the MSD, it requires a collaborative approach in which the healthcare professional delivers ongoing support (75). Self-management support comprises 14 components (75) and given limited healthcare resource availability, there is increasing interest in the potential role of eHealth to facilitate this process (305), with several potentially deliverable via eHealth (e.g. information provision and patient education, psychological support and eHealth-facilitated clinical review). eHealth is a term with contested definitions (306); for this study, an eHealth modality is defined as any specific digital technology that is applied

in the context of healthcare (114) (e.g. internet-based interventions, mobile phone applications).

A systematic review examining research from before the COVID-19 pandemic provides insight into the acceptability, challenges, and enablers to the uptake of eHealth for delivering self-management from the perspective of those with chronic MSDs (143). Key facilitators included patient empowerment and convenience, while key barriers were described as difficulties in establishing a patient-therapist relationship, technological barriers and limited digital literacy (143). The COVID-19 pandemic, described as a “black swan” moment (307), appears to have been a significant catalyst for the implementation of eHealth modalities into routine practice (124), providing a unique opportunity for real-world evaluation of this hitherto underutilised method of delivering physiotherapy. Hence, an up-to-date exploration of people with MSDs and physiotherapy perspectives on eHealth is warranted to guide future implementation, improving uptake and sustainability beyond the pandemic.

While there has been research published on patients’ (145) and physiotherapists’ (112, 146) experience of eHealth since the COVID-19 pandemic, it mainly focuses on telehealth-facilitated clinical review, one component of self-management support. The attitudes and experiences of people with MSDs and physiotherapists working in musculoskeletal (MSK) practice toward a more comprehensive understanding of eHealth-mediated self-management support are largely unknown. Furthermore, these studies (112, 145, 146) appeared to take place in the context of initial COVID-19 lockdowns, among a population who had to use telehealth to access physiotherapy, which may have potentially biased findings. Some pre-COVID-19

research suggests that people with MSDs felt eHealth options were best suited as a supplement rather than a replacement for face-to-face care (147).

A lack of user involvement in the development process of an eHealth intervention has been repeatedly criticised within the literature (179, 192), and is thought to contribute to low intervention adherence and high attrition rates, which are key challenges for eHealth interventions (149). This study is part of a larger project, 'eHealth: It's TIME', which aims to develop and test the feasibility of an eHealth-mediated self-management support intervention for those with MSDs. Therefore, the aim of this study was to explore the perceptions of people with MSDs and physiotherapists towards eHealth-mediated supported self-management. Identifying and exploring end-users' needs, experiences and preferences are early steps in a user-centred development process (191).

3.3 Methods

3.3.1 Study Design

An interpretive descriptive design was utilised for this study, which draws on experiences and evidence from clinical practice leading to findings with clear clinical implications, rather than research that aims to theorise (308). The philosophical underpinnings of the interpretive descriptive approach are constituted by constructivist epistemological assumptions, meaning that knowledge is not absolute, but is socially constructed through the subjective person who experiences it (308). This is in keeping with the study's aims; to understand each participant's own subjective reality about self-management support and their views and beliefs about eHealth. The Standards for Reporting Qualitative Research were followed (309). This

study took place within both the public and private physiotherapy settings as an almost 50:50 two-tier 'public-private' model of MSK physiotherapy services exists in the Republic of Ireland (38).

3.3.2 Participants and study procedure

Ethical approval was obtained from the Clinical Research Ethics Committee of the Cork Teaching Hospitals. Participants gave either electronic or written informed consent before data collection began with consent re-confirmed at the outset of each interview.

Purposive sampling was utilised to recruit both individuals with a MSD (based on eHealth experience, symptom duration and rural/urban residence) and MSK physiotherapists (based on clinical experience and setting). Participants were recruited via physiotherapy departments, the Irish Society of Chartered Physiotherapists (ISCP) and social media. Individuals with a MSD were eligible to participate if they had a MSD and were receiving/had received physiotherapy since the COVID-19 pandemic began in the Republic of Ireland (first case: 29/2/20) were English speaking, 18 years or older, and able to provide informed consent. Participants with pain of specific pathological origin (e.g., infection, malignancy), and those that were pregnant or had surgery within the past six months were excluded. Physiotherapists were eligible to participate if they worked predominantly in MSK (at least 50% of their time) in either the public or private setting. Interested participants were asked to contact the researcher. Sufficient sampling was deemed to have occurred when the major themes showed depth and variation in terms of their development, determined through iterative analysis during the data collection (310).

Thirteen MSK physiotherapists (7 male and 6 female) (**Table 6**) and thirteen people with MSDs (4 male and 9 female) (**Table 7**) participated in the study.

Table 6: Participant demographics - MSK Physiotherapists (n = 13)

MSK Physiotherapist Characteristics	Number interviewed
Gender (male/female)	7 male / 6 female
Age range (mean)	26 – 42 (35)
Years qualified range (mean)	4 – 19 (12)
Work grade	Senior (n = 7) Clinical Specialist (n = 4) Private practitioner (n = 2)
Workplace setting*	Public hospital (n = 10) Private practice (n = 3) Primary care (n = 1)
Geographical location	Urban (n = 11) Rural (n = 2)
Experience of using eHealth	Pre COVID-19 (n = 7) Since COVID-19 (n = 6)
*Multiple answers possible MSK; musculoskeletal	

3.3.3 Data collection and processing

Semi-structured telephone interviews were conducted between March and November 2021 and audio recorded. Field notes were also taken. Semi-structured interview topic guides, informed by a literature review and the study aims, were developed (**Appendix 5 and 6**). Interviews lasted between 10 and 50 minutes (average = 27 min). All interviews were transcribed verbatim. Transcripts were imported into NVivo (311).

Table 7: Participant demographics – People with MSDs (n = 13)

People with MSDs Characteristics	Number interviewed
Gender (Male/female)	4 male / 9 female
Age range (mean)	24 – 77 (58)
Location of physio*	Private practice (n = 8) Public hospital (n=4) Private hospital (n = 3) Primary care (n = 1)
Geographical location	Urban (n = 6) Rural (n = 7)
Higher degree/professional qualification	Yes (n = 11) No (n = 2)
Employment status	Retired (n = 5) Full time employment (n = 5) Unable to work due to sickness/disability (n = 2) Student (n = 1)
Site of musculoskeletal problem	Lower limb (n = 5) Multiple (n = 3) Other (n = 3) Upper limb (n = 2)
Duration of symptoms	< 1 month (n = 2) 1 – 3 months (n = 3) 4 – 6 months (n = 1) 1 – 2 years (n = 1) 3 – 4 years (n = 4) > 4 years (n = 2)
Experience of eHealth within Physiotherapy	Yes (n = 8) No (n = 5)
*Multiple answers possible MSD; musculoskeletal disorder	

3.3.4 Data analysis

The data was analysed using reflexive thematic analysis (RTA) (310). RTA is about ‘the researcher’s subjectivity as analytic resource and their reflexive engagement with theory, data and interpretation’, rather than measures of inter-coder agreement (310). As a result, the analysis was primarily conducted by the lead researcher (MK). The data was analysed inductively, thus developing themes from the data rather than using a preconceived list of themes (312). Both semantic and latent coding was used

in the analysis. As a result, information could be double-coded in accordance with the semantic meaning communicated by the participant and the latent meaning interpreted by the researcher (313). RTA (310) involves six steps. In step one, MK achieved data familiarisation through repeated listening of the interviews and reading and re-reading each interview transcript several times. In step two, initial codes were generated by MK using open coding which resulted in a wide array of potential interpretations of the data. In step three, MK revised codes where necessary and collated them under initial themes. Codes and initial themes were compared between interviews from the person with a MSD perspective and the physiotherapist perspective, to understand concepts and initial themes from different viewpoints, thus triangulating the data. Data triangulation was cross-checked by JMcV. In step four, initial themes were reviewed and refined within and across groups (i.e., people with MSDs and physiotherapists). Step five involved further refining, defining, and naming themes. All members of the research team discussed and agreed on the final themes (314). Step six involved writing up a coherent 'story' about the data.

3.3.5 Research team, reflexivity, and trustworthiness

Reflexivity is essential to promote trustworthy and quality results (314, 315). Strategies utilised to enhance the rigour and trustworthiness of the research are outlined in **Table 8** (316). The first author (MK) is a part-time PhD candidate, experienced in MSK clinical practice, and now works in an academic role. The semi-structured telephone interviews were conducted by MK who had undertaken training in qualitative interview techniques. The other members of the research team

include three academic physiotherapists (JMcV, BF & DM) and one academic General Practitioner (CB); all of whom have qualitative research experience. MK completed reflexivity memos throughout the analysis process to engage with and identify possible subjective bias brought to the analysis (315). For example, MK was the project lead on a telephone-based physiotherapy service (317) and was aware of her personal preference for eHealth when interpreting the data. To further enhance the trustworthiness of the work, the analytical process and initial codes and themes developed by MK were checked by JMcV.

3.4 Results

Three themes were identified: (1) Flexibility within a blended care model, (2) eHealth as a facilitator of self-management support (3) Technology: Getting it right. The themes and subthemes are outlined in **Table 9**. Each theme is discussed and illustrated with quotes [PT = physiotherapist, PMSD = patient].

Table 8: Strategies for enhancing trustworthiness

Criteria	Strategy	Details
Credibility	Prolonged engagement	Lead researcher (MK) conducted all interviews MK repeatedly listened, read, and re-read each interview transcript several times
	Triangulation	Both people with MSDs and physiotherapists were interviewed, allowing for perspectives from two different groups (i.e., the intended end-users of the intervention to be developed) MK analysed the data, while another researcher (JMcV) reviewed the data analysis process and results to confirm credibility
	“show rather than tell” (318)	The research team aimed to ‘show rather than tell” (318) by including participants' voices as much as possible.
Transferability	Thick description	The use of detailed demographic and context descriptions will enable readers to decide if results are applicable within their settings
Dependability and confirmability	Audit trail	A detailed description of the data collection and analysis process Confirmability was achieved through the discussion of the analysis process by MK and JMcV once initial codes and themes were named. Final themes were discussed and agreed upon by all members of the research team
Reflexivity	Diary	Reflexivity memos were completed by MK during the analysis process A reflexivity paragraph is included in the methods section of this paper, discussing possible biases as researchers
MSD; musculoskeletal disorder		

Table 9: Themes and Subthemes

Flexibility within a blended care model	eHealth as a facilitator of self-management support	Technology: Getting it right
Therapeutic relationship		Infrastructure and resources
Expectations		User experience

(1) Flexibility within a blended care model

A blended care approach was broadly acceptable to most participants as *“it can’t ever be all technology”* (PMSD-K). eHealth-mediated self-management support interventions had *“a place”* (PT-12) and should be incorporated *“into our normal practice”* (PT-7), although this role was mainly viewed as follow-up as *“everyone would need a physical assessment at the very start”* (PMSD-D). Many physiotherapists agreed that, where appropriate, patient choice should dictate the service delivery method *“that best suits them”* (PT-1) following an initial in-person appointment.

People with MSDs considered this flexibility within their episode of care to be very reassuring:

“I’d be happy in the knowledge, that at any stage that I could request in-person follow-up... if that was made clear” (PMSD-C)

Flexibility was also considered important for physiotherapists, as it was acknowledged that there are a cohort of patients who were not interested in eHealth modalities, which was not necessarily related to technology literacy. Participants

were keen that future developments would not overlook this, with flexibility incorporated into any new care pathways involving eHealth.

“make provision for those that just don't want it and aren't interested in it... I would hate to feel that patients...aren't getting as good a quality service because they don't want that.” (PT-7)

Subtheme 1 - Therapeutic relationship

Most participants agreed that it was *“much easier”* (PMSD-G) to build a therapeutic alliance if there has been some initial face-to-face contact. People with MSDs reported that they would be *“more receptive”* (PMSD-A) to follow-up via eHealth if they had initially met the physiotherapist face-to-face.

Many participants felt that as non-verbal communication was more limited via eHealth, it was difficult to have certain conversations as people did *“not communicate with you, maybe as honestly, or as truthfully as they would on a face-to-face”* (PT-9). This difficulty in conveying certain information meant the interaction via eHealth was perceived to be more impersonal:

“when I got up there and I got to talk to them face-to-face and actually tell them how much I was you know maybe struggling to get around and that to get a bit of empathy even you know for how you're feeling and how you're dealing with it is harder to get across in a video.” (PMSD-H)

Subtheme 2 – Expectations

Both physiotherapists and people with MSDs felt that a ‘hands-on’ approach was important for appropriate diagnosis and hence why an initial in-person assessment was preferred:

“to have the physio.. acquainted with where you have the pain or the soreness.” (PMSD-B)

“I think it's very hard to diagnose....through telehealth or eHealth unless it's a very clear presentation....you can only do a rudimentary assessment.” (PT-10)

One patient spoke of their experience of obtaining the correct diagnosis online, but that an in-person physical assessment provided an extra level of confidence:

“just having the hands-on diagnosis... gave me an extra level of confidence which is probably a mindset I agree....she was perfectly well able to diagnose.” (PMSD-L)

Some MSK physiotherapists perceived the expectation of hands-on therapy as a passive attitude towards rehabilitation, with patients *“looking for the quick fix”* (PT-8), and often being a little *“surprised...in terms of their role”* (PT-2), perhaps indicating a lack of understanding and a more biomedical rather than biopsychosocial viewpoint. Some physiotherapists were frustrated by the perceived tension between

a hands-on and self-management approach, with these not considered mutually exclusive:

“I think there’s this massive drive now to not be hands-on...But a lot can be lost...those initial sessions where you’re spending a bit more time with patients, it’s how you buy their trust and...how you can implement a self-monitoring approach that’s much more effective.” (PT-7)

Most people with MSDs that had experience with eHealth spoke of opting for an appointment or class via eHealth due to COVID-19 because *“it was better than nothing”* (PMSD-J). While for some this view did not change following participation in online exercise classes, others spoke of improved acceptance with a blended approach *“the perfect answer”* (PMSD-K). This mixed response following eHealth engagement was also common among physiotherapists; for some, it met or exceeded their expectations *“of what it was perceived as needing to be at that stage as a stopgap”* (PT-12), with these physiotherapists keen to explore its future use beyond COVID-19, while for others, it was considered a *“good backup option”* (PT-10) if unable to provide face-to-face care.

(2) eHealth as a facilitator of self-management support

Given the imbalance between healthcare resource availability and the prevalence of MSDs, eHealth modalities were considered a feasible solution in the medium to long-term to facilitate behavioural change and manage setbacks:

“it’s so important to be able to get reminders or prompt or support when you fall off the wagon when you’re a patient...while this isn’t always feasible to be done in person....eHealth is the perfect solution to help people stay on track... without...compromising too much of the clinicians time” (PT-3)

Some physiotherapists felt that current services do not serve those with long-term MSDs well with a lack of support acknowledged: *“they are left. Okay, here are all your resources and you go off and manage it” (PT-3).*

There was broad agreement among all participants of the benefits of eHealth regarding information provision. People with MSDs were keen to have exercise videos rather than a home exercise sheet *“to reassure that I have the proper technique” (PMSD-C).* Another person with a MSD spoke of the benefit of being videoed doing their home exercises, as the MSK physiotherapist could individualise cues which was very helpful:

“when you hear him talking, naming the three or four most important points it was very useful.” (PMSD-H)

For MSK physiotherapists though, eHealth did not only facilitate the provision of a home exercise programme but also provided a wealth of information that a person with a MSD could be directed to *“so that when they go away, and they think about*

it, that they have the opportunity to you know, re-engage with the information if they haven't taken it all on board at the time of the consultation” (PT-5).

There was general agreement among both groups of participants that eHealth could increase motivation to complete home exercise programmes and increase general physical activity levels.

“it's [Fitbit] amazing, you know, it certainly, you know, encourages you to do the specified amount that you have been told to do.” (PMSD-A)

(3) Technology: Getting it right

Subtheme 1 – Infrastructure and resources

While issues with connectivity were described as *“sometimes an issue”* (PT-12) by MSK physiotherapists working in an urban setting, this problem was more pronounced for those working and living in rural areas, which caused considerable frustration:

“broadband is not as good as it should be.... And it can be very frustrating you know. If you’ve a Zoom thing and it freezes... Oh my God almighty you’d nearly want to take a Valium before you start.” (PMSD-J)

Both groups of participants referred to a lack of resources such as devices, headsets, webcams, and space as a barrier to engagement with eHealth. For MSK physiotherapists, many implied that while access to resources had improved since the onset of the pandemic, it remained far from a perfect situation.

“We got a lot more laptops sanction here than in the whole history of primary care... but it’s still hard enough and there isn’t enough space to have say a quiet room to do telehealth in... you just have to have your headphones and just maybe hotspot off our phones.” (PT-13)

For the MSK physiotherapists, there was a varying degree of infrastructure in place prior to the COVID-19 pandemic. Some MSK physiotherapists worked at sites which utilised electronic health records, describing the adoption of telehealth as relatively painless: *“it actually transformed overnight for us here”* (PT-6). However, many physiotherapists did not have electronic health records in situ and felt that this was crucial for the successful sustainable implementation of eHealth:

“we need to start looking at developing and rolling out, you know, electronic records....more equipment and more investment...as a nation, we are probably just a little bit behind ...particularly in the public system” (PT-8)

Subtheme 2 – User experience

Most people with MSDs self-reported moderate to high technical literacy levels, and felt that these skills had improved due to the pandemic and increased use of video teleconferencing during lockdowns:

"I've got a lot more confident now and I just think it's not going to eat me, It's not going to bite me. You know you'll always be able to retrieve stuff even if you do go blank..... I google everything now you know. There's nothing to be afraid of" (PMSD-J)

Many MSK physiotherapists spoke of an adjustment period following the introduction of eHealth, with confidence improving through practice: *"the more you do it, and the more you get comfortable doing it, you know, the better it gets"* (PT-8). Another physiotherapist spoke of how clinician confidence *'instils confidence in our patients'* (PT-2). This was touched on by a few people with MSDs, with therapist comfort and efficiency viewed as important factors in ensuring the experience was positive:

"but physios do need to be... streamlined. It was efficient to be honest and it was very useful" (PMSD-H)

The majority of MSK physiotherapists and people with MSDs preferred videoconferencing consultations as these were perceived to be superior in replicating a face-to-face appointment compared to a telephone consultation:

"With a video call at least you could like show and she [physio] can see the way you're doing the exercises...and maybe advise if you're doing it wrong the same as if you were in the consulting room with her.. if you're on a phone call... you'd be just describing stuff yourself." (PMSD-D)

Although many agreed telephone consultations were a useful solution for technical difficulties, for those with less confidence in technology or those that do not have access to the internet or an appropriate device:

“Everyone we see has access to a telephone. So, I suppose that will be the primary use. And I think, if you're looking at eHealth options, that's probably the most likely one.” (PT-2)

It was important for both groups of participants that eHealth *“makes life easier for clinicians and provides quicker and better access for patients”* (PT-1) and that *“you’ve to be mindful that it’s (technology) not taking up the physio’s time either you know away from appointments.”* (PMSD-G). This is noteworthy considering that some MSK physiotherapists felt poor integration and interoperability of systems was creating more administrative duties:

“It's an extra three or four steps that you have to do for each patient. So, it's a little bit more admin heavy” (PT-6)

Regarding the type of eHealth, there was a general sense from both participant groups that any programme developed should be accessible via both an internet browser and an app. This meant that *“they could log on to on multiple devices,*

depending on where they were... they might be doing their exercises in work one day, and then they just want them on their phone, but they don't have the app. It's at home on the tablet" (PT-2). People with MSDs spoke of how engagement with an app *"depends on the capacity on your phone. Like my phone now the storage is full"* (PMSD-G) and how a platform that can be accessed on multiple devices is *"gonna appeal to more people"* (PMSD-H).

3.5 Discussion

This study explored the attitudes and experiences of MSK physiotherapists and people with MSDs regarding eHealth-mediated self-management support. While there has been some work exploring perceptions of physiotherapists and/or people with MSDs to eHealth, much of this research has been done before the COVID-19 pandemic (143, 319). Those studies published during COVID-19 (112, 145, 146) predominately focused on eHealth-facilitated clinical review, which is just one component of self-management support. Given the extraordinary shift towards the use of eHealth within MSK physiotherapy practice, due to COVID-19 and the need to reframe MSK care (60), this timely study aims to provide an overview of factors that need to be considered to ensure that eHealth adoption in MSK physiotherapy is more than just temporary. Although differences may exist in health care systems, cultures, and populations, these findings from the Republic of Ireland are relevant for MSK physiotherapy practice worldwide. The unmet need of people with MSDs is a global problem, and physiotherapists work toward the same global goals for MSK rehabilitation services (15), as described by the World Health Organisation (320).

A key finding of this study is that both physiotherapists and people with MSDs were open to the future use of eHealth interventions, within a flexible, blended care model, which is consistent with the existing research (145, 146). This blended care model would involve initial face-to-face contact, with eHealth reserved for follow-up care. Some concerns were expressed by both groups of participants relating to assessment and diagnosis, a lack of hands-on contact and difficulties establishing a therapeutic relationship with eHealth, which has previously been reported (112, 145, 146). Flexibility (i.e., patient choice dictating service delivery method) was also considered important, given individual barriers to the use of eHealth mentioned within this study, such as low motivation, limited resources, and perceived poor outcomes. While some people with MSDs will opt for eHealth after one or two face-to-face appointments, others will likely view it as a means of aftercare or checking in, and there will be those that will not wish to opt for it at all. A flexible blended care model will minimise the risk of the digital divide widening (321), while also serving as a means of individualising the intervention and facilitating eHealth acceptance and engagement (322). Guidance and personal feedback could also help address the attrition/adherence challenges associated with eHealth interventions (149, 322) although establishing the most cost-efficient approach to this will be of paramount importance.

There was broad agreement among participants that eHealth could facilitate multiple components of self-management support. As has been previously reported (323, 324), participants felt that eHealth could facilitate follow-up clinical review with videoconferencing generally preferable to telephone. Participants in the current study felt that telephone-facilitated clinical reviews were a necessary option given

the digital divide among patient populations (325). Physiotherapists also stated that telephone-based consultations facilitated quick check-ins, efficiently supporting self-management and that both eHealth modalities, videoconferencing and telephone remain options for follow-up clinical review. Both groups of participants considered eHealth to be useful in terms of patient education, particularly as it supports the use of multimedia education using videos. Indeed video delivered information has been shown to be more effective than written information in terms of engagement and information uptake (326). As has been previously reported (327, 328) physiotherapists acknowledged the challenges associated with initial behavioural change and sustaining such change. However, an eHealth intervention incorporating self-monitoring functions (e.g., home exercise programme logging, physical activity, and exercise logging) along with digital reminders in-between regular sessions, could support such change (329).

This study sought to address the issue of lack of user involvement within eHealth intervention design (179, 192), which may partly explain the low adherence and high attrition rates associated with the use of such interventions (149). Similar to other research (112), a barrier noted by some physiotherapists was increased administrative duties, which may be partly explained by poor interoperability (330). Seamless bidirectional flow of data between various disparate devices over a network is the ultimate goal of interoperability (331). This is an important consideration to ensure eHealth acceptance, given that limited availability of time in the clinical setting is a well-known challenge (192). Furthermore, an eHealth intervention that was accessible on multiple platforms was considered most useful

given individual preferences and differing resources, although this is in contrast to existing research (332, 333).

3.5.1 Implications

Given concerns around assessment and diagnosis and establishing a therapeutic relationship, eHealth interventions may be best reserved for follow-up care. Flexible blended care models can serve as a means of individualising the intervention, facilitating acceptance and engagement. Considering this study's findings and previous work (179), the next study in this 'eHealth: IT's TIME' project will test a low-fidelity prototype of an intervention that facilitates follow-up self-management support via integrated remote monitoring and behavioural change.

3.5.2 Strengths and limitations

The principal strength of this study was the rigor of its methods, including the purposive sample encompassing MSK physiotherapists and people with acute and persistent MSDs from both public and private physiotherapy settings. The iterative process of analysis and synthesis of qualitative data added further rigor. Another strength of this project was the involvement of key stakeholders in the design and development of a multicomponent eHealth-mediated self-management support intervention. However, the results of this study should be interpreted in light of their limitations. Most people with a MSD were over the age of 45, and most were female, which may limit the transferability and trustworthiness of the results. Lastly, the lead researcher (MK) is experienced in MSK clinical practice, with some participants

known to MK. To minimise any resulting bias, reflexivity, and regular peer debriefing were implemented.

3.6 Conclusion

This study offers insights into the perception of eHealth-mediated self-management support interventions from those with MSDs and physiotherapists. The study provides considerations that will inform the design and development of a future eHealth intervention. The participants considered an eHealth intervention an acceptable method to facilitate follow-up self-management support within a flexible blended care model. This study also highlights the importance of continued user involvement.

Ethical Approval

Ethical approval was obtained from the Clinical Research Ethics Committee of the Cork Teaching Hospitals.

Funding

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Disclosure of Interest: None

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Chapter 4

Paper 3: Design and Development Study

Design and Development of an **eHealth** Intervention to Support Self-Management
in People with **Musculoskeletal Disorders**:

‘eHealth: It’s TIME’

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4.1 Abstract

Objective

This study aimed to co-design and develop a user-centred, theory-based eHealth-mediated self-management support follow-up prototype for adults with musculoskeletal disorders.

Design

A three-step system development cycle was employed. Step one involved creating intervention features and content, with two focus groups reviewing prioritised eHealth intervention elements based on earlier research. Step two involved heuristic testing using Nielsen's 10 heuristic principles. Step three incorporated qualitative think-aloud interviews and the System Usability Scale.

Setting

Republic of Ireland

Participants

Step one included adults with musculoskeletal disorders ($n = 12$). Step two involved five reviewers. Step three included people with musculoskeletal disorders ($n = 5$) and musculoskeletal physiotherapists ($n = 5$).

Results

Participants in step one approved four main intervention components, which map to recognised theoretical frameworks, and suggested increased use of visual and interactive elements. Heuristic testing in step two identified design and navigation issues. In Step 3, usability testing, additional navigation, content and design recommendations were identified. The overall median system usability score (interquartile range) was 75 (0) out of 100 for adults with musculoskeletal disorders

and 77.5 (2.5) out of 100 for musculoskeletal physiotherapists, indicating good usability.

Conclusion

A theory-based, user-centred eHealth-mediated follow-up self-management support prototype has been developed for people with musculoskeletal disorders, with the next steps focusing on feasibility testing in clinical practice, with a more diverse population.

Keywords: eHealth; self-management; musculoskeletal pain; intervention development; user-centred design approach

Clinical Messages

- There is a need for more effective self-management interventions for musculoskeletal disorders, with growing interest in the role of eHealth.
- It is recommended that individuals with musculoskeletal disorders be actively involved in the development of eHealth interventions, which should be grounded in theory.
- A new eHealth-mediated self-management support intervention is being co-developed with patients, based on theory.
- Four main components to support self-management have been identified: an information library, goal-tracking, a support forum, and a 'contact your physiotherapist' feature. These have been included in the prototype intervention.

4.2 Introduction

The burden of musculoskeletal disorders is becoming more profound, leading to a corresponding increase in the demand for rehabilitation (32). Despite this, significant gaps exist, with rehabilitation services ill-equipped to meet the high demand (32). The World Health Organisation's "Rehabilitation 2030: A Call for Action"(334) has highlighted this care disparity, with eHealth interventions increasingly recognised as an urgently needed, scalable, and cost-effective solution.

Self-management involves patient education and behaviour modification, aimed at teaching people the skills to manage all aspects of their condition (75). Self-management is not the sole responsibility of the person with the musculoskeletal disorder (75); the treatment approach is collaborative with the clinician providing continuous support. Given the strain on healthcare systems, there is increasing interest in the role of eHealth to provide this support.

An eHealth intervention is any digital technology applied in a healthcare setting (306). Based on end-user preferences (223), for this study, the term refers to an internet-based or mobile application intervention, two of the most common eHealth intervention types (179). Despite fragmented literature (179), studies provide moderate-quality evidence that eHealth interventions can reduce pain and improve function for people with musculoskeletal disorders (69, 156-158). However, these benefits are typically short-term (69), modest (156), and their long-term efficacy remains unproven (157, 179). Although user-centred design is recommended (199), it is often not adopted in eHealth intervention development, which may contribute to poor engagement and limited impact (176). This gap may stem from a

lack of clear guidance on tailoring this process to suit different aims and settings (176).

This study aims to co-design a theoretically robust eHealth prototype for follow-up self-management support for people with musculoskeletal disorders, based on their preferences. Designing eHealth interventions to change health behaviours is complex and requires a strong theoretical foundation for effectiveness (172). While many eHealth interventions reference theory (179), they often fail to clearly link components to theoretical constructs (173), representing an implementation barrier (79, 175-177). This gap has prompted calls for interventions to be mapped against recognised taxonomies (173, 177, 178). The 'eHealth: It's TIME' project is novel in its integration of three key frameworks: the Practical Review in Self-Management Support taxonomy (75), which identifies broad intervention components such as remote monitoring with feedback (179), Michie et al's (79) Behaviour Change Technique taxonomy, which details distinct behaviour change techniques such as goal setting and self-monitoring (177), and persuasive system design principles (183), such as nudges and prompts, to enhance behavioural change (175). Combining these frameworks and utilising a user-centred design approach, a theory-based, patient-centred prototype for follow-up self-management support has been developed for people attending musculoskeletal primary care physiotherapy services. This project is guided by the Center for eHealth Research Roadmap (195) and the Medical Research Council framework (335).

4.3 Methods

The methods are described in detail in the study protocol paper (336) and are outlined briefly below. Reporting of this study was primarily guided by the GUIDance for the rEporting of intervention Development framework (GUIDED) (337), with the reporting of the qualitative components informed by the COREQ checklist (338).

The 'eHealth: It's TIME' project is being conducted in the Republic of Ireland, where musculoskeletal physiotherapy services exist within an almost 50:50 two-tier 'public-private' model. MK, a female senior musculoskeletal physiotherapist with over 13 years of experience, is leading the project. She holds a taught postgraduate masters in musculoskeletal physiotherapy, works in the public healthcare sector, and is currently a part-time PhD candidate. MK, trained and experienced in qualitative interview techniques, collected all the data. The research team also includes three academic physiotherapists (JMcV, BF, & DM), one academic General Practitioner (CB) and one software developer (EO'R).

The Center for eHealth Research Roadmap (195) informed the design and development of the eHealth-mediated follow-up self-management support intervention. This eHealth-specific roadmap, derived from the review of numerous eHealth and development frameworks, fulfils the Medical Research Council framework criteria (335) while offering more practical guidance. Since this project relates to the design and development of an eHealth intervention (rather than the implementation or evaluation), the focus is on the first three phases of the Roadmap. For the contextual inquiry phase, a comprehensive systematic scoping review (179) was conducted to map the current literature, highlighting that people with

musculoskeletal disorders are seldom involved in developing eHealth-mediated self-management interventions. For the value specification phase, a qualitative study (179) was conducted to establish stakeholder perceptions on eHealth-mediated self-management support since the COVID-19 pandemic began in the Republic of Ireland (first case: 29/2/20). These interventions were considered broadly acceptable, although primarily as a follow-up option due to concerns about assessment, diagnosis and establishing a therapeutic relationship.

The eHealth: It's TIME intervention was developed to enhance self-management support for people with musculoskeletal disorders, a key research priority (62). The development process aimed to co-design and develop an evidence-based and theory-based multi-component prototype for follow-up self-management support via integrated remote monitoring and behavioural change. Based on the contextual inquiry (179) and value specification phases (223), the prioritised eHealth intervention components (**Appendix 2**) include an information library, a goal-tracking feature, a social forum, and a chat function. eHealth: It's TIME intervention will be accessible via computer, laptop, tablet and smartphone. Each person with a musculoskeletal disorder will be provided with a confidential username and password. This intervention is intended for individuals with musculoskeletal disorders who are attending musculoskeletal primary care physiotherapy services, as part of a flexible blended care model. It will be specifically utilised for follow-up care, allowing individuals with musculoskeletal disorders the flexibility to engage in the intervention between face-to-face appointments or toward the end of their care

episode, typically before discharge. The feasibility of this approach will be evaluated as part of the next phase of this project.

This study, conducted between January and October 2023, followed a three-step system development cycle study: the creation of intervention features and content (Step 1); heuristic testing (Step 2); and usability testing (Step 3) (see **Figure 5**). Ethical approval was granted by the Clinical Research Ethics Committee (CREC) of the Cork Teaching Hospitals (REF: ECM 4 (f) 20/09/2022).

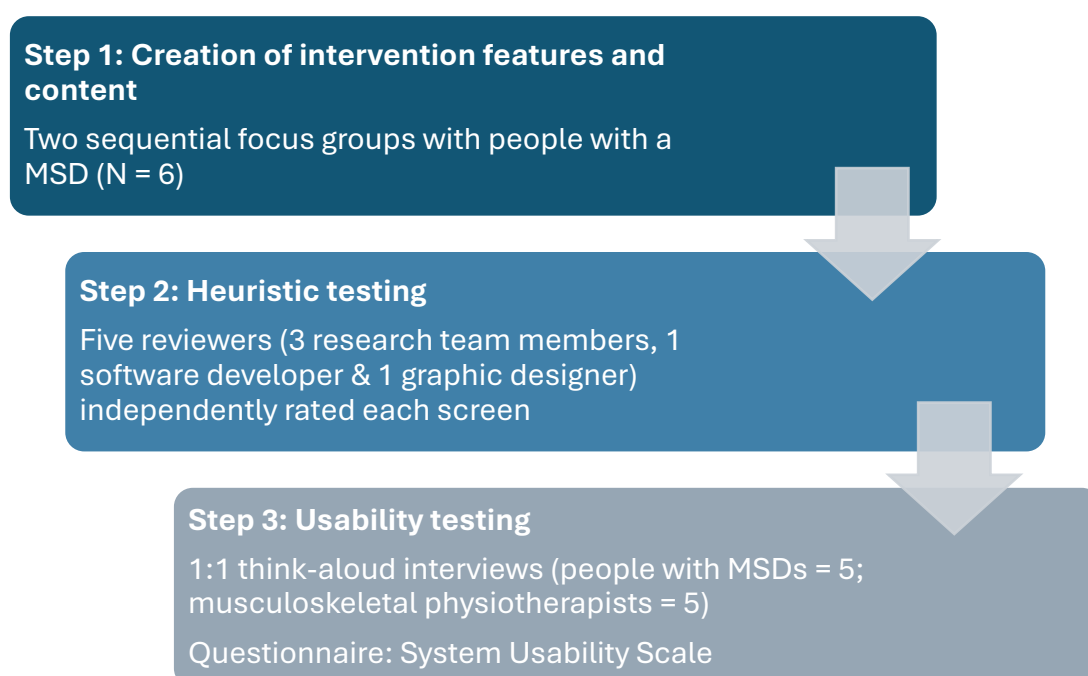


Figure 5: Study overview

Two of the 22 participants in this study's qualitative component were known to the interviewer, MK, before the study's commencement. Given the challenges associated with this such as the interviewer losing objectivity and participants not being completely truthful in their responses, MK leveraged certain strategies to mitigate these risks. Aware of her personal preference for eHealth (317), MK completed

reflexivity memos throughout the study to avoid projecting her biases and remain open to views that challenged them, aiming to improve the intervention's contextual fit. Other trustworthiness strategies employed within this study are described in the study protocol (336).

4.3.1 Step 1: Creation of intervention features and content

Before the first focus group, paper prototypes of the prioritised eHealth intervention elements were created. The Web Content Accessibility Guidelines (WCAG) 2.1 (339), recognised internationally for enhancing web content accessibility, were considered at each iterative step of the study. In line with recommendations, the readability of content was rated at US grade ≤ 6 (age 11 – 12 years) with Microsoft Office Software used to confirm this.

All individuals with a musculoskeletal disorder (i.e., target population) met the following eligibility criteria: English speaking (judged by lead researcher MK during pre-interview communication); 18+ years old and can provide electronic or written informed consent. Individuals who had surgery within the past six months, were pregnant, or had pain of specific pathological origin (e.g., malignancy, fracture, infection, or inflammatory disease); were excluded.

A convenience sampling strategy was employed for this study. Recruitment was advertised on social media (Twitter/X) and via email requests circulated to primary and secondary care in Cork, Ireland, patient support groups, professional organisations, and university staff. All interested participants received the participant information leaflet. At one site, Mercy University Hospital, musculoskeletal physiotherapy staff identified participants, and MK conducted eligibility screening.

MK informed potentially eligible participants about the study and provided them with a participant information leaflet. Following a 24-hour 'cooling-off period', MK telephoned the individual with a musculoskeletal disorder, to confirm their interest in participating.

All participants provided electronic consent via Qualtrics (Qualtrics, Provo, UT). Before the focus group, demographic details and the eHealth Literacy Scale were also obtained via Qualtrics.

The first focus group involved the six participants reviewing the paper prototype (see **Figure 6**), with a topic guide (**Appendix 7**) utilised to flexibly guide the discussion on element/feature acceptability, least and most liked element and helpful and unhelpful aspects of other health apps and websites previously used. Based on this feedback, a refined click-through prototype was developed using Figma, an online design and prototyping tool (<https://www.figma.com/>), for the participants of the second focus group to review.

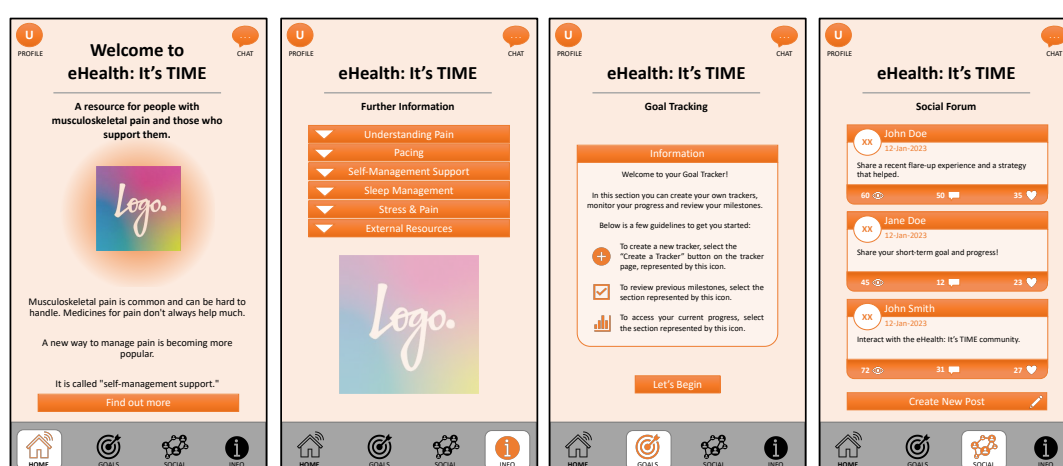


Figure 6: Mobile app paper prototype examples.

For the second focus group, a semi-structured topic guide (**Appendix 8**) was developed to elicit participant views on the individual website and app pages, the functional elements such as hover-effect and click, and other tailoring features. Due to scheduling difficulties, two of the six participants in the second focus group completed one-to-one interviews utilising the same Focus Group 2 topic guide, in line with the study protocol (336). Both topic guides were developed by the research team and informed by the study aims and a literature review.

All focus groups took place remotely via Microsoft Teams and lasted between 43 and 71 minutes. Field notes were taken in all focus groups. The focus groups were audio recorded, transcribed verbatim, and imported into NVivo. MK completed a descriptive synthesis of the focus group transcripts (340), systematically summarising all suggestions for prototype refinement. This summary was then reviewed by JMcV and EO'R, who revised the list as required to ensure feasibility within the study's context. The prototype was subsequently refined according to this revised list before heuristic testing.

4.3.2 Step 2: Heuristic testing

Heuristic testing was completed by a panel of five reviewers, consisting of three research team members (BF, DM & CB) and two external experts (a graphic designer and a software developer), none of whom were involved in Step 1. The 10 heuristic principles of Nielsen (341) were used to evaluate the refined web-based and mobile application-based prototype. Each web and application page was independently rated (+1 = complies, -1 = does not comply, or 0 = partially complies), with comments provided to justify scores. At a consensus meeting, the ratings were discussed, and

an agreement was reached on items to be addressed before usability testing, with the prototype refined accordingly.

4.3.3 Step 3: Usability testing

This step employed mixed methods, combining a qualitative think-aloud interview with quantitative data obtained via the System Usability Scale administered at the end of the interview. This approach is recommended to evaluate prototype usability (176).

Participants in this step included both individuals with a musculoskeletal disorder and musculoskeletal physiotherapists. For individuals with a musculoskeletal disorder, with no prior exposure to the eHealth: It's TIME prototype development, the same eligibility criteria and recruitment strategy as outlined in Step 1 was utilised. All musculoskeletal physiotherapists met the following criteria: working predominantly in musculoskeletal therapy (at least 50% of their time) in either the public or private health setting. A convenience sampling strategy was employed with recruitment for the study advertised on Twitter/X and email requests circulated via physiotherapy managers in Cork, Ireland and relevant mailing list groups within the Irish Society of Chartered Physiotherapists.

All interested participants were sent a participant information leaflet and the consent form via Qualtrics. Demographic details and the eHealth Literacy Scale were also obtained via Qualtrics before the interview, in line with Step 1. A sample of five has been shown to identify 77 – 85% of usability issues (342) and hence deemed an adequate target for both participant cohorts.

A think-aloud approach was utilised for the interviews; participants were asked to engage with the technology on their preferred device (mobile phone = 5; laptop = 4; desktop = 1) to work through five relevant scenarios (**Appendix 9 & 10**) while simultaneously verbalising their thoughts, opinions, and feelings about each screen.

All interviews except one took place via Microsoft Teams, with one participant preferring to have the interview in person in a private room within the university. The interviews lasted between 38 and 83 minutes and were audio recorded. MK took field notes during each interview. All interviews were transcribed verbatim, with transcripts imported into NVivo.

The data was analysed using directed (deductive) content analysis (343), generating themes for suggestions to improve the application and website, relating to navigation, content, and design. This process was conducted by MK and cross-checked by the research team. The resultant final list was then utilised by MK and EO'R to further refine the eHealth: It's TIME prototype. The quantitative data (i.e., System Usability Scale scores) were descriptively analysed using Microsoft Excel.

4.4 Results

The results of each step of this study are described below, guided by the Template for Intervention Description and Replication checklist (242).

4.4.1 Step 1: Creation of Intervention Features and Content

A total of 12 people (**Table 10**) participated in one of the two focus groups. Participants were predominately female (83%, n= 10/12), under the age of 65 years (83%, n=10/12) and held a higher degree or professional qualification (67%, n= 8/12). All participants had a chronic musculoskeletal disorder, with 50% (6/12) having more than one musculoskeletal pain site.

Table 10: Step 1 – People with MSDs (n=12)

People with MSDs Characteristics	Number interviewed
Gender (male/female)	Male (n=2); Female (n=10)
Age range yrs. (Median [IRQ])	61 [12]
Geographical location	Urban (n= 8) / Rural (n=4)
Higher degree/professional qualification	Yes (n= 8) / No (n =3) / Prefer not to say (n=1)
Employment status	Full time employment (n = 5); Retired (n = 4); Unable to work due to sickness/disability (n = 3)
Site of musculoskeletal problem	Multiple (n = 6); Thoracic (n = 2); Lumbar (n=2); Upper limb (n = 1); Lower limb (n = 1)
Duration of symptoms	7 – 12 months (n = 1); 1 – 2 years (n = 1) 3 – 4 yrs. (n = 1); > 4 yrs. (n = 9)
Electronic devices commonly utilised (can use multiple devices)	Mobile phone (n=12, 100%); Laptop (n= 8, 67%); Desktop (n= 5, 42%); Tablet (n= 5, 42%)
Electronic devices utilised (mobile phone, laptop, tablet & desktop)	1 (n=0); 2 (n=5); 3 (n= 6); 4 (n= 1)
Internet use (hours per week)	<4 (n=3); 4 – 9 (n=2); 10 – 15 (n=3); >15 (n=4)
eHealth Literacy (eHEALS*), (Median [IRQ])	30.5 [7.25]
IQR: interquartile range *eHEALS: eHealth Literacy Scale (0-40; higher scores indicate better self-perceived eHealth literacy (344)	

The participants from the first focus group (n=6) approved the four main prototype components: an information library, a goal-tracking feature, a social forum, and a chat function. However, they suggested renaming the latter two components to 'support forum' and 'contact your physiotherapist'. The goal-tracking feature was ranked as the most favoured but was also jointly ranked as least favoured alongside the Contact Your Physiotherapist component (**Table 11**).

I'm one of the ones who said the one I liked least [goal tracking] and to be honest I thought they were all very useful. But I had to pick one...it's just purely I'm old fashioned in that I just like to write things down and I would tend to do that with a goal, as opposed to having it on any electronic device (Person with musculoskeletal disorder, P2)

The reason I didn't like the goal thing so much was because I already have my fitbit connected to my phone. So I don't really need another one. But I do think the information library is invaluable because my pain is dreadful, my sleep is dreadful (Person with musculoskeletal disorder, P6)

Table 11: Most favoured and least preferred intervention components (n=6)

Most favoured	Goal tracking (n = 4) Support forum (n=1) Information library (n=1) Contact Your Physiotherapist (n=0)
Least preferred	Goal tracking (n = 2) Contact Your Physiotherapist (n=2) Support forum (n=1) Information library (n=1)

Recommendations included prioritising app development over the website and incorporating a variety of goal templates, alongside a 'Create your own' option. Integrating a Chatbot with the 'contact your physiotherapist' function was also suggested to address general queries.

Now I'm not suggesting that... we take our medical advice from a BOT, but there will be aspects of this like general information...that may well be very suitable for chat BOT (Person with musculoskeletal disorder, P5)

Setting clear support forum rules and implementing some form of moderation were also advised.

I know just from my only experience they have it very clear....what will and won't be accepted and you sign up to that. And I have seen posts being removed and people being removed from the groups. So if you go down this route, there might be a need for some monitoring (Person with musculoskeletal disorder, P1)

The second focus group (n=6) proposed several enhancements to improve accessibility and usability. These included using more “icons, images” (Person with musculoskeletal disorder, P7) with less text, adding a section on Pain Acceptance, and offering content suggestions for the 'Understanding Pain', 'Pacing', and 'Self-management Support' sections. They also recommended changing the colour scheme and enabling users to add qualitative information within the goal-tracking feature to provide context, especially when goals are unmet.

maybe a feature here....say Tuesday the 10th was a particularly bad day and just being able to input a bit of qualitative information....so that there's more of a context around that. (Person with musculoskeletal disorder, P12)

Furthermore, they suggested that posts within the support forum should have a saving or ‘pinning’ feature for users.

useful as well is some mechanism to kind of pin or save a post or a thread that you'd find particularly useful. Because.....get lost in the ether after a while (Person with musculoskeletal disorder, P8)

The four approved components are outlined in **Table 12** and map to the Practical Reviews in Self-Management Support Taxonomy (75), behaviour change techniques (79), and persuasive system design principles (183) (**Table 13**).

Table 12: Overview of intervention components

Component 1: Information Library	Web and application pages with content on the following: • Self-management • Understanding pain • Acceptance • Pacing • Sleep Management • Stress & Pain • Flare-Up Management Plan • Free External Resources This content was based on the program manual for a chronic pain management program, branded as PEEP (Pain Education Empowerment Program)(345, 346), with this acknowledged on the first page of the Information Library. This content was continuously updated based on feedback received. With permission granted, some of the free external resources referenced are related to programs developed by the Centre for Health, Exercise & Sports Medicine, University of Melbourne (347).
Component 2: Goal Tracking	Web and application pages related to the following: 1. Adding up to four trackers – users can select from a predefined list or choose the ‘Create your own’ option 2. Viewing daily progress 3. Viewing monthly progress, with the option to add notes for the current day or retrospectively for a previous day 4. Personalising goal-tracking reminders in Settings: a. A ‘Left Today’ Reminder – on/off, with ability to set a time (i.e., “not done for today by”) b. Overdue reminder – on/off, with ability to set time (i.e., “missed logs yesterday at”) c. Progress report reminder – on/off, with ability to set day and time d. Individual tracker reminders – can be individually turned on/off, with up to 3 alerts and customisable reminder text 5. Personalising praise messages in Settings: a. ‘Day streak’ message for each goal – on/off b. ‘Perfect day’ message for completing all goals for the day – on/off c. Completion sound – on/off 6. The treating physiotherapist will be able to remotely monitor these goals

Component 3: Support Forum	Web and application pages related to: 1. Support forum rules, with an option to agree or disagree (e.g., “I agree that I will not sell or promote any products”) 2. If agreed, access to the support forum, including options to support, tag, and search posts a. Example post in prototype: “Share a recent flare up experience and a strategy that helped”
Component 4: Contact Your Physiotherapist	The web and application page features two tabs: one for sending asynchronous messages to the treating physiotherapist, and another with a chatbot to answer general queries

Table 13: Main prototype components mapped to Practical Reviews in Self-Management Support Taxonomy, Behaviour Change Technique Taxonomy & Persuasive System Design Principles

Component	Practical Reviews in Self-Management Support Taxonomy (75)	Behaviour Change Technique clusters and techniques from Michie’s Behaviour Change Taxonomy (79)	Persuasive System Design Principles (183)
Information Library with content on the following: • Self-management • Understanding pain • Acceptance • Pacing • Sleep Management • Stress & Pain • Flare-Up Management Plan • External Resources	• Training and rehearsal of psychological strategies • Information provision and patient education • Remote monitoring with feedback and action plans	Goals and planning • Action planning Shaping knowledge • Instruction on how to perform a behaviour • Information about antecedents Natural consequences • Information about health consequences • Information about emotional consequences Regulation • Reduce negative emotions • Conserving mental resources	Suggestions Trustworthiness Expertise Surface credibility Real-world feel Verifiability Social comparison
Goal tracking feature • Reminders	• Remote monitoring with	Goals and planning • Goal setting	Praise Personalisation

• Motivating messages • Progress/Milestones	• feedback and action plans • Adherence support and lifestyle interventions	• Review behavioural goals • Discrepancy between behaviour and goal Feedback and monitoring • Feedback on behaviour • Self-monitoring of behaviour • Self-monitoring of outcome of behaviour Associations • Prompts/cues Self-belief • Focus on past success	Tailoring Self-monitoring Reminders Simulation
Support forum	• Adherence support and lifestyle interventions	Social support Comparison of behaviour • Social comparison	Social support Social comparison
Contact your Physiotherapist	• eHealth-facilitated clinical review (Asynchronous)	Social support	Social support Social comparison

4.4.2 Step 2: Heuristic Testing

At the consensus meeting, agreement was reached that the main issues to be addressed before usability testing were: 1) the addition of a mission statement highlighting that the intervention is to be used alongside physiotherapy, 2) error prevention (i.e., able to go backwards/cancel), 3) design and 4) consistency across the intervention concerning how users interact with the intervention. Examples of changes implemented include the introduction of more colour with the font changed to improve the overall aesthetics of the prototype.

4.4.3 Step 3: Usability Testing

Ten participant interviews [people with musculoskeletal disorders (n=5), and musculoskeletal physiotherapists (n=5)] were conducted (**Tables 14 and 15**).

Table 14: Step 3 – People with MSDs (n=5)

People with MSDs Characteristics	Number interviewed
Gender (male/female)	Female (n=5)
Age range yrs. (Median [IRQ])	42 [10]
Geographical location	Urban (n= 5)
Higher degree/professional qualification	Yes (n= 2) / No (n =2) / Prefer not to say (n=1)
Employment status	Full time employment (n = 1); Student (n = 1); Unable to work due to sickness/disability (n = 3)
Site of musculoskeletal problem	Multiple (n = 4); Lumbar (n=1)
Duration of symptoms	> 4 yrs. (n = 5)
Electronic devices commonly used (can use multiple devices)	Mobile phone (n=5, 100%); Laptop (n= 2, 40%); Desktop (n= 1, 20%)
Electronic devices used (mobile phone, laptop, tablet & desktop)	1 (n=2); 2 (n=5)
Preferred device for usability testing	Mobile phone (n=3); Laptop (n=2)
Internet use (hours per week)	4 – 9 (n=2); 10 – 15 (n=2); >15 (n=1)
eHealth Literacy (eHEALS*), (Median [IRQ])	29 [1]
IQR: interquartile range *eHEALS: eHealth Literacy Scale (0-40; higher scores indicate better self-perceived eHealth literacy(344)	

Table 15: Step 3 – MSK Physiotherapists (n=5)

MSK Physiotherapist Characteristics	Number interviewed
Gender (male/female)	Male (n=2); Female (n=3)
Age range yrs. (Median [IRQ])	39 [4]
Geographical location	Urban (n= 4) / Rural (n=1)
Years qualified (Median [IRQ])	16 [4]
Work grade	Clinical Specialist (n = 2); Senior (n = 1); Private practitioner (n=2)
Workplace setting	Private practice (n = 3); Primary care (n = 1); Private hospital (n = 1)
Electronic devices commonly used (can use multiple devices)	Mobile phone (n=5, 100%); Laptop (n= 4, 80%); Desktop (n= 3, 20%); Tablet (n=3; 60%)
Electronic devices used (mobile phone, laptop, tablet & desktop)	1 (n=0); 2 (n=2); 3 (n=1); 4 (n=2)
Preferred device for usability testing	Mobile phone (n=2); Laptop (n=2); Desktop (n=1)
Internet use (hours per week)	4 – 9 (n=2); 10 – 15 (n=2); >15 (n=1)
eHealth Literacy (eHEALS*), mean (range)	35 [3]
IQR: interquartile range *eHEALS: eHealth Literacy Scale (0-40; higher scores indicate better self-perceived eHealth literacy(344))	

Similar responses were noted among the participants concerning the prototype's content, navigation and design. All people with a musculoskeletal disorder were female with the majority (80%, n =4/5) reporting widespread musculoskeletal symptoms. The musculoskeletal physiotherapists were experienced clinicians with a minimum of 14 years qualified, with the majority (80%, n =4/5) working in the private healthcare setting.

The qualitative data from the usability testing was categorised into three predefined categories: navigation, content, and design. A navigation-related recommendation was to use pop-up messages within the application to inform users when they are directed to resources outside the app.

if they get a bit lost if they start clicking a back button and they can't get back to the app. As long as they know that it's opening in a different section (Physiotherapist, PA)

Regarding content, users suggested that the 'Flare-Up Plan Template' be editable and saveable within the application or website.

a lot of the time when you're in severe pain you can't think properly.....that they have it all in one place yeah (Person with musculoskeletal disorder, P15)

For design, there was a strong recommendation for the addition of a logo and consistent branding.

The first thing is I don't like the background and there's no logo... Branding experts can nail this (Physiotherapist, PC)

The overall median System Usability Scale score (interquartile range) was 75 (0) out of 100 for people with a musculoskeletal disorder and 77.5 (2.5) out of 100 for musculoskeletal physiotherapists, indicating usability was good (348). System Usability Scale scores of 71.4, 85.5, and 90.9 correspond to overall usability ratings of "good", "excellent" and "best imaginable", respectively (348).

4.5 Discussion

This study provides insight into a user-centred, systematic, multi-method approach for designing and developing a prototype for adults with musculoskeletal disorders. The prototype facilitates follow-up self-management support, integrating remote monitoring with the four main intervention components mapping to recognised behavioural change taxonomies (175). Informed by the evidence-based Center for eHealth Research Roadmap (195), this study provided an opportunity to clarify and

build on the findings from the contextual inquiry (179) and value specification phases (223). By employing a user-centred, iterative approach, the *eHealth: It's TIME* prototype is expected to demonstrate improved usability, greater user satisfaction, and better clinical outcomes, compared to those developed using traditional methods (349).

This study details a three-step iterative co-design approach which contributes to the knowledge base on involving stakeholders effectively in the development process, with this knowledge gap considered a possible explanation for the lack of user involvement within the eHealth literature (195). This study employed a multi-method approach, incorporating focus groups, think-aloud usability interviews, heuristic evaluation, and the System Usability Scale, in line with recommendations, with these methods commonly occurring in the design phase of the Center for eHealth Research Roadmap (176). By incorporating these diverse methods, the study aimed to achieve an optimal fit between the technology, stakeholders, and context, thereby enhancing the potential uptake of the *eHealth: It's TIME* intervention in clinical practice (176).

Based on the preferences of people with musculoskeletal disorders and musculoskeletal physiotherapists, the *eHealth: It's TIME* prototype incorporates four main components: an information library, a goal-tracking feature, a support forum, and a 'contact your physiotherapist' feature. This complex intervention includes all five eHealth-suitable components (179) of the Practical Reviews in Self-Management Support taxonomy (75). While approximately 36.5% of eHealth-mediated self-management support interventions for people with musculoskeletal disorders included all five components (179), to our knowledge, no systematic review has

evaluated their effectiveness or impact within musculoskeletal healthcare. In other disease areas, no single component has been identified as ‘optimal’ or essential’, although consensus suggests that a range of components is necessary for significant improvements in disease self-management (82).

This study provides evidence supporting the use of recognised behaviour change taxonomies in the eHealth: It’s TIME follow-up self-management prototype, aligning with the NICE evidence standards framework for digital health technology (178). Although often not explicitly reported (173, 175), these taxonomies are commonly employed during the design phase of the Center for eHealth Research Roadmap (176). This approach aims to enhance self-efficacy, improve self-management skills, and increase overall intervention effectiveness (175). To achieve this and support sustained behaviour change, the Behaviour Change Technique taxonomy (79) and the Persuasive System Design model (183) were applied alongside the Practical Reviews in Self-Management Support taxonomy (75). This application of behaviour change taxonomies is relatively novel in the musculoskeletal eHealth literature with getUBetter (350) being the only other example to our knowledge. This app incorporates 25 behaviour change techniques and several persuasive system design principles, with preliminary results indicating improved symptoms, disability, and self-management ability. However, a large-scale randomised controlled trial with economic evaluation is necessary to confirm its effectiveness.

The challenges of poor uptake and implementation of eHealth interventions in clinical practice are widely acknowledged (351). The principal strength of this study is the theory-informed, user-centred iterative design and development approach,

which is expected to enhance future implementation. This study resulted in the development of a multicomponent eHealth-mediated self-management support follow-up prototype for people with musculoskeletal disorders. The aim is to improve long-term self-management support while minimising the demand on clinicians' time, in line with stakeholder preferences (223). Several limitations are acknowledged, with the homogeneity of the study population being foremost. Most people with musculoskeletal disorders were female, held higher degrees or professional qualifications, and reported good levels of self-perceived eHealth literacy. Consequently, this sample likely does not represent the diversity of the future end-user population. The next step is to test the feasibility of the refined high-fidelity prototype within clinical practice (336). Guidelines for evaluating the feasibility of recruitment of diverse populations will be followed (352), with interviews embedded within the trial design to gain insight into the participants' overall experience utilising the prototype. A second study limitation is that the prototype is changing rapidly. Despite meeting the prioritised elements, the current version is relatively simple, with further development necessary.

The next step is to conduct a feasibility trial to acquire more information on feasibility, acceptability, and preliminary efficacy to support self-management. This research will also analyse the perceived impact and actual usage (e.g., through log data analysis) of the different components to optimise and tailor the eHealth intervention. Following this, a large-scale randomised control trial will evaluate the long-term effectiveness and economic impact of the eHealth intervention (177, 179). The trial will include a process evaluation to explore whether the identified intervention components, behaviour change techniques and persuasive system

design principles contribute to facilitating sustainable behaviour change and self-management (177).

Based on end-user preferences and utilising a systematic, iterative process, an eHealth-mediated follow-up self-management support prototype has been developed for people with musculoskeletal disorders. The next phase of the project involves testing the feasibility of this prototype within clinical practice, utilising a diverse population.

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Chapter 5

Discussion

5.1 Chapter overview

This thesis aimed to advance the evidence on eHealth-mediated self-management support interventions for people with MSDs by identifying gaps in the fragmented literature, establishing key implementation barriers and facilitators, and applying a user-centred, theory-informed approach to develop an eHealth-mediated self-management support intervention for people with MSDs. This research demonstrates how the eHealth-mediated self-management support literature can progress to generate more robust evidence, which is essential for successfully adopting these interventions in the post-pandemic era. A suite of reporting guidelines was utilised to ensure detailed and transparent reporting of user-centred, theory-informed approaches, as recommended by the Enhancing the Quality and Transparency of Health Research (EQUATOR) Network (353). Additionally, this thesis incorporates several established frameworks, including those for eHealth development, complex interventions and behaviour change (75, 79, 183, 195, 335).

A significant outcome of this work is the development of the eHealth: It's TIME intervention, designed to enhance self-management support for people with MSDs, which is a key research priority (62). This intervention aligns with the core principles of Ireland's *Sláintecare* model of care (57), which aims to deliver universal, timely, and integrated care (54, 354, 355), as well as with the HSE's National Framework for the Integrated Prevention and Management of Chronic Disease in Ireland 2020-2025 (57).

In this final chapter, the key findings are presented and discussed in relation to the existing literature. The findings include: (1) characterisation of eHealth-mediated self-management support intervention components; (2) blended care with

eHealth as follow-up, and (3) an applied example of a user-centred design approach, with intervention components mapped to established theoretical frameworks (described in **Table 16**). Furthermore, this chapter reflects on the strengths and limitations of the thesis, discusses its implications and recommendations for future research, and concludes with a summary of the overall findings.

Table 16: Integration of findings from all three PhD studies

Key Findings	Thesis Findings		
	Study 1 (Chapter 2): eHealth Interventions to Support Self-Management in People With Musculoskeletal Disorders, “eHealth: It’s TIME” — A Scoping Review	Study 2 (Chapter 3): eHealth interventions to support self-management: Perceptions and experiences of people with musculoskeletal disorders and physiotherapists - ‘eHealth: It’s TIME’: A qualitative study	Study 3 (Chapter 4): Design and development of an eHealth intervention to support self-management in people with musculoskeletal disorders - ‘eHealth: It’s TIME’
Complex interventions: characterisation of components and characteristics	Most of the eHealth-mediated self-management support interventions were complex interventions with multiple components (≥ 3 PRISMS components) Adherence support and lifestyle interventions were the most common components of the PRISMS taxonomy identified (n = 59; 94%) Training and rehearsal of psychological strategies were the least common (n = 41; 65%) 63 eHealth-mediated self-management support	N/A	This eHealth-mediated self-management support prototype represents a complex intervention, which includes all five eHealth-suitable components of the PRISMS taxonomy. These components include adherence support and lifestyle interventions, rehearsal of psychological strategies, information provision and patient education, eHealth-facilitated clinical review, remote monitoring with feedback, and action plans

	interventions were detailed using the TIDiER checklist with considerable variation noted in intervention characteristics such as intervention provider, frequency and duration. This represents an important initial step toward gaining a clearer understanding of intervention characteristics		
Blended care with eHealth for follow-up	Most interventions utilized a combination of face-to-face (i.e., in-person) and eHealth modality format	Participants expressed concerns about eHealth being used for assessment and diagnosis, face to face considered important for establishing a therapeutic relationship. As a result, they felt eHealth should be reserved for follow-up purposes Flexibility within a blended care model was one of the three main themes identified. This model of care will minimize the risk of the digital divide widening and serve as a means of individualizing the intervention, facilitating acceptance, and engagement.	The participants from the first focus group (n=6) approved the four main prototype components: an information library, a goal-tracking feature, a support forum, and a 'contact your physiotherapist' feature An eHealth-mediated follow-up self-management support prototype has been developed for people with MSDs, based on their preferences for integration within a blended care model

		eHealth was recognised as a facilitator of self-management support	
User-centred design and theoretical foundations	With respect to intervention development, 76% (n = 48) indicated the use of theories or frameworks. These included cognitive behavioural theory, acceptance and commitment theory, social cognitive theory, and the transtheoretical model of behaviour change. However, a lot of detail was not provided on how intervention components are linked back to these theoretical constructs. A lack of user involvement with only 22% (n = 14/63) involving individuals in the design of the intervention.	The identification and exploration of end-users' needs, experiences and preferences, which are early steps in the user-centred development process Technology: Getting it right – A lack of resources and suboptimal user experience remains a challenge.	Main prototype components mapped to Practical Reviews in Self-Management Support Taxonomy, Behaviour Change Technique Taxonomy & Persuasive System Design Principles Design and development study utilises a user-centred design approach PhD Thesis informed by the The Center for eHealth Research Roadmap • Study 1: Contextual Inquiry • Study 2: Value Specification • Study 3: Design phase

5.2 eHealth-mediated self-management support interventions are complex interventions

The limited understanding of eHealth-mediated self-management support intervention components represents a significant knowledge gap (190), which must be addressed to effectively translate research into practice (190, 356). Study 1 (Chapter 2) addressed this gap by characterising 63 eHealth-mediated self-management support interventions using the PRISMS taxonomy (75). Understanding these components is essential for investigating intervention fidelity (i.e. the extent to which interventions are implemented as intended (357, 358)), effectiveness, and optimisation (359, 360). The latest MRC guidance for developing and evaluating complex interventions reinforces the importance of understanding intervention components, including identifying existing interventions for evaluation (190, 227).

While the PRISMS taxonomy has been used in the development of the HSE framework for self-management support (84) for chronic obstructive pulmonary disease (COPD), asthma, diabetes and cardiovascular disease, as well as for evidence synthesis in these and other conditions (82, 83, 361, 362), it has not been applied in the MSD literature prior to Study 1 (Chapter 2). One explanation for this oversight may be that the taxonomy, despite being intended to simplify the concept of self-management, is complex and may have limited utility in the context of MSDs (363). Alternatively, its universal and comprehensive nature may be viewed as a strength, offering a clearer understanding of self-management support interventions and serving as a valuable framework for their design and description (75). Another explanation for the absence of the PRISMS taxonomy in the MSD literature is the widespread failure to recognise MSDs as long-term conditions requiring integrated

management, similar to other chronic diseases such as diabetes (90). This lack of recognition may partly explain why MSD management is inadequate in many parts of the world (90).

Characterising existing eHealth-mediated self-management support interventions will lead to a better understanding of these complex, multi-component interventions, thereby facilitating their successful implementation (75). By applying the PRISMS taxonomy, the scoping review (179) offers a format for identifying the components most conducive to intervention effectiveness. Additionally, it provides valuable information for researchers looking to adapt existing interventions for different populations or contexts (362) as this efficient approach to intervention development becomes increasingly common (364, 365). Furthermore, this overview of eHealth-mediated self-management support interventions has informed the development of the eHealth: It's TIME intervention, presented in Chapter 4. This complex intervention includes all five eHealth-suitable components of the PRISMS taxonomy, and the contribution of this theory-driven eHealth development process will be discussed further in Section 5.4.

Building on this, a significant contribution of the scoping review (179) (Chapter 2) and a crucial step in advancing eHealth-mediated self-management support research is the application of the TIDiER checklist (242). This checklist was used to detail the 63 eHealth-mediated self-management support interventions included in the review, representing an essential step toward a better understanding of the characteristics for people with MSDs.

5.3 eHealth-mediated self-management support as follow-up care

The attitudes and experiences of physiotherapists and people with MSDs toward eHealth-mediated self-management support interventions were likely influenced by the increased uptake of eHealth during the COVID-19 pandemic. Study 2 (223), presented in Chapter 3, provides an up-to-date exploration of this previously underutilised option, guiding future implementation. Previous studies, primarily conducted during the COVID-19 lockdowns (112, 145, 146), explored telehealth-facilitated clinical reviews, often driven by necessity, which may have introduced bias in how eHealth was perceived (147). In contrast, Study 2 (Chapter 3) (223) offers novel insights into how eHealth can function as a multi-component, complex intervention for self-management support when both face-to-face and eHealth options are available (366).

Unlike earlier studies that focused on telehealth as the sole means of accessing physiotherapy (112, 145, 146), this thesis contributes valuable knowledge on how eHealth can be integrated into models of care for MSDs, with a particular emphasis on its implementation in MSK physiotherapy healthcare in the Irish context (142). Specifically, Study 2 (223) explored MSK physiotherapists' and service users' perceptions of factors that may influence the future implementation of eHealth-mediated self-management support in Ireland's MSK physiotherapy services. These findings offer useful insights into where challenges may arise and inform the development of future implementation strategies. These findings were mapped to the Consolidated Framework for Implementation Research (CFIR) (144), a comprehensive meta-theoretical framework based on 19 other implementation theories, which outlines various constructs that influence eHealth implementation

(141). This mapping, conducted as part of a systematic review by van Tilburg et al. (142), is summarised in **Table 17**. This knowledge may support the development of tailored implementation strategies by highlighting factors that could influence the future integration of eHealth into MSK physiotherapy services.

Table 17: Overview of barriers and facilitators mapped to CFIR, according to van Tilburg et al. (142)

CFIR domain, construct, and subconstruct	Barriers (-)	Facilitators (+)
<i>Domain 1: Digital Health Service Characteristics</i>		
Relative advantage	- Quality of care: Physical examination may not be as thorough compared to usual face-to-face care - Patient–healthcare professional relationship: Difficult if initially met via eHealth – managed if eHealth reserved for follow-up	+ Adherence + Self-management + Motivation through support + Continuous care chain + Blended care
Adaptability		+ Flexibility: Can be tailored to patient needs
Design quality and packaging		+ Modality: Accessible on multiple devices
<i>Domain 2: Outer Setting</i>		
Patient needs and resources	- Personal traits of patient E.g. poor digital literacy	
<i>Domain 3: Inner Setting</i>		
Readiness for Implementation—Available Resources	- Lack of physical space - Lack of electronic health records - Technology-related issues E.g. Poor/no internet connection, lack of devices - Time	+ Time E.g. Telephone check-ins: Allow quick, efficient follow-up with patients

	E.g. More admin tasks due to poor interoperability	
Domain 4: Characteristics of Health Care Professionals		
Knowledge and Beliefs About the Intervention	- Healthcare professional acceptance E.g. Viewed by some as a temporary solution during the pandemic	+ Healthcare professional acceptance E.g. Acceptance improved with eHealth exposure
Domain 5: Process		
	N/A	N/A
CFIR: Consolidated Framework for Implementation Research		

A significant facilitator identified in Study 2 (Chapter 3) is the blended care model, which combines initial face-to-face contact with eHealth for follow-up. This approach, identified as the most common care pathway in Study 1 (179), was found to be broadly acceptable to both physiotherapists and people with MSDs. This acceptability is consistent with earlier findings (145, 146) and expands on them by demonstrating that these preferences persist when both face-to-face and eHealth options are available. Study 3 (224) (Chapter 4) further reaffirmed the acceptability of this model for people with MSDs.

One of the key reasons for the preference for a blended care model among people with MSDs and physiotherapists was the concern about the lack of physical examination, an issue consistently raised in both pandemic-era research (112, 145, 146) and more recent studies (134, 367). This concern reflects a broader issue related to the over-medicalisation of common injuries that may not always require medical intervention (368). This, in turn, contributes to what has been termed a ‘super wicked

problem’ (53), characterised by complex, interdependent factors and the absence of simple solutions.

Findings from Study 2 (223), along with other literature (112, 367), suggest that a blended care model, with eHealth reserved for follow-up, may help transition MSK healthcare from the prevailing biomedical model, one of the key factors contributing to the ‘super wicked problem’ (60), toward a biopsychosocial approach. This transition, in line with the WHO’s ICF framework (20), could be achieved by aligning the expectations of people with MSDs and enabling the therapist to act as a coach, facilitating self-management as treatment sessions progress (112, 223, 367).

While this care model may provide a practical solution to the shortcomings of the prevailing biomedical model (60), it is important to recognise that eHealth also carries the risk of exacerbating low-value care by delivering care that is ineffective, inefficient or misaligned with patient preference. This highlights the need for careful management of these unintended risks (113).

In addition to blended care, another key facilitator identified by participants was flexibility. Study 2 (223) (Chapter 3) provides evidence that flexibility helped individualise the intervention, promote eHealth acceptance and engagement, and ensure digital inclusion within the MSK physiotherapy service in Ireland. This flexibility aligns with key elements of national and international frameworks, including Ireland’s *Digital for Care – A Digital Health Framework for Ireland 2024 – 2030* (369), Ireland’s *Digital Inclusion Roadmap* (370), the UN’s “Leave No One Behind” principle (371), and a recent report by the King’s Fund (372), an independent charity working to improve health and care in England.

While this care model appears acceptable and promising, the practicalities of implementing it within primary care settings remain uncertain. This thesis offers early insights into factors that may influence implementation; however, further research is needed to assess the intervention's readiness for use in real-world settings. Commonly reported implementation challenges in the literature include technology-related issues such as difficulties with set-up and operation, workflow disruption, limited digital infrastructure and low levels of digital literacy (142) — some of which are likely to be particularly relevant in the Irish primary care setting, where staff shortages and poor digital infrastructure have been noted (39, 373). In addition to technical solutions, organisational support will be essential. Implementation may be facilitated by strategies such as providing educational resources to staff, identifying local opinion leaders or champions, and developing strong stakeholder interrelationships (374). Future feasibility and implementation studies can help explore these factors and inform context-appropriate strategies to support meaningful uptake.

5.4 An applied example of a user-centred design approach, with intervention components mapped to established theoretical frameworks

A lack of user involvement and insufficient detail regarding the theoretical foundations of eHealth interventions remain significant challenges in the MSD literature. To address these gaps, this thesis contributes to the understanding of implementing a user-centred, theory-informed approach to developing an eHealth-mediated self-management support intervention for people with MSDs.

Guided by the evidence-based CeHRes Roadmap, Study 3 builds on the findings from the earlier contextual inquiry (Study 1) and value specification (Study 2) phases. It employs a three-step, iterative co-design process using multiple methods – focus groups, think-aloud usability interviews, heuristic evaluations, and the System Usability Scale. These methods, commonly used in the CeHRes Roadmap’s design phase, ensure a comprehensive approach to achieving an optimal fit between the technology, stakeholders, and the context (176). This approach enhances the potential adoption of the eHealth: It’s TIME intervention in clinical practice (176).

Study 3 also demonstrates the effective integration of recognised theoretical frameworks into the *eHealth: It’s TIME* self-management support prototype, aligning with the NICE evidence standards for digital health technologies (178). Applying the BCT taxonomy (79), PSD model (183), and PRISMS taxonomy (75) aims to enhance self-efficacy, improve self-management skills, and support sustained behavioural change – key factors for increasing intervention effectiveness (175).

In comparison, other existing interventions, such as *e-Exercise* (375) and *getUBetter* (350), provide valuable insights but differ in their approach to theoretical integration and user-centred design. *e-Exercise* is a blended care intervention evaluated for non-specific low back pain (332, 376), neck and/or shoulder complaints (377), and hip and knee osteoarthritis (378), which followed a user-centred design approach guided by the CeHRes Roadmap (375). However, unlike *eHealth: It’s TIME*, *e-Exercise* did not comprehensively map its intervention components to recognised theoretical frameworks, potentially limiting its implementation, replication and effectiveness (190). This limitation could partly explain why this blended care

intervention has not proven to be more effective than face-to-face physiotherapy for people with hip/knee osteoarthritis (378) or non-specific low back pain (376). Indeed, Koppelaar et al. (376) suggest that the intervention content, based on the Royal Dutch Society for Physiotherapy guidelines for low back pain (379), may be insufficient to support long-term self-management at home.

In contrast, *getUBetter*, a self-management app recommended by NICE for non-specific low back pain pending further evidence (380), mapped its intervention components to two theoretical frameworks – the BCT taxonomy (79) and the PSD model (183). However, *getUBetter* provided limited detail on stakeholder input during its co-design process and did not employ the PRISMS taxonomy (75, 173). Since recent literature suggests that the BCT taxonomy (79) alone does not capture all behaviour change strategies, authors have recommended using the PRISMS taxonomy (75) as a supplement to provide a more comprehensive understanding of intervention content (190).

This thesis addresses these limitations by integrating three theoretical frameworks, the BCT taxonomy (79), the PRISMS taxonomy (75) and the PSD model (183), into the *eHealth: It's TIME* intervention. This combination offers a more theoretically grounded, user-centred approach to eHealth intervention development for MSDs than previously reported, potentially enhancing its effectiveness, implementation, and replication in clinical practice (175, 176, 190).

5.5 Preparing for feasibility and efficacy testing

Insufficient rigorous testing and scientific evidence regarding effectiveness have been recognised as significant challenges for existing eHealth interventions (69, 151,

154, 155, 168, 170, 171, 381-383). This PhD thesis addresses these challenges by aligning with the CeHRes Roadmap (195) and the MRC framework for developing and evaluating complex interventions (76), focusing on the initial phase: developing the eHealth intervention.

Following the completion of this PhD, the next phase in the development process will evaluate the feasibility of *eHealth: It's TIME*, which was renamed *ePhysioSupport* based on feedback from usability testing with end-users. *ePhysioSupport* was designed to support self-management among adults with chronic MSDs in Irish MSK primary care services. While the development process was informed by a user-centred design approach, the extent to which the final prototype reflects the perspectives of the intended users may be limited. Despite significant efforts to recruit primary care MSK physiotherapists and service users from public MSK services, the majority of participants involved in Studies 2 and 3 were from private or acute care settings. This recruitment challenge may reflect broader systemic barriers — such as limited staffing (39) and poor digital infrastructure (373) within primary care — which may also affect the future implementation of the app. As such, although the intervention shows promise, its readiness for use in the intended setting remains preliminary. Further co-design and feasibility testing within the actual primary care context are needed to ensure its acceptability, usability, and fit for purpose.

The overall aim of this phase is to evaluate the feasibility of *ePhysioSupport*, to inform further refinement of the intervention and trial procedures, and to determine the feasibility and appropriateness of progressing to a definitive large-scale trial. For this phase, the updated MRC framework (227) will replace the older

guidance, with this updated guidance aligning more closely with the CeHRes Roadmap (195) by emphasising non-linear, iterative refinement and stakeholder involvement. This updated guidance serves as a pluralistic guide for intervention implementation and evaluation (384), introducing six core elements to be considered at every phase (385). The MRC framework checklist will be completed (360) to operationalise these elements. Additionally, before feasibility testing begins, the *ePhysioSupport* prototype will be refined into a fully functional beta version.

5.5.1 Study design

While formal study planning has not yet commenced, the initial proposal outlines a three-phase study using a parallel mixed-methods approach (386):

- Phase 1: A quantitative cluster randomised feasibility study.
- Phase 2: A qualitative process evaluation.
- Phase 3: A feasibility economic evaluation.

This study will be conducted in the physiotherapy primary care setting in Cork, Ireland.

5.5.2 Patient and public involvement

From the outset, patient and public involvement (PPI) will be embedded into this post-PhD feasibility study. In September 2024, a PPI support meeting was held with Dr Emmy Racine, Programme Manager for the PPI Ignite Network at UCC, to discuss the integration of PPI into the study. PPI Ignite is a network dedicated to promoting and supporting high-quality PPI (387). PPI input will serve two primary objectives:

facilitating the recruitment of a diverse population (i.e., male, no higher degree or professional qualification, low eHealth literacy) and improving participant retention, both of which are well-documented challenges in eHealth research (133, 164, 199).

To meet these objectives, it is imperative that the PPI representatives themselves come from diverse backgrounds. To support meaningful collaboration, the PPI Planning Template will be completed (388). The provisional plan is to include four people with MSDs from under-served groups, with recruitment to be carried out through patient support organisations such as Chronic Pain Ireland and Arthritis Ireland, as well as primary care physiotherapists, Cork-based GPs and the Cork/Kerry Patient and Service User Engagement Officer (389).

5.5.3 Recruitment feasibility

To assess recruitment feasibility for a future efficacy trial, the feasibility study will follow Stewart et al.'s guidelines (352), which outline eight steps, including defining recruitment goals, tracking recruitment processes, and summarising recruitment outcomes using a tracking database. If recruitment goals are unmet, adjustments will be made for the large-scale RCT.

5.5.4 Feasibility outcomes

The feasibility study will focus on several key outcomes, including:

- **Acceptability:** Assessed via semi-structured interviews and by examining recruitment and retention rates.
- **User engagement:** measured by usage patterns (i.e., amount, frequency, duration, and depth of usage) among people with MSDs.

- **Feasibility and appropriateness of clinical and economic outcome**

measures: Assessed based on completion rates, the extent of missing data, and insights from the qualitative process evaluation (390, 391).

5.5.4.1 Clinical outcome measures

This feasibility study will explore the following outcome measures to assess their acceptability and feasibility in preparation for a large-scale effectiveness trial:

- **Pain interference and pain severity:** Measured with the short version of the Brief Pain Inventory, which has demonstrated acceptable internal consistency and reliability in people with non-cancer pain (392).
- **Pain self-efficacy:** Assessed using the Pain Self-Efficacy Scale (PSEQ) (393), which has good psychometric properties (394).

5.5.4.2 Economic outcomes

An economic evaluation involving a cost-consequence analysis will be conducted with early input from a health economist, in line with updated MRC guidance (227). Cost-consequence methods provide a comprehensive breakdown of costs and benefits and are recommended for evaluating complex eHealth interventions (178, 227, 395, 396). Healthcare resource use, absenteeism, and presenteeism will be captured via a self-reported questionnaire developed using questions adapted from various surveys identified on the Database of Instruments for Resource Use Measurement (DIRUM) (397), with permissions obtained from the original copyright holders. The outcome of interest is the completion rate for this questionnaire.

Intervention costs will be calculated based on the patient's total number of face-to-face physiotherapy sessions, as well as the per-patient costs for developing, hosting, and maintaining *ePhysioSupport*. Additionally, the EQ-5D-5L (398) will be administered to people with MSDs to measure health-related quality of life. Providing more precise estimates than the EQ-5D-3L (399), the EQ-5D-5L will be used to derive utility values for calculating quality-adjusted life years, in line with recommendations from Ireland's Health Information and Quality Authority (HIQA) (400). Completion rates, missing data, and process evaluation insights will measure the acceptability of the EQ-5D-5L for economic evaluation.

5.5.5 Consideration of alternative study designs for future research

The proposed cluster randomised feasibility trial represents an appropriate and necessary next step in line with the CeHRes Roadmap (195) and MRC guidance (227), providing critical insight into the acceptability, usability, and practicality of deploying *ePhysioSupport* within Irish MSK primary care physiotherapy services. However, given the complexity of this eHealth intervention and its intended use in real-world care, future research may benefit from incorporating a broader range of study designs (227). For example, a subsequent hybrid effectiveness-implementation trial (e.g. Hybrid Type 2) could enable concurrent testing of both clinical outcomes and strategies to support real-world uptake (401). A stepped-wedge cluster design may also be suitable if a phased rollout is needed or a parallel trial design is not feasible (402). In addition, n-of-1 studies could offer valuable insights into individual-level responses, particularly in the context of the heterogeneous population of people with chronic MSDs (403). A realist evaluation could complement these approaches

by exploring how, why, and in what contexts ePhysioSupport produces outcomes — particularly useful for understanding variation in engagement and effectiveness across different care settings and user experiences (404). These designs, considered alongside feasibility findings and stakeholder priorities, will help inform a pluralistic and methodologically robust research trajectory to support the implementation and scale-up of *ePhysioSupport*.

5.6 Strengths and limitations

This PhD Thesis has several strengths, the principal being its rigorous, user-centred, iterative design and development approach. This methodology ensures that ePhysioSupport is both methodologically sound and clinically applicable. Following the CeHRes Roadmap, each project phase builds systematically on the previous one, creating a logical progression from conceptual inquiry (Study 1, Chapter 2) to design (Study 3, Chapter 4). This systematic multi-phase, multiple-method approach is a key strength, as it facilitates the integration of emerging concepts throughout the process. Consequently, this iterative refinement optimises the fit between the ePhysioSupport prototype, its end-users, and the specific context, thereby enhancing the likelihood of successful uptake in practice (176).

Integrating the PRISMS taxonomy (75), BCT taxonomy (79), and PSD model (183) into ePhysioSupport's design is a key strength, as it grounds the project in well-established, evidence-based frameworks. This approach enhances the potential for successful implementation into practice, promoting more effective and sustained engagement with healthy behaviours (173, 405, 406). Mapping the intervention

components aligns with best practices (177, 178) and enhances transparency and replicability (173, 190).

Despite these strengths, some limitations should be considered when interpreting the results. The most notable limitation is sampling bias, as males, individuals without a higher degree or professional qualification, and those with low levels of self-perceived eHealth literacy are underrepresented in Study 3 (224). While this is a common issue in user-centred design eHealth approaches (199), urgent attention is required to ensure that developed eHealth interventions meet the needs of people from under-served populations rather than reinforcing existing health inequalities (407). Known barriers to inclusion in eHealth research for under-served groups include time constraints, feeling unqualified to participate, language or eHealth literacy challenges, and lack of consistent access to the internet or appropriate devices (407, 408). Recruitment and retention strategies will be co-developed with the PPI panel, as discussed in Section 5.5, a widely used (409) and effective approach to increasing recruitment (410).

Secondly, the absence of PPI in this thesis represents a limitation. Although individuals with MSDs contributed actively to developing this eHealth intervention, their involvement differed from PPI (411), which has been shown to enhance trial success, implementation, and dissemination of findings by engaging people with lived experience as research partners (410, 412). This PhD project began in 2019 before PPI Ignite was established at UCC in 2021 (413). The lack of PPI reflects limited knowledge and resources available in the early stages of this project, which are recognised barriers for doctoral researchers (414, 415). However, as discussed in

Section 5.5, PPI will be embedded into the post-PhD feasibility trial with the support of the PPI Ignite Network at UCC.

Finally, data on comorbid conditions was not captured in the self-reported questionnaire for the qualitative study (Chapter 3) or the design and development study (Chapter 4). Given that individuals with chronic pain have a higher prevalence of chronic conditions (416-418), it is likely that some participants with MSDs had comorbidities. The absence of this data limits a complete understanding of the diverse self-management support needs of individuals managing multiple health conditions. To address this, comorbidity data will be collected in the feasibility trial following recommendations from the HSE's framework for self-management support (84).

5.7 Implications

5.7.1 Implications for policy

The implementation of eHealth interventions is a strategic priority for the provision of healthcare in Ireland (373). While COVID-19 prompted a rapid, albeit haphazard, adoption of eHealth in clinical practice, this uptake has not been sustained (419). This thesis contributes to the evidence on eHealth-mediated self-management support, presenting two key policy implications to support the sustainable implementation of these interventions.

Firstly, while a flexible blended care pathway that incorporates eHealth for follow-up is generally acceptable to both people with MSDs and MSK physiotherapists (as discussed in Chapter 3 (223) and Chapter 4 (224)), Ireland's *Digital Health Strategic Implementation Roadmap* (420) lacks detailed strategies for

implementing this approach. This gap poses a significant risk to the successful adoption of blended care. A recent HIQA survey (421) confirms that most healthcare professionals want clear protocols to guide service delivery. One potential tool that may assist clinicians is the clinical decision aid, *Checklist Blended Physiotherapy* (422), which helps physiotherapists determine a person's suitability for blended care. This checklist consists of eight items, including digital skills, health literacy, motivation, and safety. However, the feasibility and predictive validity of this tool are unknown (142). To ensure effective implementation of blended care pathways, policymakers must prioritise the development of clear guidelines and resources for clinicians.

This thesis highlights a significant gap in user involvement during the development of eHealth interventions for people with MSDs (Study 1, Chapter 2) (179), while also providing insights on actively engaging end-users in the design and development of eHealth-mediated self-management support interventions (Study 3, Chapter 4) (224). Despite widespread recommendations for a user-centred design approach (169, 192, 193), it is not often implemented in practice. Therefore, a key policy implication is prioritising user-centred design in eHealth development. Policymakers should promote or mandate the co-design of eHealth interventions with end-users to ensure they are patient-centred and address the real needs of the target population. Additionally, there should be a strong emphasis on transparent reporting of these co-design processes to advance the field.

5.7.2 Implications for practice

The perspectives of people with MSDs and MSK physiotherapists, as explored in Chapters 3 and 4, provide essential insights for developing eHealth-mediated self-

management support within their clinical settings. Study 1 (Chapter 2) (179) offers a comprehensive overview of eHealth modalities, linking them to specific MSK diagnoses, outcomes, and intervention characteristics. Mapping the 63 eHealth interventions by modality type and MSK diagnosis yields practical information to guide clinical decision-making.

Study 2 (Chapter 3) (223) suggests several factors that may need to be considered when planning for the implementation of eHealth-mediated self-management support interventions in MSK physiotherapy services in Ireland. These include key infrastructural elements such as electronic health records, access to quality internet, interoperable systems, physical space, and appropriate devices (e.g., headsets). The study also indicates that eHealth may be best suited to follow-up self-management support, a perspective supported by Study 3 (Chapter 4). This knowledge also has implications for physiotherapy education. Currently, eHealth physiotherapy practice is under-represented in Irish and international professional competency standards (423). Furthermore, there is little reference to eHealth in the national self-management support curriculum (424). Updates to curriculum and training that prepare physiotherapists to incorporate eHealth into their practice, particularly for follow-up self-management support, are urgently needed (423).

Chapters 2 - 4 also provide valuable insights into the specific components of self-management support that can be delivered through eHealth. They highlight the features that people with MSDs find most valuable. Additionally, Chapter 4 maps these intervention components to recognised behavioural change taxonomies, offering practical insights for clinicians and developers on how to incorporate

theoretical frameworks when designing eHealth interventions to enhance behavioural change.

5.8 Suggestions for future research

This research has important implications for how researchers should approach the future design and development of eHealth-mediated self-management support.

Table 18 outlines specific recommendations from each chapter of this thesis.

Furthermore, this research has broader implications for future research on the design and development of complex interventions, providing insights into the transparent reporting of user-centred, theory informant development approaches.

Table 18: Suggestions for future research from each chapter

Chapter #	Finding / Limitation	Suggestions for future research
Chapter 2	The broad scope of eHealth modalities may have limited detail on specific intervention types, despite stratification by modality type	Future reviews could apply narrower inclusion criteria or focus on individual modalities to enable more targets analysis
	Considerable variation in intervention types and reporting made it challenging to synthesis and interpret the eHealth-mediated self-management support literature	To improve this, researchers should adopt standard eHealth reporting guidelines (300)
	This scoping review identified two studies evaluating the role of video conferencing in supporting self-management, an eHealth modality that was rapidly introduced into routine clinical practice in response to the COVID-19 pandemic	It is imperative that future research adopts a co-design model when evaluating the role of video conferencing and other eHealth modalities in supporting self-management.
	Most eHealth modalities were evaluated in populations with chronic pain, back pain, and osteoarthritis.	To provide better guidance for clinical practice, high-quality research is also required for the broad range of MSDs managed by health care systems.
	Lack of healthcare utilisation and follow-up data	Future studies should also evaluate the impact of these interventions on healthcare utilisation and increase the length of follow-up.
Chapter 3	Barriers and facilitators to eHealth-mediated self-management support for MSK physiotherapy healthcare in Ireland were identified	Future research should prioritise the development of implementation strategies, test them, and systematically evaluate implementation outcomes.
Chapter 4	A theory-based, user-centred eHealth-mediated follow-up self-management support prototype has been developed for people with MSDs	As discussed in Section 5.5, future research should test the feasibility of this prototype in clinical practice with a diverse population, in preparation for a large-scale trial with both process and economic evaluations

	Four main features to support self-management have been identified, which map to the PRISMS taxonomy, BCT taxonomy and the PSD model.	Future research should investigate whether the identified intervention features, as well as the PRISMS taxonomy components, BCT taxonomy, and the PSD model, contribute to long-term behaviour change and improved self-management
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Study 1 (Chapter 2) (179) identified significant variation within the eHealth-mediated self-management support literature, reflecting the broad and evolving nature of eHealth itself – a term that encompasses diverse modalities, delivery formats, and levels of clinician involvement. While this breadth was appropriate for the scoping review’s objective of mapping the landscape, it may have limited the level of detail that could be drawn about specific intervention types and their applications. Future reviews may benefit from more focused inclusion criteria or stratification by modality to support clearer interpretation and clinical applicability. To improve clarity and consistency in future work, the adoption of reporting guidelines such as CONSORT-EHEALTH (Consolidated Standards of Reporting Trials of Electronic and Mobile HEalth Applications and onLine TeleHealth) (300) is recommended to standardise and enhance the quality of reporting. The scoping review (179) (Study 1, Chapter 2) builds on a systematic review published in 2015 (123) that focused on three eHealth modality types (telephone, interactive voice response, and internet) in adults with chronic, non-headache, noncancer pain, extending the scope to encompass seven eHealth modalities for MSDs. A notable gap persists in the economic evaluations of these interventions, as reaffirmed by recent reviews (156, 425). This gap likely stems from the unique complexities of economic evaluations in eHealth, which differ from traditional healthcare innovations like pharmaceuticals or simple medical devices (395, 426-431).

Key challenges include the rapid evolution of eHealth interventions (395), the lack of established methodologies due to heterogeneity (428), and the complexity of interventions that impact multiple outcomes (395, 427-430). Traditional cost-utility and cost-effectiveness analysis tools, which typically focus on single outcomes, are

often insufficient in evaluating eHealth interventions (432). This limitation may partly explain the findings from a recent cluster randomised controlled trial, which indicated that blended physiotherapy was no more cost-effective than face-to-face physiotherapy for people with nonspecific low back pain, from both societal and healthcare perspectives (376).

Future research should consider the use of cost-consequence analysis, which provides a detailed breakdown of costs and various benefits and is increasingly recommended for evaluating complex eHealth interventions (178, 395, 396). As healthcare systems face mounting financial pressures globally (433-435), robust economic evaluations are crucial for ensuring the successful adoption and scalability of eHealth interventions (436, 437).

As previously discussed, Study 2 (223) (Chapter 3) identified barriers and facilitators to eHealth-mediated self-management support for MSK physiotherapy healthcare in Ireland, with these findings subsequently mapped to CFIR by van Tilburg et al. (142) (**Table 17**). Future research should focus on tailoring these strategies to address the specific barriers and facilitators identified in Table 5.3, using the CFIR-ERIC (Expert Recommendations for Implementing Change) matching tool (438, 439) to enhance the effective implementation of *ePhysioSupport*.

An essential concept to consider in future research investigating intervention components and characteristics associated with increased effectiveness is intervention fidelity (440, 441). Intervention fidelity refers to the degree to which an intervention is delivered as intended according to the study protocol and is critical for the development and testing of evidence-based interventions (442). In the feasibility trial of *ePhysioSupport*, fidelity will be closely monitored, as it plays a key

role in identifying components that may not be implemented as expected. Understanding and addressing issues of fidelity will allow for the refinement of the ePhysioSupport intervention prior to conducting a full-scale trial (441). Ensuring high fidelity is critical to drawing accurate conclusions about the intervention's effectiveness and optimising its future implementation (441).

5.9 Conclusion

Timely access to high-quality MSK healthcare is a global issue, one that is expected to worsen. eHealth-mediated self-management support is considered a possible solution to this worldwide problem. This research demonstrates its acceptability among both people with MSDs and MSK physiotherapists when integrated into a flexible, blended care pathway, particularly for follow-up care.

This PhD project aimed to co-design and develop an eHealth-mediated follow-up self-management support prototype based on end-user preferences, utilising a systematic iterative process. Furthermore, this research offers early insights into factors that may influence the implementation of eHealth in MSK physiotherapy in Ireland, contributing to the evidence base that can inform the design of future feasibility and implementation strategies for clinical practice. This research also contributes to the growing knowledge base on developing user-centred, theory-informed eHealth interventions.

Designed with evaluation and implementation in mind, the eHealth: It's TIME (ePhysioSupport) intervention has the potential to positively impact the lives of people living with MSDs, enhance eHealth design and development processes,

expand access, and transform how self-management support is delivered in the future.

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Appendices

Appendix 1: eHealth modality definitions/explanations

Telephone supported

These interventions typically involve telephone support from health care professionals with expertise in the specific subject matter to supplement a structured internet intervention. The main aim is to 'provide support and encouragement for use of the internet intervention, and to address any concerns in relation to the internet-based content' (443).

Telephone-based

Intervention delivered via telephone calls between a patient and health care professional (2-way interaction) to support self-management (444) through knowledge exchange, goal setting, action planning and maintenance (445).

Internet-based

Structured programs that participants can interact with by utilizing mobile devices or computers. They can 'support self-management by facilitating goal setting, self-monitoring and providing behavioral/symptom-related feedback' (443)^(p. 3).

Virtual reality

A three-dimensional computer generated environment, which facilitates an individual to interact with, explore and manipulate objects by stimulating human senses (446).

Interactive voice response

This technology is a 'method for interaction between an individual and a computer through the medium of a telephone'^(p. 39) using the touch-tone keypad (267). Typically an automated script poses questions and the caller keys in responses using the telephone keypad.

Mobile phone applications

Mobile-based or mobile-enhanced programs that provide health-related services for tablets, smartphones and other communication devices.

Video teleconferencing

This involves a combination of high-quality audio and video via internet protocol networks to enable real-time interactions between individuals which can be utilized for clinical support, healthcare management and diagnostic purposes.

Appendix 2: Value Specification

Element	Requirements	Uses	Description
Information Library	N/A	Website, Mobile App	A Library of information physios can direct patients to. Audio, Videos, Text
Social Forum	User Account System	Website, Mobile App	A forum where patients can interact with both physios and patients. They can form their own support groups/ get advice etc.
Data Entry	User Account System	Website, Mobile App	Users can enter data to track their progress. Steps, Time asleep, Etc.
Data Tracking	User Account System	Mobile App Only	A mobile phone app could track steps and other similar data Like Google Fit
Milestones	User Account System, User Data	Website, Mobile App	Positive feedback to patients when they hit milestones. Awards, medals, can be commented on or “liked” by other patients?
Chat	User Account System, Available On-Call Physios?	Website, Mobile App	Web Chat, Audio Chat, Video Chat
API	User Account System, User Data	External Systems	Existing Healthcare systems can (with changes) easily connect to this system and send/ retrieve information about patients (if allowed)

Appendix 3: Scoping Review Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Participants: Adults with a MSD	Participants: - With pain of specific pathological origin (e.g., infection etc.) - Following surgery - Pregnancy
Concept: eHealth interventions^a that support self-management^b	Concept: eHealth modalities that involve remote monitoring without an explicit decision-making role
Context: - All health system models - All countries.	Context N/A
Types of studies: - All qualitative & quantitative dominant studies - All mixed method studies - Published in English	Types of studies: - Study protocols - Dissertations, theses, conference abstracts & case studies - All sources without reference to empirical research
^a An eHealth modality is considered to be some specific form of technology that is applied in the context of health care (114, 229, 447). ^b Self-management was defined as any intervention that aimed to empower patients to be active decision makers who deal with social, emotional or medical management of their condition with the aim of improving their independence and quality of life (74).	

Appendix 4: Characteristics of Included Studies in Scoping Review (n = 87)

Characteristics of included studies (n=87)							
eHealth modality type	Study & year (Reference) Design	Target population Study size Age (years)	Format Provider Frequency Duration Follow-up	Description of intervention	Components of the interventions mapped to PRISMS taxonomy	Reported study outcomes /Author's findings	Study results
Internet-based (n=22)							
Internet-based	Chiauzzi et al 2010(448) RCT	Chronic back pain N = 209 (E = 104, C = 105) Age = 46.14	eHealth only Provider: N/A - eHealth modality fully automated Frequency: twice per week Duration: four weeks Follow-up: six months	painACTION-Back Pain internet program Lessons, interactive tools, personalized assessments, & articles based on CBT & self-management principles <i>Comparator: text-based material</i>	- Information provision & patient education - Training & rehearsal of psychological strategies - Adherence support & lifestyle interventions	Body Functions: - Improved coping, pain, anxiety & depression - Mean self-efficacy change did not differ between groups Activities & Participation: - Improved stress - Physical functioning did not differ between groups	 
Internet-based	Williams et al (2010)(265) RCT	Fibromyalgia N = 118 (E = 59, C = 59) Age = 50.46	eHealth only Provider: N/A - eHealth modality fully automated Frequency of internet based self-management modules: Approx. weekly, recorded use	Standard care plus access to a Web-Enhanced Behavioral Self-Management program - "Living Well with Fibromyalgia" 13 modules, each of which featured:	- Training & rehearsal of psychological strategies - Information provision & patient education - Remote monitoring with feedback & action plans	Body Functions: - Pain improved - Fatigue, sleep, depression & anxiety did not differ between groups Activities & Participation:	

			of self-management skills monthly Duration: Six months Follow-up: none	• Video lecture • Written summaries of video lecture • Homework & self-management forms • Supplemental educational materials unique to each topic (e.g., audio relaxation exercises & readings) <i>Comparator: standard care</i>	• Adherence support & lifestyle interventions	• Physical functioning improved	
Internet-based	Kristjánsdóttir et al (2011)(252) Mixed methods	Chronic musculoskeletal pain N = 6 Age = 36.3	Mixture of face-to-face & eHealth Provider: nurse Frequency: mixed; diary entries three times per day, feedback daily except weekends Duration: 4 weeks Follow-up: none	Internet based intervention via a web-enabled mobile phone • One 1:1 face-to-face meeting with therapist – provided with written exercises, relaxation CD and lent web-enabled mobile phone • Completed 3 diary entries per day – prompted by text message • Therapist provided daily feedback (except weekends)	• Information provision & patient education • Remote monitoring with feedback & action plans • Adherence support & lifestyle interventions • Training & rehearsal of psychological strategies • eHealth-facilitated clinical review	• Supportive, meaningful and user friendly • High response rate with few technical issues • Feasible	
Internet-based	Jelin et al (2012)(449) Qualitative	Chronic musculoskeletal pain N= 7 Age = unavailable	See Kristjánsdóttir et al (2011)(252) for internet-based intervention. This followed in-patient multidimensional rehabilitation	See Kristjánsdóttir et al (2011)(252) for internet-based intervention. This followed in-patient multidimensional rehabilitation	See Kristjánsdóttir et al (2011)(252) for internet-based intervention. This followed in-patient multidimensional rehabilitation	Mixed • Experienced support via feedback & diaries • However, ambivalence in: • Using internet-based technology • Feedback as challenging but positive	

Internet-based	Buhrman et al (2013)(454) RCT	Chronic Musculoskeletal conditions N = 72 (E = 36, C = 36) Age = 40.1	eHealth only Provider: Graduate psychology students Frequency: Weekly Duration: Eight weeks Follow-up: Six months	Guided internet-based CBT intervention 8 weekly modules – information part & practical part including assignments - Homework submission via secure platform - Written feedback from therapist via secure platform – encouragement, advice & non-specific support <i>Comparator: moderated online discussion group</i>	- Information provision & patient education - Remote monitoring with feedback & action plans - eHealth-facilitated clinical review - Training & rehearsal of psychological strategies - Adherence support & lifestyle interventions	Body functions: - Catastrophizing, pain-related distress, anxiety & depression improved - Maintenance of improvement exhibited at 6-month follow-up Activities & Participation: - QOL unchanged	 
Internet-based	Krein et al (2013)(455) RCT	Chronic LBP N = 229 (E = 111, C = 118) Age = 51.6	Mixture of face-to-face & eHealth Provider: Multiple providers – physical therapist delivered face-to-face back class, research staff participated in & monitored forum posts Frequency of internet-based program: mixed – pain or activity related messages on website changed every second day, other components weekly Frequency/duration of back class – not specified, had to attend prior to participation Duration: Twelve months	Pedometer-based, internet-based intervention based on 'Stepping Up to Health' program - Uploading pedometer - Internet-based intervention - automated walking goals, feedback, motivational messages - Social support via e-community - Weekly email reminders to upload pedometer data <i>Comparator: standard care with pedometer</i>	- Remote monitoring with feedback & action plans - Adherence support & lifestyle interventions – e-communities, weekly email reminders - Information provision & patient education	Body functions: - Fear avoidance beliefs did not differ between groups at any time point - Self-efficacy appeared to be the same or worse at 6 months for both groups; this difference did not persist at 12 months Activities & Participation: - Disability improved post-treatment, was not maintained at 12 months	 

			Follow-up: 3 months	• ACT-participant stories • Can keep personal diary • Counseling support via email within encrypted system Expressive writing control condition • 9 modules on expressive writing • Each module started with psycho-education, followed by a specific writing assignment • Included online personal diary <i>Other comparator: wait list control</i>	• Remote monitoring with feedback & action plans • eHealth-facilitated clinical review •	• Improvements in depression, pain intensity & catastrophising compared to both other groups at 3 months follow-up Activities & Participation: • Disability improved compared in E compared to both other groups at 3 month follow-up	
Internet-based	Irvine et al (2015)(457) RCT	LBP within past 3 months N = 597 (E = 199, alternate care group = 199, C = 199) Age = unavailable	eHealth only Provider: N/A - eHealth modality fully automated Frequency: Mixed – tracked pain management activities daily, received weekly emails with messages & prompts Duration: 8 weeks Follow-up: 4 months (8 weeks after intervention concluded)	Mobile-Internet based intervention – ‘FitBack’ • Pain & activity self-monitoring tool • Gain-framed text & video messages, which are segmented to address issues specific to each job type – sitters, standers, drivers & lifters • Journaling feature • Provides graphs to help users identify trends in pain level Alternate care group: • Initial email & 8 reminder emails, which included links to 6 websites re LBP	• Training & rehearsal of psychological strategies • Adherence support & lifestyle interventions • Information provision & patient education • Remote monitoring with feedback & action plans	Body functions: • Greater improvement in pain compared to C & alternate care group at 4-month follow-up • Catastrophising was unchanged • Self-efficacy improved Activities & Participation: • Improved functionality, quality of life, & well-being compared to C post treatment & at follow-up	 

Internet-based	Nordin et al (2016) (285) RCT	Chronic musculoskeletal conditions N = 109 (E = 60, C = 49) Age = 43	Mixture of face-to-face & eHealth Provider: Multiple - MMR consisted of treatment from at least three different healthcare professionals (physiotherapist, physician, OT, psychologist, or psychosocial counsellor, nurse) Frequency: Mixed – internet-based intervention – weekly for first 8 weeks MMR – at least 2-3 sessions weekly for first 6 weeks Duration: 4 months Follow-up: 12 months	MMR + Web-BCPA MMR: • CB approach • Supported by a rehabilitation coordinator • Copy of individualised rehabilitation plan ± significant others • Home exercise • Education • Relaxation • Mindfulness • Counselling • PT may consist of acupuncture, manual therapy, TENS, hydrotherapy • OTs may provide Ergonomics, activity planning, & functional training Web-BCPA • No therapist guidance • 8 modules • Information • Interactive assignments (self-tests & self-developed action plans) • Exercises, assimilated via educational texts, videos • Writing tasks • Relaxation & basic body awareness therapy exercises <i>Comparator: MMR</i>	• Information provision & patient education • Remote monitoring with feedback & action plans • Adherence support & lifestyle interventions	Body functions: • Self-efficacy & pain intensity unchanged • Catastrophizing improved at 4- & 12-month follow-up	
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Internet-based	Calner et al (2017)(286) RCT	Chronic musculoskeletal conditions N = 109 (E = 60, C = 49) Age = 43	See Nordin et al 2016(285)	See Nordin et al 2016(285)	See Nordin et al 2016(285)	Body functions: - Average pain intensity - unchanged Activities & Participation: - Pain related disability, work ability & health related QOL - unchanged	 
Internet-based	Nordin et al (2017)(458) Qualitative	Chronic musculoskeletal conditions N = 19 Age = 45	See Nordin et al 2016(285)	See Nordin et al 2016(285)	See Nordin et al 2016(285)	- Increased self-confidence & empowerment in dialogue with healthcare professionals. - Solitary work had an important role to acquire knowledge & insights - Higher user control regarding timing may further increase participation	
Internet-based	Pearson et al (2016)(459) Mixed methods	Widespread musculoskeletal conditions (Hip, Knee, back pain or multiple) N =83 for postal survey (42% response rate) Age = 67 Focus Groups (n = 24) Age = unavailable Interviews = 8 Age = unavailable	eHealth only – primarily codesign study Provider: N/A - eHealth modality fully automated Frequency: Unstructured – Degree of frequency not specified Duration: One time access Follow-up: none	Internet-based version of ESCAPE-pain - Codesign study - Prototype website with limited function and offline material	- Information provision & patient education - Remote monitoring with feedback & action plans - Adherence support & lifestyle interventions - Training & rehearsal of psychological strategies	- Older people more likely to accept internet-based program as an adjunct to face-to-face care rather than a replacement - Have concerns about safe use & quality of information - Users require a credible website that provides personalized information, support,	

						No differences in mental or physical QOL	
Internet-based	Bendelin et al (2018)(460) Qualitative	Chronic musculoskeletal conditions N = 29 Age = 37	Mixture of face-to-face & eHealth – aftercare following inpatient rehab Provider: multiple – pain psychologist, could consult with OT, PT and pain physician Frequency: weekly Duration: 20 weeks Follow-up: none	Internet-based aftercare programme (ACP) - Resembled self-help book with 8 modules - Assignments and worksheets - Extensive therapist guidance during first 4 weeks, worked more independently during latter 4 modules	- Information provision & patient education - Training & rehearsal of psychological strategies - Adherence support & lifestyle interventions - Remote monitoring with feedback & action plans - eHealth-facilitated clinical review	- Value-based goals are important - Experiencing a beneficial effect of acceptance strategies can facilitate with problem solving & commitment to treatment - Research needed to investigate whether individualized therapist guidance is helpful to establish goals & contribute to maintenance	
Internet-based	Bennell et al (2018)(461) RCT	Osteoarthritis (Hip OA) N = 144 (E = 73, C = 71) Age = 61.3	Mixture of face-to-face & eHealth Provider: physiotherapist Frequency: mixed. Online education & internet based intervention – weekly, physiotherapy – every 3 weeks, HEP three times per week Duration: mixed. Online education & internet based intervention – 8 weeks,	Automated internet based PCST prior to HEP First 8 weeks - Online education – 8 information sheets, one per week - PCST – 'PainCoach' as per Rina et al (2015)(243) Weeks 8 -24 5 physiotherapy sessions face-to-face	- Information provision & patient education - Training & rehearsal of psychological strategies - Remote monitoring with feedback & action plans - Adherence support & lifestyle interventions	Body functions: - Pain coping improved at week 8 & sustained at 24 & 52 weeks in E - Hip pain on walking improved in both E & C, no difference between groups Activities & Participation:	

			physiotherapy – weeks 8 – 24 (16 weeks), HEP from weeks 8 – 52 – 44 weeks in total Follow-up: 12 months	for HEP (30 mins in duration) <i>Comparator: online education only in first 8 weeks – 8 information sheets, one per week</i> <i>Weeks 8 -24</i> <i>5 physiotherapy sessions face-to-face for HEP (30 mins in duration)</i>		- Greater improvement in function at week 8 in E compared to C - Groups did not differ at week 24 Environment factors: - Medication use was similar in both groups over the study period	 
Internet-based	Petrozzi et al (2019)(253) RCT	Chronic LBP N = 108 (E = 54, C = 54) Age = 50.4	Mixture of eHealth & face to face Provider: multiple - physiotherapy or chiropractor Frequency: mixed. Standard physical treatment – 12 sessions over 8 weeks. Internet based intervention - weekly Duration: mixed. Standard physical treatment – 8 weeks. Internet based intervention – 5 weeks. Follow-up: 6 & 12 month	Internet-based psychological program (MoodGYM) in addition to standard physical treatment - Weekly telephone reminder – MoodGYM – research assistant - If report distress as a result of MoodGYM – referral to psychologist <i>Comparator: 12 standard physical treatment sessions</i>	Training & rehearsal of psychological strategies	Body functions: - Self-efficacy – did not differ between groups at 6 or 12 months - No additional benefit to MoodGYM with standard physical treatment Activities & Participation: - Disability – did not differ between groups at 6 or 12 months - No additional benefit to MoodGYM with standard physical treatment	 

Telephone-based	Thomas et al (2002)(463) RCT	Knee OA N = 786 (Exercise + telephone = 121, exercise, telephone + placebo tablet = 114, exercise = 235, telephone = 160, placebo = 78, no intervention = 78) Age = 62	Mixture of face-to-face & eHealth Provider: research nurse Frequency of in-person exercise: initially every 2 weeks for first 8 weeks, then at 6 month intervals Frequency of telephone calls: monthly Duration: 2 years Follow-up: none	- Self-paced knee exercise program with graded elastic bands - Telephone contact – monitor symptoms & advice on pain management - Placebo tablet – dolomite health food product <i>Comparator: standard care</i>	- Information provision & patient education - Remote monitoring with feedback & action plans - Adherence support & lifestyle interventions - eHealth-facilitated clinical review	Body functions: - Pain improved - Anxiety & depression was not altered by any of the interventions Activities & Participation: - Knee specific physical function improved - General physical function (SF-36) was not altered by any of the interventions	 
Telephone-based	Thomas et al (2005)(464) RCT	Knee OA N = 786 (Exercise + telephone = 121, exercise, telephone + placebo = 114, exercise = 235, telephone = 160, placebo = 78, no intervention = 78) Age = 62	See Thomas et al(463)	See Thomas et al(463)	See Thomas et al(463)	Environmental factors: Cost of delivering the exercise program unlikely to be offset by any reduction in medical resource use	
Telephone-based	Damush et al (2003)(465) RCT	Acute LBP N = 211 (E = 106, C = 105) Age = 45.5	Mixture of face-to-face & eHealth Provider: Multiple Providers (Telephone calls: Research staff; In person classes: Session leaders) Frequency: 3 in person classes – once per week Telephone calls to participants at 4, 6, & 8 weeks; thereafter once per month Duration:	Self-management program: 3 in-person classes – information about acute LBP, goal setting, problem solving & social support - Class handouts – recommended exercises - Classes on audiotape & a cassette player – provided if participant missed a class - Physician letters of support – encouraging	- Information provision & patient education - Remote monitoring with feedback & action plans - Adherence support & lifestyle interventions - Training & rehearsal of psychological strategies - eHealth-facilitated clinical review	Body Functions: Short term improvements in emotional functioning & self-efficacy	

Telephone-based	Odole & Ojo (2013)(469) Obs	Knee OA N = 50 (E = 25, Clinic based group = 25) Age = 55.5	Mixture of face-to-face & eHealth Provider: Physiotherapist Frequency: three times per week Duration: six weeks Follow-up: none	- Assessment & provision of copy of standardized HEP face-to-face in clinic - Structured telephone call thrice-weekly to monitor & coach - Exercise log book <i>Comparator: clinic based physiotherapist administered standardized HEP</i>	- Information provision & patient education - Adherence support & lifestyle interventions - eHealth-facilitated clinical review - Remote monitoring with feedback & action plans	Body functions: - Pain improved (comparable to clinic-based group) post treatment Activities & Participation: - Physical functioning improved (comparable to clinic-based group) post treatment	
Telephone-based	Odole & Ojo (2014)(470) Obs	Knee OA N = 50 (E = 25, Clinic based group = 25) Age = 55.5	See Odole & Ojo (2013)(469)	See Odole & Ojo (2013)(469)	See Odole & Ojo (2013)(469)	Activities & Participation: HRQOL – improved (comparable to clinic-based group) post treatment	
Telephone-based	Salisbury et al (2013)(249) Mixed methods	Musculoskeletal conditions Quantitative: N = 2256 (E = 1513, C = 743) Age = 48 Qualitative: N = 57 Age = 58	Mixture of face-to-face & eHealth Provider: Physiotherapist Frequency: Unstructured Duration: Unspecified Follow-up: none	'PhysioDirect' Telephone assessment and advice service - Initial assessment and advice - Sent written advice about self-management and exercise - Invited to phone back to discuss progress in 2-4 weeks - If telephoned back, offered further advice +/- face-to-face	- Information provision & patient education - Adherence support & lifestyle interventions - eHealth-facilitated clinical review - Remote monitoring with feedback & action plans	Quantitative: Activities & Participation: - Physical component score was similar in both groups Qualitative: - Broadly acceptable - Seen as first step in accessing treatment rather than replacing a face-to-face consultation. - Many valued the faster access to	

				appointment as indicated <i>Comparator: usual care – face-to-face assessment and treatment</i>		advice & care & found the physiotherapists to be helpful during telephone consultations. However, some found the service to be impersonal & remote	
Telephone-based	Bennell et al (2017)(471) RCT	Knee OA N = 168 (E = 84, C = 84) Age = 62.3	Mixture of face-to-face & eHealth Provider: Multiple – musculoskeletal physiotherapists & 5 female telephone health coaches with health backgrounds (3 nurses, 1 occupational therapist, 1 health psychologist) Frequency: Mixed - PT - weeks 1, 3, 7, 12 & 20 Coaching - weeks 2, 4, 8, 13, 21 & 25 ± 6 additional calls can be made at any time during the 6 months Duration: 6 months Follow-up: Month 12 & month 18	5 x individual physiotherapy sessions & 6 to 12 telephone sessions with a health coach. - Information booklet - Exercise handouts - Pedometer - Exercise/physical activity log sheets <i>Comparator: physiotherapy only (5 individual sessions)</i>	- Information provision & patient education - Adherence support & lifestyle interventions - Remote monitoring with feedback & action plans - Training & rehearsal of psychological strategies - eHealth-facilitated clinical review	Body functions: - Pain improved in both E & C, no difference between groups – Addition of simultaneous coaching did not augment benefits of a PT prescribed PA program Activities & Participation: - Function improved in both E & C, no difference between groups – Addition of simultaneous coaching did not augment benefits of a PT prescribed PA program	 
Telephone-based	Hinman et al (2016)(251) Qualitative	Knee OA N = 6 patients with knee OA Age = 62	See Bennell et al (2017)(471)	See Bennell et al (2017)(471)	See Bennell et al (2017)(471)	- Perceived as beneficial - Balance needed with regards to structure & flexibility to promote individualization as indicated - Video conferencing rather than telephone may facilitate relationship building	

Telephone-based	Schaller et al (2017)(472) RCT	Chronic LBP N = 412 (E = 201, C = 211) Age = 51.9	Mixture of face to face & eHealth Provider: multiple – movement coaches & inpatient rehabilitation (therapist specified) Frequency: mixed face to face contact – 3 times in 3 weeks/during inpatient stay Web-based platform – unspecified Inpatient rehabilitation –not specified Telephone aftercare – twice in one month (week 8 & 12) Duration: Inpatient rehab – 3 weeks 3 face to face contacts – one hour Web-based platform – 6 months Follow-up: 12 months	Multicomponent intervention – 'Movement Coaching' - Small group intervention – 23 face to face sessions during inpatient rehabilitation - Tailored telephone aftercare - Web 2.0 intervention – did not meet criteria for internet based intervention – unstructured <i>Comparator: low intensity control</i> 2 oral presentations (30 minutes) that were available for download after During inpatient rehabilitation	- Information provision & patient education - Remote monitoring with feedback & action plans - Adherence support & lifestyle interventions - eHealth-facilitated clinical review	Activities & Participation: - Total or domain specific PA (leisure, workplace & transportation) unchanged - Total PA worsened over 12 month study period Environmental factors: - Use of other healthcare services, medication use & sick leave change did not differ between groups at 6 month follow-up	
Telephone-based	Goode et al (2018)(244) RCT	Chronic LBP N = 60 (PA + CB intervention = 20, PA = 20, C = 20) Age = 70.3	Mixture of eHealth & face-to-face Provider: multiple – physiotherapist & Exercise counsellor Frequency: mixed. Physiotherapist – one call every 4 weeks – 3 in total. Exercise counsellor – week 1, 2, 3, 5, 6, 7, 8, 10, 11, 12 Duration: 12 weeks Follow-up: none	12 week telephone supported PA program & CB therapy intervention PA program - Telephone calls from physiotherapist - Addressing functional & clinical issues - Telephone calls from exercise counsellor - PA goals - Barriers to goals	- Information provision & patient education - Remote monitoring with feedback & action plans - eHealth-facilitated clinical review - Adherence support & lifestyle interventions - Training & rehearsal of psychological strategies	Activities & Participation: - Timed 'Up & Go' improved in both treatment groups compared to C – favored PA vs PA + CB intervention - Activities of daily living self-report measure improved in both treatment groups compared to C – favored PA vs PA + CB intervention	

				No contact unless technical issues or mental health emergency <i>Other comparator: waitlist control</i>		& further improved at 3-month follow-up. Environmental factors: Improvements in medication & healthcare use across treatment & control groups	
Internet based with telephone support	Friesen et al (2017) (266) RCT	Fibromyalgia N = 60 (E = 30, C = 30) Age = 47.5	See Dear et al (2013)(277) Follow-up: 4 weeks	See Dear et al (2013)(277) <i>Comparator: waitlist control</i>	See Dear et al (2013)(277) •	Body functions: - Improved symptom severity, depression, pain & fear of pain - Smaller effects observed for anxiety - Changes maintained at 4-week follow-up Activities & Participation: - Small improvement in physical health post treatment, maintained at 4 weeks	 
Internet based with telephone support	Dear et al (2018)(275) RCT	Chronic musculoskeletal conditions See Dear et al (2015)(276) 12 & 24 month follow-up	See Dear et al (2015)(276)	See Dear et al (2015)(276)	See Dear et al (2015)(276)	Body functions: - Improvements in pain, anxiety & depression were maintained at 12 & 24 months. - No differences between treatment groups were noted Activities & Participation: - Improvements in disability were maintained at 12 & 24 months for disability.	

				<i>Comparator: moderated online discussion forum</i>			
Internet based with telephone support	Peters et al (2017) (289) RCT	Chronic musculoskeletal conditions N = 284 (internet positive psychology intervention = 117, internet CB intervention = 116,, C = 51) Age= 48.9	eHealth only Provider: Graduate psychology students Frequency: Mixed internet based intervention – weekly. Telephone support - weeks 1, 3, 5 & 7) Duration: 8 weeks Follow-up: 6 months (excludes C)	Internet based positive psychology self-help program – 'Happy Despite Pain' • 8 modules • Self-compassion diary & letter to oneself • Gratitude exercises • Savoring diary • Best possible self exercise • Telephone support • Email support (weeks 2, 4, 6, & 8) Internet based CB intervention • Based on Buhrman et al (2004)(480) • 8 modules • Telephone support • Email support (weeks 2, 4, 6, & 8) <i>Other comparator: waitlist control</i>	• Training & rehearsal of psychological strategies • Information provision & patient education • eHealth-facilitated clinical review •	Body functions: • Depression improved in both treatment groups compared to C post treatment. • No differences between both treatment groups at 6 months • Anxiety & catastrophizing improved for both groups compared to C post treatment, maintained at 6-month follow-up • Pain intensity – unchanged Activities & Participation: • Improvements in physical impairments in both treatment groups, similar to improvements in C	 
Internet based with telephone support	Geraghty et al (2018)(482) RCT	LBP N = 87 (internet intervention + PT support = 29, internet intervention + usual care = 30, C = 28) Age = 58	eHealth only Provider: Physiotherapist Frequency: mixed. Internet based intervention – weekly. Telephone support – 3 calls over a 4-week period Duration: 6 weeks Follow-up: 3 months	Internet based intervention – 'SupportBack' • 6 sessions • Graded goal setting • Self-monitoring • Tailored feedback • Automated weekly email reminders • Telephone support SupportBack plus usual care <i>Other comparator: standard care</i>	• Information provision & patient education • Remote monitoring with feedback & action plans • Adherence support & lifestyle interventions • Training & rehearsal of psychological strategies • eHealth-facilitated clinical review	Body functions: • Pain intensity improved in all 3 groups • Greatest improvement in SupportBack + PT support vs SupportBack + usual care • Pain catastrophizing worsened in both C & SupportBack + PT support	

						• Fear avoidance beliefs improved in all 3 groups Activities & Participation: • Disability improved in all 3 groups • Greater improvement in disability in SupportBack + PT support vs. C, compared to SupportBack + usual care vs. C.	
Internet based with telephone support	Geraghty et al (2019)(483) Qualitative	LBP N = 15 Age = 56.2	See Geraghty et al (2018)(482)	See Geraghty et al (2018)(482)	See Geraghty et al (2018)(482)	• Feasible • Highlighted importance of self-management & PA while providing reassurance • Prompts & reminders helped with the behavioral change & maintenance • Pre-existing condition or severity acted as barriers • Less useful for those with mild LBP • Telephone support provided additional reassurance & motivation	
Internet based with telephone support	Higgins et al (2020)(247) Mixed methods	Chronic LBP N = 15 (Qualitative) Age = 50.9 N = 58 (Quantitative) Age = 55	eHealth only Provider: other (study staff) Frequency: weekly Duration: 10 weeks Follow-up: none	Internet-based self-management program – 'PAIN Ease' – Pain eHealth for Activity, Skills and Education • Screening via telephone or in-person • Self-directed – no clinician involvement	• Information provision & patient education • Remote monitoring with feedback & action plans • Adherence support & lifestyle interventions	Quantitative: Body functions: • Within-subject improvement for pain interference, mood and depression Qualitative:	

				- Weekly telephone calls by study staff - Step count - Sleep tracking - Relaxation practice - Coping skills modules 'Test Your Knowledge' quizzes	Training & rehearsal of psychological strategies	- May benefit from technology-delivered interventions, which may also reduce pain interference - Internet based intervention is feasible & satisfactory	
Mobile phone application with telephone-support	Amorim et al (2019)(484) RCT	Chronic LBP N = 68 (E = 34, C = 34) Age = 58.3	Mixture of face to face & eHealth Provider: Health coaches Frequency: mixed. Face to face assessment & interview occurred once at beginning of intervention. Coaching – every 2 weeks, mobile phone application – unstructured. Duration: 6 months Follow-up: none	Patient centred PA intervention - Information booklet - Individually tailored PA plan with guidance from coach - Face to face assessment & interview - Telephone coaching - Activity tracker - Mobile phone application – IMPACT app - Weekly personalized messages <i>Comparator: standard care</i>	- eHealth-facilitated clinical review - Remote monitoring with feedback & action plans - Adherence support & Lifestyle interventions - Information provision & patient education - Training & rehearsal of psychological strategies	Body functions: - Pain - unchanged Activities & Participation: - Disability - unchanged Environmental factors: 38% reduced rate of care seeking in E (p = 0.14)	  
Interactive voice response with telephone-support	Kroenke et al (2014)(281) RCT	Chronic musculoskeletal conditions N = 250 (E = 124, C = 126) Age = 55.2	Mixture of eHealth & face-to-face Provider: multiple (nurse care manager & physician pain specialist with primary care physician) Frequency of IVR: weekly for the first month, every other week for months 2 & 3, & monthly for months 4 through 12 Frequency of telephone support: Scheduled for 1	Telephone-delivered collaborative care management intervention - 'Stepped Care to Optimize Pain Care Effectiveness (SCOPE)' - IVR automated symptom monitoring - Optimised analgesic management consisting of 1 face-to-face meeting with nurse & 2 scheduled telephone support calls	- eHealth-facilitated clinical review - Adherence support & lifestyle interventions - Remote monitoring with feedback & action plans	Body functions: - Pain improved - Depression improved - Anxiety & sleep unchanged Activities & Participation: - Physical functioning unchanged Environmental factors: - Opioid use unchanged	  

				<i>Comparator: standard care (includes written prescription from physician)</i>			
Mobile Phone Application	Lo et al (2018)(263) Obs	Chronic widespread musculoskeletal conditions (Chronic neck & back pain) N = 158 Age = Not reported	eHealth only Provider: multiple – physiotherapists, rehabilitation doctor, clinical scientist. Frequency: unstructured Duration: unspecified Follow-up: none	Artificial intelligence mobile phone application – “Well Health Mobile App” • Tailored exercise rehabilitation program based on symptoms- self report questionnaire • Artificial intelligence algorithm determined HEP • Re-assessment every 2 weeks • Exercise videos – points rewards when full length of video played • All users could contact medical team • Points-based reward utilized to promote engagement Educational material via social media platform	• eHealth-facilitated clinical review • Information provision & patient education • Remote monitoring with feedback & action plans • Adherence support & lifestyle interventions	Body functions: • Pain intensity - improved	
Mobile Phone Application	Mecklenburg et al (2018)(486) RCT	Chronic knee pain N = 162 (E = 101, C = 61) Age = 46.5	eHealth only Provider: N/A - eHealth modality fully automated Frequency: mixed. Exercise therapy – 3-4 times per week, education – once per week, symptom logging – twice per week, activity tracking – at least 3 times per week, CBT – frequency not defined, team &	Mobile phone based digital care program – ‘Hinge Health Digital Care Program’ • Sensor guided exercise therapy • Education • CB therapy • Weight loss • Psychosocial support via personal coach & team-based interaction • Activity tracking	• Information provision & patient education • Remote monitoring with feedback & action plans • Adherence support & lifestyle interventions • Training & rehearsal of psychological strategies • eHealth-facilitated clinical review	Body functions: • Pain & stiffness improved compared to C post treatment Activities & Participation: • Function improved compared to C post treatment Environmental factors: • Likelihood of having surgery in the next 1	  

			coach interaction – at least once per week Duration: 12 weeks Follow-up: none	<i>Comparator: 3 education pieces regarding self-care for chronic knee pain</i>		year, 2 years & 5 years compared to C – reduced/ improved	
Mobile Phone Application	Shebib et al (2019)(487) RCT	LBP N = 177 (E = 113, C = 64) Age = 43	See Mecklenburg et al (2018)(486)	See Mecklenburg et al (2018)(486)	See Mecklenburg et al (2018)(486)	Body functions: - Pain – improved Activities & Participation: - Disability – improved	 
Mobile Phone Application	Toelle et al (2019)(488) RCT	Back pain N = 101 (E = 53, C = 48) Age = 42	Mixture of eHealth & face-to-face Provider: multiple – physical examination - medical doctor, within chat function of app – physiotherapist/ sports scientist Frequency: 4 times per week Duration: 3 months Follow-up: none	Mobile phone application based MDT back pain treatment – ‘Kaia App’ - Back pain specific education - Physiotherapy/ physical exercise - Mindfulness & relaxation - Pain diary <i>Comparator: 6 individual physiotherapy sessions over 6 weeks plus high-quality online education</i>	- Information provision & patient education - Training & rehearsal of psychological strategies - eHealth-facilitated clinical review - Adherence support & lifestyle interventions	Body functions: - Pain intensity – improved Activities & Participation: - Functional ability & well-being – unchanged Environmental factors: - No group different regarding pain medication	  
Mobile Phone Application	Huber et al (2017)(489) Obs - retrospective	LBP N = 180 Age = 33.9	See Toelle et al (2019)(488)	See Toelle et al (2019)(488)	See Toelle et al (2019)(488)	Body functions: Pain – improved	
Mobile Phone Application	Yang et al (2019)(490)	Chronic LBP N = 8 (E = 5, C = 3)	Mixture of face-to-face & eHealth	Mobile phone based self-management plus	Remote monitoring with feedback & action plans	Body functions: Self-efficacy improved	

	RCT	Age = 42.7	Provider: physiotherapist Frequency: mixed. HEP 4 times daily. Frequency of physiotherapy not specified Duration: 4 week Follow-up: none	physiotherapy – app called 'Pain Care' - Exercise reminder via app - Pain diary via app - Sharing inputted data via email - Can tailor reminders via App Comparator: physiotherapy only	- eHealth-facilitated clinical review - Adherence support & lifestyle interventions	- Pain – positive trend but no within- or between-group differences Activities & Participation: - Bodily pain & mental health aspects of health related QOL - improved - Disability – improved	 
Mobile Phone Application	Hasenöhr et al (2020)(250)	LBP N = 27 (Quantitative analysis of secondary data) Age = 44.8 N = 16 (Qualitative semi structured interviews) Age = 45.1	Mixture of face-to-face & eHealth Provider: other (orthopaedic specialist) Frequency: unstructured Duration: 4 weeks Follow-up: none	Mobile phone application - Videos of 48 therapeutic exercises - App decided exercises depending on acute or chronic diagnosis inputted by physician - Physician could modify suggested exercises - After finishing each exercise, patients could give feedback via traffic light system – if 'red' or excessive amount of 'yellow', doctor was alerted	- eHealth-facilitated clinical review - Adherence support & lifestyle interventions	Quantitative: Activities & Participation: - Disability and QOL domains physical functioning, bodily pain and vitality improved Qualitative: - Feasible & well-accepted - Pilot data points towards efficacy of the intervention.	 
Mobile Phone Application	Hauser-Ulrich et al (2020)(268)	Chronic musculoskeletal conditions N = 102 (E = 59, C = 43) Age = 44	eHealth only Provider: N/A - eHealth modality fully automated Frequency: daily Duration: 8 weeks Follow-up: none	Automated mobile phone application-based CB therapy chatbot - painSELfManagement (SELMA) - Pain diary - Delivers psychoeducation from day 1 to 21 in daily text messages - Day 22 until the end, SELMA delivers CB therapy intervention modules	- Training & rehearsal of psychological strategies - Information provision & patient education - Adherence support & lifestyle interventions	Body functions: - Pain intensity-improved Activities & Participation: - Well-being improved - Pain related impairment – small improvement, similar to C	 

			Follow-up: none	- Skills rooted in pain CBT - Relaxation training - Optimised in VR group with visual bio-feedback - Mindfulness <i>Comparator: audio-only version of the VR program</i>		improved similarly in both E & C Activities & Participation: Pain-related interference with activity & stress improved	
Internet-based with video conferencing (n=1)							
Internet-based with video conferencing	Bennell et al (2017)(493) RCT	Chronic knee pain N = 148 (E = 74, C = 74) Age = 61.2	Via eHealth only Provider: physiotherapists Frequency: Mixed – PCST – weekly Physiotherapy via skype – approx. fortnightly (7 over 12 weeks) Duration: 3 months Follow-up: 6 months	Exercise + PCST - Online educational material 7 individual physiotherapy sessions vis skype - HEP - PCST – 8 weekly sessions plus monthly reminder emails <i>Comparator: online educational material</i>	- Information provision & patient education - eHealth-facilitated clinical review - Training & rehearsal of psychological strategies - Remote monitoring with feedback & action plans - Adherence support & lifestyle interventions	Body functions: - Improved pain, sustained for at least 6 months Activities & Participation: - Improved function, sustained for at least 6 months Environment factors: - Co-interventions & medication use was similar in both groups over the study period	  
Internet-based with video conferencing	Hinman et al (2017)(248) Qualitative	Chronic knee pain N = 12 Age = 39	See Bennell et al (2017)(493)	Bennell et al (2017)(493)	Bennell et al (2017)(493)	- Overall positive experience using Skype as service delivery model for exercise management - Feasible & acceptable & has potential to increase access to supervised exercise management	
Key - Outcomes							

-  **Not applicable**
-  **Outcome improved post intervention**
-  **Outcome worsened post intervention**
-  **Outcome unchanged post intervention**
-  **Outcome had mixed results (some improved and/or some did not change and/or some worsened)**

Abbreviations

ACT, Acceptance and Commitment Therapy; AIMS2, Arthritis Measurement Impact Scales-2; C, control; CB, cognitive behavioral; E, experimental; FM, fibromyalgia; HEP, home exercise programme; LBP, low back pain; IVR, interactive voice response; M, male; MDT, multidisciplinary team; MMR, multimodal pain rehabilitation; N/A, not applicable; OA, osteoarthritis; Obs, observational; OT, occupational therapist; PA, physical activity; PCP, Profile of Chronic Pain; PCST, pain coping skills training; PT, physiotherapy; QOL, quality of life; RCT, randomized controlled trial; TENS, transcutaneous electric nerve stimulation; TUAG, timed up and go; VAS, visual analogue scale; VR, virtual reality; Web-BCPA, Web Behaviour Change Program for Activity; WHO, world health organisation

Appendix 5: Chapter 3 (Study 2) Interview Guide – MSK Physiotherapists

Topic Guide Key Questions and Prompts
The purpose of this interview is to gain a greater understanding of your experience and opinion on the use of technological platforms (e.g. mobile, computer, tablet) in physiotherapy. Do you _____ consent to taking part in audio recorded telephone interviews about your thoughts and opinions on the use of technology within physiotherapy* Thank you very much for agreeing to take part in the study, I really appreciate you giving up your time to talk with me. If you would like to stop the interview at any time just let me know and it will be stopped. We can then start again when you are ready.
(a) Understanding of self-management support
What is self-management support in your opinion? <i>Prompts:</i> - Are you familiar with this term? - What is your experience of this in the clinic? - What are the advantages of this approach? - What are the disadvantages?
(b) Experiences, expectations and needs regarding eHealth
Have you used any form of eHealth with patients? <i>Prompts:</i> - How did you find this? Did it meet your expectations? - If not, why? - What factors would reduce/limit your use of eHealth - Are you still using?
(c) Willingness to use eHealth for self-management purposes
Do you think you would be interested in using technology to help a patient manage their “musculoskeletal disorder”? Do you think you would be willing to use eHealth to help a patient to manage their condition? <i>Prompts:</i> - Do you think it could be helpful? Why/ why not? - What would make you more likely to use eHealth? - What would make you less likely to use eHealth?
Is there anything else you would like to tell me about your experience with technological platforms (e.g. mobile, computer, tablet) in physiotherapy? Is there anything I left out?
*Please note consent will be re-confirmed by the researcher at the outset of the interview and consent obtained orally. This process will be digitally recorded by the researcher.

Appendix 6: Chapter 3 (Study 2) Interview Guide – People with a MSD

Topic Guide Key Questions and Prompts
The purpose of this interview is to gain a greater understanding of your experience and opinion on the use of technological platforms (e.g. mobile, computer, tablet) in physiotherapy. Do you _____ consent to taking part in audio recorded telephone interviews about your thoughts and opinions on the use of technology within physiotherapy* Thank you very much for agreeing to take part in the study, I really appreciate you giving up your time to talk with me. If you would like to stop the interview at any time just let me know and it will be stopped. We can then start again when you are ready.
(a) Understanding of self-management support
What are your first thoughts and feelings about receiving care and encouragement from healthcare professionals to help you manage your “musculoskeletal disorder” and make decisions about it? <i>Prompts:</i> - Have you previous experience of this? - Have you any worries/concerns?
(b) Experiences, expectations and needs regarding eHealth
How would you feel about using technology during your sessions with the physiotherapist? <i>Prompts:</i> - How did you find this? Did it meet your expectations? - If not, would you have been interested in using? - What factors would reduce/limit your use of eHealth - Would you recommend to family or friends?
(c) Willingness to use eHealth for self-management purposes
Do you think you would be interested in using technology to help you manage your “musculoskeletal disorder”? <i>Prompts:</i> - Do you think technology could be helpful? Why/ why not? - What would make you more likely to use technology? - What would make you less likely to use technology?
Is there anything else you would like to tell me about your experience with technological platforms (e.g. mobile, computer, tablet) in physiotherapy? Is there anything I left out?
Note: “musculoskeletal disorder” will be replaced with the presenting complaint of the patient
*Please note consent will be re-confirmed by the researcher at the outset of the interview and consent obtained orally. This process will be digitally recorded by the researcher.

**Focus Group 1 Guide – Participants with a Musculoskeletal Condition
Version 1**

Topic Guide Key Questions and Prompts

My name is Marie Kelly, and I am a PhD research student and Lecturer in Physiotherapy at UCC.

The purpose of this focus group interview is to get your feedback and preferences on some technology features we have developed based on earlier research.

Please answer yes or no to the following question:

Do you consent to taking part in audio recorded focus group interview about your thoughts and opinions on the technology features that will be presented to you*

Thank you very much for agreeing to take part in the study, I really appreciate you all giving up your time to attend this focus group interview.

If anyone would like to stop the interview at any time just let me know and it will be stopped. We can then start again when you are ready.

Ground rules:

- We want you to do the talking
- There are no right or wrong answers
- What is said in this room stays here

1) Feature adoption/acceptability/sustainability

Think about yourself or others using this feature:

- Do you like anything about this concept? Why?
- Is there anything you dislike about this concept?/Why?
 - How could we make it better?
- How would this feature have been useful in the past? Presently? Future? Regarding your needs.

2) Overall website strengths and weaknesses (Monopoly activity)

Description of monopoly activity (i.e. each of you will be given €100 in €5 denominations. You can spend it all on one feature, or spend € among numerous features).

Present features most liked:

- Tell me why you valued _____ feature.

Present features least liked:

- Tell me why you did not value _____ feature.
- What would make this feature better? Why?

3) General concepts

Tell me what you/others do not/may not like about this website? Explain?

Are there any health apps/websites you have used to help manage/learn about your musculoskeletal condition in the past month?

- Tell me about them.
- What did you like/dislike about them?

**Focus Group 2 Guide – Participants with a Musculoskeletal Condition
Version 1**

Topic Guide Key Questions and Prompts

My name is Marie Kelly, and I am a PhD research student and Lecturer in Physiotherapy at UCC.

The purpose of this focus group interview is to get your feedback and preferences on some technology features we have developed based on earlier research.

Please answer yes or no to the following question:

Do you consent to taking part in audio recorded focus group interview about your thoughts and opinions on the technology features that will be presented to you*

Thank you very much for agreeing to take part in the study, I really appreciate you all giving up your time to attend this focus group interview.

If anyone would like to stop the interview at any time just let me know and it will be stopped. We can then start again when you are ready.

Ground rules:

- We want you to do the talking
- There are no right or wrong answers
- What is said in this room stays here

1) Individual website pages

- Is there anything on this screen that is confusing? Explain.
- Is there anything you wish was or wasn't on this screen? Explain.
- What would make this the perfect version of this screen? Explain.

2) Functional elements

Which method (e.g. drag and drop, check boxes) does everyone feel would be easiest to use? Why?

- What would make this feature better? Why?
- Is there other features that may be more useful? Why?

3) Tailoring features

Submenu:

- Would you use this feature? Why/why not?
- Is there anything confusing about this feature? Why?
- Is there anything you wish was or wasn't included in this feature?
- What would make this perfect? Why?

Personalized lists (topics, questions):

- Would you use this feature? Why/why not?
- Is there anything confusing about this feature? Why?
- Is there anything you wish was or wasn't included in this feature?
- What would make this perfect? Why?

Usability scenarios – People with a Musculoskeletal Condition

1. Initial Diagnosis of a Musculoskeletal Condition

You have been recently diagnosed with a Musculoskeletal Condition. You want to learn more about what your Musculoskeletal Condition, specifically how to manage it and return to your usual hobbies as appropriate.

2. Flare-up management

Yesterday morning your pain was much improved, and you decided to get a lot of your jobs done. Today your pain is much worse. You want to know what you should do.

3. Improve exercise or physical activity levels

You have been told that increasing your exercise or physical activity levels is important for the overall management of your musculoskeletal condition. You want to find out how to get started and what is a realistic target for you.

4. Social support / healthcare professional support

You are having a bad week and finding it difficult to stick to the action plan you developed with the physiotherapist to manage your musculoskeletal condition. You are interested in discussing this with other people with a musculoskeletal condition or with the physiotherapist themselves.

5. Goal review

You set a goal with the physiotherapist in order to gradually increase your exercise or physical activity levels. A month has gone by, and you want to share your progress with others

Usability scenarios –Musculoskeletal Physiotherapist

1. Information Library

You have recently diagnosed Mr./Mrs. X with a musculoskeletal condition. You want to direct them to evidence-based information about what their musculoskeletal condition, specifically how to manage it and return to your usual hobbies as appropriate.

2. Flare-up management

Part of managing a musculoskeletal condition is being able to manage the flare ups associated with it. You want to make sure Mr./Mrs. X is prepared for managing flare ups in the future.

3. Improve exercise or physical activity levels

Mr./Mrs. X's exercise or physical activity levels are very low. Working alongside Mr./Mrs. X, you want to discuss the importance of increasing the exercise or physical activity levels, how to get started and help to set a realistic goal for them.

4. Social support / healthcare professional support

You know that having a musculoskeletal condition that impacts on a person's day to day activities can result in feelings of social isolation. This can affect a person's motivation to stick with their action plan co-developed with the physiotherapist to manage your musculoskeletal condition. You would like Mr./Mrs. X to be able to discuss their condition with other people with a similar condition. You would also like to show them how they can get in touch with you if they feel this is indicated

5. Goal review

You set a goal collaboratively with Mr./Mrs. X in order to gradually increase your exercise or physical activity levels. A month has gone by, and you want to check in with them to see how they are getting on.
