Exploring Digital Self-Management Support for Chronic Knee Pain in Physiotherapy Clinics in Jeddah, Saudi Arabia: A Two Phased Sequential Mixed Methods Study

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Lastly, I extend my heartfelt thanks to the participants and experts who made this research a reality. Your willingness to participate, collaborate and contribute to the TRAK-Saudi platform has been invaluable.

Preface

As I embarked on my internship year within the realm of physiotherapy clinics, little did I anticipate the profound impact it would have on shaping my academic pursuits. The sheer number of individuals seeking care for chronic knee pain captivated my attention, triggering an insatiable curiosity to delve deeper into the root causes behind this prevalent issue and explore viable avenues to enhance the quality of life for those burdened by this condition.

Driven by this newfound interest, I embarked on a research journey aimed at uncovering an off-the-shelf solution to alleviate the pain and reduce the burden on individuals with chronic knee pain. My focus centred on studying the impact of commercial insoles on the load experienced by walking individuals, with the hope of discovering a simple yet effective means to aid them in walking with less pain and potentially reduce the strain on their affected joint caused by body weight. The results of my research yielded promising outcomes, showcasing the efficacy of these insoles in minimising joint load, particularly when individuals increased their walking speed. This finding opened doors for the integration of these insoles into fast-paced activities such as jogging and running, providing individuals with the opportunity to engage in these endeavours without compromising their comfort.

As my passion for finding innovative solutions to address chronic knee pain grew, my Ph.D. journey expanded its horizons to incorporate the integration of technology. I seized the opportunity presented by the ongoing digital transformation in Saudi Arabia, spurred by the visionary VISION 2030 initiative launched by the government in 2016. With this backdrop, my focus shifted towards the exploration of novel ways to leverage technology for the betterment of individuals suffering from chronic knee pain.

At the heart of my Ph.D. endeavour was the aspiration to create a valuable solution that empowered individuals with knee pain, enabling them to take charge of managing their lifelong condition. By encouraging self-management skills and reducing reliance on frequent physiotherapy visits, it was my belief that their presence in clinical settings would be diminished, ultimately leading to an improvement in their quality of life. Not

only would this approach empower individuals, but it would also have the potential to reduce costs and lessen the strain on healthcare resources.

This Ph.D. journey has been an extraordinary opportunity for personal growth, enriching my knowledge and skills across various facets of chronic knee pain in the Saudi context. Along this path, I have encountered invaluable education, abundant opportunities, and numerous challenges that have paved the way for exploring unexplored areas. Through this exploration, I have laid a foundation for future work in improving the quality of life for individuals with chronic knee pain, a lifelong condition.

With profound gratitude for the experiences gained and the doors opened, I humbly present this thesis. It represents countless hours of dedication, perseverance, and an unyielding belief in the potential to bring about positive change in the lives of those affected by chronic knee pain. It is my fervent hope that this work will serve as a catalyst for advancements, illuminating a future where individuals can reclaim their freedom from pain, assume control over their well-being, and revel in a life of improved quality and vitality.

Abstract

Background and study aim: Chronic knee pain is a widespread issue globally, affecting individuals of all ages worldwide. This challenge is intensified by an aging population, sedentary lifestyles and increasing obesity rates. There is an international shift towards promoting active management approaches in line with clinical guidelines, including physical activity, dietary changes and the support of self-management. This shift has led to an evolution of digital initiatives designed to support people to self-manage their chronic knee pain. However, despite the high prevalence of chronic knee pain in Saudi Arabia, relevant research in the region remains scarce. This study aims to explore digital self-management support for knee pain within the current physiotherapy practices in Jeddah, a prominent city in Saudi Arabia.

Methods: This study employed a sequential exploratory mixed-method design. It started with qualitative interviews involving 29 participants (15 physiotherapists and 14 individuals with knee pain), analysed using reflexive thematic analysis (Phase 1). The aim was to explore how existing physiotherapy practices for knee conditions align with self-management support principles and to explore the perceptions of potential users towards digital self-management support initiatives. Part of the findings informed the adaptation of the digital intervention "TRAK" into a Saudi-specific platform named "TRAK-Saudi". In Phase 2, 12 participants (6 physiotherapists and 6 individuals with chronic knee pain) participated in remote usability testing sessions for evaluating the usability of TRAK-Saudi. The perceived usability was assessed using the Arabic System Usability Scale (A-SUS), with usability issues identified through a concurrent think-aloud approach and analysed via quantitative content analysis. Additionally, the likelihood of substituting face-to-face sessions was assessed using a 5-point Likert scale. Qualitative and quantitative data from both phases were integrated at various points to address the study's overarching aim.

Findings: In Phase 1, the findings highlighted a discrepancy between current physiotherapy practices and the foundational principles of self-management support, underscoring an essential transition towards patient-centred care. Participants generally favoured digital self-management support initiatives, advocating for their role as supplementary to in-clinic therapy rather than as replacements. TRAK-Saudi was rated highly for usability, with A-SUS scores of 77.5 by individuals with chronic knee pain and 83.3 by physiotherapists. During the navigation of TRAK-Saudi, participants initiated 53 inquiries, primarily seeking guidance and assurance. Participants also expressed strong willingness to substitute in-clinic sessions with TRAK-Saudi, reflected in median ratings of 4.5 for individuals with chronic knee pain and 5 for physiotherapists, with a mode of 5 for both type of participants.

Conclusion: Both physiotherapists and individuals with chronic knee pain demonstrated competence and openness to digital solutions. While TRAK-Saudi was user-friendly for Saudi users, current physiotherapy practices lack the clinical foundation to fully embrace digital self-management support initiatives. Significant changes in current practices are necessary to promote patient-centred care. At this stage, it is advisable for Jeddah’s physiotherapy clinics, if interested, to integrate TRAK-Saudi or similar initiatives as supplement to existing practices. This strategy aims to elevate the quality of knee care by enriching individuals’ knowledge, strengthening patient-provider relationship and improving self-management skills.

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Glossary of Abbreviations

OA	Osteoarthritis
DHIs	Digital Health Interventions
NICE	National Institute for Health and Care Excellence
RCT	Randomised Controlled Trial
WHO	World Health Organisation
TRAK	Taxonomy for the Rehabilitation of Knee Conditions
MVP	Minimum Viable Product
DETA	Digital Exercise Therapy Application
WOMAC	Western Ontario and McMaster Universities Osteoarthritis Index
KOOS	Knee injury and Osteoarthritis Outcome Score
ISO	International Organisation for Standardisation
A-SUS	The Arabic System Usability Scale
RTA	Reflexive Thematic Analysis

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Chapter One: Introduction

1.1 Introduction to the thesis

The purpose of this research is to explore digital self-management support for knee pain within current physiotherapy practices in Jeddah, Saudi Arabia. As evidenced by the dearth of published literature, self-management support for musculoskeletal conditions, regardless of the delivery method, remains a novel area within the Saudi healthcare system (Alasfour and almarwani 2022). In contrast, self-management support in digital form that offers individuals with chronic knee pain remote comprehensive support has been identified in western literature (Nelligan et al. 2019; Mrklas et al. 2020; Goff et al. 2023). Due to the cultural and societal differences between western regions and eastern regions, where Saudi Arabia is situated, and associated variations in attitudes and preferences, it is not feasible to directly apply western initiatives to Saudi individuals. Nevertheless, the insights provided by the western literature can serve as a guiding framework for the introduction process in Jeddah, Saudi Arabia.

Given the novelty of self-management support in the Saudi context, this study seeks to establish a foundation for future research by thoroughly exploring the knowledge of, skills related to and confidence in self-management among key stakeholders, primarily physiotherapists and individuals with knee pain. Adopting a pragmatic philosophical approach, this research seeks to develop a solid foundation for future investigations in this field within Saudi Arabia. By employing both qualitative and quantitative methods, various aspects related to users' perspectives on self-management and digital integration are explored.

1.2 Research problem

Statistical studies on the prevalence of chronic knee pain in Saudi Arabia reveal its substantial presence across various segments of the population, including many professions, for example, schoolteachers, faculty members and dentists, those who partake in sports, for example, runners and cyclists, and all age groups, for example, adolescents and the elderly (Alsiddiky et al. 2014; Althunyan et al. 2017; Sirajudeen et al. 2018; Mahfouz et al. 2019; Aldharman et al. 2022; Alyami et al. 2023). Often,

chronic knee pain, the causes of which are diverse, is diagnosed as being related to knee osteoarthritis (OA) (Cottrell et al. 2010; Kapural and Deering 2020). Saudi Arabia is one of the top three countries in the Middle East and North Africa in terms of prevalence of OA cases, with 6,601 cases per 100,000 people (Shamekh et al. 2022). Notably, Shamekh et al. (2022) highlight that the knee is the most frequently affected joint, accounting for over half of reported cases. Recent Saudi studies reinforce this claim, revealing prevalence rates of knee OA ranging from 18.9% to 41.5% within a population of 32 million, with increasing frequency among the elderly and those who are overweight (AlKuwaity et al. 2018; Thigah and Khan 2020; Shamekh et al. 2022; GASTAT 2022). This reported prevalence rate surpasses the global benchmark of 22.9% for individuals aged 40 and above, as determined by Cui et al. (2020) through an extensive analysis of 88 population-based studies involving over 10 million subjects.

The reasons for the high prevalence of chronic knee pain in Saudi compared to other nations are complicated and related to lifestyle and cultural factors. At the fore is the absence of a robust exercise culture within Saudi society, as highlighted by Althomali et al. (2023), and a consequential lack of physical activity amongst the Saudi population. Data collected from a systematic review of 42 studies conducted by Al-Hazzaa (2018) emphasised the inactivity among the Saudi population, with many failing to achieve the recommended 150 minutes per week of moderate-intensity physical activity that is essential for good health (WHO 2010; Lee et al. 2012). This sedentary lifestyle of Saudis is doubtless exacerbated by the extreme weather conditions in Saudi Arabia, where temperatures frequently soar to 50 degrees Celsius, deterring Saudis from engaging in physical activity.

This approach to exercise first manifests in the Saudi education system. Effective physical education programs in schools play a pivotal role in fostering lifelong physical activity habits and mitigating sedentary behaviour (Barr-Anderson et al. 2007; Mayorga-Vega et al. 2018). However, a study conducted by Alyami et al. (2023) revealed that approximately 50% of the 676 Saudi adolescents surveyed lacked access to school-based physical education, with only 11% meeting the criteria for being physically active. The lack of physical activity amongst the Saudi population has undoubtedly played a part in the surge in obesity rates (Althumiri et al. 2021). Notably,

there exists a well-established link between a high Body Mass Index and the development of chronic knee pain in Saudi individuals (Thigah and Khan 2020). To underscore this point, Alsulami et al. (2023) reported that overweight Saudi individuals constituted a significant 32% of their sample of 2,115 subjects. Finally, the traditional cross-legged sitting position commonly practiced in Saudi Arabia, often involving prolonged knee bending, has been linked to the prevalence of knee OA among Saudis (Al-Arfaj and Al-Boukai 2002).

With regard to the attitudes of those affected, a study by Aldosari et al. (2022) examined the behaviour of 473 knee OA patients in Saudi Arabia. It revealed a significant reliance on various medications, with approximately 26% to 48% of the participants resorting to these drugs to alleviate their pain. This heavy dependence on pharmaceutical interventions for knee pain management places a substantial burden on the Saudi healthcare system (Hunter and Bierma-Zeinstra 2019; Abd El-Aziz et al. 2019). The recent surge in surgical procedures for knee OA has added to this burden. There has been a 210% increase in knee replacement surgeries in Saudi over the past decade, with projections indicating an alarming 410% rise by 2040 (Sartawi 2020). This trend correlates with the increased proportion of elderly people within the population since 2014, as recent statistics have illustrated, underscoring the need for strategies aimed at reducing healthcare costs (O'Neill 2023).

In summary, chronic knee pain amongst the population of Saudi Arabia is a complex problem shaped by various factors, such as lifestyle choices, sedentary behaviour and cultural traditions. To effectively address this challenge, a holistic strategy is essential, incorporating increased public awareness regarding physical activity, lifestyle adjustments and the promotion of proactive knee pain management approaches, such as self-management support programs.

1.3 Significance of the study

The literature indicates a prevailing reliance among individuals in Saudi Arabia on pharmacological and surgical interventions as primary modalities for managing chronic knee pain, with relatively limited interest in active approaches such as physical activity (Aldosari et al. 2022). This behaviour amongst an expanding population is leading to surging demand for healthcare treatment, culminating in increased pressure

on the healthcare system, escalating expenditure and overwhelming professional workloads (Abd El-Aziz et al. 2019). This phenomenon is not unique to Saudi Arabia, as a qualitative study conducted in Australia by Teo et al. (2020) makes clear. It highlights a similar inclination among individuals with knee OA to prioritise immediate pain relief over active participation, such as engagement in physical exercises. This observation reflects the global trend amongst the population towards a dependency on healthcare interventions and highlights the necessity for healthcare professionals to emphasise the pivotal role of the individual in the management of chronic conditions (Holman 2020).

Chronic knee pain, like other chronic conditions, is linked to individual lifestyle choices, such as dietary habits and physical activity, as well as mental health (Willett et al. 2006). Consequently, clinical guidelines have increasingly highlighted the importance of integrating self-management support programs into prevailing standards of care of chronic knee pain (Kolasinski et al. 2020; Overton et al. 2022). These programs are designed to educate individuals with knee pain and equip them with essential skills so they can play an active role in controlling their condition, thus reducing their overreliance on hospital-based services (Vlaeyen and Morley 2005; Silva 2011).

The management of chronic knee pain largely involves physical exercise, a fact that may pose a notable challenge within the Saudi context, considering all the factors discussed above. However, recent updates indicate encouraging developments in this regard (Arab News 2022). Notably, Saudi Arabia's Vision 2030, a transformative national development plan introduced in 2016, prioritises the promotion of physical activity, making this a key component of its agenda (Saudi Vision 2030, 2023a). The plan sets an ambitious target of achieving a 40% participation rate in physical activities by the year of 2030 (USSBC 2020). Published surveys have revealed encouraging trends in this regard, with the prevalence of physical activity among adults in all regions of the country rising to 29.7% in 2021, representing a notable increase from the 20% recorded in 2019 (GASTAT 2022). This focus on enhancing physical activity aligns with the broader vision of improving the health and well-being of the Saudi population as part of the nation's development strategy. This positive trend aligns with the extensive array of fitness-focused facilities, events and initiatives launched to enhance the health and well-being of both Saudi nationals and residents (Saudi Sports for All

Federation 2023). The government's initiatives are strategically designed to enhance public health and well-being, featuring a multifaceted approach that includes educational facilities, community clubs, summer camps, physical activity assessments and an online teacher toolkit (Arab News 2022). Notably, technology plays a pivotal role in these endeavours, involving platforms designed to accommodate individuals of diverse fitness levels, fostering engagement in sports activities and enabling users to monitor and manage their personal health effectively (Saudi Sports for All Federation 2021).

The current landscape, marked by an increasing inclination towards physical activity in the country that aligns with the objectives of Saudi Vision 2030, suggests the appropriateness of incorporating self-management programs for chronic knee pain (Saudi Vision 2030, 2023a). It is possible that individuals in Saudi Arabia suffering from chronic knee pain may be more receptive to self-management programs than they would have been previously. Such programs have the potential to raise awareness among these individuals regarding their conditions, empowering them to take control of their health and well-being and to seek professional assistance only when truly necessary, thereby reducing the likelihood of unnecessary hospital visits (Huber et al. 2011; Barker et al. 2018). This approach aligns seamlessly with the broader objectives of promoting a healthier and more informed Saudi society as envisioned by the government's initiatives.

1.4 Structure of thesis

This Ph.D. thesis unfolds across eight chapters:

Chapter 1 (Current) lays the foundation for this research by elucidating the research problem it seeks to address and its broader significance within the target context. It sets the scene for the reader for what follows.

Chapter 2 includes a comprehensive literature review that builds a robust knowledge base. It reviews and discusses relevant published literature to identify gaps in the existing knowledge and pinpoints specific areas of interest for further exploration.

Chapter 3 is dedicated to the philosophical underpinnings guiding the research methodology. It also provides information on the selected research design and its consequential phases.

Chapter 4 provides an in-depth account of Phase 1 of this research (qualitative study). It contains information on the methods employed, the findings obtained, an in-depth discussion of key findings. It additionally presents clinical implications and study limitations and a conclusion for the phase.

Chapter 5 details the adaptation of an existing digital self-management support intervention **TRAK** to be the Saudi specific **TRAK-Saudi** platform.

Chapter 6 shifts the focus to Phase 2 of this research (quantitative usability study). It outlines the methods employed and the results then provides a discussion of the key results. It also outlines clinical implications and study limitations and a conclusion for the phase.

Chapter 7 discusses findings from the two phases of research, offering insights for researchers interested in TRAK-Saudi and similar initiatives for knee pain, and laying groundwork for future research recommendations.

Chapter 8, the final chapter, presents the overall conclusions derived from this research.

Chapter Two: Literature Review

2.1 Introduction to the chapter

This chapter aims to provide a comprehensive review of the existing literature on chronic knee pain and self-management support, with a specific focus on the Saudi population. Initially, in section **2.2**, the search strategy employed in this study to identify relevant literature is outlined. Subsequently, in section **2.3**, the chapter proceeds to provide background information on chronic knee pain, covering its biopsychosocial dimensions, epidemiological prevalence and burden while spotlighting strategies advocated in clinical guidelines to mitigate its impact. Then, in section **2.4**, the narrative progresses to explore the literature concerning self-management support. It starts by decoding key terms and concepts, reviewing behavioural theories commonly underpinning self-management support programs and outlining strategies that healthcare providers use in their practice in an attempt to support self-management. In section **2.5**, the chapter transitions to a critical examination of empirical studies that have focused on digital self-management support for chronic knee pain, inspecting various dimensions that include key considerations in development processes, user engagement and clinical effectiveness. Lastly, in section **2.6**, the focus shifts to the Saudi literature on self-management support, specifically concerning physiotherapists' perceptions, patient engagement and current technological advancements to support self-management.

This thorough literature review seeks to identify gaps in the existing body of research that warrant further exploration. The synthesis of the reviewed studies concludes by pinpointing a research evidence gap, suggesting the research aim and questions. By highlighting the gaps in existing knowledge, the chapter sets the stage for the subsequent chapters, which aim to address these gaps and contribute to advancing the field of self-management support for chronic knee pain within the Saudi context.

2.2 Literature search strategy

While a scoping review can effectively map existing literature, the multifaceted nature of the research topic necessitated a more flexible and interpretive approach, leading to the choice of a narrative review methodology (Collins and Fauser 2005; Ferrari

2015; Greenhalgh et al. 2018). The explorative study required not only the identification of existing self-management support interventions but also a critical analysis of their effectiveness, exploration of theoretical underpinnings, and consideration of cultural and contextual factors. The narrative review format allowed for the synthesis of diverse sources, including emerging technologies and concepts in the rapidly evolving field of digital health, and facilitated the drawing of conclusions that go beyond simply cataloguing existing research (Ferrari 2015). This approach was crucial for addressing the specific research questions and informing the subsequent phases of the study. The flexibility of a narrative review enabled the presentation of a more holistic understanding of the field, incorporating insights from related areas where direct evidence in this specific context might be limited, thus providing a robust foundation for innovative research in the Saudi Arabian healthcare context.

In this narrative review, relevant studies were found by searching for specific keywords that reflect the project's goal. The key words selected for this purpose relate to digital interventions and/or toolkits that support self-management in individuals with chronic knee pain. Cardiff University's Libraries, CINAHL, MEDLINE via Ovid, EBSCOhost, PubMed and Scopus were among the databases searched. In addition to these databases, the reference list of all the examined publications and systematic reviews were searched for further relevant material. Additionally, grey literature, including theses, blogs, online newspapers and governmental reports were searched for relevant unpublished data in major databases to validate claims made in this project when needed.

The literature search utilised four key concepts: "context", "type of care", "mode of delivery" and "condition". In the first concept, "**context**", the keywords employed were "Saudi*", "Saudi Arabia", "physio*" and "physical therapy". The second concept, "**type of care**", encompassed terms like "self-management", "self-care", "self*", "exercis*" and "behavi*". Concept three, which focused on the "**mode of delivery" for** self-management programs, utilised keywords such as "digital", "online", "on-line", "web*", "web-based", "Internet", "Internet-based", "computer*", "ehealth", "e-health", "mhealth", "m-health", "mobile health", "application*" and "telehealth". The fourth concept, "**condition**", included terms like "chronic knee*", "knee pain", "knee

condition*", "knee osteoarthritis", "osteoarthritis", "OA", "arthritis", "chronic pain", "musculoskeletal pain", "musculoskeletal condition*" and "joint pain". To refine the search results and pinpoint more relevant research, these keywords were used individually or combined with Boolean operators (AND, OR, NOT) using the advanced search feature on the chosen databases (Aromataris and Riitano 2014).

To ensure that articles were relevant to the scope of this project, specific inclusion and exclusion criteria were applied, with a focus on self-management support digital health interventions (DHIs) for chronic knee pain management. Articles containing protocols were excluded, but all other study designs were considered, encompassing aspects such as user feedback, initial development, usability testing and effectiveness in alleviating pain and symptoms. The selected population for these studies consisted of individuals aged 18 and above experiencing chronic knee pain. Interventions that were designed to address body joints other than the knee were excluded as they might not adequately illustrate the needs and satisfaction of participants experiencing knee pain specifically. Given the project's emphasis on digital self-management support, the search was refined to include only web-based platforms, websites and applications that prominently featured education and exercise components. This approach aligns with international guidelines from authoritative sources such as the National Institute for Health and Care Excellence (NICE), the American College of Rheumatology/Arthritis Foundation in 2019 and the Osteoarthritis Research Society International, all of which recommend education and exercise as fundamental elements of self-management support programs for chronic knee pain (Bannuru et al. 2019; Kolasinski et al. 2020; NICE 2022). No specific restrictions were placed on geographical region or time range, allowing the identification of best practice and innovative approaches that have emerged in various regions and at different time periods. However, it was decided to only include studies that were written in the English language. This decision was reasonable given the common practice of publishing Saudi literature in English, thus adhering to global publishing standards and promoting broader dissemination of research findings (Aloudah 2022).

Following an initial selection, the titles and abstracts of these publications were examined for final eligibility. A total of 24 studies were included as they best describe the areas of interest in this project. The included studies were evaluated critically using

the Critical Appraisal Skills Programme checklist (2018) for Randomised Controlled Trial (RCT) and qualitative studies to establish relevance, significance and limitations (Appendix A).

2.3 Chronic knee pain

2.3.1 Setting the scene for the section

Chronic knee pain, characterised as pain persisting for more than three months, is a prevalent health issue with various underlying causes (Nicholas et al. 2019; Hunter et al. 2022). Among these causes, OA is the most common, particularly amongst older adults (Murphy et al. 2016; Cisternas et al. 2020). However, it is important to recognise that the cause of chronic knee pain is not limited to OA and that it can be the result of patellofemoral pain syndrome, iliotibial band syndrome, tendinopathy, structural deformities and complications following knee surgery (Schwartz et al. 2015; Crossley et al. 2016; Fox et al. 2018). However, most of the literature discussed in this literature review pertains to knee OA as it is the most common cause of chronic knee pain.

2.3.2 The biopsychosocial dimensions of chronic knee pain

The concept of chronic pain has developed over the years, moving beyond the biomedical model, which focuses solely on pathological causes and a patient-reported symptom (Meints and Edwards 2018). It now embraces a biopsychosocial model that considers not only pathological factors but also biological, psychological, social and behavioural aspects that can trigger and influence a patient's experience of pain (Loeser and Black 1975; Fordyce 1976; Engel 1977; Loeser 1997; Loeser 2000). Pain is usually initiated by pathological stimuli, such as an increased inflammatory state and tissue damage (Cohen et al. 2021; Bonanni et al. 2022). However, diverse biopsychosocial factors unique to each individual primarily influence the variability in outcome and the transition from acute to chronic pain (Pincus et al. 2008; Nicholas et al. 2011; Bergbom et al. 2012; Noyman-Veksler et al. 2017).

In the knee joint, pain is commonly a response to pathological stimuli, such as degeneration, injury, infection or inflammation (Treede et al. 2019). Bonanni et al. (2022) elaborate on this in their discussion of the musculoskeletal pain cycle, noting

that these stimuli lead to the release of chemical mediators that are responsible for pain perception. Following this, neuropeptides, such as Calcitonin Gene-Related Peptide, Substance and Vasoactive Intestinal Peptide, are released. These neuropeptides have strong vasodilatory effects, facilitating the immigration of immune cells to the affected area. In pathological situations, this chain of events tends to perpetuate itself, forming a self-sustaining cycle that continuously provokes prolonged nociceptive stimulation, a process depicted in Figure 1. The presence of triggering factors significantly intensifies this continuous stimulation, a point underscored by researchers such as Tick (2015), Edwards et al. (2016), Meints and Edwards (2018) and Samoborec et al. (2018). These triggers include biological elements such as genetics, age, sex, sleep patterns and hormonal imbalances; psychological conditions, including depression, anxiety, post-traumatic stress and poor coping mechanisms; sociocultural influences, such as low education, cultural norms and inadequate social support; along with behavioural aspects, notably unhealthy dietary habits, smoking and a sedentary lifestyle (Tick 2015; Edwards et al. 2017; Meints and Edwards 2018; Samoborec et al. 2018).

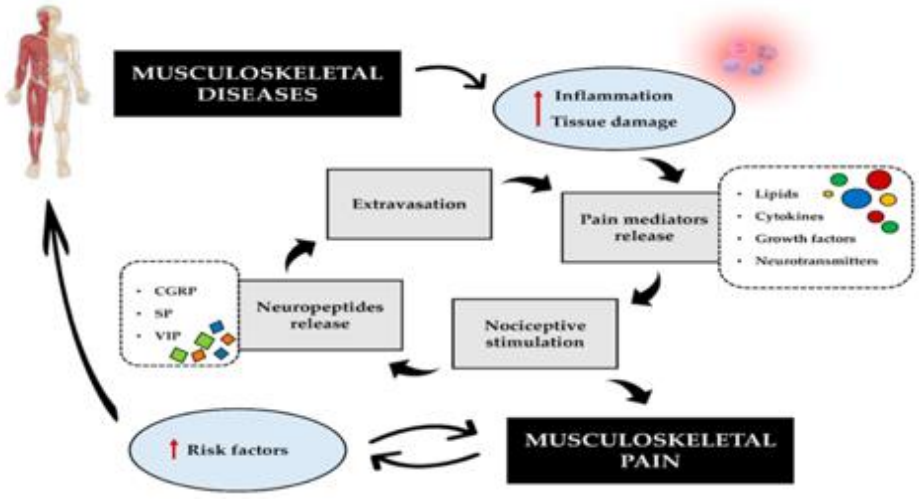

Figure 1: Musculoskeletal pain cycle.
Source: Bonanni et al. (2022)

In knee pain, the above-mentioned triggers have been found to increase the likelihood of chronicity (Dissing et al. 2017; Holden et al. 2021). In their prospective study of 504 Danish adolescents over a five-year period, Rathleff et al. (2019) found that one in every two adolescents who initially experienced knee pain continued to suffer from

persistent and severe knee pain into adulthood. The severity of this pain was not merely symptomatic but affected overall health, dictated health-related behaviours and even influenced career choices (Rathleff et al. 2019). The elevated risk of chronicity in knee pain is undoubtedly due to a complex interplay of factors, including genetic predispositions, environmental influences and occupational risks (Mills et al. 2019). However, it can also be partially attributed to the psychological and behavioural responses it provokes. These responses potentially include episodes of anxiety and depression, contributing to a more sedentary lifestyle, as highlighted by Bonanni et al. (2022), a reduction in physical activity, as seen in Rathleff et al.'s (2018) study and/or the development of kinesiophobia, which is a heightened fear of movement and potential falls, commonly observed in individuals with musculoskeletal pain, as described by Stubbs et al. (2014). Crucially, this reduction in physical activity, while initially a protective response, can result in an unfavourable cycle of decreased muscle strength and conditioning, potentially leading to an increased body mass index. From a biomechanical point, muscle weakness negatively impacts joint stability, reducing shock absorption and efficient joint load distribution, which in turn increases stress on the joint surfaces, accelerating joint degeneration (Segal and Glass 2011). Physiologically, research has also found that body fat releases inflammatory mediators like cytokines and adipokines that further contribute to joint damage, accelerating onset of knee OA early in life (Berenbaum 2012; Cicuttini and Wluka 2016; Ackerman et al. 2017).

2.3.3 Epidemiological insights into chronic knee pain prevalence

Chronic knee pain and/or knee OA is a global issue with varying distribution across continents, as highlighted by Cui et al. (2020) (refer to Figure 2). Knee OA is estimated to affect 16% of individuals aged 15 and above globally, with an incidence rate of 203 cases per 10,000 persons in those aged 20 and above (Cui et al. 2020). The past two decades have seen a significant increase in knee OA cases, totalling 365 million worldwide, attributed to factors such as population growth, an aging demographic and an obesity epidemic (Cross et al. 2014; O'Neill et al. 2018; Cieza et al. 2020; Long et al. 2022; Hunter et al. 2022; Yang et al. 2023). Cui et al. (2020) found a moderate occurrence of knee OA in developed regions like Europe and North America, with

prevalence rates ranging from 10% to 19%, and a higher presence among populations in Asia and Africa, with prevalence rates ranging from 20% to 24% (Cui et al. 2020).

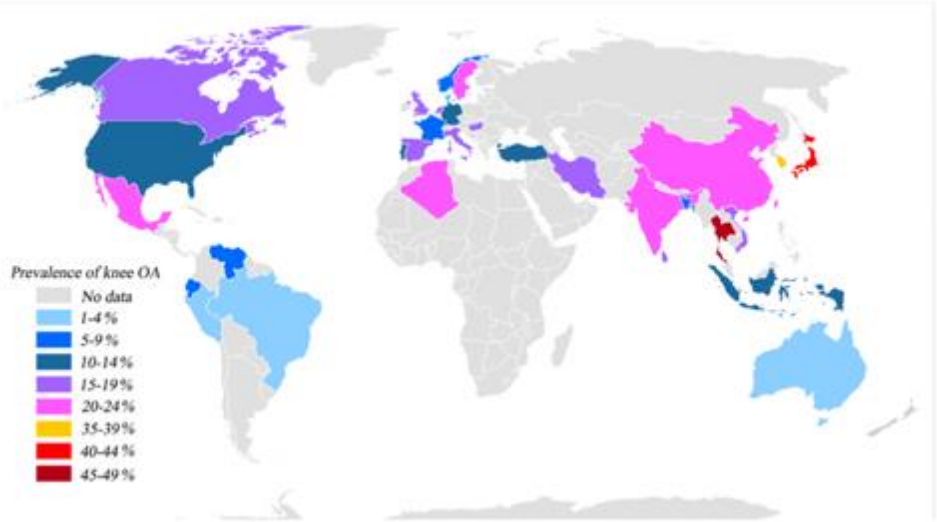

Figure 2: Global distribution of the prevalence of knee OA.
Source: Cui et al. (2020)

It is noteworthy that most of the data in the existing literature emanates from research conducted in the Americas, Europe and East Asia, as depicted in Figure 2 above (Cross et al. 2014; Chia et al. 2016; Cui et al. 2020; Ginnerup-Nielsen et al. 2021). This concentration underscores the extensive research investment in these regions, as emphasised by Fontelo and Liu (2018). However, a different scenario emerges in Africa and West Asia, where national data on chronic knee pain prevalence is notably limited (Chia et al. 2016; Cui et al. 2020; Alenazi et al. 2021). Alenazi et al. (2021) recently attempted to bridge this gap by generating evidence on knee OA prevalence in the Gulf Cooperation Council countries of West Asia, of which Saudi Arabia is a member. While their data made a valuable addition to the data available in the literature, the authors pointed out some limitations in the analysed papers, including outdated information, which may restrict the generalisability of the results to the region and the present time (Alenazi et al. 2021).

Published data marked disparities in chronic knee pain prevalence across continents, as elucidated by Cui et al. (2020). This underscores the intricate interplay between ethnicity, access to healthcare services, occupational influences and cultural practices

concerning knee pain development and its potential progression towards chronicity (Zhang and Jordan 2010). Ethnicity/race has garnered considerable attention in the academic discourse, with numerous research studies investigating the prevalence rates of knee OA among diverse ethnic groups (Jordan et al. 2009; Deshpande et al. 2016; Mat et al. 2019). For example, Callahan et al. (2021) conducted a comprehensive review of knee OA epidemiology among Americans from different ethnic backgrounds. Their work highlights the impact of interethnic variations in body structure and alignment on knee OA development, pain intensity and functional performance. Notably, Chang et al. (2010) revealed that African Americans are more prone to presenting with valgus thrust during walking when compared to their white American counterparts, thereby increasing their susceptibility to lateral knee OA. Furthermore, investigations into young immigrants from the Middle East and Africa have unveiled a notable prevalence of vitamin D deficiency within these ethnic groups. This deficiency has been linked to muscle weakness in the lower extremities, a factor that may explain the early onset of radiographic knee OA within these populations (Aucoin et al. 2013; Ramnemark et al. 2015; Granlund et al. 2016; Granlund et al. 2018).

The findings presented by Cui et al. (2020) raise questions regarding variations in the quality of healthcare systems across continents and their innovative approaches to managing knee pain, which may contribute to differences in chronicity rates. Lying at the top of the World Index of Healthcare Innovation, countries like the United States, Switzerland, Netherlands and Germany have established themselves as leaders in advanced healthcare systems (Girvan and Roy 2020). These nations have distinguished themselves by their unwavering commitment to sustainable cost structures, the utilisation of cutting-edge therapies, the provision of personalised care through innovative cures and vaccine development (Girvan and Roy 2020). These efforts extend beyond the realm of public health and act as catalysts for economic growth, facilitating the allocation of resources for healthcare expenditures (Girvan and Roy 2020). However, the situation is vastly different in low-income countries, predominantly located in Asia and Africa, where substantial population growth rates and high poverty levels are prevalent (United Nations 2022; World Bank 2023). In these nations, healthcare systems face immense pressure to provide essential healthcare services to their populations, often under resource constraints (WHO

2017). This environment increases the likelihood of inaccurate diagnoses and a deviation from clinical guidelines, which are predominantly established by leading countries worldwide (WHO 2018).

Whilst the quality of healthcare systems may have an impact on rates of chronic knee pain, it can be further assumed that Asia's elevated rates of knee OA may be caused by the prevalence of physically demanding occupations. This notably include agriculture and construction, which may entail heavy lifting and repetitive stress on the knee joint. The recent blog by Ryu (2023) highlights that Asia has one of the highest concentrations of agricultural workers globally. China and India, in particular, stand out with roughly 200 million agricultural labourers each, and these workers constitute a significant portion of their total workforce, ranging from 25% to 43% (Ryu 2023). Wang and colleagues' (2020) study confirms this claim. Their analysis, which involves 71 studies, provides robust evidence that occupations like agriculture substantially elevate the risk of developing chronic knee pain by as much as 52% (Wang et al. 2020). This underscores the substantial burden chronic knee pain places on economies, healthcare systems and individuals in developing countries, as indicated by Yang et al. (2023).

Lastly, cultural and religious practices in Asia that require prolonged knee bending or squatting positions have been cited as contributing factors to elevated rates of chronic knee pain (Cui et al. 2020). These postures are not only deeply embedded in daily cultural routines but are also integral to religious observances, where positions of prostration and kneeling during prayers demand extended knee flexion (Pattayakorn et al. 2010; Danes-Daetz et al. 2024). This increases the likelihood of individuals developing chronic knee pain, a phenomenon observed in Saudi populations with the tradition of sitting cross-legged, as previously highlighted in Chapter 1 (Al-Arfaj and Al-Boukai 2002; Palmer 2012). However, recent evidence suggests a more balanced perspective is needed. While prolonged kneeling and similar activities can contribute to knee pain under certain conditions, they also have the potential to improve joint health by increasing range of motion and preserving articular surfaces (Chamsi-Pasha and Chamsi-Pasha 2021). This approach shifts the focus from seeing these practices solely as contributors to chronic knee pain to understanding them as integral aspects of daily life that might offer protective benefits when done in moderation and with

proper technique (Dahaghin et al. 2009). By adopting this view, developers can better appreciate these activities' role within the cultural context and develop more culturally sensitive interventions that respect these traditions while addressing the population's health needs.

2.3.4 Burden of chronic knee pain

Knee OA, a common cause of chronic knee pain, has become the 10th most significant contributor to the number of years people live with disabilities worldwide, leading to significant personal, societal and economic burden (Palazzo et al. 2016; Kyu et al. 2018; WHO 2023). Musculoskeletal conditions, including knee-related ones, directly impact the subject's ability to physically function without pain and limit joint movement, affecting daily life activities and job-related tasks (Nakamura et al. 2011; Woolf et al. 2012; Harden et al. 2013). As the population ages and lifestyles become more sedentary, factors closely associated with the risk of knee OA, the world could be on a trajectory toward a potentially alarming surge in chronic knee pain cases (Ginnerup-Nielsen et al. 2021).

In terms of the societal and personal impact of chronic knee pain, it is a formidable contributor to absenteeism, with individuals being compelled to miss workdays due to unbearable pain, a phenomenon extensively documented in the literature (Agaliotis et al. 2014; Fransen et al. 2015; El-Tallawy et al. 2021). In more severe instances, this unbearable pain may lead to job loss as individuals find themselves unable to meet the demands and requirements of their jobs' leading to diminished productivity (Laires et al. 2018). The gravity of this issue is highlighted by the longitudinal study carried out by Agaliotis et al. (2013), which involved a cohort of 360 Australians with chronic knee pain. Their findings indicate that 79% of these individuals, equivalent to 283 subjects, reported a significant reduction in productivity while at work, highlighting the profound societal impact of this condition (Agaliotis et al. 2013). The situation in developing countries, where a substantial portion of the labour force is engaged in physically demanding occupations, is worse and has been linked with shortened working lives (Litchfield et al. 2016; Pedersen et al. 2020). The consequences of job loss can be dire for populations already burdened with high poverty rates (World Bank 2023). Financial problems stemming from unemployment can have a cascading effect,

leading to reduced access to essential treatments, altering living conditions and negatively affecting mental well-being (Modrek et al. 2013; Frasquilho et al. 2015; Margerison-Zilko et al. 2016). The additional financial burden of treatment costs and job loss only serves to worsen an already distressing scenario, and depression, a well-documented consequence of chronic knee pain, may set in (Tsuji et al. 2019).

Additionally, when examining chronic knee pain from an economic perspective, a complex network of financial consequences becomes apparent, affecting individuals, healthcare insurers and entire countries (Gupta et al. 2005; Xie et al. 2008; Salaru et al. 2014; Hunter et al. 2014; Leifer et al. 2022). In countries where healthcare services are funded through taxation, like the United Kingdom, or predominantly rely on private systems, as seen in the United States, the financial burden falls squarely on individuals or health insurers (Sussex et al. 2019; Tikkanen and Abrams 2020). This financial strain only amplifies as the severity of knee pain intensifies, leading to an increased demand for treatments, as clarified by Jackson et al. (2020). For those with chronic knee pain, the quest for relief encompasses a spectrum of treatment modalities, ultimately culminating in knee arthroplasty, an expensive facet of knee OA management (Bozic et al. 2012; Cohen et al. 2016). In the United States, for instance, the lifelong expenditure on nonoperative treatments has been estimated to be between $12,400 to $16,000 per individual, consuming approximately 53.37% of the annual income of low-income Americans (Losina et al. 2015; Kochhar and Sechopoulos 2022). Conversely, in countries where public healthcare services are universally available, like Saudi Arabia, there is a tendency to overuse the healthcare available. This excessive utilisation of medical services, apparent within the domain of musculoskeletal healthcare, may provide no obvious benefits and, on occasion, may even cause harm (Elshaug et al. 2017; Traeger et al. 2017). Zadro et al. (2020) explore the main factors driving healthcare overuse, shedding light on the direct influence of payment models on this issue. The accessibility of cost-free healthcare services can unintentionally lead to a scenario wherein individuals consult numerous physicians and seek duplicative or unnecessary treatments and medications (Zieff et al. 2020).

The global burden of chronic knee pain has received increasing attention from healthcare researchers who are actively looking for ways to alleviate the strain on healthcare systems and the individuals affected. One noteworthy development in this

regard is the treatment strategies recommended by practical clinical guidelines (Bruyère et al. 2019; Bannuru et al. 2019). These guidelines emphasise the importance of multimodal interventions for managing chronic knee pain, with recommendations for conservative treatments outnumbering pharmacological options (Bruyère et al. 2019; Bannuru et al. 2019; Kolasinski et al. 2020; Overton et al. 2022). Conservative treatments, which include exercise, patient education, self-management and weight management, play a central role in modifying lifestyles to enhance quality of life while minimising medication use (Kloppenburg and Berenbaum 2020). They also aim to slow down the progression to joint replacement surgery, which does not always guarantee improvement (Waimann et al. 2014; Wylde et al. 2018; Kolasinski et al. 2020; Arden et al. 2020). In a report published by the National Institute for Health and Care Research, drawn from a comprehensive analysis of over 30 physiotherapy-related research studies, there is a strong endorsement of high-quality, personalised physiotherapy-led rehabilitation (NIHR 2018). This approach has the potential to reduce the need for additional medical investigations, resulting in cost savings and improved outcomes in terms of symptom management and work productivity for individuals with chronic knee pain (NIHR 2018).

Exercise has emerged as a cornerstone in the conservative management of chronic knee pain, with a wealth of evidence underscoring its effectiveness (Bruyère et al. 2019; Bannuru et al. 2019). Beyond its standalone benefits, incorporating exercise into comprehensive self-management programs has shown even greater promise (Kolasinski et al. 2020). These holistic programs, which blend patient education, targeted exercise regimens and lifestyle adjustments, have demonstrated notable improvements in symptom relief, enhanced physical function, reduced dependency on medications and decreased absenteeism due to illness, all while maintaining a low risk profile (Skou and Roos 2017; Kolasinski et al. 2020). The strategic integration of self-management support into healthcare delivery not only empowers individuals to take control of their condition but also signifies a pivotal shift towards sustainable healthcare practices, easing the current burdensome reliance on medical interventions (Dineen-Griffin et al. 2019).

2.3.5 Lessons learned from the reviewed literature in this section

It can be inferred from the literature above that chronic knee pain is a dynamic condition resulting from a complex interplay of biopsychosocial factors. This realisation necessitates a paradigm shift towards interdisciplinary treatment strategies that embrace personalised care and promote the sharing of decision-making between affected individuals and healthcare providers. Such strategies, as highlighted by researchers like Gatchel et al. (2014) and Cohen et al. (2021), are critical for addressing the unique manifestations of knee pain in each individual, particularly given the condition's tendency towards chronicity. The early identification of individuals at high risk, as advocated by Holden et al. (2021), is critical in order to apply timely, multimodal treatment plans.

Furthermore, the literature reveals that chronic knee pain is globally prevalent, with significant regional variations, and can be attributed to factors such as ethnicity, healthcare access, occupational habits and cultural and religious practices. This variation is underscored by the research findings of Cui et al. (2020), which point to extensive studies in the Americas, Europe, and East Asia but a notable scarcity of data from Africa and West Asia, indicating a critical gap in understanding chronic knee pain on a global scale. The contrast between advanced healthcare systems in some regions and resource-limited settings in others further complicates the management and burden of the condition worldwide, calling for the development of management approaches that are not only culturally sensitive but also tailored to the specific needs and resources of different regions.

Finally, the issue of chronic knee pain, especially resulting from OA, is identified as a significant contributor to disability that impacts personal well-being and economic stability (Palazzo et al. 2016; Kyu et al. 2018; WHO 2023). The expected increase in the incidence of chronic knee pain, driven by sedentary lifestyles and an aging population, is likely to place additional strain on healthcare systems globally (Ginnerup-Nielsen et al. 2021). Addressing this challenge effectively demands a comprehensive strategy that prioritises conservative management techniques, such as exercise and patient education, over reliance on pharmacological interventions or surgical procedures. Such an approach aims to improve symptom control, enhance work productivity and elevate overall quality of life, thereby addressing the personal and societal challenges posed by the condition (Dineen-Griffin et al. 2019).

2.4 Self-management support

2.4.1 Setting the scene for the section

Health, as first defined by the World Health Organisation (WHO), signifies a condition of complete physical, mental and social well-being, extending beyond the mere absence of disease or infirmity (WHO 1984). Changes have been made to the earlier definition to make it more dynamic by defining health as “the ability to adapt to one's environment” (Koplan et al. 2009). However, as per this modified definition, individuals with chronic conditions are seen as definitively ill, which has been viewed as a counterproductive. Huber et al. (2011) argue that WHO’s definition ignores the human ability to overcome life's physical, mental and social challenges and live a life of fulfilment and well-being despite a chronic disease or disability. For this reason, the concept of health has been expanded to include self-management, proposing that health is "the ability to adapt and self-manage in the face of social, physical, and emotional challenges" (Huber et al. 2011). This shift reflects changing demographic and epidemiological trends, particularly the rise in chronic diseases and multimorbidity (Fortin et al. 2010; Van de Velde et al. 2019; Chowdhury et al. 2023). Consequently, the management of chronic illness is moving away from the traditional biomedical model, in which the patient is a passive receiver of care, towards a model that centres on self-management support, with individuals actively participating in their care alongside healthcare providers (Holman and Lorig 2000; Bodenheimer et al. 2002; Grady and Gough 2014).

2.4.2 Decoding healthcare self-management: key terms and concepts

A concept is a word or phrase that represents an idea or phenomenon in an abstract manner, giving it a distinct identity or significance (Burns and Grove 2009). In the context of self-management programs, the focal motivational construct is the individual, referred to as the "self" (Omisakin and Ncama 2011). Rogers (1959) defines the self as “the organised, consistent, conceptual entity composed of perceptions of the characteristics of “I” or “me” and the perception of the relationships of the “I” or “me” to others and to various aspects of life, together with the value attached to these perceptions”. The self is shaped through interactions with others and involves

awareness of being and functioning (Omisakin and Ncama 2011). Since the early 1990s, many terms have been used interchangeably in the literature to refer to self-management practices (Bentzen et al. 1989; Dean 1989; Jones et al. 2011). These include self-care, self-management and self-management support. Each term will be detailed consecutively to highlight their differences and specify which concepts are being adopted in this research.

Self-care, as defined by the Self Care Forum (2020) is “the actions that individuals take for themselves, on behalf of and with others in order to develop, protect, maintain and improve their health, wellbeing or wellness”. Healthy individuals actively engage in different self-care behaviours, spanning from physical exercise to psychological therapy, to improve their physical and mental health and reduce the risk of illness (Richard and Shea 2011; Matarese et al. 2018; Martínez et al. 2021). Researchers who have explored the concept of self-care in their studies have concurred that self-care is an old practice that is deeply ingrained in human behaviour and precedes the founding of formal healthcare systems, the aim of which is to maintain well-being and manage acute conditions (McCormack 2003; Martínez et al. 2021). It is a practice that is built upon the knowledge individuals acquire from different sources available to them that enables them to gain the skills to effectively maintain their personal wellbeing (Narasimhan et al. 2019). Interestingly, the prominence of self-care practices has fluctuated over time. At points in history, self-care took a back seat as advanced healthcare practices and technology seemed to offer comprehensive solutions, particularly for acute conditions (Saunders 1994). However, in the latter part of the 20th century, a shift occurred in disease patterns from acute to chronic and prompted a renewed emphasis on self-care behaviour, with individuals being encouraged to behave in a way that helped them to remain healthy (Romeder 1999; McCormack 2003; Wilkinson and Whitehead 2008; Richard and Shea 2011; Banerjee et al. 2020).

Self-care and self-management, although sometimes used interchangeably, are interconnected yet distinct (Grady and Gough 2014). Both pertain to the key role individuals play in actively enhancing and/or restoring their health through adopting helpful behaviours. However, self-management, in particular, is a more specialised term, primarily addressing the complex domain of chronic disease management (Lorig and Holman 2003; Van de Velde et al. 2019). As defined by Van de Velde et al. (2019,

p. 10), “Self-management is the intrinsically controlled ability of an active, responsible, informed and autonomous individual to live with the medical, role and emotional consequences of their chronic condition(s) in partnership with their social network and the healthcare provider(s)”. As per the definition of Van de Velde et al. (2019), individuals living with chronic conditions need to be self-efficacious to make daily choices regarding the management of their long-term condition. This primarily involves changing unhealthy behaviours that affect their quality of life into healthier ones. (Zhao et al. 2019). The self-efficacy (confidence) to make such changes can be gained through continuous condition-specific education, knowledge of oneself (referred to as self-awareness), partnership with healthcare professionals and the support of social networks.

For individuals with chronic conditions to effectively self-manage for a lifetime, varying levels of support, whether from healthcare professionals, family and/or peers, may be needed at different points in time (Wilkinson and Whitehead 2009; Silva 2011; Boger et al. 2015). Self-management support is a popular healthcare practice nowadays which has been defined by the Institute of Medicine (2003, p. 57), as “the systematic provision of education and supportive interventions by healthcare staff to increase patients' skills and confidence in managing their health problems, including regular assessment of progress and problems, goal setting, and problem-solving support”. In this process, healthcare professionals collaborate with patients to communicate knowledge and clinical experiences, identify personal struggles, find suitable solutions, recommend effective managing behaviours and set short and long-term goals to effectively manage the condition (Silva 2011). Self-management support extends beyond healthcare professionals to include family/friends living close to the individual and peers who have the same condition (Grady and Gough 2014). Family and close friends can form an emotional support system and help with tasks like medication management. Peer support extends beyond clinical treatment and into daily life, offering non-clinical, lived experience-based strategies, which could also be tailored to the unique cultural context of the group (NHS 2023).

In this thesis, the focus will primarily be on the term "self-management support" to describe the role of healthcare providers in this supportive journey. The term "self-management" will also be used, albeit to a lesser degree, when exploring strategies

that individuals with knee pain adopt for their own care. Table 1 summarises the three terms.

Term	Definition	Who it applies to	Purpose	When to apply	External support
Self-care	The actions that individuals take for themselves, on behalf of and with others in order to develop, protect, maintain and improve their health, wellbeing or wellness.	Individuals, families and communities.	To maintain physical, mental, and emotional health, prevent illness or manage an acute illness.	Anytime/when having an acute injury and/or illness.	May or may not be needed.
Self-management	The intrinsically controlled ability of an active, responsible, informed and autonomous individual to live with the medical and emotional consequences of his/her chronic condition(s) in partnership with his/her social network and the healthcare provider(s).	Individuals with a chronic health condition.	To reduce the burden of chronic illnesses. To cope with the physical, social and mental consequences of chronic illnesses.	Long-term, chronic health conditions.	May or may not be needed.
Self-management Support	The systematic provision of education and supportive interventions by healthcare staff to increase patients' skills and confidence in managing their health problems, including regular assessment of progress and problems, goal setting and problem-solving support.	Healthcare professionals, community health workers, peers, family and caregivers.	To provide people with the information and skills that enhance their ability to manage their chronic health condition.	Long-term, chronic health conditions.	May be needed to develop skills and knowledge of support strategies.

Table 1: Self-care, self-management and self-management support.

2.4.3 Behavioural theories underpinning healthcare self-management support

According to Davis et al. (2015), a theory is a collection of concepts or principles designed to explain or predict a specific phenomenon or behaviour. Consequently, the integration of theories on behaviour into the development phase of a program has consistently been promoted within the self-management literature (Bos-Touwen et al. 2015; Araújo-Soares et al. 2019; Henriques and de Sousa Loura 2023). These types of theories are formulated to either explain an individual's behaviour in the context of change (why, when and how a behaviour does or does not occur) or help to select strategies most able to facilitate change within a given context and timeframe (Michie et al. 2018). Hayden (2022) states that healthcare providers can better understand the circumstances that contribute to individuals either accepting and adopting new healthy behaviours or resisting them by employing theories on behaviour. In the context of self-management support, the most cited theories of behaviour are social cognitive theory, theory of planned behaviour, self-determination theory, self-regulation theory and the transtheoretical model (Henriques and de Sousa Loura 2023). The following paragraphs discuss each one of these theories to explain their key concepts, focus and application in self-management support programs.

Social cognitive theory was first developed by Bandura (1999) and has emerged in the literature as the most suitable model for understanding health-related behaviours in individuals with chronic conditions (Bandura 2009; Wattanakul 2012; Obirikorang et al. 2022). Bandura's earlier social learning theory posits that observational learning, a process whereby individuals absorb behaviour by observing a model and retaining, imitating and being motivated by the observed actions, is crucial in shaping one's behaviour (Bandura and Walters 1963; Bandura 1977). Social cognitive theory, as articulated by Glanz (2001), is the cognitive formulation of social learning theory, cognitive processes having been added to the equation. Bandura hypothesised that an individual cognitively processes information from the environment and determines their own behavioural responses to it. In the context of self-management support, this theory focuses on encouraging health behaviours by altering cognitive processes and increasing an individual's belief in their ability to accomplish a task (self-efficacy) (Bandura 1999; Smith et al. 2022). The key constructs of social cognitive theory are observational learning, self-efficacy and reinforcement (Glanz 1997). Each construct

is explained in Table 2 below with its corresponding strategies in self-management support programs that are believed to promote behaviour change, as found in the literature.

Key concept	Description	Related strategies to facilitate behaviour change
Observational learning	People learn by directly observing the experiences of others and imitate them.	Peer support Group-based programs
Self-efficacy	A person's confidence in their own ability to successfully perform a behaviour.	Goal setting Skill mastery via practice Receiving feedback Self-monitoring Problem-solving Rewards
Reinforcement	Positive reinforcement can increase the likelihood of a behaviour being repeated.	

Table 2: Key concepts of social cognitive theory and related strategies. Sources: Schunk and Pajares (2010), Jang and Yoo (2012), Tougas et al. (2015) and LaMorte (2022a).

According to social cognitive theory, enhancing an individual's self-efficacy, their belief in their own ability to perform necessary behaviours for effective condition management, can be achieved by integrating a range of strategies into the framework of self-management support programs. These strategies encompass goal setting, which directs efforts to make planned changes; self-monitoring, which fosters self-awareness and vicarious learning through observation; self-reinforcement, whereby the attainment of goals reinforces and strengthens self-efficacy through the mastery of experiences; problem-solving, which involves critically examining challenges and identifying effective solutions; social support, which provides encouragement and assistance in adopting and maintaining desired behaviours; and managing emotional states, aiming to address fears and misconceptions that may hinder the adoption of desired behaviours.

The **theory of planned behaviour**, developed by Ajzen (1991), suggests that an individual's behaviour is determined by their intention to engage in that behaviour. According to Ajzen (1991), the relationship between intention and action is influenced

by three key factors, which are attitude, subjective (social) norms and perceived behavioural control. This theory depends on self-reflection, including an individual's capacity to evaluate their attitudes, beliefs and perceptions regarding the behaviour, the importance of the behaviour by significant others and the perceived effort required to perform it (Lee and Lina Kim 2017). Table 3 explains the three key factors of the theory with related strategies that could be incorporated in self-management support programs to promote behaviour change, as found in the literature.

Key factor	Description	Related strategies to facilitate behaviour change
Attitude	Subject's intent is influenced by their personal evaluation of a particular behaviour of interest (favourable or unfavourable).	Patient-centred communication. Personalisation of program content addressing individual's belief, motivators and status of social support. Shared decision-making.
Subjective (social) norms	Subject's intent is influenced by social pressure and expectations exerted by significant others, such as family and friends, or societal norms.	
Perceived behavioural control	Subject's intent is influenced by self-beliefs in own capability to successfully perform the behaviour and overcome any challenges that may be encountered.	Self-monitoring Goal setting Skill mastery Feedback

Table 3: Key aspects of the theory of planned behaviour.
Sources: Lee and Lina Kim (2017) and Pourmand et al. (2020).

According to the theory of planned behaviour, individuals with chronic conditions may be hesitant to engage in behaviour change programs, like for self-management support, due to negative perceptions, lack of social support or low self-efficacy. To enhance the intention to participate, different strategies found in the literature could be incorporated during program development. For example, Lee and Lina Kim (2017) raise the importance of understanding individuals' personal beliefs and motivations related to the intended behaviour as well as how their social network views their involvement in this behaviour. This approach aligns with patient-centred care, where

patients actively collaborate with healthcare professionals to create a treatment plan tailored to their specific needs, goals and circumstances. This approach promotes shared decision-making, enhancing patient engagement and boosting their confidence in their ability to effectively control their health (Pourmand et al. 2020). This can also be enhanced by incorporating self-efficacy and reinforcement strategies previously discussed in the social cognitive theory, such as goal setting, problem-solving and feedback.

Within the context of healthcare self-management, **self-determination theory** frequently emerges in discussions (Deci and Ryan 1985; Knox et al. 2021). It is a motivational theory that focuses on internal sources of motivation, including the desire for personal growth and satisfaction. It explains the interaction between social environments and individual psychological needs, shaping motivation, personal development and overall well-being (Ryan et al. 2019). This theory suggests that every individual has three fundamental psychological needs, which are autonomy, competence and relatedness, that serve as the foundation for growth and development (Deci and Ryan 1985). Table 4 explains these psychological needs with related strategies that could be incorporated into self-management support programs to promote behaviour change, as found in the literature.

Psychological needs	Description	Related strategies to facilitate behaviour change
Autonomy	Individuals are autonomously motivated when they feel a sense of free will and choice in their actions with no external pressure.	Patient/self-management education Patient-centred communication Shared decision-making
Competence	Individuals perceive themselves as competent when they believe they can influence important outcomes, for example, pain levels.	Problem-solving Skill mastery Self-monitoring Feedback Professional support
Relatedness	Individuals feel respected, understood and cared for by healthcare providers or social network.	Patient-centred communication Shared decision-making Personalisation Social support Group-based programs

Table 4: Psychological needs of self-determination theory.
Sources: Williams et al. (2004), Ryan et al. (2008) and Stenberg et al. (2022).

As can be seen above in Table 4, self-determination theory focuses on the inner drivers that guide individuals when considering change. The literature discusses specific strategies that align with this theory and aim to activate autonomous motivation within individuals so they will engage in behaviour change programs (Williams et al. 2004; Ryan et al. 2008; Stenberg et al. 2022). Clearly, individuals with chronic conditions must develop intrinsic readiness for change, which can only come about via a process involving sufficient education, skill development and social and expert support. Through applying these strategies, individuals' fundamental psychological needs for autonomy, competence and relatedness can be met, thereby fostering a profound sense of empowerment, contentment and intrinsic drive in relation to their efforts to effectively manage their conditions.

Another theory frequently discussed in the context of health self-management is Bandura's **Self-regulation theory** (1991). This theory is a conscious, personal management system involving a process of directing one's own thoughts, behaviours

and emotions to attain intended goals (Baumeister et al. 2007; Zhao et al. 2019). According to this theory, individuals must actively contribute to their own motivation, behaviour and development to engage in desired behaviours. This can be achieved through skills such as self-monitoring, self-evaluation, self-reinforcement and self-instruction. Each of these skills is further explained in Table 5, along with potential tools and strategies that can be acquired to facilitate self-management or integrated into self-management support programs, as found in the literature.

Skills	Description	Related tools/strategies to facilitate behaviour change
Self-monitoring	The process of observing one's own behaviour and associated consequences.	Activity tracker Symptom diary
Self-evaluation	The process of comparing oneself at some point to oneself at an earlier point of time or a standard measure towards achieving goal.	Goal setting Self-feedback
Self-reinforcement	The process of encouraging oneself to engage in desired behaviour.	Self-reward Positive affirmations
Self-instruction	The process of guiding and directing oneself regarding a particular behaviour.	Self-talk

Table 5: Skills needed to make a change according to the self-regulation theory. Sources: Clark et al. (2014) and Sage et al. (2017).

Lansing and Berg (2014) highlight in their paper that successful self-management of chronic conditions hinges upon the establishment of a solid groundwork of self-regulation skills. To achieve their goals, individuals must exercise command over their own thoughts, such as those related to the consequences of their health condition or any feelings of embarrassment when carrying out desired behaviours in the presence of others. Effectively managing inner conflicts between one's sense of self and ego can significantly contribute to the sustained practice of desired behaviours, and this is often referred to as "adherence". This adherence, in turn, has the potential to yield improved health outcomes (Graves et al. 2010).

The **transtheoretical model of change** by Prochaska and DiClemente (1983) serves as a framework that incorporates multiple behavioural theories and constructs in order to understand and guide behaviour change. This model is based on the belief that people do not change behaviours quickly and decisively but rather that change in behaviour happens continuously through a cyclical process involving six stages (Raihan and Cogburn 2020; LaMorte 2022b). These stages are precontemplation, contemplation, preparation, action, maintenance and termination. Each stage requires the use of different strategies to facilitate progression to the next stage and ultimately achieve behaviour maintenance, which is the desired outcome (Prochaska and Velicer 1997). Table 6 below elaborates on these stages along with potential strategies to promote change tailored to each stage, as found in the literature.

Stage	Description	Related strategies to facilitate behaviour change
Precontemplation	No intention for a change (might be defensive when the idea of change is proposed).	Patient education Patient-centred communication Peer discussion
Contemplation	The individual becomes aware of the problem and develops intentions to overcome it (no action has been taking yet).	Patient-centred communication Problem-solving
Preparation	Developing intentions to take action leading to a change.	Self-management education Patient-centred communication Peer discussion
Action	Actions are taken to bring about a change.	Problem-solving Goal setting
Maintenance	Efforts are made to maintain behaviour over the long-term.	Self-regulation skills (self-monitoring, self-evaluation. etc.).
Termination	No intention to return to previous negative behaviours.	

Table 6: Stages of the transtheoretical model of change.
Sources: Prochaska and Velicer (1997) and LaMorte (2022b).

According to the transtheoretical model of change, individuals with chronic conditions need to be assessed prior to recommending self-management behaviours to explore their current stage on the change cycle (Jensen et al. 2003). By implementing these strategies in accordance with the specific stage of change, individuals are more likely to successfully navigate their way through the model and maintain their desired behaviour.

2.4.3.1 Synthesising Behavioural Theories in the Context of Chronic Knee Pain

This analysis critically examines these theories, comparing and contrasting their approaches and efficacy in addressing the unique challenges of chronic knee pain management.

Social Cognitive Theory and the Theory of Planned Behaviour share a focus on cognitive processes in shaping behaviour but differ in their specific emphases. Social Cognitive Theory, with its central concept of self-efficacy, has demonstrated significant improvements in pain self-efficacy and physical function in individuals with knee OA (Hurley et al. 2018). Similarly, the Theory of Planned Behaviour has shown efficacy in predicting adherence to exercise regimens, particularly through its focus on behavioural intentions and perceived behavioural control (Sniehotta et al. 2014). However, Social Cognitive Theory may not adequately account for environmental and socioeconomic factors, while the Theory of Planned Behaviour has been faulted for not fully capturing the emotional and habitual aspects of pain-related behaviours (Armitage and Conner 2001; Edwards et al. 2019). These limitations highlight a shared weakness in addressing the multifaceted nature of chronic pain management.

In contrast, Self-Determination Theory and Self-Regulation Theory focus more on the motivational aspects of behaviour change. Self-Determination Theory emphasises intrinsic motivation and autonomy support, showing promise in promoting long-term adherence to self-management behaviours (Ng et al. 2012). Self-Regulation Theory, on the other hand, provides valuable insights into how individuals set and pursue health-related goals, adapt to pain fluctuations, and maintain self-management behaviours over time (Leventhal et al. 1980). Both theories have demonstrated improvements in pain coping strategies and functional outcomes; however, they differ in their limitations. Self-Determination Theory may not adequately address pain-related fear and avoidance behaviours, while Self-Regulation Theory has been criticised for not fully accounting for the impact of social and environmental factors on self-regulation processes (Ryan et al. 2008; Mann et al. 2013). This comparison reveals a gap in addressing both psychological barriers and contextual factors in chronic pain management.

The Transtheoretical Model stands somewhat apart from the other theories in its stage-based approach to behaviour change. It has proven useful in tailoring interventions to individuals' readiness to change, demonstrating improvements in stage progression and adoption of self-management behaviours in knee OA patients (Johnson et al. 2014). However, unlike the other theories which focus on ongoing processes, the Transtheoretical Model's rigid stage-based approach may oversimplify

the ongoing, fluctuating nature of chronic pain, where individuals often move back and forth between different stages rather than following a linear path (West 2005). This distinction highlights the need for models that can capture the dynamic nature of pain management behaviours.

When comparing the theories' applications in chronic knee pain management, it can be seen both overlaps and unique contributions. Social Cognitive Theory and the Theory of Planned Behaviour both provide valuable frameworks for understanding and influencing health behaviours, but Social Cognitive Theory's emphasis on self-efficacy may be particularly relevant for pain management tasks (French et al. 2012). Self-Determination Theory and Self-Regulation Theory both address motivational aspects, but Self-Determination Theory's focus on autonomous motivation may be especially relevant for long-term adherence to self-management strategies (Ryan et al. 2008). The Transtheoretical Model, while useful for tailoring interventions, may be less equipped to address the ongoing, fluctuating nature of chronic pain management compared to the other theories (Prochaska and Velicer 1997).

Despite their individual strengths, all five theories share a common limitation: when applied in isolation, they fail to capture the full complexity of chronic knee pain self-management. This shared weakness underscores the need for an integrated approach that combines the strengths of multiple theories. For instance, combining Social Cognitive Theory's focus on self-efficacy with Self-Determination Theory's emphasis on intrinsic motivation could yield interventions that not only enhance individuals' confidence in their ability to manage pain but also promote autonomous motivation for long-term adherence (Keefe et al. 2018; Nijs et al. 2016). Similarly, integrating elements from ecological models of health behaviour into Self-Regulation Theory-based interventions could address the influence of social and environmental factors on self-management processes (Sallis et al. 2015). Ecological models suggest that health behaviours are influenced by multiple levels of factors, including individual, interpersonal, organisational, community, and policy levels, providing a comprehensive framework for understanding the complexities of chronic pain self-management (Bronfenbrenner 1979; McLeroy et al. 1988). Furthermore, the limitations of The Transtheoretical Model's stage-based approach could be mitigated by integrating it with more dynamic models of behaviour change, such as the Health

Action Process Approach (Schwarzer 2008). This approach distinguishes between a motivational phase, where individuals form intentions, and a volitional phase, where intentions are translated into actions. This two-phase model allows for a more flexible understanding of behaviour change, recognising that individuals may revisit earlier phases or experience relapses, which is particularly relevant in chronic pain management. By combining the Transtheoretical Model's stage-based insights with the Health Action Process Approach's more fluid, adaptive approach, interventions could become better equipped to handle the complexities and fluctuations inherent in chronic pain experiences (Schwarzer 2008; Sniehotta et al. 2014).

In conclusion, while each of the discussed theories offers valuable insights into self-management of chronic knee pain, they also have some limitations when applied in isolation. The comparison of these theories reveals gaps in addressing the multifaceted, dynamic nature of chronic pain management. Researchers and future developers should focus on integrating multiple theoretical perspectives to create more comprehensive and effective interventions. This integrated approach should aim to address both individual cognitive factors and broader environmental influences, incorporate both rational decision-making processes and emotional aspects of pain-related behaviours, combine motivational strategies with pain education, and account for the dynamic nature of behaviour change in chronic pain management.

2.4.4 Self-management and self-management support in clinical practice

The overarching goal of self-management support is to enhance the self-efficacy of individuals with chronic conditions through developing six essential skills, which are problem-solving, decision-making, resource utilisation, establishing patient–provider partnerships, action planning and self-tailoring (Lorig and Holman 2003). The literature demonstrates a strong correlation between self-efficacy and long-term self-management behaviours that lead to better health outcomes among individuals with different chronic conditions (Wu et al. 2016; Geng et al. 2018). In clinical practice, the support offered by healthcare providers to individuals with chronic conditions tends to adhere to a structured approach. This approach underscores the importance of establishing a strong patient-provider relationship and a solid foundation of knowledge as the initial steps in assisting individuals with chronic conditions with self-management (Schaefer et al. 2009).

The development of all the aforementioned skills relies on the foundation of a robust patient-provider relationship. In self-management support, healthcare providers must attempt to create this relationship in the initial sessions, with the goal of establishing trust and boosting the individual's confidence in their healthcare provider (Schaefer et al. 2009). Patient-provider trust in this context plays a pivotal role in facilitating several crucial outcomes. Firstly, individuals who have trust in their healthcare providers are more likely to disclose personal information as well as discuss lived experiences and preferences during sessions, which is fundamental to delivering tailored self-management support (Franklin et al. 2018). Secondly, individuals with a high level of trust in their healthcare providers tend to be more receptive to new care strategies, hold a more favourable perception of their care and exhibit better adherence to recommended approaches (Lee and Lin 2009; Thom et al. 2014; Schoenthaler et al. 2014). Thirdly, trust has been shown to play a key role in motivating individuals to embrace positive behavioural changes, a central aspect of the self-management concept (Wu et al. 2022). Establishing this trusted relationship begins with patient-centred communication, as previously discussed in this section, characterised by actively listening to individuals' shared experiences and demonstrating respect for them and their stories (Allinson and Chaar 2016; Liu and Jiang 2019; Hong and Oh 2020).

The primary objectives of this trusted relationship are to instil motivation for change, offer guidance on taking proactive steps and equip individuals with the necessary tools to sustain positive changes. It is worth emphasising that all communication is two-way, with individuals coping with chronic conditions actively contributing by sharing their lived experiences with healthcare providers. This collaborative interaction allows healthcare providers to gain profound insights into the psychosocial factors that can either facilitate or impede the adoption of self-management behaviours. To further improve this key aspect of support, certain self-management support training courses incorporate skills training for motivational interviewing (The Health Foundation 2011; Phillips et al. 2018). Motivational interviewing is a therapeutic type of interviewing that aims to boost an individual's motivation and commitment to change by eliciting and intensifying their own reasons for change within an empathetic and accepting environment (Arkowitz et al. 2015). While not strictly theory-driven, motivational interviewing aligns with the self-determination theory, emphasising individual needs

for autonomy, competence and relatedness (Bischof et al. 2021). Proficient healthcare providers in motivational interviewing possess the skills for active and reflective listening, which are vital components of this approach. Through active listening, providers uncover individuals' goals, concerns, lifestyles and social commitments, and they then use this information to craft tailored self-management support plans (Bischof et al. 2021).

Patient-provider communication in self-management support includes providing individuals with chronic conditions with two types of education: patient education and self-management education, which differ in their specific objectives. Patient education aims to impart knowledge about the condition itself, covering aspects such as its natural progression, potential treatment strategies and expected management outcomes (Bodenheimer et al. 2002). On the other hand, self-management education empowers individuals with chronic conditions by equipping them with the skills needed to independently self-manage their condition (Bodenheimer et al. 2002). These two forms of education are complementary and work together to enhance an individual's confidence in actively engaging in various self-management tasks, including problem-solving, decision-making and symptom monitoring. This comprehensive understanding of their health condition, acquired from a highly trusted source, empowers individuals to take an active role in their self-management journey (van Berkel et al. 2015; Liu and Jiang 2019; Hong and Oh 2020). Education has consistently proven to be a fundamental component of effective self-management support programs, leading to improved health outcomes and a better quality of life for individuals with chronic conditions (Timmermans et al. 2023).

Building on the foundation of an effective patient-provider relationship and tailored education aligned with the individual's change stage, self-management support evolves. It moves beyond merely exchanging knowledge and experiences to include setting goals and solving problems collaboratively (Jonkman 2016).

Supporting individuals with chronic conditions in their lifelong journey of self-management entails several essential components, including equipping them with problem-solving skills for addressing daily challenges and granting them the autonomy to make informed decisions (Lorig et al. 1999; Grady and Gough 2014). In healthcare, providers play a crucial role in supporting individuals with chronic conditions to self-

manage through guided problem-solving. This involves facilitating discussions to help individuals identify problems and generate solutions and then to evaluate the practicality and potential outcomes of these solutions (Boger et al. 2015; Van de Velde et al. 2019). These scenarios often involve critical aspects like medication management, lifestyle changes and seeking medical care. Importantly, a systematic review of 33 studies by Devan et al. (2018) highlighted the effectiveness of this approach. Their review found that guided problem-solving not only supports sustained self-management routines but also significantly boosts confidence levels in individuals with chronic pain (self-efficacy).

Building on the role of healthcare providers in facilitating guided problem-solving, the next crucial step involves collaborating with individuals to develop actionable plans based on the decisions made. Action plans consist of a set of short-term goals aimed at achieving the larger intended behaviour. The goal-setting theory is a motivational strategy concept commonly employed to facilitate behaviour change (Bailey 2017). It is one of the most frequently employed components in interventions targeting behaviour change, including those for self-management (Michie et al. 2018). The literature consistently supports the connection between goal-setting theory and sustained motivation and high performance (Travers et al. 2015; Locke and Latham 2019). Failing to achieve goals can have a negative effect on an individual's confidence in performing intended behaviours (Bailey 2017). Therefore, breaking down larger goals into short-term ones has been found to be an effective strategy for improving success rates and self-efficacy (Ordóñez et al. 2009; Pearson 2012; Bailey 2017). This approach is further enhanced through continuous feedback, positive self-talk, peer support and celebrating small victories along the way, often referred to as self-rewards (Bailey 2017).

Within self-management support, healthcare providers assume a primary responsibility in guiding individuals on the how and when of utilising external support resources, including access to healthcare services, community resources, financial aid and technology. This skill reflects an individual's capacity to identify and seek the appropriate resources necessary for self-managing their conditions effectively. It is worth noting that this skill was previously underscored by Lorig and Holman (2003) as an aspect often overlooked by care providers. However, there appears to have been

an improved focus on this in the past decade. This observation is grounded in the efforts invested by developers in recent self-management support initiatives, especially their online versions. Some of these initiatives have been designed to offer users a wide array of external links, connecting them to different support providers, including healthcare professionals and educational materials (Goff et al. 2023). Moreover, an emerging trend is the integration of online support toolkits with in-clinic support, supporting individuals with chronic conditions with a point of contact throughout their self-management journey (Morton et al. 2017).

2.4.4.1 Insights from the Clinical Applications of Self-Management Support in Physiotherapy Practice:

While the theoretical framework for self-management support by Lorig and Holman (2003) provides a comprehensive foundation, its application in specific clinical contexts, particularly in physiotherapy for chronic knee pain, reveals a landscape of challenges and opportunities. Killingback et al. (2022) conducted a qualitative review of 11 studies investigating physiotherapists' perspectives on implementing self-management practices. The findings emphasiaed that although physiotherapists acknowledged the importance of encouraging active patient participation, they often struggled to balance their perceived professional authority with the empowerment necessary for self-management approaches. This tension sometimes led to behaviours that prioritized professional control, reflecting broader healthcare models where clinicians traditionally occupy an authoritative role (Mudge et al. 2015). When patients rejected their advice, it was sometimes perceived as a challenge to the physiotherapists' professional identity. Such thinking contrasts with self-management approaches, which advocate for shared decision-making between care providers and patients (Elwyn 2001). While some physiotherapists recognised that patients possessed valuable knowledge about their conditions, they still viewed themselves as the experts in therapy. The study suggests that therapists should reflect on their own expertise and recognise the value of the patient's lived experience. Failing to do so may lead to a dynamic of paternalism, where the therapist assumes a dominant, controlling role, potentially undermining the patient’s autonomy (Alabdullah et al. 2022).

From the patient's perspective, Wallis et al. (2019) conducted a systematic review of qualitative studies examining the experiences of people with knee OA in managing their condition. The study underscored the critical role of healthcare professionals in providing clear communication, support, and information to patients. Negative experiences, such as feeling unheard or dismissed, negatively affected patients' attitudes towards management, emphasising the need for patient-centred communication and shared decision-making. These findings resonate with the principles outlined earlier, particularly the importance of establishing a strong patient-provider relationship and providing tailored education. The challenges identified in both Killingback et al. (2022) and Wallis et al. (2019) highlight the potential benefits of incorporating motivational interviewing techniques into physiotherapy practice. This approach could address the reported power imbalance by encouraging a more collaborative environment and enhancing patients' motivation for change.

Spink et al. (2021) similarly explored the complexities of self-management implementation, focusing on the patient perspective in chronic musculoskeletal pain, including knee pain. Their systematic review highlighted that while patients were equipped with problem-solving skills and action planning, practical barriers such as time constraints and a lack of ongoing support impeded the long-term success of these interventions. This aligns with Lorig and Holman’s (2003) framework, which emphasises the importance of continuous healthcare support to reinforce self-management behaviours. However, the study critiques the framework's overly optimistic assumption that patients, once empowered, can sustain self-management independently. Spink et al.'s findings suggest that without consistent reinforcement from healthcare professionals, self-management strategies may weaken in the face of daily challenges and systemic pressures. This critique resonates with Killingback et al. (2022) and Mudge et al. (2015), who observed that physiotherapists often struggle to surrender professional control. While Spink et al. (2021) focused on patients' needs for ongoing professional support, Killingback et al. demonstrated that physiotherapists may unintentionally undermine self-management by overemphasising their authority. Both perspectives reveal that the theoretical benefits of self-management, such as patient autonomy and empowerment, may be limited by entrenched power dynamics within healthcare. Spink et al.'s study further suggests that the expertise of therapists remains essential, not as a means of control, but to sustain the therapeutic alliance

necessary for patient engagement, echoing discussions of trust and collaboration in therapeutic relationships as seen in Krupnick et al. (2006) and Babatunde et al. (2017).

Together, these studies reveal that the application of self-management support in physiotherapy practice is not merely a matter of providing patients with tools for self-care but requires a delicate balance of professional expertise and patient autonomy. Yet, as with many studies in this field, the above studies are limited by its focus on individual patient barriers within Western healthcare settings, raising questions about how self-management strategies might be adapted to different cultural contexts and healthcare systems.

2.4.5 Lessons learned from the reviewed literature in this section

It can be inferred from the literature above that self-care, self-management and support from healthcare professionals are closely interconnected concepts, emphasising the centrality of the individual or "self" in the continuum of wellbeing and healthcare (Bentzen et al. 1989; Dean 1989; Omisakin and Ncama 2011; Jones et al. 2011). This exploration reveals an understanding that while self-care represents an age-old, instinctual practice aimed at preserving wellness and managing health independently (McCormack 2003; Martínez et al. 2021), self-management goes deeper into the complexities of chronic disease management, necessitating an active, informed and collaborative approach involving individuals and their healthcare systems (Lorig and Holman 2003; Van de Velde et al. 2019). The concept of self-management support further expands this dialogue, highlighting the essential role of healthcare professionals, family and peers in providing the necessary support to enhance individuals' confidence and abilities to manage their health (Wilkinson and Whitehead 2009; Silva 2011; Boger et al. 2015).

This layered understanding underscores a pivotal shift towards patient-centred healthcare, where empowering individuals becomes paramount to reduce the burden of chronic conditions (Schaefer et al. 2009). Self-management support of chronic conditions involves proactive, long-term engagement, necessitating individuals' active involvement in decision-making and lifestyle modifications. This evolution transforms traditional patient roles, positioning individuals as co-leaders in their healthcare

journey, a change facilitated by healthcare providers through empowerment and collaboration (Allinson and Chaar 2016; Liu and Jiang 2019; Hong and Oh 2020). Such empowerment is rooted in a strong foundation of knowledge and a partnership enriched by the exchange of lived and clinical experiences, fostering trust and understanding of biopsychological aspects (Franklin et al. 2018). These efforts are directed towards developing essential skills like problem-solving and decision-making, culminating in personalised action plans that resonate with the patient's values and preferences.

Central to this process is the application of theoretical frameworks on behavioural change, which guide the transition from understanding self-management support principles to their practical application (Michie et al. 2018). These frameworks, incorporating theories and models of behaviour, delve into the intricacies of human intentions and the myriad factors influencing them, thereby facilitating the development of effective behaviour change strategies (Araújo-Soares et al. 2019). Recognising the complexity of human behaviour, these comprehensive models are instrumental in aiding individuals, especially those with conditions like chronic knee pain, to adopt and maintain behaviours that promote long-term health. As a result, theories of behaviour in particular will be frequently cited in subsequent sections discussing self-management support programs.

2.5 Leveraging digital technology for self-management support of chronic knee pain

2.5.1 Setting the scene for the section

Technology is revolutionising healthcare self-management support for individuals with chronic conditions by offering innovative remote support through digital health interventions (DHIs) (Morrison et al. 2014; Adriaans et al. 2021; Abernethy et al. 2022). These interventions, involving mobile applications, websites and wearable sensors, provide a flexible means of self-management support, enabling patient care both independently and in conjunction with healthcare providers (McLean et al. 2016). By incorporating education, behavioural change and communication tools, DHIs facilitate essential health behaviours, such as improved medication adherence and increased physical activity, to manage chronic conditions more effectively (Morton et al. 2017;

Ballou-Nelson 2018). The development process of these digital interventions is iterative, incorporating feedback from a wide range of stakeholders, particularly those experiencing the chronic conditions targeted by the interventions, ensuring their relevance and effectiveness (O'Cathain et al. 2019).

Digital health interventions were initially conceived to address barriers to healthcare access, including transportation difficulties, time constraints and care costs (Brundisini et al. 2013; Ackerman et al. 2016). They have become particularly valuable in musculoskeletal self-management support, offering crucial support to remote or underserved populations (Brundisini et al. 2013; Ackerman et al. 2016; Palcu et al. 2020). A significant increase in the development of DHIs has been observed, with a systematic review by Valentijn et al. (2022) identifying 56 DHIs created from 2002 to 2022, indicating a surge in innovation over the last two decades. These interventions are designed to either stand alone or supplement primary care services, with the goal of enhancing pain management, functional outcomes and self-management behaviours among individuals with musculoskeletal pain. The quality of the evidence supporting their efficacy, as confirmed by Valentijn et al. (2022), underscores the potential of DHIs to significantly improve health outcomes for those with chronic musculoskeletal conditions.

A total of seven self-management support DHIs for individuals with chronic knee pain were found in the literature and selected as evidence in this chapter. Selection was based on a set of defined criteria, which are detailed as follows. First and foremost, the search was confined to those exclusively addressing knee joint in order to maintain a homogenous cohort throughout the study. This strategy was employed to minimise biases potentially introduced by the inclusion of subjects with health conditions in other joints, who may exhibit varied responses to physical activity, as reported in Hinman et al. (2015). This consideration is especially pertinent to the hip joint, which is frequently co-analysed with knee conditions in studies of DHIs (Bossen et al. 2016; Pearson et al. 2016; Dahlberg et al. 2016; Kloek et al. 2018; Pelle et al. 2019). Furthermore, the review prioritised interventions that adhere to evidence-based practice, particularly those that incorporate exercise and education as recommended by current clinical guidelines for the conservative management of chronic knee pain, to mirror the

interventions applied in clinical settings (Bruyère et al. 2019; Bannuru et al. 2019; Kolasinski et al. 2020; Overton et al. 2022).

2.5.2 Synopsis of digital health interventions for chronic knee pain self-management support

The DHIs under review are outlined in Table 7: Hinge Health, TRAK, My Knee Exercise, Knee OA Minimum Viable Product (MVP), Digital Exercise Therapy Application (DETA), My Dear Knee and My Knee toolkit (Spasić et al. 2015; Smittenaar et al. 2017; Button et al. 2018; Nelligan et al. 2019; Mrklas et al. 2020; Gruner et al. 2021; Alasfour and Almarwani 2022; Goff et al. 2023). The included DHIs originated from the US, Australia, the UK, Canada and Saudi Arabia, reflecting a global effort, with most coming from countries with advanced healthcare systems (Roy 2020). The presence of Saudi Arabia in this list highlights its proactive steps towards aligning with the global trend in healthcare innovation, demonstrating its commitment to advancing healthcare practices through digital means (AlBasri 2022).

Furthermore, the delivery platforms of these DHIs vary, with TRAK, My Knee and My Knee Exercise being web-based (accessible through mobile phones, tablets and laptops) and thus catering to diverse user needs and accessibility preferences (Montecuollo 2014). Conversely, Hinge Health, DETA, Knee OA (MVP) and My Dear Knee capitalise on the spread of smartphones, adopting mobile applications (apps) to facilitate health management on the go (Shanahan 2022). Lastly, as seen in table 7, TRAK, Hinge Health and DETA were designed for a broad audience with chronic knee pain, whilst the other four interventions specifically target those specifically with knee OA.

Study Authors (Developers)	Country of origin	Intervention	Target Audience	Platform type
Smittenaar et al. (2017)	United States	Hinge Health	Chronic knee pain	Mobile application
Spasić et al. (2015) Button et al. (2018)	United Kingdom	TRAK	Knee conditions	Web-based
Nelligan et al. (2019)	Australia	My Knee Exercise	Knee OA	Web-based

Mrklas et al. (2020)	Canada	The Knee OA (MVP)	Knee OA	Mobile application
Gruner et al. (2021)	United States	DETA	Nonoperative knee conditions	Mobile application
Alasfour and Almarwani (2022)	Saudi Arabia	My Dear Knee	Knee OA	Mobile application
Goff et al. (2023)	Australia	My Knee toolkit	Knee OA	Web-based

Table 7: General details of the selected self-management support DHIs for chronic knee pain.

Each one of the seven DHIs is described in-detail below along with any research supporting their development.

Hinge Health: This is a mobile application that has been developed for individuals with chronic knee pain. It is to be used with wearable bands equipped with motion sensors. The application aims to provide them with the knowledge and tools needed to self-manage their condition without relying significantly on prescription medicines and surgery (Smittenaar et al. 2017). Sensor-guided exercises, education, cognitive behavioural therapy, psychological support, weight loss and an activity tracker are all part of the app. Personal health coaches assist participants as an aspect of teams that give additional support and motivation throughout the program (Smittenaar et al. 2017). The clinical effectiveness of the Hinge Health intervention, which focuses on pain and function, was evaluated over a 12-week period through RCT conducted by Mecklenburg et al. (2018). The findings from this study will be discussed in detail later in this section.

TRAK: TRAK stands for Taxonomy for the Rehabilitation of Knee Conditions (Button et al. 2013). Originally created as a Facebook page by Spasić et al. (2015), this web-based intervention was later moved to its own website by Button et al. (2018). The discussion in this section will primarily focus on TRAK, the website, while also referencing the TRAK App suite in certain areas. This approach aims to provide a comprehensive overview of its development and evaluation journey. TRAK was developed through an iterative process, grounded in theory, evidence-based practices and person-centred approaches and guided by the Medical Research Council (MRC)

framework for developing and evaluating complex interventions (Craig et al. 2008; Button et al. 2013; Button et al. 2015; Spasić et al. 2015; Murray et al. 2016). It aims to support individuals to self-manage their knee conditions and consequently alleviate demand on physiotherapy services (Button et al. 2018). The TRAK website features dual interfaces: one for physiotherapists and one for individuals. Physiotherapists use their interface to prescribe personalised video-based exercise plans and monitor patient progress. On the individual side, the interface provides access to exercise videos, educational content, progress tracking, goal setting, automated reminders and remote advice from a physiotherapist (Button et al. 2018). TRAK has not yet been evaluated for clinical effectiveness in RCT.

My Knee Exercise: This is a self-directed website developed by Nelligan et al. (2019), complemented by an automated text messaging system, designed to assist individuals with knee OA. The intervention aims to provide easy access to recommended OA exercises and support healthcare providers in delivering exercise therapy to knee OA patients on a broad scale. The website features educational materials, a 24-week structured self-directed strengthening program, a logbook to track progress and a system for sending reminder text messages periodically. Along with the Hinge Health app, the clinical effectiveness of the My Knee Exercise website on pain and function was evaluated in RCT (Nelligan et al. 2021).

The Knee Osteoarthritis Minimum Viable Product (MVP): Developed by Mrklas et al. (2020), The Knee OA (MVP) is a mobile application designed to support self-management and augment patient–physician communication concerning knee OA. The app has features like a goal-setting page, tailored goal-related activities and exercises, self-management educational materials and tracking tools, all aimed at empowering users to effectively manage their knee OA. The Knee OA (MVP) was assessed by Shewchuk et al. (2021) in a 6-week pilot trial that focused on its usability, quality and effectiveness in terms of improving the quality of life of individuals with knee OA. While the findings of Shewchuk et al. (2021) contribute to the understanding of clinical effectiveness, they require further validation through more rigorous research designs in order to be regarded with a high level of confidence.

Digital Exercise Therapy Application (DETA): DETA is an innovative mobile application that was developed by Gruner et al. (2021) to empower individuals with knee conditions through facilitating home-based management of their symptoms, addressing the prevalent challenges associated with accessing standard physiotherapy care. The DETA app offers users access to exercise videos, clear step-by-step exercise instructions, educational content and session reminders. It also uses gamification, which involves the use of game-like features to keep users engaged. In RCT, Gruner et al. (2021) assessed DETA's effectiveness to alleviate pain and enhance function in individuals with nonoperative knee pain over a span of eight weeks.

My Dear Knee: This mobile application was developed by Alasfour and Almarwani (2022) and aims to enhance adherence to home exercise routines among older women with knee OA in Saudi Arabia. The app provides a standardised lower limb strengthening exercise routine, coupled with features like an exercise log, alerts and a monitoring system. Additionally, it incorporates in-person education sessions where users are informed about knee osteoarthritis and the prescribed exercises. To date, there have been no studies that further investigate the "My Dear Knee" application or trials of it as an intervention to evaluate its effectiveness.

My knee: This is an online educational and self-management resource created by Goff et al. (2023) for individuals with knee OA. Described by its creators as a toolkit, it integrates the educational priorities of those with knee OA and physiotherapists into a resource informed by theory, clinical guidelines and evidence. The toolkit features videos, animations and interactive elements designed to educate users about knee OA, its management and the significance of exercise therapy. Additionally, it includes a self-assessment feature for users to track their symptoms and a goal-setting function to assist them in establishing and accomplishing their exercise therapy objectives. To date, there have been no additional studies that further investigate My Knee.

2.5.3 Development and core components of digital health interventions for chronic knee pain self-management support

Three topics are covered in this subsection: design, intervention components and usability.

2.5.3.1 Designing digital health interventions for chronic knee pain self-management support

Self-management support is rooted in the principle of individualisation, tailoring strategies to the unique characteristics and needs of each person (Dineen-Griffin et al. 2019). The approach thrives on personalisation, ensuring that the support mechanisms are aligned with the personal attributes and requirements of the individual, promoting a more effective and resonant strategy for self-management support. This philosophy extends to the context of digital self-management support. Here, the term co-design often emerges in the contemporary literature as a guiding principle, advocating for collaborative design processes (Mrklas et al. 2020; Goff et al. 2023).

Co-design, within this context, signifies the collaborative involvement of a diverse team, including prospective users and multidisciplinary professionals, throughout the developmental journey from conceptual design to practical implementation (Eysenbach 2005; Meyerowitz-Katz et al. 2020; Bennion et al. 2020; Barnum 2021). This approach is considered best practice and aims to develop a human-centred design, ensuring that the end product resonates with the needs of future users, ensures navigational proficiency and delivers overall satisfaction (ISO 9241-210, 2018; Slattery et al. 2020). The move towards co-design is a response to concerns about user disengagement in behavioural interventions (Meyerowitz-Katz et al. 2020; Raeside et al. 2023). The absence of co-design in the development of interventions has been a point of contention among scholars, with critics highlighting its infrequent and uneven application in practice (Mrklas et al. 2020; Goff et al. 2023). Within the scope of this review, it is noted that DHIs such as My Dear Knee by Alasfour and Almarwani (2022) and Hinge Health by Smittenaar et al. (2017) were not co-designed. In contrast, other included DHIs did incorporate co-design to varying degrees, underscoring an inconsistency in the adoption of this development strategy across the field. Different obstacles could justify inconsistent approaches among healthcare researchers. Contributions from Grindell et al. (2022) and Singh et al. (2023) highlight

these obstacles and their relationship to impeding the broad acceptance of the co-design approach. In their papers, the authors identify possible key challenges, which include limited research budgets, strict hierarchical structures preventing equal collaboration and insufficient evidence supporting the long-term effectiveness and cost-effectiveness of co-design (Grindell et al. 2022; Singh et al. 2023).

An example of a co-design approach can be seen in The Knee OA (MVP) by Mrklas et al. (2020) in which family physicians, patient researchers, individuals with knee OA, key stakeholders and industry partners were invited to co-design sessions. This inclusive strategy aids the gathering of unique insights from each group addressing different aspects of the intervention, from clinical effectiveness and patient experience to practical implementation and market viability, creating a solution that is well-rounded and tailored to meet the multifaceted needs of end-users (Barnum 2021). While Mrklas et al. (2020) showcased a comprehensive approach by incorporating a wide array of stakeholders, other interventions like TRAK by Spasić et al. (2015) and Button et al. (2018) and My Knee by Goff et al. (2023) primarily engaged healthcare professionals and patients. This approach was even more focused in My Knee Exercise by Nelligan et al. (2019), which only targeted patients with knee OA, and in DETA by Gruner et al. (2021), which involved physiatrists and physiotherapists. Potential users, in this case individuals with chronic knee pain, ought to be at the forefront of the co-design process, ensuring that the intervention developed remains relevant and engaging for them in the long run (Goff et al. 2023).

Moreover, the co-design approach is characterised by its iterative nature, where ongoing feedback is essential for continuous improvement until the final product meets the needs and expectations of all stakeholders (de Beurs et al. 2017). Not all co-designed interventions in this review provide detailed development processes, especially on iterative testing, as observed by Gruner et al. (2021) and Nelligan et al. (2019), yet there are still notable examples that do.
In TRAK, for instance, Spasić et al. (2015) engaged three software experts to uncover any usability concerns and to recommend further enhancements to the preliminary design of TRAK App suite, the first version of the intervention. Subsequent feedback from 15 physiotherapists and 16 patients, gathered through carefully crafted questionnaires, provided insights into digital literacy, app usability and user

satisfaction. This feedback was then analysed both quantitatively and qualitatively, leading to further refinements of the app, ensuring that the intervention was well-tailored to its intended users. The evolution of TRAK continued with Button et al. (2018), who tested the website version with physiotherapists and patients in a clinical setting through a mixed methods study. This phase led to further updates, such as substituting pictures with exercise videos, allowing personalised patient plans and integrating new educational content on self-management. Feedback from physiotherapists also prompted the removal of the contact portal to decrease workload and address potential risks associated with unanswered patient inquiries (Button et al. 2018).

To further illustrate, Mrklas et al. (2020) co-designed The Knee OA (MVP) using input gathered from a qualitative study involving patients with knee OA and family physicians all sharing suggestions on the needed content based on lived experiences and clinical experience (Barber et al. 2019). This foundational phase was followed by three iterative co-design focus group sessions, engaging a diverse cohort of 28 participants. Each session was instrumental, with insights gleaned directly influencing the subsequent stages, culminating in a consensus on the app's functional requisites, harmonised with the priorities of both patients and healthcare professionals. The resulting app prototype was later examined by Shewchuk et al. (2021) through a mixed-method design. A cohort comprising 18 patients with knee pain and seven family physicians provided insights via qualitative interviews. Patients concentrated on the app's ease of use and its ability to improve OA knowledge and self-management as well as facilitate better communication with practitioners, who in turn evaluated the app's clinical relevance and its potential to enhance patient-provider interactions (Shewchuk et al. 2021).

2.5.3.2 Key components of digital health interventions for chronic knee pain self-management support

In reviewing the selected DHIs, it was found that the components can be split into two main types: foundational components and engagement-provoking strategies, as noted in several studies (Spasić et al. 2015; Smittenaar et al. 2017; Nelligan et al. 2019; Mrklas et al. 2020; Gruner et al. 2021; Alasfour and Almarwani 2022; Goff et al. 2023). Foundational components are chosen for their proven benefits in clinical outcomes, whereas engagement-provoking strategies are picked based on literature and understanding of the theoretical foundations driving engagement. Table 8 lists components of each selected DHI, showing the sources and theories that influenced their selections.

DHIs / developers	**Sources for foundational components (Exercise and education)**	**Engagement- provoking strategies**	**Theoretical underpinnings**
Hinge Health Smittenaar et al. (2017)	Previous digital musculoskeletal work on exercises with pain coping training, telephone-based coaching, behavioural change and cognitive behavioural therapy (Nevedal et al. 2013; Dobson et al. 2014; Irvine et al. 2015).	- Activity tracker - Symptom tracker - Cognitive Behavioural Therapy - Peer support and personal health coaches. - Reminders	Social cognitive theory and the theory of planned behaviour
TRAK Spasić et al. (2015) Button et al. (2018)	TRAK ontology (Button et al. 2013) Systematic review (Button et al. 2015)	- Activity tracker - Symptom tracker - Face-to-face physiotherapy sessions	Aligned with the Behaviour Change Wheel (Michie et al. 2011a)
My Knee Exercise Nelligan et al. (2019)	Previous literature on exercise protocols and intensity for knee OA (Sharma et al. 2003; Garber et al. 2011; Cross et al. 2014; Bennell et al. 2017).	- Activity trackers - SMS reminders - Contact us "button"	The Behaviour Change Wheel
The Knee OA (MVP) Mrklas et al. (2020)	Input from family physicians and patients.	- Activity trackers - Symptom tracker	A grounded theory-based research process "patient-to-patient" (Miller et al. 2016)
DETA Gruner et al. (2021)	Data from physiatrists and physiotherapists and influenced by the evidence that highlights the effectiveness of stepped exercise therapy coupled with education and self-management on clinical outcomes, including ESCAPE-pain program (Hurley et al. 2007).	- Activity trackers - Symptom tracker - Periodic phone calls - Reminders	N/A

My Dear Knee Alasfour and Almarwani (2022)	Previous literature on the efficacy of strengthening exercises for lower limbs (Lange et al. 2008; O'Reilly et al. 1999; Bennell et al. 2017).	- Activity trackers - In-person education - Alerts	N/A
My Knee toolkit Goff et al. (2023)	A systematic review of education interventions in published trials; appraised web-based information about knee OA; and concept mapping to identify education priorities of people with knee OA and physiotherapists.	- Symptom tracker	Motivational interviewing, principles of andragogy, and theories related to enhancing self-efficacy.

Table 8: Components of the selected digital self-management support interventions for chronic knee pain.
Abbreviations: **DHIs** Digital Health Interventions, **TRAK** Taxonomy for Rehabilitation of Knee conditions, **MVP** Minimum Viable Product, **DETA** Digital Exercise Therapy Application, **SMS** Short Message System, **N/A** Not Applicable, **OA** Osteoarthritis.

With regards to foundational components, exercise and education are the cornerstone of all the self-management support interventions included in this review (NICE 2022). A consistent practice across the DHIs reviewed is the careful choice of foundational components, based on previous research that verifies their clinical effectiveness. For instance, Gruner et al. (2021) in their DETA intervention, which used published recommendations, posited that a structured exercise regimen, tailored to individual users and augmented with education, can yield superior health outcomes. In a parallel vein, Alasfour and Almarwani (2022) incorporated lower limb strengthening exercises into their My Dear Knee intervention, a choice anchored in established research. An innovative approach was adopted for TRAK, where exercises were derived from a prior ontology, the TRAK ontology, crafted by the same research team, in addition to a systematic review (Button et al. 2013; button et al. 2015). Within TRAK ontology, Button et al. (2013) charted a standardised care pathway for knee rehabilitation, drawing from a comprehensive literature review and a nationwide UK survey of clinical practices. Their objective was twofold: to establish an infrastructure applicable to future DHIs and to enable precise mapping of the utilised treatment components (Button et al. 2013).

The delivery method of foundational components in the reviewed DHIs varies. For exercise programs, different visual aids are employed to enhance understanding and correct execution of exercises. Hinge Health by Smittenaar et al. (2017), TRAK by Button et al. (2018), My Knee Exercise by Nelligan et al. (2019) and DETA by Gruner et al. (2021) have video demonstrations, whereas My Dear Knee by Alasfour and Almarwani (2022) has animated images. Educational materials are also presented in various formats across interventions. My Dear Knee by Alasfour and Almarwani (2022) uniquely offers in-person education, merging the digital experience with a personal touch. This approach allows uninterrupted access to support, offering users the flexibility to revisit materials as required, a feature that is highly valued and deemed beneficial in the self-management journey (Patten et al. 2022). Hinge Health by Smittenaar et al. (2017) and My Knee Exercise by Nelligan et al. (2019) mainly use text-based formats for educational materials. However, My Knee Exercise also incorporates video interviews with peers and experts, enriching its content. This multimedia approach accommodates various learning preferences, potentially improving user engagement and understanding (Blank et al. 2003; Chakraborty 2019).

In contrast, DETA's approach to delivering educational content is less clear, with references to "educational materials" but a lack of detail (Gruner et al. 2021).

Engagement-provoking strategies are key in terms of influencing the clinical outcomes of self-management support DHIs (Burley et al. 2020). They are selected to directly target the drivers of engagement that initiate and sustain the necessary behaviour change, which in this case is the adherence to foundational components (Mohr et al. 2014). The reviewed papers did not offer substantial information regarding the basis for choosing engagement-provoking strategies. However, reflecting on the earlier discussion about behaviour change theories and their influence on the selection of engagement-provoking strategies, it can be inferred that the developers' choices are somewhat rooted in theoretical foundations. This is particularly true for interventions where the developers have explicitly stated the use of behaviour theories during the development stages. For instance, Mecklenburg et al. (2018) disclosed that the development of Hinge Health was guided by behavioural change theories, including social cognitive theory and the theory of planned behaviour. Similarly, Button et al. (2018) and Nelligan et al. (2019) integrated the Behaviour Change Wheel, a behaviour change model, into TRAK and My Knee Exercise, respectively (Michie et al. 2011). The engagement-provoking strategies, as per the included papers in this review, include activity trackers, symptoms self-monitor, reminders and external human support.

Starting with activity trackers, they are, as defined by Andre and Wolf (2007), tools designed to record and provide feedback on an individual's movement, for example, the number of daily steps and/or time spent in physical activity. Rehabilitation experts hypothesise that the integration of activity trackers into self-management support DHIs may serve as a motivational catalyst for less active individuals, with the knowledge that their activity levels are being monitored (Vogel et al. 2017; Leese et al. 2019). This hypothesis may explain the inclusion of activity trackers in nearly half of the interventions reviewed here. Hinge Health by Smittenaar et al. (2017) employs motion sensors for real-time feedback, while My Dear Knee by Alasfour and Almarwani (2022) features an automatic recorder for physiotherapists to monitor users' exercise adherence. TRAK by Button et al. (2018) and My Knee Exercise by Nelligan et al. (2019) require users to manually log their activities, whereas DETA by Gruner et al.

(2021) incorporates elements of gamification, which is increasingly recognised for its potential to make physical therapy more engaging by introducing game-like elements into therapeutic activities (Hendrickx et al. 2021; Evans et al. 2023).

Additionally, most of the interventions examined actively promote user engagement by incorporating self-monitoring tools within their platforms, allowing individuals to record symptom fluctuations and monitor their condition's progression. The interventions that do this are Hinge Health, TRAK, The Knee OA (MVP), DETA and My Knee toolkit (Smittenaar et al. 2017; Button et al. 2018; Mrklas et al. 2020; Gruner et al. 2021). This approach, whereby participants log pain, function and exercise data and adapt the intervention to their needs as seen in DETA's exercise adjustments, promotes self-awareness and instils a sense of accomplishment, effectively driving motivation (Jaarsma et al. 2019; Gruner et al. 2021). The foundation of this strategy is deeply rooted in established behavioural change theories, such as social cognitive theory and self-regulation theory (Schunk and Pajares 2010; Clark and Zimmerman, 2014; Tougas et a. 2015; Sage et al. 2017). These theories focus on the empowerment of individuals, suggesting that self-awareness can facilitate and sustain positive behavioural shifts. The non-integration of symptom self-monitoring in interventions like My Knee Exercise by Nelligan et al. (2019) and My Dear Knee by Alasfour and Almarwani (2022) indicates a potential weakness of these DHIs.

Alerts and reminders were found to be integral to the design of several DHIs under review, specifically Hinge Health by Smittenaar et al. (2017), My Knee Exercise by Nelligan et al. (2019), DETA by Gruner et al. (2021) and My Dear Knee by Alasfour and Almarwani (2022). Enhancements to The Knee OA (MVP) are expected to include alerts and reminders, a decision informed by user feedback, as documented by Shewchuk et al. (2021). However, there are no reports of similar updates for TRAK by Button et al. (2018) or My Knee toolkit by Goff et al. (2023). Evidence suggests that such features in remote healthcare interventions play a dual role. They not only prompt patients to engage in specific behaviours but also foster a sense of shared responsibility and enhance patient autonomy in managing their own healthcare (Perri-Moore et al. 2017).

In Hinge Health by Smittenaar et al. (2017), the reminders, delivered through text messages and emails, are reactive in nature. They are triggered when a participant's engagement falls below the recommended intensity (Mecklenburg et al. 2018). Such multi-channel communication (text and email) is believed to be a smart step, increasing the likelihood of capturing the user's attention (Jena 2021). My Dear Knee by Alasfour and Almarwani (2022), on the other hand, adopts a proactive approach in which the app sends timely alerts, such as "It's time to exercise", aiming to instil a routine and proactively address adherence issues. This consistent nudge might help in habit formation, making the exercise regimen a part of the user's daily routine (Keller et al. 2021; Sobolev et al. 2023). My Knee Exercise by Nelligan et al. (2019) uses a Short Message System adherence support system, a direct and often effective communication channel. Short Message System, given its ubiquity and high open rates, has been proved to be effective in encouraging care seekers to stick to their medical regimen (Schwebel and Larimer 2018).

Moreover, a common recognition of the value of human touch and personalised support was noticed across the seven DHIs included. This element is especially crucial for individuals managing chronic conditions as it helps mitigate feelings of isolation and supports sustained engagement with the intervention (Fledderus et al. 2015; Iovino et al. 2023). Hinge Health by Smittenaar et al. (2017) provides robust support for each user through a personal coach, fostering accountability and adherence to the program. The coach also encourages community building via in-app discussions, allowing for the sharing of experiences and support. On the other hand, My Dear Knee by Alasfour and Almarwani (2022) emphasises supervised exercise sessions, ensuring that participants fully understand and can perform exercises correctly before doing them remotely. Button et al. (2018) describe a comparable approach for TRAK, where patients use the intervention in conjunction with face-to-face sessions. This hands-on approach, coupled with structured guidance and education in My Dear Knee and TRAK, is believed to enhance the participants' understanding and execution of exercises, promoting self-efficacy and adherence to the intervention (Rogers et al. 2016; Collado-Mateo et al. 2021). My Knee Exercise by Nelligan et al. (2019), while seemingly minimalistic in its approach with a "Contact us" button, offers a direct line of communication. This simple feature can be powerful, providing users with an avenue to seek clarification, report issues or get additional support when needed.

DETA prioritises participant safety by monitoring for adverse events. The proactive approach of a research coordinator periodically checking in via telephone ensures that any potential issues are promptly addressed. Additionally, users are encouraged to report adverse events, fostering a sense of responsibility and trust in the platform. While The Knee OA (MVP) by Mrklas et al. (2020) and My Knee toolkit by Goff et al. (2023) do not specify direct communication features, they are designed to complement in-person care, allowing users to report progress and concerns, thereby facilitating more effective patient-provider interactions during visits.

2.5.3.*3 Evaluating the usability of digital health interventions for chronic knee pain self-management support*

The International Organisation for Standardisation (ISO 9241-11, 2018) defines usability as "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". Early assessment of usability, including satisfaction rates, can provide insights into future user behaviour and adoption, which explain the high interest in it in five out of the seven DHIs included in this review (de Beurs et al. 2017; Spasić et al. 2015; Button et al. 2018; Nelligan et al. 2019; Shewchuk et al. 2021). Usability is recognised as a fundamental aspect of best practice in creating digital applications, with numerous established standards citing it as a critical criterion for evaluating DHIs (NHS England 2018; MHRA 2021; ORCHA 2024). The focus on usability is particularly pertinent in healthcare applications, where users may encounter difficulties due to health-related or age-related challenges (Whitlock and McLaughlin 2012; Zapata et al. 2015).

Usability assessments can employ qualitative, quantitative or mixed-method approaches, each of which is capable of providing distinct insights into the user experience, crucial for refining and improving the intervention's design and usability (Budiu 2017; Barnum 2021). The choice of method often depends on the specific objectives of the assessment and the stage of development (Barnum 2021). In the studies by Spasić et al. (2015), Shewchuk et al. (2021) and Goff et al. (2023), usability testing took place during the co-design phase. This stage of development is critical for pinpointing potential enhancements, and the qualitative feedback obtained was particularly valuable. It provided detailed insights into how users interact with the

system, identified specific functional issues and offered a deeper, contextual understanding of the user experience.

Feedback from the participants on the TRAK App suite, The Knee OA (MVP) and My Knee toolkit interventions consistently highlighted three key areas for improvement: readability, personalisation and user engagement (Spasić et al. 2015; Shewchuk et al. 2021; Goff et al. 2023). With regards to readability, there was a concerted call for enhancing the clarity of content. This included streamlining the language within the TRAK App suite and the The Knee OA (MVP) to make it more understandable. Additionally, suggestions for My Knee toolkit and the The Knee OA (MVP) focused on increasing the font size and boosting contrast to better serve users with varying visual abilities and literacy levels. Also, the feedback across the studies underscored the need to tailor the interventions more closely to users' individual needs, highlighting the impact of personalisation on psychological factors such as motivation and engagement (Burgers et al. 2015; Hutmacher and Appel 2022). Users of the TRAK App suite proposed the integration of a goal-setting feature, whereas for The Knee OA (MVP) and My Knee toolkit, there was an emphasis on customising exercise programs to match users' specific physical activities and requirements. Participants suggested several enhancements to the interventions to bolster user engagement. For the TRAK App suite, these included transitioning from static imagery to interactive videos along with the addition of a progress tracker and reminders. For The Knee OA (MVP), the introduction of a rewards system for goal attainment was recommended. Users of My Knee toolkit called for an increased number of videos featuring real-life experiences and expert advice to provide more depth and context to the user experience. These insights suggest that users are looking for DHIs that are not just informative but also adaptive and responsive to their evolving health needs and lifestyles. Quantitative data alone cannot provide sufficient information to achieve this degree of personalisation and responsiveness (Alwashmi et al. 2019).

Spasić et al. (2015) and Shewchuk et al. (2021) extended their usability assessments to include quantitative evaluations of the overall usability of their interventions. They employed the System Usability Scale (SUS), a reliable metric where scores exceeding 68 suggest above-average usability (Brooke 1996). The TRAK App suite achieved SUS scores of 78 from patients and 75 from physiotherapists, indicating its high

usability (Brooke 1996; Spasić et al. 2015; Vlachogianni and Tselios 2021). In contrast, The Knee OA (MVP) received lower SUS scores, with patients rating its usability as marginal at 57.8 and physicians deeming it unacceptable at 39.1 (Shewchuk et al. 2021). While Shewchuk et al. (2021) did not provide reasons for these low scores, it is assumed that the disparity in usability scores between the knee OA (MVP) and the TRAK App suite may be attributed to the different user demographics in the studies. The TRAK App suite was assessed by a younger cohort, with patients averaging 23.12 years and physiotherapists 37.46 years, whereas The Knee OA (MVP) was evaluated by an older group, with patient and healthcare professional mean ages of 68 and 43.5 years, respectively. It has been established, as per Bangor et al. (2008), that older age groups tend to give lower SUS scores, potentially due to a decrease in technological engagement as age increases.

In contrast, the usability of Hinge Health by Smittenaar et al. (2017) and My Knee Exercise by Nelligan et al. (2019) was rated during the trial. At this point, the developers' interest in usability tended to focus on evaluating user satisfaction. User satisfaction, recognised by the ISO 9241-11 (2018), is closely linked to the likelihood that users will recommend the DHI to others. The scores reflect not only the users' approval of the system's functionality but also their endorsement of the intervention as an effective form of healthcare delivery (Manzoor et al. 2019). Smittenaar et al. (2017) assessed user satisfaction of Hinge Health by employing the Net Promoter Scale, a common tool for determining user satisfaction in online health applications (Hajesmaeel-Gohari et al. 2022). In their study, participants with chronic knee pain rated their likelihood to recommend the program on a scale from 0 to 10. The results showed a high satisfaction rate, with scores averaging 9.2 at week 12 and slightly increasing to 9.3 by six months, indicating a consistent endorsement of the program. Nelligan et al. (2021) collected satisfaction scores of My Knee Exercise in their RCT on a scale from 0 to 7. The intervention group's satisfaction score was 5.6 out of 7, significantly higher than the control group's 4.4, reflecting a favourable response to the DHIs.

2.5.4 User engagement with digital health interventions for chronic knee pain self-management support

Engagement, as defined by Christensen et al. (2009), is the measure of how many participants fully experienced the proposed intervention and remained committed to it through the completion of the trial. Kelders et al. (2012) further clarify engagement as the extent to which a patient's actions correspond with the prescribed regimen set forth by the healthcare provider. Investigating engagement within the included interventions at this level of review is thought to help determine whether clinical effectiveness outcomes can be attributable to the intended interaction with the intervention. Out of the seven DHIs reviewed, five assessed user engagement. These are Hinge Health, TRAK, My Knee Exercise, DETA and My Dear Knee. These DHIs primarily determined engagement by monitoring participants' adherence to prescribed exercise programs (Mecklenburg et al. 2018; Button et al. 2018; Nelligan et al. 2021; Gruner et al. 2021; Alasfour and Almarwani 2022).

Engagement in My Knee Exercise and My Dear Knee was assessed consecutively through user self-reports, using exercise logs and the validated Exercise Adherence Rating Scale (Newman-Beinart et al. 2017). Significant results were reported for both interventions, favouring the intervention groups compared to the control groups (Nelligan et al. 2021; Alasfour and Almarwani 2022). There was a significant between-group difference in adherence rates (26.60% higher in the app group), with a moderate effect size in My Dear knee. Similarly, users of My Knee Exercise demonstrated a significant between-group difference in adherence, with a mean difference of 2.6 units on the Exercise Adherence Rating Scale, favouring the intervention.

Conversely, in Hinge Health and DETA, the user engagement data collection was automated in the intervention arm and self-reported in the control arm. This discrepancy in assessment approaches across groups undermined the validity of direct comparisons between results in this review. For Hinge Health, engagement was measured based on the intervention group's completion rate of the program components, but the absence of a parallel assessment for the control group precluded a comparative analysis. The intervention group's data revealed that 59 out of 87 participants (67%) finished the 12-week digital program, maintaining a 95% weekly

engagement rate. Similarly for DETA, participant engagement was automatically monitored through the app by tracking the duration of exercise video views, considering a session complete if over 75% was watched. In contrast, the control group self-reported their session attendance. Despite these differing methodologies, the results indicated no significant variance in the average number of weekly sessions between the DETA group (2.6 sessions) and the control group (3.2 sessions) ($P > .05$).

In TRAK, different aspects were measured to assess user engagement (Button et al. 2018). With regards to patients, engagement was measured through logging onto the website and 12-week follow-up assessments (Button et al. 2018). Among the 48 patients in the TRAK group, 32 (66.67%) accessed TRAK from their homes and 29 (60%) completed the follow-up assessments. Engagement among physiotherapists was evaluated based on the creation and updates of personalised exercise plans for patients. Out of 32 physiotherapists in the TRAK group, 29 (91%) co-created personalised plans but only 11 (34%) made updates, reflecting a decrease in website use over time. This study outperformed other studies reviewed by illustrating the difference in engagement levels between patients and physiotherapists, which is important to understand when healthcare providers are an active part of the proposed DHI. The observed reduction in physiotherapist engagement over time shed light on potential environmental and organisational challenges critical to consider when developing DHIs for integration into clinical practice. The physiotherapists in Button et al. (2018) mention factors such as the length and scheduling of appointments, limited time for TRAK usage during consultations, inadequate training on TRAK and technology access within physiotherapy services. Button et al. (2018) present these usage statistics without explicitly mentioning the data sources, which presumably came from the system's backend. The data was initially gathered to inform the future application of TRAK and identify training needs, but the lack of detailed data reporting was noted as a limitation by the study's authors.

Engagement results and user satisfaction scores discussed earlier, both can indicate user “acceptance” of the technology proposed, which represents more than mere performance indicators of a technology during trials (Borsci et al. 2019). They embody a complex combination of intrinsic and extrinsic factors that shape users' perceptions, reflecting an interchange between system design, usability, and individual and

environmental influences (Borsci et al. 2019). To deconstruct and interpret these multifaceted results, researchers have developed theoretical models, with the Technology Acceptance Model (TAM) emerging as a pivotal construct, predicated on the dual pillars of perceived usefulness and perceived ease of use (Davis 1989). The model's focus on cognitive factors potentially neglects the role of emotional, social, and contextual variables in shaping technology acceptance (Bagozzi 2007). Recognising these limitations, subsequent iterations of TAM have attempted to broaden its scope. For instance, the Unified Theory of Acceptance and Use of Technology (UTAUT) incorporated social influence and facilitating conditions, while UTAUT2 further expanded to include hedonic motivation, price value, and habit (Venkatesh et al. 2003). These expansions reflect a growing acknowledgment of the multifaceted nature of technology acceptance. However, they may not provide the strongest theoretical foundation for studying patient adoption and continued use of technology due to differences in the factors influencing health behaviours, such as social, emotional, personality, and cognitive factors (Adler and Matthews 1994). For instance, the Patient Technology Acceptance Model has been developed to address the unique factors influencing technology acceptance in healthcare contexts (KL and Karsh 2006). Moreover, there is an increasing recognition of the dynamic nature of technology acceptance, suggesting that user perceptions and behaviours may evolve over time as they gain experience with a system. This temporal aspect of technology acceptance underscores the importance of adaptive interventions in promoting sustained technology use, particularly in healthcare settings where long-term engagement is crucial for managing chronic conditions (Almutairi et al. 2023).

In conclusion, while models like TAM and its extensions have provided valuable insights into technology acceptance, future research should focus on developing more flexible, context-sensitive frameworks that can account for the complex interplay of individual, social, and environmental factors in shaping technology adoption and use. Such approaches will be particularly vital in healthcare settings, where the successful implementation of digital health interventions depends on an understanding of patient needs, preferences, and contexts.

2.5.5 Assessing the clinical effectiveness of digital health interventions for chronic knee pain self-management support

Evaluations of non-operative interventions for chronic knee conditions focus on pain relief as a key indicator of treatment success, given its strong association with disability and functional limitations in knee conditions (Creamer et al. 2000; Sandhar et al. 2020; Naja et al. 2021). A total of four DHIs out of the seven selected in this review assessed their effectiveness on pain and function, namely Hinge Health, My Knee Exercise, DETA and My Dear Knee (See Table 9) (Mecklenburg et al. 2018; Nelligan et al. 2021; Gruner et al. 2021; Alasfour and Almarwani 2022). These studies compared the DHIs with controls, for example, standard treatment in Mecklenburg et al. (2018), physiotherapy care in Gruner et al. (2021) and education in Nelligan et al. (2021). The outcomes are generally encouraging, with significant improvement in pain and physical function consistently being reported by individuals with chronic knee pain.

DHIs / developers	**Author of the RCT**	**Participant characteristics** Age, BMI: mean ± SD, and Sex: (N female/male)	**Comparator**	**Follow-up**	**Outcome measures**	**Results** Intervention vs Control
Hinge Health Smittenaar et al. (2017)	Mecklenburg et al. (2018)	**Intervention:** 46 ± 12, 27 ± 5, (43/58) **Control:** 47 ± 12, 28 ± 4, (14/40)	Knee care education and usual treatment.	12 weeks	**Pain:** KOOS **Function:** Short version KOOS physical function.	**Pain:** (Significant reduction of 7.7, 95% CI 3.0 to 12.3, P=.002) in favour of intervention. **Function:**(Significant improvement in physical function (7.2, 95% CI 3.0 to 11.5, P=.001) in favour of intervention.
My Knee Exercise Nelligan et al. (2019)	Nelligan et al. (2021)	**Intervention:** 60.3 ± 8.2, 31.1, (60/43) **Control:** 59 ± 8.5, 31.6, (66/37)	My Knee Education website	24 weeks	**Pain:** Numerical rating scale **Function:** WOMAC	**Pain:** (mean difference, 1.6 units; 95% CI, 0.9-2.2 units; P < .001) in favour of intervention. **Function:**(mean difference, 5.2 units; 95% CI, 1.9-8.5 units; P = .002) in favour of intervention.

DETA Gruner et al. (2021)	Gruner et al. (2021)	**Intervention:** 58.5 ± 13.7, 26.7 ± 3.7, (12/12) **Control:** 55.9 ± 13.3, 27.5 ± 4.4 (9/17)	Conventional Physical Therapy	8 weeks	**Pain:** PROMIS-PI **Function:** PROMIS-FS	**Pain:** (-6.1 ± 6.7 vs -1.5 ± 6.6, P<.05, d=0.78) **Function:** (6.0 ± 6.6 vs 0.8 ± 5.8, P<.01, d=0.89)
My Dear Knee Alasfour and Almarwani (2022)	Alasfour and Almarwani (2022)	**Intervention:** 53.65 ± 3.96, N/A, (all female) **Control:** 55.15 ± 4.64, N/A, (all female)	Exercise program in hand-outs.	6 weeks	**Pain:** Arabic Numeric Pain Rating Scale **Function:** Short (WOMAC)-physical function subscale	**Pain:** (Significant difference between-groups 1.08, P= .015) in favour of intervention. (p<.001) **Function:** (Insignificant difference between-groups, P=.619). (p<.001)

Table 9: Details of the RCTs assessed the effectiveness of the selected DHIs for chronic knee pain on clinical outcomes. Abbreviations: **DHIs** Digital Health Interventions, **DETA** Digital Exercise Therapy Application, **RCT** Randomised Controlled Trial, **BMI** Body Mass Index, **SD** Standard Deviation, **N** Number, **KOOS** Knee Injury and Osteoarthritis Outcome Score, **WOMAC** Western Ontario and McMaster Universities Osteoarthritis Index, **PROMIS** Patient-Reported Outcomes Measurement Information System, **PI** Pain, **FS** Function.

Mecklenburg et al. (2018) conducted an RCT to evaluate the Hinge Health app. This involved comparing two groups over a 12 week period, one of which used the app while the other was given three education pieces on self-care for chronic knee pain. Both groups also had access to treatment as usual. The study involved 162 participants with chronic knee pain, 57% of whom were female, with an average age of 46 (SD 12) years. The intervention group, comprising 101 participants, showed notable improvements in terms of pain and function as assessed by the Knee Injury and Osteoarthritis Outcome Score (KOOS) and its short version for physical function validated outcome measures (Roos et al. 1998; Roos and Lohmander 2003; Perruccio et al. 2008). Results show significant improvements in the KOOS pain subscale and short scale, with 7.7- and 7.2- points, respectively. However, while the reported improvements were statistically significant, they may not have reached the threshold for minimal clinically important difference (MCID), typically considered to be 8 to 10 points (Roos and Lohmander 2003). This suggests that although the intervention demonstrated potential, the clinical significance of the reported improvements might be less impactful for patients than initially perceived. The study's methodological rigor was evident in its use of block randomisation to ensure balanced group characteristics and the application of computer software for randomisation. Block randomisation is favoured in RCTs because it can help ensure a balance between groups and maintain consistent baseline characteristics (McPherson et al. 2012; Bruce et al. 2022). The study lacks complete blinding, which may introduce biases that could impact the internal validity of its results (Kamper 2018). While blinding in research evaluating technology against standard treatments may pose challenges, it is noteworthy that in Mecklenburg et al. (2018), the inclusion of a technology component in the control arm could have facilitated blinding as potentially participants and assessors would have been distracted from discerning the true nature of the intervention.

Similarly, Nelligan et al. (2021) narrowed the focus of their RCT, limiting their assessment of My Knee Exercise to online self-management education. Their study took place over a 24 week period and involved 206 knee osteoarthritis patients, 61% of whom were female, with a mean age of 60 (SD 8.4) years. The participants were evenly distributed between intervention and control groups. Pain and function were assessed using a numerical rating scale and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) function subscale, respectively (Bellamy

et al. 1988). The intervention group showed greater improvements in knee pain and physical function, with significant differences in outcomes. The participants who engaged with the My Knee Exercise program had greater improvements in overall knee pain of 1.6 points (95% CI, 0.9 to 2.2 points; P < .001) and physical function of 5.2 points (95% CI, 1.9 to 8.5 points; P = .002) when compared with the control group. The P-values indicate that the differences between the intervention and control groups were statistically significant (P < .05). However, the MCID for function subscale in the WOMAC is generally considered to be approximately 11 points, suggesting that while statistically significant, the improvements in function may not represent clinically meaningful changes for patients (Tubach et al. 2005). This study stands out due to its strict application of blinding to both participants and assessors, enhancing the reliability of the results and minimising the risk of biases. The robustness of the blinding process in this study ensures that the observed benefits in pain and function can be more confidently attributed to the intervention itself rather than external factors. Yet, as with Mecklenburg et al. (2018), the clinical significance of the improvements warrants a more cautious interpretation.

Gruner et al. (2021) compared DETA to conventional physical therapy in their RCT. Their study, which took place over an 8 week period, involved 50 participants with nonoperative knee conditions, 42% of whom were female, with an average age of 57.1 years (SD 13.4). They were divided into two groups: a DETA group with 24 participants and a control group with 26. The study's sample size is smaller compared to those in Mecklenburg et al. (2018) and Nelligan et al. (2021), warranting careful interpretation of its findings. Despite this limitation, the study boasts high methodological quality (Toonders et al. 2023). The participants were primarily assessed (PROMIS) for pain and function using the Patient-Reported Outcomes Measurement Information System for pain and physical function (Brodke et al. 2016; Crins et al. 2018). The DETA group reported a significant decrease in pain scores of 6.1 points (95% CI, 3.5 to 8.4 points, P<.05, d=0.78) and a significant increase in function scores of 6.0 points (95% CI, -1.6 to 3.3 points, P<.01, d=0.89) compared to the control group after 8 weeks of using DETA. While statistically significant, the lack of established MCIDs for the PROMIS measures in knee pain populations complicates the interpretation of the clinical relevance of these improvements. However, the study did not blind its participants, potentially introducing performance bias (Kamper 2018). While achieving blinding in

behaviour change interventions may seem unfeasible, Boutron et al. (2007) recommend concealing participants' trial group assignments and specific study aims to reduce performance bias as much as possible. Nevertheless, the results of this study suggest that self-management support DHIs may be as effective as, or even superior to, traditional physiotherapy in managing chronic knee pain and improving function.

Alasfour and Almarwani (2022) investigated the effectiveness of My Dear Knee compared to traditional paper handouts in a study that took place over a 6 week period and included 40 female participants, averaging 54.40 (SD 4.3) years. They were equally divided between the intervention (My Dear knee) group and the control group, which was given a printed copy of the same exercise program. Pain was assessed using the Arabic Numeric Pain Rating Scale, which uses a scale from 0 to 10, with 10 indicating the worst pain, and is a valid and reliable tool for assessing pain intensity in patients with knee OA. Physical function was measured using the Arabic version of the reduced (WOMAC)-physical function subscale (Alghadir et al. 2016a; Alghadir et al. 2016b). The participants in the intervention group reported a statistically significant decrease in pain, but improvement in physical function was not significant when compared with the control group. Specifically, the mean difference between-groups for pain was -1.08, which was statistically significant ($p = .015$) with an effect size of 0.165. For physical function, the intervention group showed an average within-group improvement of 5.11 points (95% CI 2.45 to 7.77), which is below the 6.5 points required for clinical significance, although the confidence interval (CI) did encompass the value considered clinically meaningful. The study's methodology incorporated simple randomisation, which ensures unpredictability but might not provide a balanced distribution of baseline characteristics in smaller sample sizes (Xiao et al. 2011). This could introduce a potential limitation in the study's design. Additionally, outcome assessors were not blinded in this study, raising concerns about detection bias (Mansournia et al. 2018; Higgins et al. 2023). The study's focus on female participants reflects the unique challenges faced by Saudi women in adhering to home-based exercise routines. While this focus provides valuable insights into this demographic's needs, it also narrows the generalisability of the study findings.

The reviewed RCTs display methodological differences, particularly in terms of sample size, blinding and randomisation techniques, calling for a cautious approach when interpreting their results. However, the presence of other robust methodological elements within these studies lends weight to their findings when combined and suggests broader applicability, as follows. Firstly, a consistent effort to minimise potential confounders is evident across all studies with computerised randomisation (Mecklenburg et al. 2018; Nelligan et al. 2021; and Gruner et al. 2021; Alasfour and Almarwani 2022). Secondly, the sample sizes in the four RCTs range from 40 to 206 participants, with each study aiming for a balance between precision and statistical power to detect clinically important differences (Embry and Piccirillo 2020). Thirdly, a moderate spectrum of participant ages, with means ranging from 46 to 60 years, was included in all the studies combined (Mecklenburg et al. 2018; Nelligan et al. 2021; Gruner et al. 2021; Alasfour and Almarwani 2020). Studies by Mecklenburg et al. (2018) and Gruner et al. (2021) feature a relatively younger participant base, focusing on general knee pain management. Conversely, the remaining two studies predominantly involve an older demographic, aligning more with the common age group afflicted by knee OA (Nelligan et al. 2021; Cui et a. 2020; Alasfour and Almarwani 2020). Lastly, gender representation within the studies is also thoughtfully considered, given the heightened susceptibility of females to this type of chronic pain (Cui et al. 2020). Apart from Alasfour and Almarwani (2022), there is a commendable trend of inclusive gender participation across the RCTs (Mecklenburg et al. 2018; Nelligan et al. 2021; Gruner et al. 2021). However, while the current evidence suggests promise for DHIs in this field, there is significant room for improvement in terms of clinical impact. By focusing on these area, future developers can work towards creating interventions that not only demonstrate statistical significance but also deliver meaningful, noticeable benefits to individuals suffering from chronic knee pain.

2.5.6 Lessons learned from the selected digital health interventions for chronic knee pain self-management support in this section

It can be inferred from the literature above that iterative co-design is a recognised practice, it being well-documented in some of the selected DHIs in this review (Spasić et al. 2015; Button et al. 2018; Mrklas et al. 2020; and Goff et al. 2023). However, these DHIs have not been thoroughly tested for clinical or cost-effectiveness in order to understand the value of this development strategy (Goff et al. 2023). This reflects a

common trend in healthcare research, where the full potential of co-designed interventions, particularly in terms of their impact on health management and long-term user engagement, remains underexplored (Grindell et al. 2022). Despite this research gap, the healthcare field is increasingly advocating for co-design, especially in behavioural interventions for self-management support (Michie et al. 2017). The upfront investment in co-design, both in financial and time resources, is substantial, but the expected benefits are assumed to outweigh cost (Silvola et al. 2023). These potential benefits include the possibility of reducing healthcare costs, lowering risks and improving the quality of healthcare services, which emphasises the importance of co-design in creating personalised, effective and adaptable DHIs (Silvola et al. 2023).

Additionally, the reviewed literature reveals a concerted effort by developers of the selected DHIs to enhance user engagement and uptake, aiming to optimise the impact on clinical outcomes. A general agreement regarding the choice of strategies to stimulate engagement is evident, albeit with variations in their implementation. Given the geographic diversity of these interventions, these differences likely stem from the tailored nature of these DHIs, suggesting that developers chose the most suitable engagement methods based on the specific needs and context of their target population (Berkowsky and Czaja 2015). The level of detail reported about the interventions also varies, with some studies providing greater transparency than others. This inconsistency in reporting limits the ability to fully compare and contrast the interventions, a challenge that is recognised within the broader field of digital behavioural interventions (Thomas Craig et al. 2021).

In this review, the importance of evaluating the usability of DHIs was emphasised by the developers of most of the studied DHIs, aligning with the guidelines for best practices in digital innovation (NHS England 2018; MHRA 2021; ORCHA 2024). The assessment of usability varied across the DHIs, with diverse evaluation methods tailored to specific goals and stages of development being employed. While qualitative methods were used to refine interventions for better alignment with the needs of the target audience, quantitative assessments measured users' digital skills and their overall satisfaction with the interventions (Barnum 2021). However, notable exceptions were observed in the case of "DETA" by Gruner et al. (2021) and "My Dear Knee" by Alasfour and Almarwani (2022), where no usability testing was reported,

marking a significant oversight in their development process. Despite Alasfour and Almarwani's (2022) intention to create a user-friendly platform, they did not detail the strategies or methods employed to achieve usability, leaving a gap in their design's validation.

The effort put into designing and testing the proposed DHIs by the developers was reflected in their users' engagement. As per the four studies examined, the results of engagement were commendably high, indicating that the components of these DHIs successfully encourage sustained participation in exercise regimens. This finding adds to discussions surrounding the potential waning of users' interest and engagement over time (Wangberg et al. 2008; van Ballegooijen et al. 2014). However, the methodologies used to measure engagement present certain limitations that could compromise the integrity of the findings. For instance, My Knee Exercise and My Dear Knee relied on self-reporting, which is susceptible to inaccuracies due to recall bias or a tendency to provide socially acceptable responses rather than truthful ones, as noted by Latkin et al. (2017) and Burnell et al. (2021). Conversely, Hinge Health and DETA employed automated tracking for engagement, which likely yields more accurate data but does not allow for direct comparison with control groups not using the same method. This inconsistency in engagement measurement across studies, which has been previously highlighted by Yang et al. (2022), poses challenges for comparing the results of health interventions across different studies and may undermine the validity of such comparisons.

With regards to clinical effectiveness, the reviewed self-management support DHIs offer a promising method for managing chronic knee pain. They provide outcomes that are comparable with or better than those achieved through standard care and physiotherapy. However, the evidence from merely four studies is not robust enough to conclusively affirm the overall clinical effectiveness of DHIs. Despite this, the positive indications from these preliminary studies offer an encouraging sign, warranting additional research to further explore and validate the efficacy of DHIs in this context.

2.6 Self-management support in Saudi healthcare: practices, perceptions and technological integration

2.6.1 Setting the scene for the section

The term self-management has recently appeared in Saudi-specific literature (Al Johani et al. 2015). An examination of the Saudi Arabian literature on self-management support revealed there are only two published studies in the domain of musculoskeletal conditions, whereas the practice is widely used in the management of other health conditions, predominantly diabetes (Adem 2017; Al Johani et al. 2015; Alasfour and Almarwani 2022). There is a significant burden of chronic musculoskeletal disorders, particularly OA, within the Saudi population, placing the nation among the top three for OA cases in the Middle East and North Africa region (Shamekh et al. 2022). Recent local research highlights the extent of the issue, with knee OA reported as affecting between 18.9% and 41.5% of the country's 32 million residents (AlKuwaity et al. 2018; Thigah and Khan 2020; Shamekh et al. 2022; GASTAT 2022). The observed limited interest in self-management support for knee conditions in the Saudi literature raises questions regarding its application in clinical practice and the adherence of physiotherapists to evidence-based practice (Diener 2021).

2.6.2 Perspectives on self-management support among Saudi physiotherapists

Within the limited literature on Saudi research on chronic musculoskeletal pain self-management support, Adem's (2017) doctoral thesis stands out as a pioneering study examining the perspectives of physiotherapists and patients on this matter. Utilising a mixed-methods approach, Adem explored the intricacies of chronic lower back pain treatment to shed light on the dominant practices in Saudi physiotherapy settings and provide a foundational understanding of self-management support within the Saudi healthcare context.

In the first phase of the study, Adem (2017) surveyed a total of 101 physiotherapists from 18 cities across Saudi Arabia, focusing on their assessment of and treatment methods for chronic lower back pain. The results show a predominant focus on pain alleviation (45.5%) rather than functional improvement (27.7%) among

physiotherapists, influencing their preference for pain-centric outcome measures to estimate treatment success. Exercise and advice emerged as the most common treatment modalities chosen by 71.3% and 67.3% of the sample, respectively, yet there was a notable reliance on passive interventions like hot packs and electrotherapy (38.6%). The study highlighted a significant gap in the adoption of clinical practice guidelines, with 77% of the participants not following any standardised protocol for chronic lower back pain, which helps explain the therapist's reliance on passive treatment modalities. This finding aligns with the results of Alshehri et al. (2017), who explored the awareness and application of evidence-based practice among Saudi physiotherapists. Their survey of 376 physiotherapists revealed that 75.6% of them were relying on personal experience to make clinical decisions in their daily practice and approximately 23% were not familiar with the term evidence-based practice.

In Adem's (2017) study, 61.4% of the physiotherapists who completed the survey reported that they were integrating self-management support strategies into their daily practice. Adem (2017) also conducted semi-structured interviews with 18 physiotherapists and 16 chronic lower back pain patients, providing valuable clarification regarding the physiotherapists' actual perceptions of self-management support strategies. This approach highlights the importance of combining different sources of data to achieve a more comprehensive understanding of a phenomenon, particularly in unexplored areas (Teddlie and Tashakkori 2008; Dawadi et al. 2021). Based on the interviews, Adem (2017) found that physiotherapists and patients with chronic lower back pain in Saudi maintain a wide range of interdependent expectations, preferences and practices. Physiotherapists acknowledge the significance of active and self-management support strategies but often prioritise passive pain relief modalities, including electrotherapy and massage, to meet patient expectations and foster treatment adherence. Indeed, the patients included in the study show a high preference for receiving passive treatments, such as rest and massage, which may stem from cultural norms, past healthcare experiences or a quest for immediate pain relief (Adem 2017). This preference for passive treatments is corroborated by Alshehri et al. (2020), who found such modalities, often discouraged in clinical practice guidelines, to be prevalent in Saudi physiotherapy practice.

Adem's (2017) research further revealed that while some patients were open to active management strategies, particularly when paired with passive treatments, their knowledge of self-management practices was often limited to basic exercises and posture correction. This narrow perspective on self-management support is also reflected in the physiotherapists' approach. Although they promote active lifestyles, there appears to be a notable deficiency in their understanding and application of behaviour change models to promote the desired behaviour change, suggesting a gap in their training on the broader concepts of self-management support. This observation is corroborated by Alodaibi et al. (2022), who conducted a qualitative study into Saudi physiotherapists' perceptions of their role in promoting health among patients with musculoskeletal conditions. The study makes clear that while physiotherapists recognise the critical nature of lifestyle behaviour modification as part of patient care, they often lack the skills necessary to facilitate these changes. This highlights a gap in both undergraduate and postgraduate training that contributes to this shortfall in delivering comprehensive self-management support in Saudi (Dean et al. 2019; Alodaibi et al. 2022).

Additionally, during the interviews, physiotherapists expressed their intention to create personalised treatment plans that consider the patient's lifestyle (Adem 2017). However, they frequently reverted to prescribing treatment methods on their own due to a concern that patient participation might challenge their professional authority. This behaviour was also observed in the Saudi DHI My Dear Knee by Alasfour and Almarwani (2022), where physiotherapists alone chose the exercises for the intervention, excluding patients with knee OA from the decision-making process. This tendency suggests a paternalistic attitude towards patient involvement in decision-making, which is likely a reflection of the biomedical model's influence within the Saudi healthcare system, as discussed in the literature (Walston et al. 2008; Almoajel et al. 2012; Alotaibi et al. 2022). Despite this, there is an emerging trend in recent studies, including those by Alshehri et al. (2020) and Alotaibi et al. (2022), pointing towards a gradual shift to patient-centred care within the Saudi healthcare system. This shift, however, is not yet fully apparent in the day-to-day practices of physiotherapists, as documented by Adem (2017) and others (Al-Sahli et al. 2021). The transition to a more inclusive, collaborative model of care is underway, but the current situation suggests that more work is needed to align clinical practices with this evolving paradigm.

The study by Adem (2017) also highlights physiotherapist concerns regarding the constraints on their professional autonomy when it comes to assessment and treatment within the Saudi healthcare system. They perceive these constraints as impediments to effectively advocating for self-management approaches. The debate over the autonomy of physiotherapists in Saudi Arabia is well-documented, with discussions covering multiple issues, ranging from the need for direct access to the prevailing dominance of physicians in the healthcare system (Alghadir et al. 2020; Alosaimi et al. 2022). The literature presents mixed evidence on this matter; some sources, such as in Al-Imam and Al-Sobayel (2014) and Muaidi and Shanb (2016), suggest that physiotherapists enjoy considerable control over their clinical decisions, whereas others indicate the opposite (Alghadir et al. 2020). Nonetheless, when professional autonomy is restricted, it can significantly hinder the incorporation of contemporary, evidence-based care practices into daily practice alongside the more traditional methods that are commonly used (Lim et al. 2021).

2.6.3 Patient engagement in Saudi self-management programs

This subsection synthesises the existing data on Saudi patients' attitudes towards self-management support programs in order to establish a general understanding of levels of engagement with this model of care within the Saudi healthcare system as well as the present challenges. Studies on Saudi patients' attitudes towards self-management practises have so far been confined to diabetic patients (Al Johani et al. 2015; Saad et al. 2018; Alshahri et al. 2020). Such patients may differ from those with chronic knee and/or musculoskeletal pain; however, investigating the attitudes of patients who live in the same geographical region, hold similar cultural beliefs and are treated by the same healthcare system may aid in gaining a general understanding of the factors that influence acceptance and engagement (McQuaid and Landier 2017).

The level of patient engagement with self-management support programs among the diabetic population was determined by assessing glycaemic control (Al Johani et al. 2015; Saad et al. 2018; Alshahri et al. 2020). Al Johani et al. (2015) recruited a total of 201 participants aged between 26–65 years old with type 2 diabetes and gave them a questionnaire to complete. The results obtained from the questionnaire’s responses

show that only 15% of the participants had a controlled glucose level. The authors attributed this to the low compliance to self-management practices by the participants. Similar results were also reported by Alshahri et al. (2020). Though both studies are cross-sectional in design and the findings cannot be generalised, they suggest that despite the availability of such programs, there may be a lack of awareness, motivation, or both among those who participated in these studies.

Al Johani et al. (2015) found that diabetic patients were advised to follow a range of self-management practices, such as diet, exercise and self-monitoring of blood sugar levels. However, the advice they received fell short of international standards for self-management education in diabetes (American Diabetes Association 2009). Patients participating in the study reported not receiving any education from their clinicians that explained the importance of these activities for their condition. It appears that self-management behaviours were introduced to the patient merely as part of the usual treatment to be applied at home and were not accompanied by comprehensive education on their importance. This educational deficit is confirmed by of Saad et al. (2018) and Alshahri et al. (2020), who found that nearly 60% of patients lacked access to essential education about their condition, which is supposed to underpin self-management education. Adem's (2017) thesis further illuminates this issue, revealing that patients with lower back pain also reported receiving inadequate information from their physiotherapists, hence not addressing their concerns or the hesitancy of the disease.

Furthermore, an examination of self-management support programs for diabetes revealed another possible contributing factor. The absence of tailored self-management strategies that consider the needs of each patient may have contributed to the unsatisfactory engagement. The focus of programs has been on standard self-management practices that are globally recommended for diabetes care, including diet, exercise, foot care, medication management and glucose monitoring (Toobert et al. 2000; Al Johani et al. 2015; Saad et al. 2018; Alshahri et al. 2020). Although these practices are supported by international guidelines, the research suggests that the distinct cultural, personal and individual variances among patients are being ignored and there is a tendency to advise a standardised approach. This issue was also evident in the use of the knee-focused intervention My Dear Knee by Alasfour and

Almarwani (2022), where uniform exercise routines were provided to all app users, overlooking the critical role of personalisation in self-management support. Nonetheless, the user engagement with this digital solution was more positive than the engagement levels noted in the studies by Al Johani et al. (2015), Saad et al. (2018) and Alshahri et al. (2020), possibly due to the educational content and the inclusion of visual and interactive elements in the application.

2.6.4 Technological advancements in Saudi self-management support

Digital self-management support was first used in Saudi Arabia's healthcare system in the treatment of diabetes, providing a prototype for new interested developers to emulate. The online program SANAD, which translates to "support" in Arabic, embodies this innovative spirit. Designed by Alanzi et al. (2016), SANAD is a pioneering dual-platform system, comprising a patient-facing mobile app and a clinician-oriented website. This program is not only a tool but also a catalyst for change, designed to inspire diabetic patients to embrace an active role in their health management. By tracking and reporting their glycaemic readings, emotional well-being and daily behaviours, patients provide clinicians with a real-time window into their condition to facilitate patient-practitioner communication. The role of SANAD is to work as a supportive tool that facilitates symptom tracking and improves communication with healthcare practitioners, aligning with The Knee OA (MVP) and My Knee toolkit (Mrklas et al. 2020; Goff et al. 2023).

My Dear Knee, the home-based exercises app for women with knee OA previously discussed in this chapter, is another example of technology being used in the Saudi Healthcare system to encourage patients to manage their conditions (Alasfour and Almarwani 2022). However, some differences can be noticed between SANAD by Alanzi et al. (2016) and My Dear Knee. Patients using SANAD are active participants in their care, working collaboratively with their healthcare provider to monitor their condition (Alanzi et al. 2016). However, in Alasfour and Almarwani (2022), the participants using My Dear Knee were passive recipients of exercise regimes that were prescribed for them. Additionally, SANAD was developed via multi-stages of research, including co-design along with usability and feasibility assessment. This reflects the practice followed globally to effectively develop digital self-management

support interventions, particularly for knee conditions, as discussed previously in this review (Skivington et al. 2021). SANAD was built upon qualitative research that explored the perceptions of future users of this kind of remote management (Alanzi et al. 2014). Further studies were conducted to assess the application, aiming to evaluate its face validity and user satisfaction. The data showed that it was usable and feasibly could achieve its aims. Moreover, the patients included in the study were satisfied and supportive of the digital tool (Alanzi et al. 2016, 2018). This multi-stage effort to develop the application was not applied with My Dear Knee, particularly in terms of the lack of inclusion of user comments on the concept of the application and the digital literacy necessary to deal with such tech solutions for a prolonged period to manage chronic pain (Alasfour and Almarwani 2022).

Despite the generational differences between the SANAD and My Dear Knee participants, the average age of the former being 30 and the latter 54, their shared willingness to engage with technological solutions is indicative of the broader digital proficiency within the Saudi population (Alanzi et al. 2014; Alasfour and Almarwani 2022). This is evident in the high rates of technology device usage across diverse demographic groups in Saudi Arabia (Kemp 2023). Notably, even among the elderly, who are often presumed to be less tech-savvy, there is a substantial engagement with the Internet, with usage rates between 74.5% and 93.3% among Saudis aged 60 and above (Olson 2022; CST 2022). This widespread digital engagement is a direct result of the country's digitalisation initiatives, which have made technology an integral part of accessing various services, thereby fostering an environment conducive to the adoption of technology in healthcare self-management.

2.6.5 Lessons learned from the reviewed literature in this section

The existing body of literature reveals a complex situation regarding healthcare self-management support within the Saudi context. While Saudi physiotherapists have been found to recognise the value of self-management practices in managing chronic musculoskeletal pain, a notable gap between their conceptual understanding and practical application is evident (Adem 2017). Furthermore, physiotherapists were found to dictate care, with low involvement of patients in care decision making, which is not conducive to effective self-management as this relies on a collaborative

relationship between patient and health provider (Walston et al. 2008; Almoajel et al. 2012; Allinson and Chaar 2016; Adem 2017; Liu and Jiang 2019; Hong and Oh 2020; Alotaibi et al. 2022). Also, passive treatment approaches were found to be primarily used in physiotherapy treatment plans based on patient preferences and to deviate from updated clinical guidelines (Adem 2017; Alshehri et al. 2017; Alshehri et al. 2020).

The literature reviewed in this section also revealed a critical insight into Saudi patients' engagement with self-management support programs. Studies focusing on diabetic Saudi patients have shown low adherence to self-management practices, with education about the importance of these practices often lacking (Al Johani et al. 2015). Saudi patients exposed to this type of self-led program were not given proper self-management education and plans were not personalised to meet individual needs (Adem's 2017; Saad et al. 2018; Alshahri et al. 2020). These findings highlight the gaps in knowledge of healthcare providers in Saudi with regards to self-management support. These programs are often implemented into healthcare systems globally in stages, which include training healthcare providers on how to empower patients to co-lead the care through education, skill building and two-way communications (Leplege et al. 2007; Edvardsson et al. 2008; Silver 2018). The way in which Saudi healthcare providers were found to deliver self-management programs does not foster collaboration or empower patients and indicates a paternalistic approach to care.

Interestingly, the literature reviewed provides a glimpse of digital integration in the Saudi context that supports self-management. This is exemplified by initiatives like the SANAD program for diabetes care and the My Dear Knee app for knee OA management (Alanzi et al. 2014; Alasfour and Almarwani 2022). SANAD is a comprehensive dual-platform that engages diabetic patients in self-monitoring and clinician communication, unlike the more passive My Dear Knee app, and was meticulously developed through co-design and usability testing, unlike its counterpart. The reported willingness of Saudi patients in these studies to engage with these technological solutions, regardless of generational gap, underscores a broader trend of digital proficiency within the population (Kemp 2023). This digital readiness paves the way for the future integration of technology into healthcare self-management

support, promising to enhance the patient-provider relationship and improve health outcomes in Saudi Arabia.

2.7 Gaps in the literature and conclusion

Research within Saudi Arabia has highlighted the notable presence of chronic knee pain and Knee OA among its population, with cultural and environmental factors potentially contributing to its prevalence (AlKuwaity et al. 2018; Thigah and Khan 2020; Shamekh et al. 2022). There is a global trend of empowering patients by incorporating self-management support into treatment paradigms. This approach aims to improve quality of life, promote independence and alleviate healthcare burdens (Grady and Gough 2014; Dineen-Griffin et al. 2019). Despite the prevalence of musculoskeletal conditions in Saudi Arabia, which reflects global patterns, the Saudi literature shows a gap in the evidence on integrating self-management support into clinical settings, particularly for chronic knee pain.

The work of Adem (2017) reveals a willingness among Saudi physiotherapists to innovate and adapt, yet there is a scarcity of research activity that has resulted in a dearth of comprehensive literature. Adem's (2017) findings offer valuable insights into the current practices of Saudi physiotherapists and their engagement with self-management support for chronic lower back pain, providing a crucial starting point for researchers and intervention developers. Nonetheless, this information alone is not enough to fully depict the broader context across different regions, conditions or demographics within Saudi Arabia. To advance the understanding of self-management in Saudi Arabia's healthcare setting, it is important to focus the investigative lens on healthcare practitioners and patients to gain insights beyond those provided by Adem (2017). A robust exploration that includes the perspectives of physiotherapists and individuals with chronic knee pain across various demographics will meaningfully enhance the knowledge base.

Global efforts to integrate self-management support into the management of chronic knee pain have taken advantage of technological advancement and the wider adoption of mobile devices around the world. This has manifested in a growing number of DHIs designed to exclusively support individuals with chronic knee pain self-manage via evidence-based online resources and interactive features that were developed based on an understanding of behaviour change theories (Spasić et al. 2015; Smittenaar et al. 2017; Nelligan et al. 2019; mrklas et al. 2020; Gruner et al. 2021; Alasfour and

Almarwani 2022; Goff et al. 2023). Preliminary data on these interventions reveals their power to catch the attention of users and encourage them to engage in positive behaviours, which translates into less pain and improved function. However, literature on the Saudi context does not reflect this global effort, especially in relation to chronic knee pain. Alasfour and Almarwani (2022) are a rare exception. Their study provides insights into a specific subset of the population with chronic knee pain, namely older females, which may not reflect the broader demographic affected by this condition in Saudi Arabia.

To the best of the researcher’s knowledge, there is a notable gap in the literature concerning the perspectives of both physiotherapists and individuals with chronic knee pain on self-management support and digital integration. To date, no published study has specifically explored these key stakeholders' needs or skills in relation to utilising digital health solutions in Saudi Arabia. Understanding these perspectives is crucial to developing effective self-management strategies tailored to their needs. This approach is reinforced by previous recommendations in the literature that highlight the necessity of this research to lay a foundational understanding for future studies and for researchers interested in this field. Moreover, this research will enhance the clinical practices of physiotherapists in Jeddah and across Saudi Arabia, ultimately furthering the provision of advanced care in the management of chronic knee pain.

2.8 Research aim and questions

2.8.1 Overarching research aim

To explore digital self-management support for knee pain within current physiotherapy practices in Jeddah, Saudi Arabia.

2.8.2 Research questions for phase 1

Q1: How do current physiotherapy practices for knee conditions in Jeddah, Saudi Arabia align with self-management support principals?

Q2: How do physiotherapists and individuals with knee pain attending physiotherapy settings in Jeddah, Saudi Arabia perceive digital self-management support initiatives?

2.8.3 Research question for phase 2

How usable is the "TRAK-Saudi" platform for physiotherapists and individuals with chronic knee pain in Jeddah, Saudi Arabia?

The next chapter outlines the philosophical assumptions that guided the selection of the research paradigm, followed by the choice of research design, which was chosen to answer the research questions and fulfil the overarching aim of the study.

Chapter Three: Philosophical Underpinnings and Research Design

3.1 Introduction to the chapter

The chapter discusses the researcher's philosophical assumptions and the paradigm chosen to accomplish the research aim. It then discusses the selected research design and the reasons behind the choice. Together, these elements lay the groundwork for a comprehensive understanding of this research framework and approach, guiding the exploration that follows.

3.2 Research philosophy

A researcher's approach to any research they are conducting is influenced by their worldview, which is comprised of their beliefs and philosophical assumptions about the nature of the world and the development of knowledge (Guba and Lincoln 1994; Creswell 2018). These philosophical assumptions guide the entire research process, underpinning the way in which data pertaining to a phenomenon is gathered, analysed and used (Creswell 2014). Researchers choose a paradigm that fits their worldview, beliefs and philosophical assumptions when conducting research. That paradigm is a framework that informs the entire research process, from defining the research question to deciding how it should be answered, that is, which methods should be chosen to investigate the phenomena, and interpreting the findings, all of which ensure the reliability and validity of the research (Creswell 2014).

There is a seemingly ever-expanding plethora of paradigms, but four broad paradigms, positivism, constructivism, transformative and pragmatism, are commonly discussed in the literature (Creswell 2014; Sekaran and Bougie 2016; Kivunja and Kuyini 2017). Each of these is based on assumptions related to the following elements: ontology *(What is the nature of reality?),* epistemology *(What is the relationship between the researcher and that being researched?)*, axiology *(What is the role of values?)*, methodology *(What is the process of research?)*, and rhetoric of research *(What is the language of research?)* (Lincoln and Guba 1985; Kaushik and Walsh 2019). Every paradigm has its own perspective on each of these elements (Kaushik and Walsh 2019). More detail regarding the purpose and application of the paradigms and their perspectives on these elements are presented in Table 10.

Paradigm	Definition	Ontology (What is the nature of reality?)	Epistemology (What is the relationship between the researcher and that being researched?)	Axiology (What is the role of values?)	Methodology (What is the process of research?)	Rhetoric (What is the language of research?)
Positivism	Helps in generating causal relationships or associations that will help predict and control a phenomenon under investigation.	Singular reality	Distance and Impartiality (Data collected using tools)	Researchers conduct bias checks. (Unbiased)	An existing theory is tested by researchers. (Deductive) (Quantitative)	Formal style
Constructivism (also known as interpretivism)	Affirms that people develop subjective meanings toward things, which are influenced by the historical and cultural background	Multiple realities	Closeness and subjectivity (Data collected through site visits)	Researchers actively discuss and use their own biases and interpretations. (Biased)	From participants' views, researchers build patterns, theories, and interpretations. (Inductive) (Qualitative)	Informal style

Transformative	Examines the history or needs of a marginalised group in society, linking political, economic, and social aspects	Multifaceted and based on different social and cultural positions.	Collaboration (Active collaborative relationship with participants)	Based on human rights and social justice for all.	Researchers engage participants at all stages of the research process and conduct cyclical results reviews. (Participatory) (Either qualitative or quantitative)	Advocacy, activist-oriented
Pragmatism	Explores knowledge about a problem through mixed method design. (Problem-oriented)	Singular and multiple realities.	Practicality (Researchers collect data according to what best answers the research question)	Researchers include biased and unbiased opinions.	Researchers combine quantitative and qualitative data. (Combinatory)	Formal or informal style

Table 10: Research paradigms.
Sources: Creswell (2014), Sekaran and Bougie (2016), and Creswell and Clark (2017).

3.2.1 Pragmatism as the paradigm chosen for this research

Positivism, which is typically aligned with quantitative methods in natural science research, emphasises a reliance on measurable and observable facts to generate evidence (Smith 2015). However, a purely positivist approach, focusing solely on numerical data, may fall short when exploring the subjective experiences and meanings associated with complex human behaviour (Johnson and Onwuegbuzie 2004). An exploration of these aspects is crucial in order to gain a comprehensive understanding of the phenomena being investigated in this study.

On the other hand, constructivism, which primarily advocates qualitative methods, is effective in exploring meanings and experiences (Denzin and Lincoln 2011), but it too has some restrictions. This paradigm could be an appropriate choice when exploring participants' perceptions, such as their views on self-management support and the integration of technology into Jeddah's context. However, it limits further exploration, in the case of this study of the way key stakeholders deal with digital health solutions in real-life scenarios to build a rounded analysis of the subject matter. This is considered important in order to uncover potential needs and shortfalls in the user-technology relationship.

Although constructivism, with its qualitative focus, adeptly explores meanings and experiences, it presents challenges for fully achieving the aim of this research (Denzin and Lincoln 2011). Specifically, while it can facilitate in-depth exploration into participants' perspectives on self-management support and technology integration, it cannot adequately capture how stakeholders interact with digital self-management support solutions in practical, real-world scenarios. This gap is pertinent in the Saudi context regarding chronic knee pain management. Understanding these interactions is fundamental for exploring user-technology engagement in the Jeddah's context to determine whether the intended users are prepared for the shift towards digital healthcare management (NHS England 2021). To address this, the research involved introducing participants to a digital self-management support platform nearing completion, within a usability study designed to replicate real-world use. Given the website's advanced development stage, experts in usability recommend quantitative testing approaches (Barnum 2021). These approaches are invaluable for producing

consistent, precise data, facilitating the direct interpretation of results and enabling modifications and improvements to the proposed platform. Therefore, in the case of this research, a mixture of qualitative and quantitative data collection methods was deemed appropriate to achieve the research aim.

Researchers' perspectives on the possibility of integrating quantitative and qualitative methods in a single study have led to a division into two distinct groups: purists and pragmatists (Tashakkori and Teddlie 1998). Purists maintain a stance against the mix of these two methodologies, arguing that the fundamental differences between quantitative and qualitative approaches – in terms of their underlying philosophies, methodologies and types of data generated – are too significant to allow for effective integration (McEvoy and Richards 2006). They believe that each approach has its own unique strengths and limitations that are not compatible when combined. On the other hand, pragmatists advocate for a more flexible and inclusive approach. According to Sekaran and Bougie (2016), pragmatists support the use of diverse methods, both quantitative and qualitative, if they collectively contribute to a more comprehensive understanding and answer the research questions more effectively. This group of researchers posits that by integrating quantitative and qualitative methods, the strengths of one approach can offset the weaknesses of the other (Creswell and Creswell 2018). For example, the objectivity and generalisability of quantitative methods can complement the depth and detail provided by qualitative methods (Austin and Sutton 2014; Rosenthal 2016; Silverman 2017). The pragmatism paradigm, introduced by pragmatists, is characterised by its unique practical approach, which advocates for the use of research methods from different paradigms within a single study (Feilzer 2010). This approach is particularly justified when addressing complex or unexplored phenomena, which is the case in this research, as it allows for a more comprehensive understanding by combining different methodological perspectives (Glogowska 2011).

3.3 Research design: mixed methods

Mixed methods research aligns well with the pragmatic research paradigm, offering a comprehensive approach by integrating both qualitative and quantitative research methods. As described by Johnson et al. (2007), this research strategy involves a

combination of different viewpoints, data collection, analysis and inference techniques from both qualitative and quantitative domains.

The mixed methods approach stands out as particularly effective and compelling for studies introducing digital initiatives in healthcare settings. This integrative strategy is not just beneficial but essential, as argued by Palinkas et al. (2015) and Kip et al. (2020). They highlight the urge for diverse data types to illuminate the various dimensions of health technology implementation. This approach facilitates a thorough exploration of the context, the stakeholders involved and the technology itself, offering a comprehensive understanding that is often unattainable with a single methodological approach (Greenhalgh 2004; van Gemert-Pijnen et al. 2011; van Gemert-Pijnen et al. 2018). For example, while quantitative methods like questionnaires are adept at identifying broad patterns and trends, they may not adequately uncover the deeper, more nuanced reasons and motivations behind the acceptance or rejection of new technologies (Feijt et al. 2018). Conversely, qualitative methods, such as interviews, provide rich, contextual insights but might lack the wide-ranging generalisability and objectivity offered by quantitative approaches, elements that are crucial for a fully rounded analysis of new technological implementations (Johnson and Onwuegbuzie 2004). Employing different research methods bridges the gap between the depth of qualitative insights and the breadth of quantitative analysis. This balanced and comprehensive strategy ensures a more complete understanding of the complex interplay between people, technology and context that it is essential to grasp, particularly in unexplored settings like Jeddah, Saudi Arabia (Venkatesh et al. 2016; Sieverink et al. 2017; Sieverink et al. 2019).

Mixed methods research has four different designs which are convergent (concurrent), sequential explanatory, sequential exploratory and embedded (nested) design (Creswell and Clark 2017). More information about these designs is presented in Table 11.

Design	Process	Purpose	Level of interaction between methods	Priority
Convergent (concurrent)	Qualitative Quantitative	Answering a research question with different but complementary data	Data collected and analysed independently	Equal
Sequential explanatory	Quantitative then qualitative	Qualitative data collected to explain the quantitative findings	Quantitative data shapes qualitative data collection	Quantitative dominant
Sequential exploratory	Qualitative then quantitative	Quantitative data builds on qualitative findings	Qualitative data shapes quantitative data collection	Qualitative dominant
Embedded (Nested)	Qualitative (quantitative) or Quantitative (qualitative)	Answering a complementary research question with different data	An embedded dataset provides answers to a complementary research question	Could be Qualitative or Quantitative dominant

Table 11 Designs of mixed methods research.
Source: Creswell and Clark (2011, 2017).

In this study, a sequential exploratory design was chosen, drawing on the guidelines of O'Cathain et al. (2010) and Creswell and Creswell (2017), to investigate chronic knee pain self-management support within Jeddah's physiotherapy settings. This decision was guided by the innovative nature of the topic and the exploratory objectives of the research (Halcomb and Hickman 2015). The research was structured into two distinct phases, where insights from an initial qualitative study (Phase 1) informed the subsequent quantitative study (Phase 2). This approach necessitated a sequential rather than concurrent mixed methods design (Halcomb and Hickman 2015; George 2022). Further details of these phases of research are explained as follows along with their integration process.

3.3.1 Phase 1: an exploratory descriptive qualitative study

In this mixed methods research, an exploratory descriptive qualitative study was chosen to address the research questions (Hunter et al. 2019). This design is well-suited to explore and describe the experiences and perspectives of potential users of digital self-management support initiatives for chronic knee pain within physiotherapy clinics in Jeddah. Such exploratory research is recommended for mixed methods research exploring healthcare practices, especially in areas of interest that have received little or no previous research attention, as is the case with chronic knee pain self-management support in Jeddah (Sandelowski 2000; Hunter et al. 2019). Establishing a qualitative foundation before introducing digital self-management support initiatives in new settings has been deemed an important step (Öberg et al. 2018; Freilich et al. 2020; Frisinger and Papachristou 2023). This importance is attributed to the fact that individual interpretations, personal narratives and the intricate dynamics of cultural and social factors play crucial roles in shaping the reception and engagement with self-management support programs (Harvey et al. 2015; Varsi et al. 2021). Utilising an exploratory descriptive qualitative study at this initial stage of investigation facilitates the generation of clear and first-hand accounts of phenomena, such as the insights of patients or healthcare professionals on specific occurrences or experiences (Sandelowski 2000; Turale 2020). Aligned with the aim of this study, this exploratory framework has also been identified in recent literature as a methodological approach in assessing the feasibility of technology integration within healthcare settings, confirming its appropriateness for this research context (Olaye and Seixas 2023; Dostie et al. 2023; Frøiland et al. 2023).

3.3.2 Phase 2: a quantitative usability study

In this phase, a usability study was conducted to evaluate the usability of TRAK-Saudi platform among Saudi users. In the development of digital solutions, usability testing stands as a widely adopted method to verify whether the intended users can use the proposed platform as intended (Hardy et al. 2018; Schneiderheinze et al. 2019; Maramba et al. 2019). Usability testing, as described by Barnum (2021), involves observing user interactions with a digital system to assess task performance and provides valuable insights into the overall user experience. Guo et al. (2020) highlight that healthcare providers are hesitant to adopt a solution without evidence supporting

its various features, including usability. Notably, the Saudi literature lacks assessment of user experiences with digital health solutions, especially in the context of knee conditions. Consequently, this study was designed to address this gap, establishing groundwork for future developers in the area. The knowledge gained will support further improvements, identify training needs for potential users, and facilitate the creation of effective integration strategies that align with the specific needs of Jeddah-based users, in line with recommendations from a recent NHS England report on digital transformation in social care (NHSX 2021).

3.3.3 Integration of phases

In mixed methods research, integrating qualitative and quantitative elements can greatly enhance research effectiveness (Bryman 2006; Creswell and Clark 2011). Mixing produces more comprehensive investigation of the research question (Glogowska 2011; Zhang and Creswell 2013). As stated by Fetters et al. (2013), integration can be implemented at different levels of the research process, including design, methods, interpretation and reporting.

This research adopted an exploratory sequential design, as recommended for research with limited prior knowledge on the topic, to integrate mixed method data effectively (Fetters et al. 2013; Halcomb and Hickman 2015), employing one of the four integration strategies, which are connecting, building, merging and embedding, as outlined by Fetters et al. (2013). The "building" approach was specifically chosen in this research to integrate data at methods level (Skamagki et al. 2024). This approach allowed insights from Phase 1 to inform and establish a foundation for the quantitative phase that followed, enhancing the depth of the investigation. In specific, the findings from Phase 1 were instrumental in adapting an existing self-management support intervention, TRAK, resulting in a version tailored to meet the specific needs and recommendations of the Saudi participants (Spasić et al. 2015; Button et al. 2018) (further details can be found in Chapter 5). This strategy of adapting an existing intervention for a new context, endorsed by Moore et al. (2021), was chosen for its potential efficiency over developing a new platform from scratch. Button et al. (2018)'s was tailored to the UK healthcare system, whereas the current study adapts TRAK specifically for Jeddah, addressing unique cultural, social, and healthcare

infrastructure considerations. Button et al. (2018)'s work primarily evaluated TRAK's effectiveness in the UK. The current study, however, focused on the critical first step of assessing the adapted TRAK's usability in the Saudi context, laying groundwork for future effectiveness studies.

Additionally, to achieve integration at the levels of interpretation and reporting, Chapter 7 discusses the findings from both phases of research. This is to assist future researchers who aim to introduce digital self-management support initiatives for knee pain in Jeddah or comparable settings. It provides insights that surpass what could be inferred from the qualitative and quantitative results separately (Creswell and Clark 2017; Skamagki et al. 2024).

3.4 Conclusion

This research, which was grounded in a pragmatic paradigm, adopted an exploratory sequential mixed methods design to explore digital self-management support for chronic knee pain within current physiotherapy practices in Jeddah, Saudi Arabia. This methodological choice, supported by the literature, effectively integrates qualitative and quantitative methods to capture a comprehensive view of the research topic, integrating experiences, perceptions, environmental context and technological specifics.

The next chapter presents all the information related to the first phase of this research titled with “Perceptions of physiotherapists and individuals with knee pain of digital self-management support in physiotherapy for chronic knee pain: an exploratory descriptive qualitative study in Jeddah, Saudi Arabia”. It covers methods, findings, discussion, clinical implications, study limitations and conclusion to the chapter.

Chapter Four: Phase 1 - Perceptions of Physiotherapists and Individuals with Knee Pain of Digital Self-Management Support in Physiotherapy for Knee Pain: An Exploratory Descriptive Qualitative Study in Jeddah, Saudi Arabia

4.1 Introduction to the chapter

This chapter starts with outlining the first phase of the research using mixed methods methodologically. This is followed by a presentation of the findings. Subsequently, the chapter progresses to a discussion of the key findings, thoroughly addressing the following research questions for this phase in relation to relevant literature:

Q1: How do current physiotherapy practices for knee conditions in Jeddah, Saudi Arabia align with self-management support principals?

Q2: How do physiotherapists and individuals with knee pain attending physiotherapy settings in Jeddah, Saudi Arabia perceive digital self-management support initiatives?

4.2 Research methods for Phase 1

This study adopted an exploratory descriptive qualitative design, as explained earlier in Chapter 3 (Hunter et al. 2019). It is a qualitative design most appropriate for exploring areas where direct literature is unavailable, but surrounding ones are present, which could not provide an accurate understanding of chronic knee pain digital self-management support in Jeddah's physiotherapy clinics (Hunter et al. 2019; Turale 2020). To address the research questions for this phase, in-depth interviews were chosen as the data collection method. The subsections that follow detail the methods used in this phase and the reasons behind these choices.

4.2.1 Study setting

This study focuses on physiotherapy departments in Jeddah, Saudi Arabia. Jeddah is the second-largest city in Saudi Arabia, having a population of 4.7 million across 95 districts (See Figure 3). Jeddah, a port city that lies on the east coast of the Red Sea, is a key economic, cultural and religious hub (Al-Hathloul and Mughal 1991; Belarem et al. 2020; Britannica 2021; Baradah 2023). Its multicultural population, enriched by global immigrants and traders, creates a cultural mosaic that makes it the perfect

environment for research that aims to shed light on diverse healthcare needs (Allmark 2004; Freitag 2020). The healthcare dynamics in Jeddah are uniquely shaped by the Hajj season, an annual Islamic pilgrimage to Mecca, Saudi Arabia, which is the holiest city for Muslims (Radwan 2021). Every year, millions of pilgrims pass through Jeddah en route to Mecca, necessitating an adaptive healthcare system that can accommodate the needs of both pilgrims and local residents (Naji et al. 2020; Rahaimy 2023). This context makes Jeddah a prime location for studies on technology in healthcare (Ahmed et al. 2021; Alwadie et al. 2021; Algahtani and Shirah 2022; Alzahrani et al. 2023; Wali et al. 2023). Furthermore, transportation challenges in Jeddah, like high car dependency and limited public transport, pose barriers to healthcare accessibility (Okaz/Saudi Gazette 2022). While the Saudi Ministry of Health has introduced online health services, a gap remains in physiotherapy, underscoring the need for broader healthcare solutions (Yousef 2023).

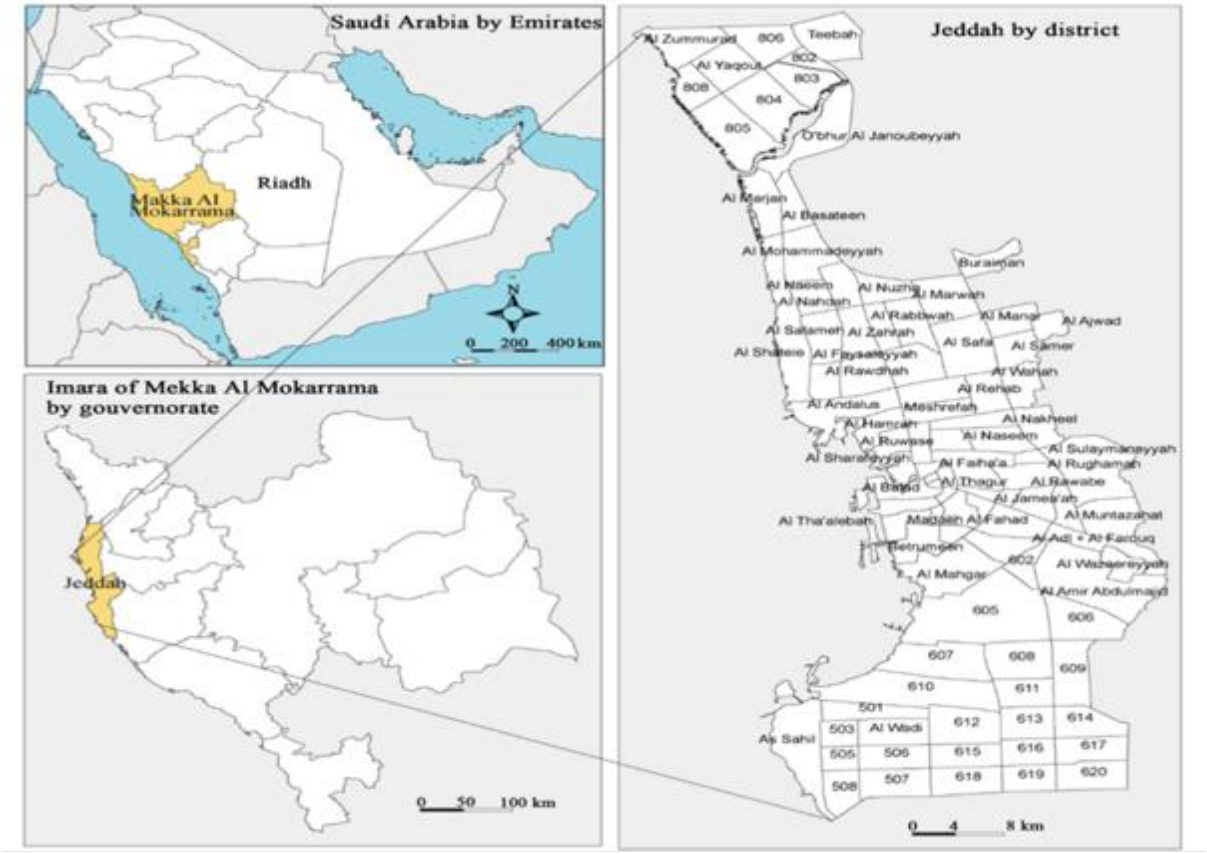

Figure 3: Map of Jeddah.
Source: Belarem et al. (2018).

In this study, three public hospitals and one private clinic in Jeddah, each situated in distinct city areas, were selected as research locations (refer to Figure 4). The choice of different healthcare settings serves to broaden the participant population and capture a wide range of perspectives while acknowledging the complex interplay between different healthcare delivery models. The public hospitals, among the four regional hospitals in Jeddah with high bed occupancy rates, represent the backbone of the city's healthcare system (Murad et al. 2024). Two of these hospitals, located on the city's periphery, primarily serve the rural outskirts, while the third, situated near the main university, serves the academic community and nearby residents. In contrast, the private clinic, acclaimed for its physiotherapy and rehabilitation services, especially for musculoskeletal conditions (Belarem et al. 2020; Pavi 2023).

This intentional mix of public and private facilities allows for an exploration of how organisational structures, resource allocation, and operational motivations influence physiotherapy practices (Lucifora 2023). Public hospitals, often driven by the need to manage long waiting lists and serve a broad population, may approach physiotherapy delivery differently from private clinics which operates under a different paradigm often influenced by medical insurance schemes (Al-Hanawi et al. 2018; Al-Hanawi et al. 2020; Belarem et al. 2020; Chandrprakash 2021; Pavi 2023). The MRC framework for developing complex interventions emphasises the importance of understanding contextual differences for effective implementation across various healthcare settings (Craig et al. 2008). By exploring physiotherapy practices across this spectrum of healthcare environments, this study aimed identify both universal challenges and setting-specific issues, aligning with contemporary frameworks for developing complex healthcare interventions. While this diversity introduces potential confounding factors, it addresses the limitation of local bias often found in studies restricted to a single location, as highlighted by Shenton (2004). This decision enhances the study's depth and validity while providing a foundation for developing interventions that can be adaptable and effective across various healthcare settings in Jeddah (Nowell et al. 2017).

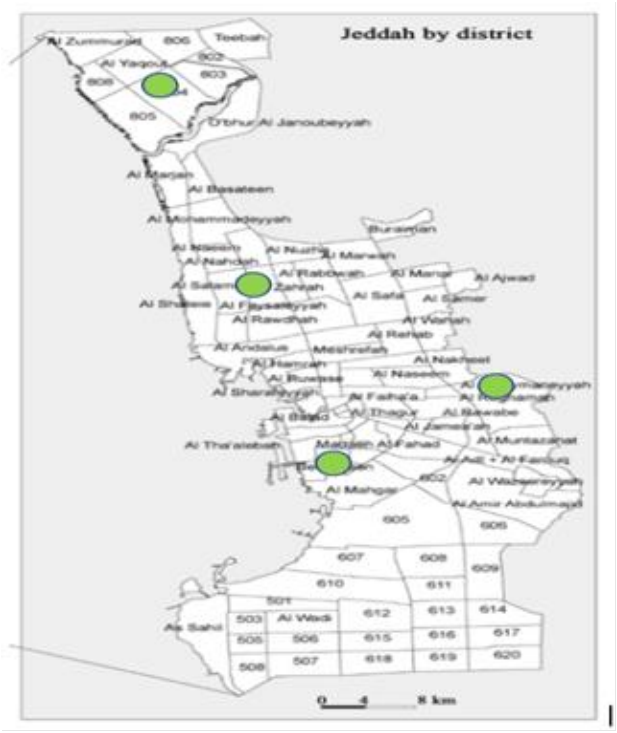

Figure 4: Locations of the selected physiotherapy departments on the city map (green dots).
Source: Belarem et al. (2018).

4.2.2 Participants

This section outlines and justifies the chosen population, sampling technique, sample size and recruitment procedure. Emphasising the importance of these aspects, Sebele-Mpofu (2020) highlights that a lack of proper justification for the chosen sample size and sampling methods can significantly affect the credibility and validity of qualitative research, making a thorough explanation in this subsection essential.

4.2.2.1 Population

This study was conducted with the involvement of two key participant types: physiotherapists dealing with knee conditions and individuals undergoing treatment for subacute/chronic knee pain in physiotherapy clinics. The subsequent paragraphs detail the reasoning behind the inclusion of these participant types, highlighting their unique contributions to the research.

The inclusion of physiotherapists as key stakeholders in this study is due to the central role they play in managing chronic knee pain (Teo et al. 2020). Their input is

particularly relevant since they are responsible for administering the non-pharmacological and exercise-based primary treatment for chronic knee pain and thus have unique insights into patient responses to this (Cross et al. 2014; Bannuru et al. 2019). They are therefore in a strategic position to contribute valuable perspectives on the practicalities of care, potential challenges and patient behaviours. As physiotherapists are potential primary users of future digital self-management support solutions, gaining a full understanding of their attitudes, readiness to adopt new technologies and training needs is crucial. Their input is assumed to influence future integration of these digital solutions into clinical practice and help ensure that they are not only effective but also in keeping with the realities of physiotherapy practice.

Furthermore, this qualitative exploratory study focuses on individuals undergoing physiotherapy for subacute (1-2 months) and chronic pain (3 months or more) (Bussières et al. 2016; Nicholas et al. 2019). Therefore, participants in this phase will collectively be referred to as individuals with knee pain throughout the text. It provides first-hand insights into the realities of knee pain management within Jeddah's physiotherapy settings. The inclusion of individuals with subacute pain alongside those with chronic knee pain deemed important, as subacute knee pain has a high potential to progress into a chronic condition (Kastelein et al. 2011; Kastelein et al. 2015). The exploratory nature of this study justifies a broader sampling approach, aiming to gather rich, diverse data that contribute to a comprehensive exploration. By including participants at various stages of their pain journey, the study seeks to reveal how physiotherapy practices, individual behaviours, and contextual factors in Jeddah may influence the progression of knee pain, identifying areas for further improvement whether in practice or personal behaviours (Bombard et al. 2018). This approach provides a dynamic picture of the current situation, essential for understanding individual needs and expectations, as well as the factors that impact long-term engagement and adherence to digital self-management support solutions (Qama et al. 2022; Whitehead et al. 2024).

The combined input of both participant types in this study was instrumental to addressing the study questions, each offering a different yet complementary perspective, facilitating triangulation of the data (Lincoln and Guba 1985; Tracy 2010; Stahl and King 2020). Triangulation, a method used in qualitative research, serves to

boost its credibility, which pertains to the degree of confidence in the accuracy and authenticity of the research findings (Lincoln and Guba 1985; Stahl and King 2020). The intention, in this study, was not to draw comparisons between these participant types, except in instances where contrasting views emerged that were critical to understanding certain aspects of the study.

4.2.2.2 Sampling technique

The participants were selected using purposive and snowball sampling techniques. This decision was informed by an assessment of various sampling methods frequently employed in qualitative research, as outlined by Gill (2020). Purposive sampling was chosen for its ability to deliberately select individuals who possess specific expertise and knowledge relevant to the research topic (Cresswell and Clark 2011). Despite some criticisms of its subjective nature, purposive sampling is valuable for capturing diverse perspectives and in-depth insights, given the varied experiences and characteristics of the participants (Etikan et al. 2015; Creswell and Clark 2017). Additionally, snowball sampling was employed, leveraging recommendations from department heads and already participating physiotherapists to identify and reach additional suitable candidates. This method effectively expanded the participant pool, ensuring a more comprehensive range of viewpoints for the study.

The sampling was guided by a specific set of eligibility criteria, as outlined below. This method was used to secure a diverse and representative sample that could assist with answering the study questions and to increase the likelihood of producing reliable and reproducible results (Hulley et al. 2013; Nikolopoulou 2022).

Physiotherapists

- Inclusion criteria: Physiotherapists who are licensed by the Saudi Commission for Health Specialties, work in outpatient clinics and regularly treat patients with knee conditions with no restriction placed to the work experience duration. This is because the study's aim was to explore perceptions, not to evaluate clinical outcomes directly tied to experience levels. All included physiotherapists were actively engaged in treating knee conditions, ensuring they met the fundamental requirement to contribute relevant insights. The diversity in

experience levels believed to enrich the data, providing a more understanding of how digital solutions is perceived across different stages of professional development.

- Exclusion criteria: Physiotherapists who are in their internship year as they may not yet have the opportunity to practice independently or make autonomous clinical decisions (Clouder and Adefila 2017; Stoikov et al. 2022).

Individuals with knee pain

- Inclusion criteria: Individuals aged 18 years or older, referred for physiotherapy specifically for knee pain, who are proficient in reading and writing in either Arabic or English and are willing to participate.
- Exclusion criteria: Individuals for whom the primary source of pain is not the knee.

4.2.2.3 Sample size

Determining the right sample size for qualitative research is the subject of ongoing debate that centres on achieving depth in understanding research topics (Sebele-Mpofu 2020). While "saturation" is a commonly referenced concept used to denote when a sample size has provided comprehensive and reliable data, scholarly opinions on its definition and practical application differ (Mason 2010; Saunders et al. 2018; Low 2019; Guest et al. 2020; Sebele-Mpofu 2020). Despite these differences, saturation is typically acknowledged to be a subjective judgment, based on whether all aspects of a theory are represented, whether new data are merely repeating existing information and whether the data collected are sufficiently detailed and relevant (Saunders et al. 2018; Sebele-Mpofu 2020).

However, it is important to clarify that saturation was not the primary aim of this study. Instead, the study was designed with an exploratory approach in mind, seeking a wide breadth of viewpoints in unexplored areas within the Jeddah context. For this purpose, purposive sampling was employed to select participants who could offer diverse and comprehensive insights, effectively representing the varied perspectives within the Saudi population (Moser and Korstjens 2018). Furthermore, an examination of

relevant literature facilitated the identification of common practices in interview-based research. In their systematic review, Vasileiou et al. (2018) focused on sample sizes in qualitative health research spanning 15 years and discovered a median of 30 interviews in studies published in respected medical journals such as the British Medical Journal and the Sociology of Health and Illness Journal. This figure aligns with the sample sizes typically observed in doctoral studies similar to this employing mixed methods and qualitative interviews. Notably, the research of Adem (2017) and Subahi (2021) lies within this category, usually incorporating between 26 to 34 interviews, thus further validating the interview numbers discovered by Vasileiou et al. (2018). With all this in mind, this study was designed to address its research questions using a purposive sample that aligns with established norms in qualitative research practice.

4.2.2.4 Recruitment procedure

The recruitment for the study began with sending a detailed explanation of the study and its eligibility criteria to the heads of physiotherapy departments at each site, recognising their role as gatekeepers. To facilitate clear communication, they were given study posters (Appendix B) and eligibility criteria sheets in both Arabic and English, the languages spoken in Saudi (Kaye 2018; AlRawi 2022). These gatekeepers then disseminated the information amongst their teams, inviting participation to effectively broaden the reach within the departments, thus fulfilling the purposive sampling. Interested physiotherapists contacted the researcher via the contact information listed on the posters for final eligibility (phone/email) and to discuss study details. Participating physiotherapists also actively engaged in the process by referring interested colleagues, thus fulfilling the snowball sampling. In addition, the physiotherapists assisted in recruiting individuals with knee pain by identifying eligible participants according to the set criteria. The diagnosis of knee pain was confirmed during their assessment to ensure accuracy and exclude any incorrect referrals. These participants were then invited to contact the researcher based on the study's posted details.

Upon showing initial interest, both physiotherapists and individuals with knee pain were provided with participant information sheets, consent forms and an interview guide (appendix C, D, E, F). These documents, detailing participant roles and rights and the study's scope, were prepared according to Cardiff University's guidelines for

studies involving human participants. They also informed participants of their right to withdraw at any point without their professional or patient status being impacted. Consent forms are crucial for matters like audio recording consent and anonymous scientific publication. Participants were given these documents at least 72 hours before their scheduled interview to allow sufficient time for informed decision-making. They also had the opportunity to discuss any aspect of their participation with the researcher before making a final decision to participate. No incentives were provided for participation in this study.

4.2.3 Data collection technique

In this study, semi-structured in-depth interviews were chosen to explore participants' perceptions and experiences as these are recognised as an effective tool for facilitating direct interaction in qualitative research (Hammarberg et al. 2016; Hennink et al. 2020). Unlike focus groups, which may inhibit free expression among participants due to any conflicting views making them feel uncomfortable, in-depth interviews offer a private setting that encourages openness and detailed personal insights (Kitzinger 1995; Moen and Middelthon 2015). This method employs an interview guide (explained in the next section) to maintain focus while remaining flexible in order to explore emerging themes, a practice well-established in healthcare research (Russell and Gregory 2003; Shenton 2004; Moen and Middelthon 2015; Knott et al. 2022).

The suitability of semi-structured interviews for the Saudi population is much debated in the existing literature. AlKhatrawi (2013) points out that participants' unfamiliarity with the interview process often leads to difficulties in engaging effectively, especially when considering the discomfort associated with recordings and the conduct of one-to-one interviews by researchers of a different gender. These challenges are typical in conservative societies with deep-seated cultural and religious norms such as Saudi Arabia’s (Evason 2019). However, it is possible for researchers to anticipate and mitigate any such problems with careful planning and sensitivity. Using female researchers is advised by scholars to boost female engagement in settings where direct interaction with males is a culturally sensitive issue (Subahi 2021; Al Subeh and Alzoubi 2021). As a female researcher, my presence inherently facilitates access to female participants, potentially mitigating some of the above noted challenges. This indicates that, with appropriate adjustments and considerations for cultural and

religious sensitivities, semi-structured interviews can be a viable method for gathering rich data in the Saudi context. Indeed, the successful application of semi-structured interviews in various Saudi Arabian studies across different fields supports their viability (Haniffa and Hudaib 2007; Alqahtani 2012; Al-Asfour et al. 2017; Alahmad et al. 2020).

Nonetheless, it is noteworthy that the literature elucidates that limited cooperation from interviewees is an international concern, indicating that it is often linked to the interviewer's lack of experience (Roulston 2014). This challenge, however, can be addressed by enhancing the researcher's interviewing skills and using probing techniques. Probing entails asking additional questions to gather more in-depth information without leading the interviewee. Questions like "Can you provide more details about that?" or "Could you give me an example?" are effective in clarifying and expanding upon interviewees' responses, as noted by Brod et al. (2009) and Alshenqeeti (2014). In an attempt to ensure that these challenges did not prevent the acquisition of rich data in this study, the researcher took proactive steps by engaging in extensive research on interviewing techniques and executing a pilot interview for practice. These measures aimed to improve the quality of the interviews and ensure effective engagement with the participants.

4.2.4 Interview guide

The use of interview guides in semi-structured interviews is key since they act as a framework that directs the discussion while simultaneously offering flexibility, thus facilitating the gathering of in-depth data (Dearnley 2005; Whiting 2008; Silverman 2013; Cridland et al. 2015). For this study, two interview guides were prepared: one for physiotherapists and the other for individuals with knee pain (Appendix F).

With regards to content, the broad discussion themes in the interview guides were primarily based on an extensive literature review, which sought to identify established knowledge and areas requiring further exploration (Åstedt-Kurki and Heikkinen 1994; Krauss et al. 2009; Cridland et al. 2015; Kallio et al. 2016). Although these themes, outlined below, were broadly consistent across all participant types, slight modifications were made to reflect their unique roles and perspectives. Refer to the

appendices F and G for the full list of questions under each of the discussion themes listed below.

Discussion themes for physiotherapists

- Clinical practice and patient demographics
- Treatment strategies and patient adherence
- Therapist-patient relationship and engagement
- Treatment plan design and patient empowerment
- Technology in healthcare

Discussion themes for individuals with knee pain

- Perceptions of physiotherapy
- Treatment plan and adherence
- Therapist-patient relationship
- Self-management and problem-solving
- Technology in healthcare

The questions associated with each discussion theme in the interview guides were derived from various literature sources, such as validated assessment tools, surveys from relevant studies and topic guides from other qualitative research (Lorig et al. 2001; Battersby et al. 2003; Podichetty et al. 2006; Shoaib et al. 2009; Ritter and Lorig 2014; Bossen et al. 2016). The specific contributions of each of these sources to the interview guides are detailed in table 12. However, since these sources are primarily western and the guides were to be used by individuals from different cultural backgrounds, issues regarding their cultural suitability were considered (Castro et al. 2010). To address these issues, a comprehensive assessment of cultural appropriateness was conducted on the final guides. This process ensured that the questions were adapted to fit the Saudi cultural context, respecting the norms and values of the target audience. Particular care was taken to eliminate any elements that might be culturally sensitive or cause discomfort, especially concerning private matters, respecting the value placed on privacy in Saudi culture (Abokhodair et al. 2017).

References	Source	Aim of source	Contribution to the interview guide
Hatcher and Gillaspy 2006	The Working Alliance Inventory-short revised	An improved assessment tool for the therapeutic alliance evaluates three essential components: (a) agreement on therapy tasks, (b) agreement on therapy goals and (c) the establishment of an affective bond.	Assisted in developing questions related to the dynamics of the relationship between individuals with knee pain and physiotherapists in healthcare settings, aiming to uncover the care model employed.
Battersby et al. 2003	The Partners in Health	The PIH scale aids healthcare professionals in introducing the self-management concept to patients/clients and provides a self-management checklist for personalised interventions.	Assisted in developing questions related to the concept of self-management that includes practices and support.
Lorig et al. 2001 and Ritter and Lorig 2014	Self-Efficacy for Managing Chronic Diseases 6-item Scale	To assess changes in self-efficacy, a significant predictor of future actions, among individuals engaged in a real-life chronic disease self-management program.	Assisted in developing questions aimed at revealing the extent of self-confidence individuals with knee pain have in managing life events and coping with the consequences of their conditions.
Podichetty et al. 2006	Study-specific survey	To evaluate and establish a relationship between the degree of Internet utilisation among healthcare professionals and its impact on clinical practice.	Assisted in developing questions pertaining to the availability of Internet connection in clinical settings and its associated uses.

Shoaib et al. 2009	Study-specific survey	To ascertain the level of awareness among healthcare professionals regarding e-health and their inclination towards its practical implementation. The survey comprised five sections, namely: knowledge about e-health, utilisation of e-health in medical practice, Internet usage patterns and interest in procuring e-health services.	Assisted in formulating questions pertaining to participants' awareness and perceptions of the existing e-health services in the country, as well as their current utilisation and acceptance of such services.
Bossen et al. 2016	Interview guide	A qualitative study that aimed to create a blended exercise therapy program for individuals with knee and hip osteoarthritis that aligns with user preferences and can be seamlessly incorporated into the daily practices of physical therapists.	Assisted in developing questions aimed at understanding participants' needs and opinions regarding an imaginary scenario depicting digital self-management support.

Table 12: List of sources that influenced the questions in the study’s interview guides.

With regards to the arrangement of questions in the interview guides, this was carefully planned to align with Kallio et al.'s (2016) suggestions on a progressive questioning format and aimed to create a relaxed environment for the interviewees. This entailed starting with simpler, more familiar questions and gradually moving towards more complex topics, a technique supported by Whiting (2008), Baumbusch (2010), Cridland et al. (2015) and Slade and Sergent (2023). In this study, the interviews began with an exploration of demographics and areas directly relevant to the participants' own experiences; physiotherapists discussed aspects of their clinical practice while individuals with knee conditions shared their experiences with physiotherapy. This approach enabled a gradual transition to more intricate themes as the conversation progressed.

Participants were introduced to the concept of digital self-management support for chronic knee pain in a scenario-based question, a method inspired by the approach of Cranen et al. (2012). In their study, Cranen et al. (2012) introduced the concept of remote rehabilitation to individuals with chronic pain in a hypothetical scenario, detailing its full range of functionalities as an alternative to face-to-face care. The use of scenario-based questions is widely recognised in qualitative research as they allow the researcher to explore individuals' thoughts and the decision-making process in relation to their healthcare (Vollmar et al. 2015). In this study, participants were told about an imaginary digital self-management support website that has educational materials and exercise list for knee pain management alongside a messaging feature to maintain communication between individuals with knee pain and physiotherapists. They were asked to share their views on substituting face-to-face physiotherapy sessions with this digital solution. This approach aimed to achieve two key goals. The first of these was to understand the participants' perceptions on individuals with knee pain taking an active role in managing their knee pain and to identify strategies to facilitate the transition to self-management in the near future. The second was to use the insights and recommendations provided by the participants to guide the adaptation of an existing self-management support website, TRAK, making it more suitable for the Saudi market (Button et al. 2018). This tailored version of TRAK would subsequently be tested in phase 2 of the study.

Pre-prepared follow-up questions and probing techniques, such as asking "tell me more" or "what do you mean?", complemented by non-verbal cues like nodding and periods of silence, were applied to ensure a smooth and natural flow of conversation. The researcher and participants shared a cultural and professional background, which allowed for a deeper understanding of the nuances that emerged in interviews. This commonality aided in developing relevant, spontaneous follow-up questions, enriching the conversation while ensuring neutrality. Baumbusch (2010) emphasises that these follow-up questions aid in simplifying the main themes and steering the discussion back to the study's focus. It is important to note that the interview guides served merely as a flexible framework for the researcher. For instance, if a participant mentioned details relevant to yet-unasked questions, the interviewer explored that information immediately before returning to the planned sequence. Additionally, any compelling insights arising during the interview were noted and further pursued with subsequent participants, ensuring a dynamic and responsive interview process.

The interview guides were initially created in English, enabling smooth collaboration within the research team. After finalising the content and format, these guides were translated into Arabic to align with the needs of the target audience. The researcher employed the back-translation technique for this purpose, a method where the Arabic version of the guides is translated back into English. This approach, recommended by Chen and Boore (2009), ensures the preservation of meaning across languages. The researcher, proficient in both English and Arabic and knowledgeable about the respective cultures and the research field, personally carried out the back-translation. Following this, the guides were rigorously reviewed by Arabic-speaking colleagues to confirm that the translated questions remained true to the original English versions, ensuring accuracy and cultural appropriateness.

4.2.5 Pilot interview

The implementation of pilot interviews in this qualitative research was a crucial step since they assessed the research tools and the overall research methodology, as underlined by Braun and Clarke (2013) and Busetto et al. (2020). The researcher in this study conducted two pilot interviews, one with a physiotherapist and one with an individual with knee pain, both of whom had characteristics closely resembling those of future study participants. The interviews were conducted in settings chosen by the

pilot participants themselves. The physiotherapist was interviewed online via FaceTime, as they preferred, while the individual with knee pain was interviewed in-person at their home. The original plan did not include conducting these pilot interviews in the actual data collection settings since the primary aim was to test the research tools rather than the interview settings. However, efforts were made to simulate the environment of the actual interviews as closely as possible. To prepare the pilot participants, the interview guides were sent to them 72 hours in advance of the interviews.

The pilot interviews were audio-recorded, with participant consent, primarily to test the recording devices for future use. These pilot interviews revealed that setting up the equipment for recording was more time-consuming than had been anticipated, prompting the researcher to improve her proficiency with the recorders before the main data collection sessions. Additionally, the obtained recordings provided an opportunity for the researcher, who lacked previous experience in research interviewing, to develop key interviewing skills. This preparatory phase covered practicing initiating conversations, managing nervousness, becoming familiar with the recording equipment and recognising nonverbal signals and vocal nuances, all of which are skills that serve to enhance data quality (Malmqvist et al. 2019). The recordings also allowed for a thorough review and refinement of the interview questions, assessing them for relevance, clarity and effectiveness in terms of meeting the study's aim (Busetto et al. 2020) (see Table 13 for details). This process led to adjustments in the questions to avoid leading or restricting participant responses, such as revising "Has your therapist ever asked you about your opinion about the prescribed treatment?" to "Could you tell me to what extent you were involved in the treatment decision?". Moreover, the pilot interviews provided insights into the expected duration of the interviews, which is important for scheduling and participant management. Following Jacob and Furgerson (2012), the interview length was set to no more than 90 minutes, respecting participants' schedules. Notably, the participants from the pilot interviews and their data were excluded from the main study to prevent any influence on the final outcomes. Table 13 below outlines the actions made post-pilot interviews to enhance the main interviews.

Category	Identified issues	Actions
Interview guides	Some questions needed reconstruction to enhance their clarity and focus, ensuring they effectively conveyed their intended meaning.	The questions were simplified, rewritten for clarity, and then tested with colleagues for validation.
	Some questions were found to unintentionally lead or influence the participants' responses.	The questions were rewritten in a neutral, non-direct manner.
Familiarity with procedure	Setting up the recorder takes some time.	More practise with recording devices and techniques of obtaining and uploading data from the device to a secure server.
	Reading the questions from the guide while interviewing.	Increasing familiarity with the topic guide to establish a comfortable and natural atmosphere during the interview.

Table 13 Identified issues and implemented actions from the pilot interviews.

4.2.6 Actual interview procedure

Before beginning each interview, the researcher introduced herself, highlighting her independence from the medical facility to provide reassurance to the participants. She reconfirmed their consent to participate, offering a succinct overview of the study's aims and interview procedures. Participants were then gently reminded that the purpose of the audio recordings was exclusively for analysis, and their consent was reverified. During the interviews, the researcher meticulously noted non-verbal cues in field notes, enriching the narrative with nuanced details about the research context and participant behaviour.

Due to the shared cultural background with the participants, the researcher understood the value of establishing rapport to build trust and facilitate open dialogue. Consequently, each interview commenced with a light, informal conversation, easing the participants into the study and fostering a relaxed environment. All the interviews were carried out in Arabic as per the interviewees' preference for their native language,

yet participants were also given the option to be interviewed in English, recognising its significant presence in the nation's medical and educational fields.

When initiating the interviews, the researcher's background as a physiotherapist influenced her expectations, leading her to anticipate similarities between her perspective and that of the participants. However, she remained careful not to influence the participants' responses. She used neutral and open-ended questions, such as "What do you think?", "How?" and "Tell me more" to encourage genuine and impartial dialogue. In situations where significant insights arose, she opted to record these in a reflective diary, refraining from interjecting these insights into the interviews. This approach, recommended by Unluer (2012), ensured that her reflections did not influence the participants' perspectives, preserving the authenticity of their responses.

4.2.7 Data analysis

This study employed an inductive approach, with data from the interviews being refined to derive meanings and develop themes (Thomas 2006). This approach is particularly useful for revealing new insights that are not evident at the outset, which is the case with self-management support for knee pain in the Saudi context. Ritchie et al. (2013) describe this as a "bottom-up" process, where observations from the real world are used to derive new knowledge or theories. To facilitate the inductive approach in this study, Reflexive Thematic Analysis (RTA) was employed, as described by Braun and Clarke (2019) and Braun et al. (2023). RTA is an analytical approach that involves identifying and examining patterns within qualitative data (Clarke and Braun 2013). RTA was chosen due to its theoretical flexibility, which enables the production of both theory-driven and data-driven findings across various research scopes and data sizes (Braun and Clarke 2006). To further reinforce the credibility of the findings, peer debriefing was employed (Lincoln and Guba 1985; Nguyen 2008). This involved two members of the supervisory team, experts in qualitative research who regularly reviewed the analysis process, providing a rigorous evaluation of the methodology and enhancing the integrity of the findings. Also, the following paragraphs serve as an audit trail for the analysis steps conducted in this study, providing a clear path for others to follow and assess the rigor and thoroughness of the process.

To prepare the data for analysis, the researcher, proficient in Arabic, personally transcribed the recordings and re-checked them for accuracy. Following Braun and Clarke's (2012) recommendations compatible with RTA, the transcriptions included spoken words, paralinguistic elements like hesitations, false starts, speech cut-offs (marked by a dash, e.g., thin-), interviewer's backchannel cues (such as mm-hm, ah-ha), laughter, long pauses (denoted by (pause) or ...) and strongly emphasised words (underscored). To ensure clarity, data extracts were edited for conciseness by removing words or clauses that were redundant or not critical to the overall meaning of the extract. This careful transcription process, aimed at reducing misinterpretation and increasing accuracy, adhered to the guidelines set by Ritchie et al. (2013) and Al-Amer et al. (2016).

Then, the Arabic transcripts were translated into English to facilitate input and feedback from the English-speaking supervisory team throughout analysis processes to ensure credibility. This aligns with common practices in research involving Arabic-speaking populations in English-speaking countries, as noted in prior studies (Bertran et al. 2015; Al-Amer et al. 2016; Alzayer et al. 2017; Guruge et al. 2018; Alwan et al. 2020; Bitar and Oscarsson 2020; Aloudah 2022). The timing of this translation step is debated in the Arabic literature, with some scholars, like Aloudah (2022), suggesting potential loss of original meaning if done before analysis. However, in the absence of specific guidelines, this researcher's decision-making for this study was driven by the unique research circumstances and the desire to prioritise the integrity and trustworthiness of the data. This commitment was met through collaboration with an experienced translator, in accordance with recommendations in qualitative cross-language research to ensure accuracy (Squires 2009; Al-Amer et al. 2015). Given the geographical variations in Arabic dialects, engaging a translator familiar with the Hijazi dialect spoken in Jeddah was crucial (Bateson 1967; Al-Jahdali 2009). The researcher initially translated the interviews independently, with a focus on accurately conveying medical terminology. Subsequently, the translator reviewed the translations, and the researcher conducted a final cross-check for consistency and integrity to maintain meanings accuracy. Throughout this cyclical process, they engaged in discussions to address any inconsistencies, ensuring an accurate representation of the participant's voice tone and overall context. The processes of RTA conducted in this study is detailed below.

4.2.7.1 Familiarisation

Data familiarisation is crucial because it allows the researcher to deeply engage with the data and gain insights related to their research questions. In this process, the researcher goes beyond a surface-level understanding and actively, analytically and critically engages with the transcripts (Braun and Clarke 2022). Familiarisation involves understanding not only what participants are saying but also why they express themselves as they do when discussing the research topic. This includes exploring the underlying meaning and nuance of their words, taking into account how context has affected them. Furthermore, familiarisation enables the researcher to reflect on their own responses to participants' experiences and the emotions evoked by them.

4.2.7.2 Coding

Coding means capturing specific and precise meanings within the dataset that are relevant to the research questions (Braun and Clarke 2022). Coding in this study was inductive; hence, codes were generated from the raw data to understand lived experiences and perceptions (Blair 2015; Braun and Clarke 2022). Two types of codes were generated: descriptive codes, which capture the explicit meanings that are indicative of participants' expressed thoughts, and interpretative codes, which delve into the implicit meanings that lie beneath the surface and may be shaped by the researcher's conceptual understanding of the data. The primary researcher acknowledged that possessing a deep understanding of the cultural context and a background in physiotherapy could potentially lead to researcher bias in the generation of codes. To address this concern, a cautious approach was maintained by rigorously adhering to principles of neutrality (Weiss 1995; Gerson and Damaske 2020). Coding was performed manually on Word documents, with coded text highlighted and codes added using the "New comment" feature. All codes were labeled and associated with the specific line number from which they were extracted, and the code was assigned to the participant's transcript. Initially, both the researcher and a colleague independently coded a few transcripts from each participant type. Through a collaborative process of comparing their coding, they reached a consensus on codes and their definitions. It is worth noting that, while this step may not be required in more advanced versions of thematic analysis, as discussed by Braun and

Clarke (2022), it was implemented in this study due to the researcher's novice skills in this particular analysis method. This approach allowed the researcher to gain confidence and proficiency in independent coding afterwards while ensuring the reliability of the analysis. Regular reviews and discussions with the supervisory team served as ongoing support and validation for the generated codes.

4.2.7.3 Themes development

Theme development is an active process, characterised by the generation of themes rather than their passive discovery (Clarke and Braun 2015; Braun and Clarke 2022). This process involves the systematic grouping of codes that share similar purposes or relevance, aiming to create coherent and meaningful patterns within the data (Braun and Clarke 2006). The coded transcripts were printed, and the codes were extracted from the transcripts and distributed on a large table to enhance data visualization (see Figure 5). Codes that shared similarities and were relevant to research questions were grouped into potential themes, whilst codes deemed irrelevant were excluded. A theme is more than a mere category; it embodies a "central organising concept" that encompasses a multitude of related ideas and aspects (Braun and Clarke 2013, p. 224). Braun and Clarke (2022) further detail that concepts are not random but are patterns emerging from various data points and are not limited to the contribution of individual participants. Consequently, even if a pattern is not prevalent throughout the data, its significance as a theme is justified if it directly pertains to the central questions of the study. This consideration has been integral to the data analysis process in this study.

Figure 5: In the process of generating themes.

The generated themes were periodically reviewed with the supervisory team to assess their relevance. The relationship between themes was also examined to ensure a comprehensive analysis. Then, the codes under the broad themes were regrouped into subthemes representing specific topics or concepts that fell under the umbrella of the main themes. At this point, a visual thematic map was generated to better visualise and understand the relationship between themes and subthemes (Braun and Clarke 2022). The map underwent a process of frequent review, resulting in the production of multiple versions of the map until a consensus was reached by the supervisory team. Themes that were found to be too diverse and not contributing to focused outcomes were considered for potential merging, separation or exclusion. This led to a reduction in the total number of themes, ensuring that only the findings contributing to the study's questions were included. The key themes selected were defined and named. The aim was to uniquely define each theme with a brief descriptive sentence to describe its scope, differentiating it from others while collectively forming a set of meaningful data containing rich information. At last, the researcher wrote an analytic narrative to describe and interpret the themes with direct quotations to support claims (Braun and Clarke 2013). Figure 6 portrays the analysis process in this study.

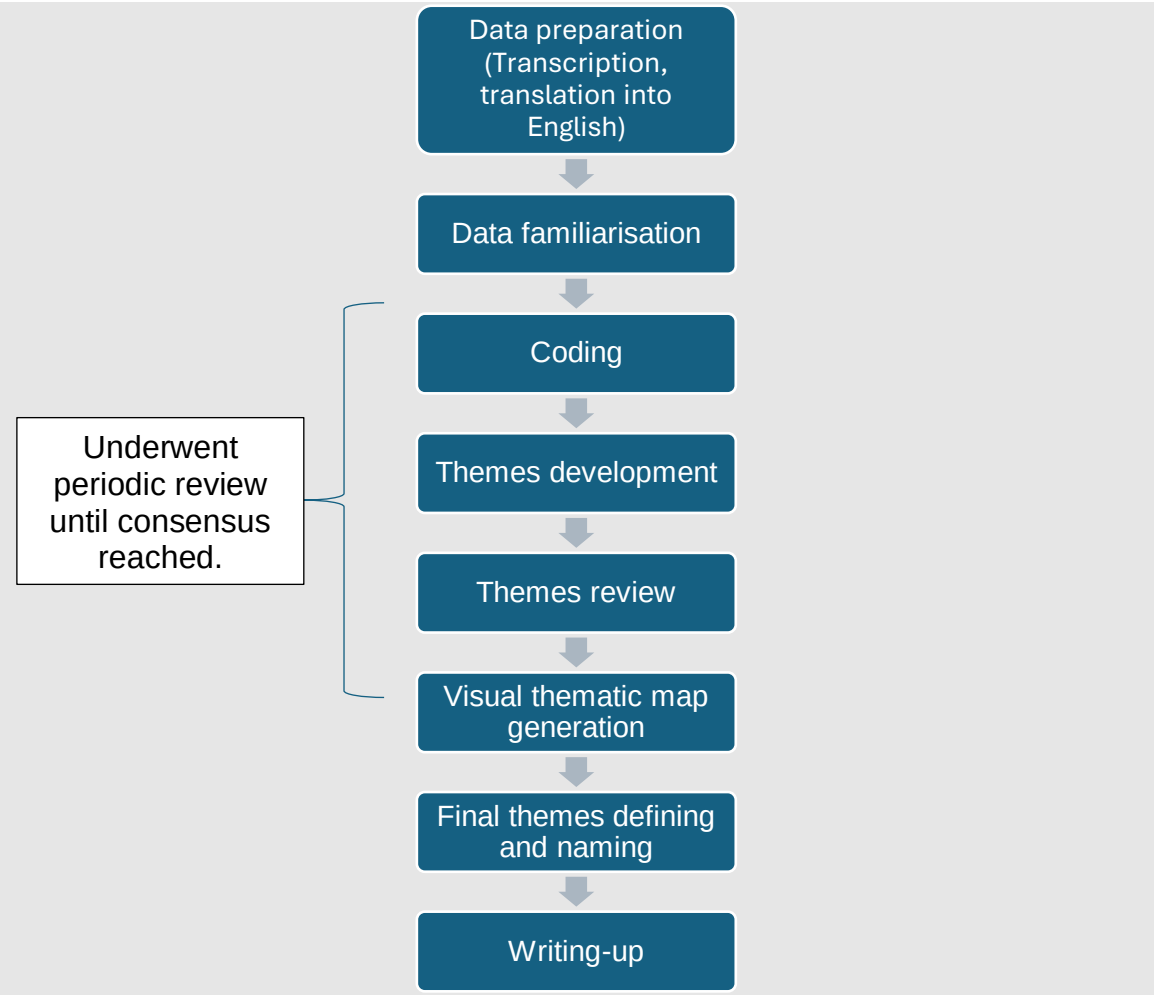

Figure 6: Process of the reflexive thematic analysis applied in this study.

4.2.8 Trustworthiness of this qualitative study

Trustworthiness in qualitative research is crucial as it determines the degree of confidence in the data obtained, its interpretation and the methodologies used to gather it (Pilot and Beck 2014). This study followed the trustworthiness criteria set forth by Lincoln and Guba (1985), including credibility, transferability, dependability and confirmability. The subsequent subsections detail the methodological acts applied in this study to achieve these criteria.

4.2.8.1 Credibility

Credibility within qualitative research is important for ensuring the trustworthiness of its findings' accuracy and authenticity, as highlighted by Lincoln and Guba (1985) and Holloway and Wheeler (2002). To enhance credibility, the literature recommends different strategies, including prolonged engagement, persistent observation,

triangulation and member checks (Anney 2014; Nowell et al. 2017). This study specifically applied triangulation and member checks. Triangulation was achieved through data triangulation, using two participant types to bring varied perspectives on nearly the same topics into the research, and environmental triangulation by selecting both private and public physiotherapy departments across various Jeddah regions to offer insights into different operational and environmental contexts (Denzin 1970; Norman and King 2020). Furthermore, the participants were invited to review their transcripts before analysis for content validation, a practice known as member check or respondent validation (Stahl and King 2020). These combined methods contributed to the study's depth, providing an array of perspectives and settings, thereby reinforcing the credibility of the findings.

4.2.8.2 Transferability

Transferability in research refers to the extent to which the findings of a study can be applied to other contexts with similar conditions, populations and phenomena (Tobin and Begley 2004; Bitsch 2005). A key strategy recommended by the literature to enhance transferability is the provision of a thick description of the study's methodology (Bitsch 2005). In this study, the researcher documented the methodology used in this methods section, ensuring that each step was clearly described. This detailed description of the methodology enables other researchers and practitioners to understand the research process fully and assess the potential applicability of the findings to other settings with comparable characteristics (Guba 1981; Li 2004). Another act that was applied in this study to enhance transferability was the selection of purposive sampling. Purposive sampling, as stated by Bitsch (2005), improves the transferability of qualitative research. Through selecting a diverse range of participants within the target group, it leads to comprehensive insights that are more likely to resonate and have some relevance when applied to other settings with comparable characteristics (Ritchie and Lewis 2003; Houghton et al. 2013).

4.2.8.3 Dependability

Dependability in research is defined as the stability of data over time and conditions. A dependable study will be accurate and consistent and easily replicated by other researchers to achieve consistent findings, underscoring the reliability of the research

process (Lincoln and Guba 1985; Elo et al. 2014; Cypress 2017). This study achieved dependability through a clear and transparent outline of the data collection and analysis methods (audit trail), making it accessible and replicable (Li 2004; Bowen 2009). The supervisory team, comprising experienced qualitative researchers, reviewed and validated the research methods (Bell 2013; Noble and Heale 2019). Additionally, experts from Cardiff University's School of Healthcare Studies conducted annual evaluations, offering insights and recommendations. Regular discussions on data collection and analysis with qualitative research colleagues—known as peer examination—further validated the methods and researcher decisions (Krefting 1991; Bitsch 2005). These collective efforts strengthened the study's dependability, allowing for its replication and verification by other scholars, thereby enhancing its overall trustworthiness.

4.2.8.4 Confirmability

Confirmability in research underscores the neutrality of findings, emphasising that outcomes are not influenced by the researcher's preconceptions but rather are grounded in the participants' responses (Connelly 2016; Cypress 2017). In this study, confirmability was achieved through an audit trail and the use of a reflexive diary, the latter involving critical reflection on the researcher's role and interaction with the participants (Lincoln and Guba 1985; Bowen 2009). To enhance reflexivity and thus confirmability, the researcher justified the methodological choices in this methods section to provide clarity on the research approach (methodological reflexivity), and fieldwork notes were kept during both the pilot and the main interviews. These practices ensured that the research findings were a true reflection of the participants' perspectives, maintaining the integrity and neutrality essential for confirmability.

4.2.9 Ethical and regulatory considerations

The measures applied in this study to maintain ethics and morals when dealing with the participants are presented below.

4.2.9.1 Ethical approval

In healthcare research, obtaining ethical approval should be, as stated by Bain (2017), a moral reflex for researchers. Ethical approval was obtained in May 2019 from the

School of Healthcare Sciences Research Ethics Committee, Cardiff University (Appendix H).

However, since the interviews were conducted at medical venues in Saudi Arabia, it was necessary to obtain additional approvals. The first approval was gained from the research ethics committee of the Directorate of Health Affairs in Jeddah, Saudi Arabia (Appendix I). This institution is the first point of contact in health research related enquires, particularly when it is directed at public hospitals in the country. Seeking permission from the Directorate of Health Affairs is an essential step in gaining access to public hospitals in Saudi and has been reported in various Saudi studies (Bawakid et al. 2017; Allebdi and Ibrahim 2020). The approval was obtained with no amendments in May 2019 (approval number 202/275). The second approval to conduct the interviews in the private clinic was obtained by meeting the director of the clinic and discussing the details of the project (Appendix J).

4.2.9.2 Ethical concerns

In this study, different measures were taken to ensure that the participants were protected, their rights to confidentiality and privacy were respected and their well-being was considered throughout the research process.

The participants voluntarily joined this study based on their interest in contributing. Their informed decision to participate was facilitated by detailed explanations provided in the participant information sheets and discussions with the researcher. They signed consent forms that clearly outlined their rights, including the option to withdraw at any time, and explained that recordings would be used for analysis and that anonymous data might be published in academic journals. On the day of the interview, these key consent aspects were reiterated to reaffirm participant approval.

In this research, maintaining participant confidentiality was a primary concern, adhered to in accordance with the General Data Protection Regulation (GDPR) 2018. All research data, including consent forms, audio recordings, diaries and transcripts, were stored under anonymous identification numbers, ensuring participants could not be identified. Personal data were kept distinctly separate from research data and securely stored to prevent unauthorised access or loss. All research materials were securely

stored in a locked cabinet in the Eastgate house building in Cardiff. Additionally, audio recordings were uploaded to a password-protected hard disk in the researcher's office for enhanced security. When sharing data with the research team or translators, thorough anonymisation was conducted to protect participant identities. These measures were vital to allowing the analysis of data without breaching confidentiality. The research's ethical integrity was further bolstered by ensuring that all quotations used in reporting strictly followed the permissions outlined in the consent forms. Before the interviews, participants were informed that the exclusive purpose of the recording device was to gain data for analysis, reinforcing confidentiality and helping them understand data usage. For privacy during interviews, private rooms with locked doors that were accessible only to authorised individuals were used, thereby upholding participant privacy and contributing to a secure and respectful research environment.

Additionally, participant safety and well-being were paramount in this study, with interviews conducted in rooms at newly built facilities, specifically chosen for their modern safety features. These included well-planned evacuation routes and emergency exits, thus ensuring a safe environment. Care was taken to avoid hazards and thus reduce the risk of accidents, for example, by the absence of damp surfaces. The interview rooms were designed to offer comfort and security, with bright lighting, effective ventilation and furnishings like comfortable seating and tables, creating a conducive environment for the participants. Water bottles and light snacks were provided to cater to the participants' needs during the interviews. To manage any distress during the interviews, a comprehensive and empathetic approach was employed. If signs of distress were observed, the interview was paused to allow the participants time to express their emotions and regain composure. A healthcare professional from the same medical centre was available for immediate support if needed. Sensitive topics were generally avoided; however, the participants were clearly informed of their right to skip any questions that might cause discomfort, and their autonomy and comfort were respected throughout the interview process.

Lastly, adhering to Cardiff University's data retention policy, the research data will be kept for five years post-study, after which it will be securely destroyed. Patient-identifiable information, such as contact details and emails, will be destroyed one year following completion of the Ph.D.

4.2.10 Summary

Jeddah's diverse demographics, unique healthcare dynamics and transportation issues make it an ideal research location for this study. Three public hospitals and one private clinic across various locations in the city were selected to ensure a varied and comprehensive participant pool. Participants included physiotherapists, offering expertise in knee pain management and technology integration, and individuals with knee pain, providing first-hand experiences and feedback on treatments and technology. They were chosen using purposive and snowball sampling methods, aligning with set eligibility criteria. The study's sample size, influenced by literature on saturation and purposive sampling, aimed for 6 to 12 interviews as a minimum base to ensure thoroughness and data richness. Data collection was conducted via in-depth, semi-structured interviews, facilitating open and thorough expression by the participants. The discussions were steered by an interview guide informed by literature and identified knowledge gaps. Data were managed anonymously and analysed using reflexive thematic analysis to extract meaningful insights addressing the research questions. The study consistently prioritised trustworthiness, ethical practices, participant safety and dignity, thereby ensuring the integrity of the findings and respecting the dignity of the participants.

4.3 Research findings for Phase 1

This section outlines the findings of the RTA conducted in this study, which were derived from semi-structured interviews with physiotherapists and individuals with knee pain in Jeddah, Saudi Arabia. These interviews explored a variety of topics, including clinical practices, treatment strategies, patient-provider relationships, patient empowerment, self-management and the integration of technology into healthcare. This section starts by providing a description of the participant profiles, followed by an overview of the key themes. It then proceeds to offer an in-depth description of each theme separately and corresponding subthemes, supplemented by direct quotations to substantiate the claims made.

4.3.1 Participant demographics

In this study, 29 participants were interviewed, including 15 physiotherapists and 14 individuals with knee pain. Table 14 presents demographic information for the physiotherapists while Table 15 presents demographic data for the individuals with knee pain. To protect participant privacy, age is shown as an average while sex, education, work experience and employment status are categorised into broad groups and percentage.

Variable	Mean (SD) (15 participants)
Age	31.53 years (± 5.6) Range: (23-44 years)
Sex	8 Females (53.33%) 7 Males (46.67%)
Education	13 Undergraduate education (86.67%) 2 Postgraduate education (13.33%)
Experience in current role	11 with ≥ 5 years (73.33%) 4 with < 5 years (26.67%)

Table 14: Participants demographics (physiotherapists).

Variable	Mean (SD) (14 participants)
Age	43.07 years (± 14.56) Range: (20-67 years)
Variable	**Frequency (%) (14 participants)**
Sex	7 Females (50%) 7 Males (50%)
Pain duration	4 Subacute (1-2 month) 10 Chronic (≥3 months)
Education	2 Primary or no formal education (14.29%) 3 Secondary education (21.43%) 6 Undergraduate education (42.86%) 3 Postgraduate education (21.43%)
Employment status	8 Employed (57.14%) 1 Self-employed (7.14%) 4 Non-employed (28.57%) 1 Retired (7.14%)

Table 15: Participants demographics (individuals with knee pain).

4.3.2 Overview of key themes

From the analysis, five key themes emerged (see Figure 7). The first theme, 'Physiotherapy practice in Jeddah', captures how physiotherapy departments operate in the region, with a focus on the professional autonomy of physiotherapists and the participation of individuals with knee pain in their treatment decisions. Following this, the second theme, 'Focus of physiotherapists in managing knee pain', sheds light on the areas physiotherapists focus on in treatment sessions to manage knee conditions effectively. The third theme, 'Self-initiated strategies to manage knee pain', shifts the perspective to the individuals with knee pain, highlighting the actions they take independently to manage their pain outside the clinical setting. The fourth theme, 'Connection to technology', explores how technology facilitates communication between physiotherapists and individuals with knee pain and thus enhances support. Lastly, the fifth theme, 'Perceptions of digital-based self-management support', uncovers the participants' perceptions of replacing face-to-face physiotherapy care with a digital self-management support platform as well as their needs in future initiatives. As this section progresses, subthemes will be presented under each corresponding theme.

It is important to restate that this study recruited two types of participants, that is, physiotherapists and individuals with knee pain, in order to triangulate data sources. This approach aimed to validate and deepen the understanding of the topic rather than compare views. However, it is important to declare that specific themes emerged more prominently from one participant type than the other. For instance, ‘Focus of physiotherapists in managing knee pain’ primarily encapsulated the views of physiotherapists while ‘Self-initiated strategies to manage knee pain’ was largely informed by individuals with knee pain. In other themes, the extent of contributions varied, with certain perspectives being more dominant. This variance highlights the diversity of experiences and opinions expressed by the two sets of participants that culminate in a rich and enlightening story.

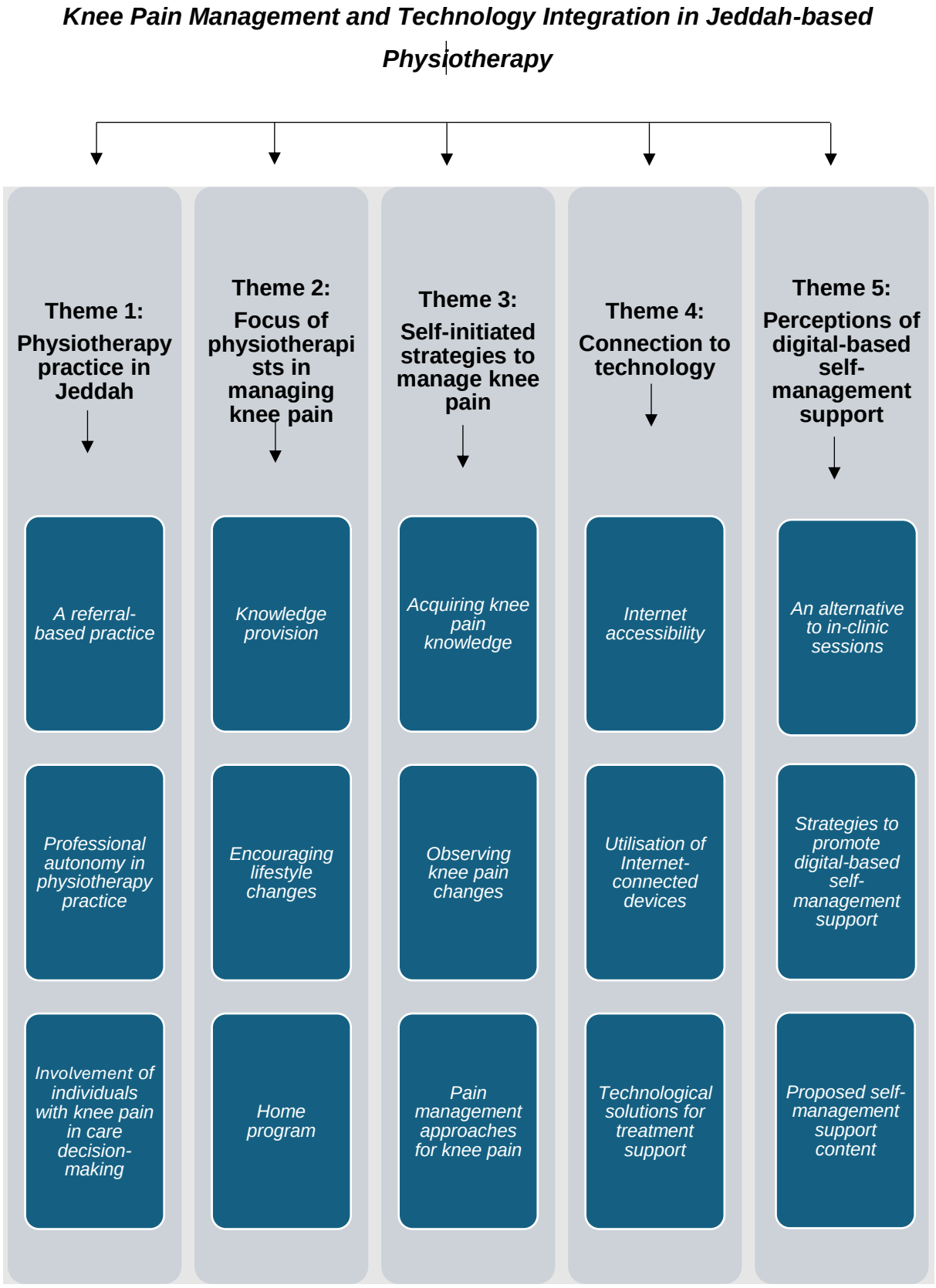

Figure 7: Summary of themes and corresponding subthemes.

From this point onwards, the findings section will provide detailed presentations of each of the five themes separately.

4.3.3 Theme 1: Physiotherapy practice in Jeddah

This theme illustrates the practice of physiotherapy in Jeddah as experienced by both physiotherapists and individuals with knee pain. It provides data on the professional autonomy of physiotherapists, covering aspects such as clinical judgement in diagnosis and referrals, as well as patient access to physiotherapy care. Additionally, it includes the degree of involvement that individuals with knee pain have in their treatment decisions and the factors that influence the development of treatment plans.

This theme is comprised of three sub-themes, which are *A referral-based practice, Professional autonomy in physiotherapy practice and Involvement of individuals with knee pain in care decision-making.*

4.3.3.1 *A referral-based practice*

This subtheme delves into the journey of individuals in Jeddah as they navigate the process of accessing physiotherapy care for knee pain. Central to this narrative is the discovery that access to physiotherapy services, whether in the public hospitals or the private clinic, depends predominantly on referrals from medical physicians.

(PT8/ physiotherapist/ Line:40)

> *"The patient is examined by the consultant, who is (name of the physician). He is the one who… refers the patient to us".*

(IKP13/ Individual with knee pain/ Line:70)

> "*Actually, I went to the doctor not the therapist".*

In the private clinic, the referral process to physiotherapists is regulated by an orthopaedic physician stationed within the clinic.

(PT8/ physiotherapist/ Line:40)

> *"The patient is examined by the consultant, who is (name of the physician). He is the one who determines the type of injury and refers the patient to us".*

Interviewees with chronic knee pain shared their experiences of treatment, which were often marked by delays.

(IKP4/ Individual with knee pain/ Line:31)

> *"I swear nearly 3 weeks later. I started last Monday… This is my second session".*

For some, the challenge was in obtaining the initial referral to physiotherapy, whereas for others, the obstacle was accessing services promptly after receiving a referral. The type of medical facility played a significant role in these experiences. Individuals at public hospitals frequently faced prolonged waits to get referrals from physicians (IKP11). In contrast, those opting for private clinics often found themselves navigating long waiting lists even after securing a referral (IKP2).

(IKP11/ Individual with knee pain/ Line:111)

> *"No one directed me to physiotherapy. They all (pause) said the same thing, the – the – obesity, that is it".*

(IKP2/ Individual with knee pain/ Line:502)

> *"As many are still on the waiting list… For your information, when I first came here, I waited for two months before I got an appointment".*

4.3.3.2 *Professional autonomy in physiotherapy practice*

This sub-theme explores the dynamics of authority and clinical decision-making among physiotherapists treating knee pain in Jeddah. In this setting, physiotherapists were found not to be rigidly confined to following the assessments on referrals made by physicians. Many physiotherapists take pride in their ability to exercise their clinical judgment. When they receive referred cases, they do not just take the physician's diagnosis at face value. Instead, they re-evaluate these cases, basing their treatment plans on their own comprehensive assessments.

(PT4/ physiotherapist/ Line:20)

> *"I rely on the evaluation I do; it is the most important thing".*

This diligent re-evaluation stems from a notable observation: occasionally, the diagnoses provided by physicians do not align with the actual complaints of the individuals.

(PT14/ physiotherapist/ Line:37)

> *"Umm almost, the doctor's diagnoses are not matching the symptoms that are seen in the patient. They are not related to the diagnosis itself".*

Interviews also revealed that both physiotherapists and individuals with knee pain recognise the control exerted by physicians over the content of physiotherapy treatments.

(PT9/ physiotherapist/ Line:117)

> *"He sends us the treatment plan".*

(IKP13/ Individual with knee pain/ Line:70)

> "*Actually, I went to the doctor not the therapist. So he examined me and approved the therapeutic program".*

This dynamic is not always harmonious. One physiotherapist voiced clear frustration with this physician-led approach, citing a perceived gap in physicians' understanding of physiotherapy and its treatments.

(PT10/ physiotherapist/ Line:149)

> *"I mean it is not an arrogance, no! This is my job and my profession, and I know better, I know better than the doctor, I mean, with respect to the doctor or the physician. But the doctor just says, 'go and do exercises'. He doesn't know what this device or this exercise does. I know even better than the doctor in this specialty. So, I'm telling you, frankly, some things are non-negotiable".*

While other physiotherapists may not have explicitly expressed the same level of frustration, their actions spoke volumes. Their efforts to modify treatment plans, deviating from physicians' recommendations, subtly indicate a similar sentiment.

(PT8/ physiotherapist/ Line:47)

> *"We determine the exercises, and that depends on where the patient is in the treatment phase and so on... We determine everything".*

4.3.3.3 Involvement of individuals with knee pain in care decision-making

This subtheme explores the dynamics of decision-making in physiotherapy settings, focusing on the role and involvement of individuals with knee pain in shaping their treatment plans. Within the scope of this study, it was observed that most physiotherapists prefer individuals with knee pain to adopt a passive role when it comes to care-related decision-making.

(PT6/ physiotherapist/ Line:188)

“I don’t engage him by asking ‘What do you think of it?’ I mean, at the end, we are the ones who decide. There are some things that are not negotiable”.

(PT8/ physiotherapist/ Line:161)

“I decide everything in the treatment program. This is better for me and the patient. When I decide everything, I take full responsibility”.

The physiotherapists, as also claimed by individuals with knee pain, often steered the course of treatment based on their professional judgment.

(IKP8/ Individual with knee pain/ Line:181)

“He said to me ‘This is your program, and you have to follow it’”.

In their narratives, physiotherapists explained the rationale for this approach. They emphasised that their clinical expertise and judgment took precedence over individual preferences. This was particularly the case when they decided that certain treatments, albeit challenging or not initially favoured by the patient, would yield greater benefits for the patient's condition.

(PT8/ physiotherapist/ Line:155)

“I mean, it is possible if there are two exercises, an easy one and a difficult one, but the difficult one will produce better results, the patient would say to you ‘No, I want the easy one, it is better’”.

(PT3/ physiotherapist/ Line:86)

“Not a 100% engagement, but I mean I ask him… But I don't let the patient, for example, choose the treatment method that he

wants and likes… No, there are things that might not be preferred by him but are crucial to be done for his condition".

Individuals with knee pain noted this disparity, particularly highlighting their discomfort with unfamiliar treatment methods employed by the physiotherapists.

(IKP11/ Individual with knee pain/ Line:72)

"They did not give me a cream or anything, only the metal piece, I do not know what it is called, it is the metal (small pause), I do not know what it is… He massaged me, using it, even though honestly, it was very painful".

Moreover, physiotherapists indicated a tendency to understand individuals' needs from their conversations, rather than directly involving them in designing their treatment plans, particularly in common conditions like knee OA. This suggests they rely more on their own interpretations of what individuals need rather than seeking explicit individual involvement in the decision-making process.

(PT5/ physiotherapist/ Line:92)

"However, in regular cases, such as knee OA and other orthopaedic conditions, I do not feel that the patients want to take part in designing the plan".

Interestingly, despite the noted control exerted by physiotherapists in treatment decisions, individuals with knee pain did not express any annoyance about this during the interviews. Instead, they showed satisfaction, indicating a sense of trust in the relationship with their physiotherapists.

(IKP14/ Individual with knee pain/ Line:65)

"And honestly, I can say that I trust him 100% … And the results are so far so good".

At the core of their practice, physiotherapists acknowledge the diversity in the experiences of individuals with knee conditions. Interestingly, not all seek relief from pain; some are on a quest for muscle strengthening or preventive care. It is this recognition of varied needs that guides the physiotherapists in their mission, as evidenced in the quotes below.

(PT1/ Physiotherapist/ Line:40)

> *"It depends on the patient, what is their main complaint? For example, does he have... Some of them say they have continuous pain all the time while others may say pain comes only with slight bending or if they strain themselves or sit on the floor. So, it depends on the patient's complaint".*

(PT2/ Physiotherapist/ Line:28)

> *"There are people who don't feel pain although they are referred for a knee problem. They are not here for pain. They come to strengthen their muscles or out of fear of getting worse in the future".*

Central to their strategy is the commitment to tailor treatment plans that align with the unique conditions and specific concerns of each individual. For instance, some treatment plans are crafted to aid individuals in managing their daily activities, especially those facing mobility challenges or difficulties in performing essential tasks, such as praying.

(PT13/ Physiotherapist/ Line:38)

> *"We ask questions like 'Where do you live? Which floor?' So, we ask about the nature of the house and everything related to the patient".*

(IKP4/ Individual with knee pain/ Line:82)

“She asked me about the way I pray. ‘Do you pray on a chair?’”.

Furthermore, the narrative reveals that the selection of exercises is not based on a one-size-fits-all solution. The physiotherapists unveiled a method that takes into account the individual’s age, lifestyle and level of physical activity.

(PT3/ Physiotherapist/ Line:82)

“First of all, I have to know if the patient is active, does she have any activities or is she only staying at home, to know what kind of exercises I should give her”.

(PT12/ Physiotherapist/ Line:64)

“When I have an old patient, I cannot give him a difficult exercise. I try not to change the position too much, and I try to be as simple as possible… as the goal is to be more functional”.

But the concern of physiotherapists extends beyond treatment content. They showed awareness of each individual’s personal circumstances that might impact the effectiveness of the treatment. Accommodating these external commitments is not just an act of empathy but a strategic move to ensure the continuity and effectiveness of the treatment plans.

(PT7/ Physiotherapist/ Line:208)

“For the patient who says, for example, ‘My daughters have exams, and I can’t come next week’ I work hard with her to reach the planned range of motion, for example, before her week off. You got it?”.

(IKP6/ Individual with knee pain/ Line:81)

“She was very clear and told me ‘Your muscles are very weak and need intensive physiotherapy to get your legs back to

normal'. I mean, currently, I am supposed to be in work, but she told me to go back to the doctor and ask him for sick leave because it will not work like this".

4.3.3.4 Summary of theme 1

This theme explores the multifaceted aspects of physiotherapy care for knee pain in Jeddah, Saudi Arabia, focusing on access to care, decision-making and the involvement of individuals with knee pain in their own care. Access to physiotherapy is predominantly referral-based, with individuals often facing delays in obtaining referrals and accessing services. Physiotherapists demonstrate autonomy in their clinical decision-making, frequently re-evaluating referred cases and basing treatments on their own assessments rather than strictly following physicians' diagnoses. Regarding the involvement of individuals with knee pain, physiotherapists tend to prioritise their professional judgment over the individuals' preferences, often perceiving them as passive participants in their care. Despite this, individuals generally express trust in and satisfaction with their physiotherapists, who are committed to tailoring treatment plans to individual needs and circumstances, considering factors like age, lifestyle, activity level and personal circumstances.

4.3.4 Theme 2: Focus of physiotherapists in managing knee pain

This theme captures the key practices and priorities of physiotherapists in Jeddah in their treatment of knee conditions as identified by the physiotherapists participating in this study. It focuses on the knowledge imparted by the physiotherapists during the therapy sessions and their objectives, highlighting the importance of lifestyle changes and home programs to treatment success.

This theme is comprised of three sub-themes, which are *Knowledge provision*, *Encouraging lifestyle changes and Home program*.

4.3.4.1 Knowledge provision

This subtheme focuses on the strategies employed during therapy sessions to further the understanding of individuals with knee pain of their condition. The consensus among the interviewed physiotherapists is that the key goal of sharing knowledge is to explain treatment methods and set realistic expectations of the therapy process.

(PT8/ physiotherapist/ Line:132)

> *"Myself and the majority of the therapists who we have in this centre, I mean, from the first session, we show the patient his treatment program 'we will do 1,2,3, and you will help us in 1,2,3, and you will work at home on this, and god willing we will start after two weeks in this when the improvement reaches this stage, and if it does not, we will start to add this and this'. So, we explain to him the full program".*

The narrative from the interviews highlights the efforts of physiotherapists to align individuals' expectations with the practical realities of physiotherapy. They emphasise the importance of being transparent in their interactions with individuals, aiming to clarify expectations about what the therapy can achieve.

(PT4/ physiotherapist/ Line:60)

> *"I try to make them understand that I am here to maintain their activity level as much as possible and that physical therapy does not mean returning you to your normal status. No, it is to prevent you from getting worse. So, I try to make this idea clear to them, so they do not keep false hopes in their minds".*

(PT8/ physiotherapist/ Line:140)

> *"We explain to them the whole program that we are going to follow, to be clear with them as much as we can, because there*

are some patients who if you are not clear with them, they can say to you 'no you did not...'. I mean, for example, if they get muscle tension, they will say to you 'You didn't tell me that I will get muscle tension' and they might start a fight for something as simple as this, so we should be clear with them about everything".

Beyond just preparing individuals for the treatment itself, some physiotherapists also stress the importance of equipping them with the knowledge and skills to self-manage their knee pain.

(PT2/ physiotherapist/ Line:111)

"I always, even with the patients, say that 'physical therapy is simple and easy, we as a therapist, studied the basics knowledge as well as the advanced one, and you as a patient can also be a therapist! There are agonists and antagonists…'. I try to explain to them that if this muscle became weak or shortened… that they can create their own exercises".

(PT6/ physiotherapist/ Line:264)

"I mean after the 20 sessions that my patient attended with me at the clinic, he would know how to work out when he is alone! Because we work on education not only on memorising, memorising, memorising. We work on education, and I show him everything, even the alternatives, because when he understands how 'multi-hip' works and how 'TheraBand' works, he will understand their main concepts. So if I did not find this tool, I can go for that one instead, it works the same. You got the idea?".

Recognising that many individuals do not have medical insurance and need to pay for therapy out-of-pocket, some physiotherapists in the private clinic show concern about individuals' financial constraints. This awareness informs the information they provide, aiming to provide effective care while being economically considerate.

(PT6/ physiotherapist/ Line:70)

> *“There are things that you ask him to do at home, so you save him money; this is the first thing”.*

However, discussions with individuals with knee pain revealed that physiotherapists often adopt a more reactive approach to information sharing. Rather than proactively offering details about conditions or treatment plans, they tend to respond to specific questions posed by individuals.

(IKP8/ Individual with knee pain/ Line:191)

> *“I mean we started straight away, but I was asking him like ‘how long do you expect me to stay here’ and he was answering me with ‘it could be 7,8 or 9 weeks’”.*

4.3.4.2 Encouraging lifestyle changes

This subtheme reports external factors that physiotherapists consider crucial for enhancing the effectiveness of treatment. The data highlights how physiotherapists engage in two-way communication with individuals with knee pain to identify and adjust lifestyle elements that might negatively impact the recovery process.

(PT2/ Physiotherapist/ Line:40)

> *“From the beginning, there are common questions, such as ‘How do you live your life?’ to reach together at the end an agreed solution. It is possible that I do exercises with her, and then she still has bad habits at home. So, I start to fix this from the beginning”.*

A notable aspect of this approach, as highlighted in the below quote, is the physiotherapist's dedication to not just short-term pain relief but long-term condition

management. This is exemplified by allocating the final two therapy sessions to teaching individuals about preventing problem recurrence through lifestyle changes.

(PT14/ Physiotherapist/ Line:184)

> *"In some cases, we cannot solve the problem 100%. If the patient does not modify their lifestyle, the problem will continue… I also tell them that even if they are good now, once they get back to their current lifestyle, the pain will return. I dedicate the last two sessions to teaching them how to prevent the recurrence of the problem".*

This approach also includes considering the emotional challenges faced by individuals in their daily lives. As mentioned by the physiotherapist below, the emotional struggles of individuals could negatively affect improvement.

(PT5/ Physiotherapist/ Line:130)

> *"I met a young patient who was tense all the time. She told me that even in her sleep 'I press hard on my teeth'. So, regardless of all the things I tried to do with her, her pain did not improve even after 12 sessions at the clinic! So, when I realised her general stress and her problems at home, I sat and chatted with her about how her mental status affects her improvement and taught her that 'try to lay down as I taught you before and start to do deep breathing'".*

4.3.4.3 Home programme

This subtheme elucidates the crucial role that home programs play in the treatment of knee pain, as described by physiotherapists. The central focus here is on how integral these programs are to the improvement of the condition.

(PT3/ Physiotherapist/ Line:109)

> *"I told you before that half of the treatment is at home as well, by exercises. So, for sure he will be given a full home program".*

Home programs extend beyond exercises to include techniques for pain management. Physiotherapists carefully craft these programs and guide individuals on how to effectively manage pain that may arise when performing home exercises or everyday activities.

(PT8/ Physiotherapist/ Line:245)

> *"It is necessary to show them that when they get back home, they will do these exercises 1,2,3. If they feel pain, do this, and if they have pain with this exercise, please stop it. So, we give them a full program to follow at home as if they are with us in the clinic. I mean, in terms of cold packs and hot packs, where they should put them exactly, and how the exercises are done. I mean, I do not say to them 'go home and bend'. No, I show them the way of bending that they should follow at home".*

However, a key challenge that emerges in this subtheme is the issue of adherence to these home programs. Many individuals with knee pain tend to rely more on clinic-based treatment rather than consistently following their prescribed home exercise routine.

(PT5/ Physiotherapist/ Line:53)

> *"When they come to the session, I say to them 'come on and show me the exercises that you have done at home'. Most of them, honestly (laughter), they do not do it. They do not even remember it. They say 'okay, remind me of it'. And when I ask them 'so, you did not do it?', they reply 'honestly, no'. God, they are the majority".*

This reliance on in-clinic care is especially evident among older individuals, who often focus on immediate pain relief over other therapeutic goals in their sessions.

(PT13/ Physiotherapist/ Line:66)

> *"I cannot convince some patients, especially the old ladies of like 70-80. They say 'What remains of my life? Why do you want to bother me with those exercises? Just release the pain'".*

The problem of adherence is compounded in the case of elderly individuals living alone. Without someone to remind or encourage them, maintaining a regular exercise routine becomes more difficult, as evidenced by the physiotherapists.

(PT7/ Physiotherapist/ Line:137)

> *"If they have a daughter with them at home, I mean, I feel it helps the patients a lot if they have someone with them in the house! But those who live alone (voice exiled with her mouth) no! But it works a bit with those who have a house maid, but children, in specific, have a role in the treatment".*

Physiotherapists also noted that adherence to home programs is influenced by the individuals' daily life responsibilities and commitments.

(PT2/ Physiotherapist/ Line:47)

> *"I swear to God, sometimes they are honest. I mean, they say that 'my life is not helping me do it, today I did it once, I did not do it because I was invited somewhere'. This is the most typical reason".*

(IKP13/ Individual with knee pain/ Line:58)

> *"I go to work from morning till afternoon, I take a nap, then I go outside for groceries, I go back in the evening, and if I have some extra time, I do the exercises".*

This challenge is particularly pronounced among females with knee pain. According to their narratives, women tend to show less engagement in home exercises compared to men, often citing family responsibilities or the inability to perform the exercises alone as reasons.

(IKP3/ Individual with knee pain/ Line:76)

> *"I swear I am lazy. In addition to the other responsibilities I have at home, my children and grandchildren… So, it is difficult to leave them and go to my bedroom to do it there (laughter)… I rely a lot on the session".*

In contrast, males in the study generally displayed a better commitment to regaining their previous activity levels and returning to work.

(IKP14/ Individual with knee pain/ Line:135)

> *"I have a motivation goal to go back to my life, and the most important thing is to go back to my job".*

Additionally, physiotherapists have observed that some individuals struggle with remembering the exercises. To address this, they provide supplemental materials, aiming to enhance recall.

(PT1/ Physiotherapist/ Line:51)

> *" Some of them say I do not know the exercises even if they do... I mean, I often give them pictures or something".*

4.3.4.4 Summary of theme 2

This theme underscores the topics physiotherapists often focus on when treating knee conditions to improve treatment efficacy. It focuses on the importance of educating individuals with knee pain about the selected treatment methods, setting realistic expectations and establishing clear communication. However, according to the individuals with knee pain who were interviewed, physiotherapists tend to provide knowledge and information primarily in response to their immediate questions and concerns rather than offering guidance and education in advance. The theme also highlights the necessity of adapting lifestyle factors for successful recovery, showcasing how physiotherapists engage in meaningful dialogues with individuals to address long-term condition management while also considering their emotional health. Furthermore, it highlights the crucial role of home exercise programs and the challenges associated with adherence, with particular attention to the challenges faced by older adults and women, such as living alone and balancing daily responsibilities.

4.3.5 Theme 3: Self-initiated strategies to manage knee pain

This theme covers the proactive measures taken by individuals with knee pain outside the clinical environment to manage their conditions. It encompasses their approaches to enhancing their understanding of the condition, their responses to changes in their knee pain and the strategies they employ for pain management, as described in their narratives.

This theme is comprised of three sub-themes, which are *Acquiring knee pain knowledge*, *Observing knee pain changes and Pain management techniques for knee pain*.

4.3.5.1 Acquiring knee pain knowledge

In this subtheme, the focus is on the personal initiatives taken by individuals with knee pain to acquire information about their condition. The stories of a subset of those participants reveal a tendency to seek knowledge independently. These individuals engage in various activities to educate themselves, including consulting evidence-based research and hospital booklets.

(IKP9/ Individual with knee pain/ Line:361)

> *"The thing I know, as they say, the studies that I have come across (pause), I mean they say that when the injury is fresh, put ice on it to stop the blood spreading, as they say, into the surrounding areas, and at the same time it helps you not feel pain. This is the thing that I know".*

Another important source of information for these individuals is online platforms. Some of them have turned to websites and YouTube videos to better understand their condition and potential treatments.

(IKP2/ Individual with knee pain/ Line:264)

> *"Look, just before you came here, I was watching a YouTube video on my mobile. I wanted to have a look at additional exercises".*

During the interviews, a noteworthy aspect was the confidence displayed by these individuals when discussing their condition. While they are not representative of all individuals with knee pain, their confidence in the information they provided was evident.

(IKP2/ Individual with knee pain/ Line:296)

> *"I'm telling you, for my knees, the joint range is not going to increase… I'm telling you, it will never be more than 115 degrees… it differs from one to one… First of all, my bodyweight is very high because of the prolonged sitting in the (pause). I don't move a lot. I don't walk these days. I don't walk. Yes, I do my exercises, but without any free walking."*

This contrasts with other individuals who lacked such comprehensive information. The latter group expressed scepticism about the tools used and the benefits of the

treatments they received, highlighting a gap in their understanding and a lack of confidence in the therapy process.

(IKP11/ Individual with knee pain/ Line:72)

> *"They did not give me a cream or anything. Only the metal piece, I do not know what it is called. It is the metal (small pause). I do not know what it is… He massaged me, used it, even though, honestly, it is very painful".*

Additionally, those with a strong medical knowledge often showed a willingness to share their experiences and their proactive efforts in seeking the most effective treatment for their condition.

(IKP9/ Individual with knee pain/ Line:206)

> *"So, to be honest with you, I contacted (name of a specialist hospital in the country) about this matter because I have been told that they want to try stem cell therapy, and I want to know if my case (pause), because as you know, if it is really osteoarthritis (pause), I mean osteoarthritis has no definite cure… It has no definite cure except by stem cell therapy or joint replacement if your condition has reached a certain degree. That is why I am now in contact with them. And they told me to bring a report from the doctor so they can decide what to do".*

4.3.5.2 Observing knee pain changes

This subtheme covers findings related to participants' awareness of any condition changes. The interviews reveal that individuals with knee pain display a remarkable ability to observe changes in their knee conditions, particularly outside the clinical environment. Pain emerged as the primary indicator of these changes, as consistently reported by the participants.

(IKP1/ Individual with knee pain/ Line:175)

> *"I can notice the change… because I often tell her, if I, for example, have pain. What I mean is that at the beginning of the sessions here, my knee became better, then, all of a sudden, I had pain again, and I told her about it".*

These individuals demonstrated a heightened awareness of their knee condition, particularly noting any alterations in the softness or texture of the affected joint.

(IKP2/ Individual with knee pain/ Line:388)

> *"I feel heaviness in my knee, and it will never return to normal or even the same as the unoperated one. Look how the unoperated knee is soft and flexible, and look at this one, how rigid it is (pointing to the operated one)".*

Their approach to managing these observations is reflective. They actively notice change, analyse potential reasons for these changes and, importantly, communicate these findings to their physiotherapists.

(IKP9/ Individual with knee pain/ Line:283)

> *"A while ago, I passed through a period of, as they say, a relapse, but thank God. It could be a wrong exercise, joint fatigue or something like this. So what happened? A backlash. So I stayed for 3 or 4 days with a swelling, but then it returned to its normal situation… So I read and told him what happened with me. He tried to figure out the case, then said 'it could be specific exercises that cause the fatigue'".*

Interestingly, the data revealed a common practice among physiotherapists of asking individuals to assess their knee joint independently at the beginning of each session.

This routine appears to have encouraged the participants to become more attentive to their knee condition.

(IKP14/ Individual with knee pain/ Line:115)

> *"He asks me 'How are you today? How do you feel? How are you doing with the pain? Can you do this? Can you do this exercise?' … If I could summarise it, I would say that he was speaking to my body through me".*

4.3.5.3 Pain management techniques for knee pain

This subtheme focuses on the strategies employed by individuals outside the clinical setting to manage their condition and reduce the strain on the affected joint. A noteworthy insight from the interviews was the approach taken by some female participants in managing their household duties. To alleviate the physical demands at home, they reported hiring housemaids, indicating a conscious effort to minimise the stress on their knee joints during daily activities.

(IKP2/ Individual with knee pain/ Line:372)

> *"I do nothing at home. I have 5 housemaids. I don't even know what is in the kitchen. I only tell them the things I want to be done, including food. I used to travel alone to attend international exhibitions, but now, I cannot… I take the girl with me".*

In the workplace, other participants detailed specific strategies they have adopted to manage their workload. These adjustments are geared towards minimising the stress on their knee joint during the workday, as exemplified in the quote below.

(IKP11/ Individual with knee pain/ Line:268)

> *"My work, (pause) thank God as a teacher on my own I do not have any (pause), I mean I divided my work, when it comes to*

students, and so my students are making it easy for me now to explain the exercises and the groups for the sports activities".

At home, various pain-relief methods were highlighted. The most common techniques included applying ice packs and using pain-relieving gels, indicating a preference for immediate, accessible forms of pain management.

(IKP12/ Individual with knee pain/ Line:230)

"I put the cold packs on, and I put on the lotion they gave me and the creams, and I take the bills and I put olive oil on and thank God".

Interestingly, only a small number of participants shared strategies related to exercise for managing knee pain.

(IKP2/ Individual with knee pain/ Line:247)

"I often go to a public gym. One day I come to the clinic and the other day I go to the gym… Like what I do here, but I do it there so that I don't miss a day. And there I do aerobics in the pool because water is very important for the knee joint because of bodyweight".

A particularly intriguing aspect of the findings was the use of traditional medicine, especially among female participants, a few of whom reported using herbal remedies and manual techniques such as massage.

(IKP4/ Individual with knee pain/ Line:20)

"I went to midwives before who do traditional therapy like massage, the same as the things they do for me here".

(IKP6/ Individual with knee pain/ Line:178)

> *"I was following traditional medicine (laughter). I mean drinking specific herbal teas".*

4.3.5.4 Summary of theme 3

This theme highlights how individuals with knee pain proactively manage their knee pain. They actively seek information using resources like research materials, online platforms and hospital booklets, which was seen to boost their confidence when discussing their conditions with the researcher. Notably observant of changes in their knee joint, they analyse and communicate these changes to their physiotherapists, demonstrating a reflective approach to monitoring their condition. In managing pain, different strategies were employed, from hiring help to alleviate physical demands at home to adjusting work routines and using immediate pain-relief methods like ice packs and gels. Some, particularly women, also explore traditional medicine practices like herbal remedies and massage, showcasing a diverse range of methods to cope with knee pain.

4.3.6 Theme 4: Connection to technology

This theme focuses on the dynamics between physiotherapists and individuals with knee pain in relation to technology, shedding light on the accessibility of technological devices to both parties. It explores how technology serves as a tool for information access, communication and support in the context of physiotherapy practices.

The theme is comprised of three sub-themes, which are *Internet accessibility*, *Utilisation of Internet-connected devices* and *Technological solutions for treatment support.*

4.3.6.1 Internet accessibility

In this subtheme, the narrative explores the accessibility of Internet resources among participants, as revealed through the interviews. Participants were asked about their access to the Internet, both at the clinic and at home, unveiling good digital connectivity across various ages and socioeconomic backgrounds.

While not every individual with knee pain owned such a device personally, many mentioned relying on family members who possessed Internet-enabled devices. This aspect of shared digital access is exemplified by the below quote from a female participant with knee pain. She explained her choice of using a mobile phone without Internet connectivity, stating her reliance on a family member who owns an Internet-connected device.

(IKP12/ Individual with knee pain/ Line:267)

> *"My daughter who is studying at university has a computer."*

From the perspective of the physiotherapists, the narrative also sheds light on the availability of Internet-connected computers within physiotherapy departments. It was found that in both private and public settings, there are a limited number of such computers, and these are typically shared among all the physiotherapists in a unit.

(PT5/ Physiotherapist/ Line:141)

> *"I saw only one computer, and when it was down, they said to one therapist to use the one at the reception".*

4.3.6.2 Utilisation of Internet-connected devices

This subtheme focuses on the uses of the Internet mentioned by the participants in the interviews. They were found to frequently turn to the Internet as a resource to learn about their health conditions. This not only included their own knee pain but also extended to other health topics affecting their family members.

(IKP11/ Individual with knee pain/ Line:310)

> *"Honestly, sometimes I go to the Internet to ask about it, ask about that problem I am suffering from, by writing that I have so and so, and it comes on the Internet page, and I go on".*

However, most physiotherapists in the study expressed strong reservations about individuals relying on online sources for health information. Their concerns were twofold. Firstly, they were concerned that their patients may not be able to assess the credibility of online information (PT1), and secondly, they felt there was a risk of their patients encountering misleading content that could exacerbate their fears and misconceptions about their health conditions (PT5).

(PT1/ Physiotherapist/ Line:196)

> *"I mean, I don't believe in all online sites; I mean, the patient will enter and write down his complaint in Google, and it will come up with things that are not official or unproven as any person can write and post anything there. So, for this reason".*

(PT5/ Physiotherapist/ Line:176)

> *"I mean, some people when they read about something, they become more scared and think that they have a serious condition".*

A specific subset of individuals with knee pain, primarily those involved in academia or enrolled in educational programs, reported using the Internet for academic research and related activities.

(IKP8/ Individual with knee pain/ Line:277)

> *"The Internet is everything to me, I mean everything... I am a researcher, and my work involves searching, websites, social media, mostly using my iPhone but also on the computer. And like this, the internet is everything...".*

In terms of practical use, some participants mentioned using Internet-connected devices for organising future events, such as booking flights or scheduling hospital appointments, including physiotherapy sessions.

(IKP2/ Individual with knee pain/ Line:421)

> *“I use it for everything, everything. I have just booked an appointment with my doctor in London. I travel myself all over the world”.*

(IKP3/ Individual with knee pain/ Line:248)

> *“For the appointment booking, we book for my sessions here through it”.*

From the perspective of the physiotherapists, computers installed in their departments serve several functions. They provide access to reports from various departments, such as radiology and the laboratory, assist in monitoring and adjusting patients' appointments and enhance overall treatment coordination.

(PT8/ Physiotherapist/ Line:276)

> *“I mean, in our situation, we use it for reports. I mean, commonly for writing reports. This is the only thing, or schedules, modifying our schedules. These are the things we use the computers for”.*

(PT11/ Physiotherapist/ Line:176)

> *“The computer that we have here at the clinic, I use it to look for the radiological results, admission history, surgeries history and so on. I look for lab tests that have been done before as well as the patient’s appointment”.*

However, only a few physiotherapists reported using these devices actively to share treatment-related content with their patients.

(PT7/ Physiotherapist/ Line:280)

> *"Patients' schedules, reports, our schedules too… What else? Information about the modalities we use if the patient would like to know more about it. Morning shifts, night shifts and Ramadan shifts".*

4.3.6.3 Technological solutions for treatment support

In this subtheme, the narrative explores how physiotherapists actively support individuals with knee pain in adhering to home programs, with a particular focus on the use of technology, especially mobile phones. Physiotherapists have adopted innovative methods to ensure accurate exercise execution at home. One such method involves encouraging individuals to use their mobile phone cameras to record themselves while performing exercises at home so these clips can be shown to the physiotherapist at the clinic for feedback.

(PT8/ Physiotherapist/ Line:249)

> *"I ask some of them to film themselves for me. It is useful if they record a video clip for me while they are bending at home so I can know if the way they are doing it is wrong or right because some of them comprehend the information a bit slowly. I mean, not all people have the same level of comprehension".*

Another beneficial use of mobile technology is seen during clinic sessions, where physiotherapists tend to record the individuals while performing exercises. These recordings provide a visual reference to review at home, helping them to remember the correct steps and techniques used for the exercises.

(PT4/ Physiotherapist/ Line:127)

> *"I often film them while they are doing the exercise. I tell her 'Let me film you on your phone', and in my opinion, this is better than giving them printed photos. Photos are not always clear to the*

patients, and when they see themselves doing the exercise on the video, they remember it well and perform it better".

These practices, as stated by the physiotherapists, are especially valuable for elderly individuals, who may face difficulties in recalling the exact execution of their exercises.

(PT7/ Physiotherapist/ Line:329)

"If the number of exercises increases, I mean, if we started to do the seventh or eighth exercise, the patient would start to say 'No, I started to forget, I did not do the…' At this time, you say that 'We are going to film, auntie. Next time bring your phone or your daughter's phone'".

The narrative further reveals that the relationship between physiotherapists and individuals often extends beyond regular clinic hours, facilitated through personal mobile phones. This extended communication, including phone calls, video calls and messages, allows physiotherapists to monitor the performance of home exercises to ensure they are being done correctly and respond to any additional questions individuals with knee pain may have.

(PT15/ Physiotherapist/ Line:76)

"Some of them send me videos to check if they are doing the exercises right or wrong … So, there is a communication between us to make sure they are doing the exercises".

(PT8/ Physiotherapist/ Line:256)

"The patient might take a long time with me until he understands the exercise. We do it like two or three times, and I ask some of them to film themselves or speak to me live. I mean, to call me live, and like this, and showing me the exercise 'Am I doing it right or not?'".

This communication often occurs outside official Internet platforms, with physiotherapists providing their personal mobile numbers to patients.

(PT9/ Physiotherapist/ Line:284)

> *“I give them my number and answer their questions. They send me ‘I felt this today’. Or sometimes, after 4 or 6 months of the session, they ask me ‘I am going to travel, do you have any advice for me?’ Or ‘Should I wear this brace in the airplane or not?’”.*

4.3.6.4 Summary of theme 4

This theme captures the role of the Internet and technology in knee pain management, focusing on access to the Internet, uses of Internet-connected devices and technological solutions for treatment support. Participants across various ages and socioeconomic backgrounds reported good access to the Internet, both at home and in clinics. Individuals with knee pain widely access the Internet for health information, though physiotherapists caution against the reliability of online sources. The internet was found to be used for further reasons, such as work and school and booking healthcare appointments. In clinical settings, shared Internet-connected computers are common, but their use for patient education is limited. Innovative uses of technology, particularly mobile phones, have emerged as crucial in supporting home exercise programs, with physiotherapists using video recordings and personal communication to enhance exercise adherence, especially for the elderly.

4.3.7 Theme 5: Perceptions of digital-based self-management support

This theme focuses on the participants' reactions to a proposed self-management support website for knee pain, presented as a hypothetical scenario. The website, as described in the interviews, featured three main elements: educational material, a hub for exercises and a communication tool. It was introduced as a substitute to in-person physiotherapy sessions.

A total of three sub-themes forms this theme, which are: *An alternative to in-clinic sessions, Strategies to promote digital-based self-management support and Proposed self-management support content.*

4.3.7.1 An alternative to in-clinic sessions

This subtheme covers the perspectives shared in interviews about the hypothetical website potentially replacing face-to-face care for knee pain. Most physiotherapists viewed this idea positively for individuals with chronic knee pain, who are expected to take a more active and responsible role in managing their treatment, albeit with certain conditions.

(PT1/ Physiotherapist/ Line:267)

> *"Knee OA is a chronic case, so it is better that the patient communicates with us through the website and visits the clinic once a month to see their therapist if something changes in their condition instead of getting a new set of sessions every time".*

Additionally, most physiotherapists supported shifting from in-person therapy to a digital self-management support platform, especially for younger individuals. However, they raised concerns about older individuals, pointing out potential difficulties related to limited technological proficiency within this group.

(PT15/ Physiotherapist/ Line:279)

> *"It's a great idea but not for the old people, no… Because old people cannot go online, they are not going to like it".*

The interviews also revealed that the elderly typically seek physiotherapy clinics primarily for quick pain relief and might be hesitant to embrace remote care options, as underscored in the quotes provided.

(PT4/ Physiotherapist/ Line:169)

"There are patients who are old age, and therapy means to them 'just give me now the treatment that will benefit me, nothing else'. I mean, they are not willing to search for any information or do anything for themselves… It's hard, it is hard to do if they are old. Originally, it is hard to let them understand the concept of the website".

(PT5/ Physiotherapist/ Line:266)

"I will also give it to young patients more. The elderly will not accept and will say 'Do you not want me to come to you?' (Laughter)".

The integration of the website into treatment regimens was proposed as a solution to long waiting lists at clinics. It was thought that acute cases needing immediate face-to-face care could be prioritised, while those with chronic knee pain could be effectively managed through the website.

(PT12/ Physiotherapist/ Line:332)

"Umm... the number of patients will decrease in the clinic, so we can treat the acute cases. Honestly, sometimes the 6 sessions are not enough for the chronic cases, and at the same time, we have to do a discharge because of the waiting list".

Additionally, some physiotherapists expressed interest in using the website in addition to face-to-face sessions, rather than completely replacing them. They viewed the website as a beneficial resource for post-clinic follow-up with individuals who have knee pain, particularly after they have completed their in-person therapy sessions (PT4). They highlighted the necessity for individuals with knee pain to visit the clinic for thorough monitoring and observation of any changes in their condition (PT3).

(PT4/ Physiotherapist/ Line:209)

> *"I prefer that my patients complete all the sessions with me first, then I use the website to follow-up with them…. After 12 sessions, when they have completed their course with me and I am sure that they have reached a good progression level, at least 70%, then it is not a problem to work with them, doing the other 20% from home."*

(PT3/ Physiotherapist/ Line:204)

> *"I am with the idea of observing my patients by myself to look at the degree of improvement, for example, in the range of motion, their way of doing the exercises, and if there are things that they are doing wrong… And after I see them, I can add more things for them to do on the website".*

Despite the general optimism, there were reservations about the cultural acceptance of this shift in healthcare. A minority of therapists expressed doubts about society's readiness for such a change (PT6), whereas another therapist argued that the current digitalisation trends in the country presented an ideal opportunity for such advancements in healthcare (PT11).

(PT6/ Physiotherapist/ Line:480)

> *"Not now! Maybe later. Here in Saudi Arabia, not yet. I do not think that the patient will be convinced. I mean, in my opinion, neither the patient nor the therapist will be convinced. I mean, the therapist cannot see with their eyes the patients. Sometimes you might ask them to do, for example, a leg extension, and you want them to raise and see their thigh move! I mean to me, I want them to do it while I am watching them, to look for any substitutions if they exist, you know. I mean, I want it in front of me, I want to see it myself, and the patient wants me to be there for them".*

(PT11/ Physiotherapist/ Line:220)

> *"Our society is 'in progress' on this stuff. We did not have something similar in the past, and now the situation has changed a lot. So, once that the idea becomes available, I expect it to have, as they say, a very, very social echo. It will be a very nice thing".*

From the perspective of individuals with knee pain, the majority supported the idea of replacing face-to-face sessions with a self-management support website. This preference was more pronounced among the male participants as opposed to the females, who favoured in-person sessions.

Among those who supported the website, perspectives varied regarding its implementation. Some viewed it as a beneficial supplement to face-to-face therapy, appreciating the flexibility it would offer in scheduling clinic appointments. They valued occasional in-person interactions but also recognised the advantages of the website.

(IKP2/ Individual with knee pain / Line:188)

> *"If, for example, I can have two sessions a week here in the clinic, then I will work with the therapist through the website for the other two sessions. I will use it for sure".*

Others perceived the website as a time-saving measure that could enhance their understanding of their condition. To this group, the website seemed like a viable alternative to in-person clinic sessions.

(IKP8/ Individual with knee pain / Line:348)

> *"I mean, I support the idea… First of all, it saves time, I mean, because I do not have to come and go every time. The second thing I see is that it is better to educate yourself instead of anyone here guiding you. I mean, here you take the information from the therapist so you can work by yourself".*

A key observation was that individuals more receptive to online care exhibited greater confidence in managing their pain independently. Their language reflected a sense of self-sufficiency in terms of dealing with their symptoms at home.

(IKP11/ Individual with knee pain / Line:413)

> *"I do not know about other people, I do not know, but for me I prefer to do the exercise myself, I like to work on myself… And there is more time ahead of me, I don't need to make it in a specific time. I have until the end of the night to do the exercise".*

In contrast, female participants who were reluctant to use the website preferred the physical presence of a therapist during sessions. They linked this preference to the need for supervision during exercises and direct communication with therapists, underscoring the importance of face-to-face interactions for expressing concerns and receiving guidance.

(IKP6/ Individual with knee pain / Line:237)

> *"I prefer taking the sessions here with her… because I like to have someone with me, I mean, someone who observes me, tells me right or wrong. I mean, I can do it alone, but I can't do it properly, like when she observes me...".*

4.3.7.2 Strategies to promote digital-based self-management support

In this subtheme, the narrative explores strategies highlighted during interviews aimed at expanding the reach of a self-management support website as an alternative to in-person care for knee pain. A key focus is on various approaches proposed by physiotherapists to make the website more accessible and user-friendly, particularly for elderly adults and those less familiar with digital platforms.

A main strategy highlighted by physiotherapists was the involvement of family members in aiding elderly adults with knee pain to effectively use the website.

(PT11/ Physiotherapist/ Line:248)

> *"I mean, they are not able to use the website, apps and this stuff or, as they say when the patient's IQ does not help him to use technology and similar things, or he does not know how to use it. But you can fix this by letting his relative help him to use it".*

During the interviews, it was evident that several physiotherapists were keen to actively instruct individuals with knee pain on the optimal use of the self-management support website. They suggested dedicating specific portions of therapy sessions to thoroughly explain the website's diverse features and functionalities.

(PT8/ Physiotherapist/ Line:421)

> *"I mean, if the session will be two hours and you are supervising the patient doing specific exercises, there will be communication between you and them, and they might start saying to you 'I went yesterday to this place, I did this, and…' while doing the exercise. I mean, we can use this time to show them what to do at home and how to use the website… I mean, there will be a discussion between me and them".*

Furthermore, the introduction of informative booklets was another strategy put forward. The goal of these booklets is to explain the website's content and functionalities, making it easier for users to understand and engage with the website effectively.

(PT3/ Physiotherapist/ Line:253)

> *"I recommend, for example, having a brochure that explains everything about how to use the website. … and it has a list of instructions, so, the patient does not need any external help. I simply give them the paper and they can do it by themselves".*

4.3.7.3 Proposed self-management support content

In this subtheme, the narrative unfolds around the feedback from participants on the content proposed for future digital self-management support initiatives. There was notable agreement among participants on what digital platforms should include, with a unified endorsement for the inclusion of educational resources, exercise programs and a communication portal as fundamental elements.

Participants with knee pain specifically emphasised the need for detailed medical information. They expressed a desire for content that covers the root causes of their pain, potential triggers and home-based treatment options.

(IKP1/ Individual with knee pain / Line:237)

> *"Honestly, the first thing I wish for is information about the types of sport injuries because there is more than one injury. Also, umm, a lot of information about home treatments... and what should be done in every injury. I mean more information".*

(IKP2/ Individual with knee pain / Line:457)

> *"On the website, they should explain all the knee cases, as well as photos of their physiotherapy treatment. I mean, the things that we can do at home according to the case and how to do it… There should be instructions about certain things, like don't push heavy things like furniture pieces and so on… you know? These small things that people often do in their daily life that cause them harm".*

Additionally, the importance of dietary information was highlighted, especially its relevance to recovery for those who have experienced knee injuries.

(IKP6/ Individual with knee pain / Line:212)

“Healthy food, I mean the healthy food that the human can eat during the course of treatment, which can help in wound healing or, for example, in fractures”.

The consensus on the necessity of educational content extended beyond those with knee pain, with physiotherapists also strongly advocating for this component in their interviews. This highlights the shared belief in the importance of educational resources as a key component of future initiatives.

(PT7/ Physiotherapist/ Line:393)

“I feel education. Yes, I feel this is the most important point, to let the patient understand their condition, for example, to explain for them lower limb biomechanics, what are the knee compartments. If they have a swelling in this area, what does it mean, and if there, what does it mean? I feel that education is good”.

The inclusion of exercise materials was another key aspect emphasised by the participants. They proposed that future initiatives should offer a range of resources, primarily in the form of graphics and videos, to effectively demonstrate exercises.

(IKP10/ Individual with knee pain / Line:379)

“Maybe, for instance, when I put my name, I can find the name of my injury. That is the first thing I have. It would tell me, for example, this exercise is done like this, and it would be graphic… It would be an explicatory graphic, I mean… This exercise, when I do the exercise, it would have something like an animation”.

The participants particularly highlighted the effectiveness of videos as the preferred medium for presenting exercise information on the digital platform, considering them to be a superior format for demonstrating exercise routines and techniques.

(IKP13/ Individual with knee pain / Line:265)

“I prefer videos so I can go back to them and do the exercises alone”.

(PT5/ Physiotherapist/ Line:210)

“Exercise videos, not photos. I want it to be in videos how they can manage their pain at home. For example, lay down, sit, use hot or cold packs. I mean, teach them how to deal with the pain away from the clinic visits”.

However, some physiotherapists voiced a preference for retaining control over the exercise content on the platform, suggesting a reluctance to allow individuals to have any input in this area.

(PT3/ Physiotherapist/ Line:192)

“For example, I give them a video link or something to go back to on this website… I prefer this website not to include things that are not relevant to the patient’s condition. I do not want the patient to enter and choose their exercises by themselves. No, I prefer them to find their exercises ready at the website”.

Addressing the issue of adherence, a challenge commonly faced by individuals with knee pain, physiotherapists suggested incorporating a reminder feature. This tool was envisioned to help maintain consistency with exercise routines, as highlighted by the physiotherapists' comments.

(PT13/ Physiotherapist/ Line:262)

“We also need a reminder to remind people of the exercises. A lot of people forget to do them”.

(PT1/ Physiotherapist/ Line:240)

“Photos of exercises, and if there could be a reminder to tell them to do their exercises. For example, they set the times of doing the exercises, like in the reminder part of the phone, and this reminds them about them every time”.

The participants also highlighted the perceived need for ongoing communication between physiotherapists and individuals with knee pain. Physiotherapists preferred this for closer monitoring of exercise execution while individuals with knee pain saw it as essential for reaching out in case of unexpected issues during home exercises.

(PT15/ Physiotherapist/ Line:246)

“Umm, maybe live chat… Live chat with the patient to tell him what to do… Yes, video call… I cannot tell him what to do with the voice chat, it has to be video chat”.

(IKP11/ Individual with knee pain / Line:419)

“If I can make a note for him that I couldn’t do that and that, or I did something different, and it would appear as a message. No, that is nice, for me excellent”.

4.3.7.4 Summary of theme 5

Most individuals with knee pain were supportive of the idea of transitioning from in-clinic sessions to a self-management support website. Notably, this support was more prevalent among male participants than female ones. Physiotherapists, while endorsing the website, suggested its use be tailored to specific individual groups. They identified the young adult population as the most suitable candidates for this digital approach. Recognising the challenges faced by those with limited technological skills, the physiotherapists proposed three distinct strategies to facilitate website usage. These included involving a family member, integrating website training into therapy sessions and developing a manual booklet. This theme also presents data showing a consensus between physiotherapists and individuals with knee pain on key features

of future digital self-management support initiatives. A significant focus was placed on educational materials, exercise videos and a communication tool.

4.3.8 Summary

The study conducted 29 interviews in four physiotherapy settings in Jeddah, Saudi Arabia, involving 15 physiotherapists and 14 individuals with knee pain. Reflexive thematic analysis of the interviews generated five main themes. Theme 1, titled ‘Physiotherapy practice in Jeddah,’ highlighted issues related to access to care, often hindered by delayed referrals. It also noted the independent judgment exercised by physiotherapists in designing treatment plans while viewing individuals with knee pain as passive recipients of care. In theme 2 ‘Physiotherapists’ focus in managing knee pain,’ the focus was on the provision of education, the emphasis on lifestyle adjustments, and the challenges associated with adherence to prescribed home exercises. Theme 3 ‘Self-initiated strategies to manage knee pain,‘ described how individuals with knee pain proactively sought to manage their condition. This included acquiring health-related knowledge, monitoring and communicating changes in their condition to physiotherapists, and utilising various pain management techniques. Theme 4 ‘Connection to technology,’ discussed the ubiquitous access to the Internet at home and in clinics, the integration of Internet-connected devices into daily life, and the role of technology in supporting knee care. Lastly, theme 5 ‘Perceptions of digital-based self-management support,’ found a consensus among participants on the essential features of future digital self-management supports, such as educational content, exercise videos, and communication tools. A majority of the participants expressed support for transitioning from face-to-face care to digital platforms, subject to certain conditions.

4.4 Discussion of Phase 1

Here, key findings obtained from the 29 semi-structured interviews conducted in this study are discussed in relation to the relevant literature and the two main research questions for this phase.

4.4.1 Discussion of findings related to research question one (Phase 1): How do current physiotherapy practices for knee conditions in Jeddah, Saudi Arabia align with self-management support principles?

Findings from themes ‘Physiotherapy practice in Jeddah’, ‘Focus of physiotherapists in managing knee pain’, ‘Self-initiated strategies to manage knee pain’ and ‘Connection to technology’ answer research question 1.

Overall, the findings show that the pathway to accessing physiotherapy in Jeddah is referral based. Yet, physiotherapists exhibit autonomy in determining treatment strategies, often deviating from initial physician recommendations. Physiotherapists often prioritise their own clinical judgment over patient preferences in exercise plans, and individuals with knee pain generally express confidence in their physiotherapists’ choices, which are mostly influenced by their needs and characteristics. However, the patient education aspect reveals a reactive approach rather than a proactive one, with physiotherapists indicating its common presence and individuals with knee pain saying that it only happens at their request. Notably, home exercise programs are highlighted as integral components of treatment plans, yet challenges with adherence persist, especially among populations such as older adults and women with multiple daily responsibilities. Interestingly, some individuals show proactive management of knee pain, employing diverse strategies that include seeking out information through various resources, monitoring changes in their condition and employing active and passive pain management techniques.

4.4.1.1 Physiotherapists Dominate the Care Journey

This research provides important insights into how decisions are made between physiotherapists and individuals with knee pain in Jeddah, a topic not widely addressed in Saudi research (Alkhatrawi 2013; AlShubaily and Chiarello 2022). These insights are valuable for researchers aiming to introduce self-management support

programs into unfamiliar settings and needing to assess whether these new initiatives align with established practices or not (O'Connell et al. 2018). The findings from theme 1 titled 'Physiotherapy Practice in Jeddah' reveal that physiotherapists often play a dominant role in the treatment process, which can restrict patients' active involvement in their own care decisions. Statements from physiotherapists in the study, such as "*We are the ones who decide. There are some things that are not negotiable*" highlight a tendency to minimise the patient's role in decision-making. This observation is consistent with the paternalistic healthcare model identified by Varkey (2021) whereby healthcare providers' views on what is best for the patient are prioritised over those of the patient, who is excluded from care decisions. Such a paternalistic approach contrasts with the concept of shared decision-making, which is essential for an effective delivery of self-management support in healthcare (Lorig and Holman 2003; Jonkamn 2016; Hoffmann et al. 2022). Shared decision-making, as defined by Murray et al. (2006), involves a cooperative effort whereby both the patient and the healthcare provider, each an expert in their own right, engage in open communication to reach joint care decisions.

The findings of this research indeed align with findings from the Saudi literature, which explores shared decision-making within different physiotherapy contexts in Saudi Arabia, such as lower back pain and paediatric care (Alkhatrawi 2013; AlShubaily and Chiarello 2022). These studies highlight that many physiotherapists prefer a paternalistic approach to healthcare rather than engaging in collaborative practices with patients. This issue, however, is not exclusive to Saudi Arabia. Hoffmann et al. (2022) have identified a slow adoption of shared decision-making in physiotherapy practices globally. For instance, a study of 357 German physiotherapists revealed a lack of understanding about implementing shared decision-making, with a significant portion favouring the paternalistic model. This possibly reflects a wide educational gap in medical training for physiotherapists, particularly in areas of collaborative care and shared decision-making. Such an educational shortfall is evident in Saudi Arabia's medical educational programs as well (Alabdullah et al. 2022). This likely explains why advocates for self-management emphasise the development of training programs for healthcare providers, aimed at those expected to integrate these programs into clinical settings (Bodenheimer et al. 2002; Kantilal et al. 2022). A prime example is the Education and Training Curriculum on Multiple Chronic Conditions, which was created

by the United States Department of Health and Human Services (HHS 2015). This curriculum provides healthcare providers with a comprehensive toolkit, enriching their understanding of self-management support and detailing strategies for its seamless integration into practice whilst addressing any shortfalls.

The observed dominance of physiotherapists regarding treatment decisions in the departments visited can likely be linked to the referral-based nature of physiotherapy practice in the region (Alghadir et al. 2015; Al-Eisa et al. 2016; Al-Abbad and Al-Haidary 2016; Alosaimi et al. 2022). In theme 1, both physiotherapists and individuals with knee pain underscored the critical role of physician referrals, which typically include specific treatment instructions, for accessing physiotherapy services, reflecting the findings in the literature (Larsson and Najafi 2014; Rotor and Capio 2018). Though physiotherapists in this study were found to be autonomous and able to recraft treatment plans, working in a referral-based system poses challenges to their ability to engage fully with evidence-based practice (Lim et al. 2021; Shah and Prakash 2023). Indeed, Alshehri et al.'s (2017) survey of 376 Saudi physiotherapists revealed a notable dependency on personal experience rather than evidence-based practice, with about a quarter being unfamiliar with the latter concept. The limitations imposed by referral-based practice, including restricted time and resources, further heed the implementation of evidence-based practices (Hasani et al. 2020). Specifically, theme 4, 'Connection to Technology', highlights the limited number of computers in physiotherapy departments. This scarcity, also noted in the literature, restricts physiotherapists' access to research databases and reduces the time available for them to review literature (Hasani et al. 2020). Given these factors and the relatively recent enthusiasm for integrating shared decision-making into physiotherapy as a move towards more patient-centred care, the lack of such practices in the departments studied is understandable (Dukhu et al. 2018; Hoffmann et al. 2020).

Interestingly, in this study, individuals with knee pain showed no objection to being excluded from care decisions, instead demonstrating a high trust in their physiotherapists' decisions. This might suggest that a paternalistic approach aligns with the preferences of some patients. Particularly in healthcare contexts like Saudi Arabia, where "the doctor knows best" mindset is prevalent, patients may have grown accustomed to, or even prefer, relying on the expertise of healthcare professionals

(Alabdullah et al. 2022). AlHaqwi et al. (2015) investigated this dynamic, surveying 236 patients at a family practice centre in Saudi Arabia. Their findings revealed an intriguing preference distribution; while a majority (57%) favoured shared decision-making, a considerable portion (28%) expressed a preference for the paternalistic model. This was mostly reported among older participants, females and those with chronic conditions, groups that mirror the population with chronic knee pain (AlHaqwi et al. 2015; Lee et al. 2019; GBD 2019). It could be that the lack of shared decision-making in Saudi healthcare might have influenced patients' expectations and made them more comfortable with not participating in care decisions. Effectively integrating self-management support programs necessitates empowering individuals with knee pain so that they are more autonomous as well as ensuring their voices are heard and their opinions valued in their care decisions (Krist et al. 2017; Baird et al. 2019). This can be achieved through educating both individuals and physiotherapists about patients' rights, challenging paternalism and encouraging patient autonomy, as recommended in relevant Saudi literature (Alabdullah et al. 2022; Alotaibi et al. 2023a).

4.4.1.2 Individuals with Knee Pain Influence Exercise Plans

Theme 1 reveals that exercise plans for individuals with knee pain are tailored according to their specific needs and characteristics. Physiotherapists highlighted the importance of considering factors such as the individual's age, primary complaint, functional limitations, lifestyle and personal circumstances when creating these plans. This approach is somewhat resonated by Adem (2017), who noted the significance of considering patients' lifestyles in developing treatment plans for lower back pain. However, this study suggests that physiotherapists in Jeddah employ a more complex approach, demonstrating a comprehensive recognition of each individual's unique needs and characteristics. This comprehensive in designing exercise plans is supported by the qualitative findings of Teo et al. (2021), who describe how Australian physiotherapists manage chronic knee pain through tailored plans. This scenario aligns with a core principle of patient-centred care essential for self-management support programs: personalised care (Wijma et al. 2017). To achieve personalisation, physiotherapists work to understand the unique history, needs, preferences, beliefs, values and circumstances of each patient, facets also explored by physiotherapists in

this study (Cooper et al. 2008; Larsson et al. 2010; Harman et al. 2011; Kidd et al. 2011; Salloum et al. 2023).

Personalised care, however, extends beyond merely tailoring treatment; it places the individual, rather than the techniques, at the core of the therapeutic process (Trede 2000; Salloum et al. 2023). It involves designing a personalised treatment plan, developed through two-way dialogue and partnership with the patient, that empowers individuals to learn about and manage their condition independently, incorporating exercises, advice and education (Cooper et al. 2008; Rindflesch 2009; Pashley et al. 2010; Harman et al. 2011). The physiotherapists interviewed shared their efforts to personalise individuals' care through advice on lifestyle changes, as highlighted in theme 2 titled 'Focus of physiotherapists in managing knee care'. They recognised the influence lifestyle choices have on recovery and recurrent hospital visits, findings that are supported by Alodaibi et al. (2022). In their study, Alodaibi et al. (2022) interviewed 12 Saudi physiotherapists who commonly agreed that promoting proper nutrition, physical activity and mental health awareness is part of their practice scope. A critical finding by Alodaibi et al. (2022) was that such practices were not part of the undergraduate physiotherapy education but were acquired on the job. This observation indicates that physiotherapists, both in this study and in Alodaibi et al. (2022), are broadening their professional scope by integrating health promotion into their practice despite its absence from their entry-level education, showcasing their flexibility and dedication to holistic patient care.

Within the scope of personalised care, patient education emerges as a key strategy (Salloum et al. 2023). It enables physiotherapists to convey important information, enhances self-efficacy and self-management skills and improves overall clinical outcomes (Hoving et al. 2010; Louw et al. 2011; Ndosi et al. 2015). This study highlights a debate around patient education, revealing a disconnect between physiotherapists, who regard it as an integral part of care, and individuals with knee pain, who perceive its depth and quality as reliant upon their inquiry. Notwithstanding this discrepancy, the literature consistently highlights the role of effective patient education in improving treatment compliance and implementing lifestyle modifications (Gold and McClung 2006; Sharaf 2010; Larsen et al. 2014; Paterick et al. 2017; Mensorio et al. 2019). Theme 2 of the study sheds light on the common challenge

physiotherapists face in ensuring compliance with home exercises amongst individuals with knee pain in Jeddah, a challenge that is often referred to in the global literature (Jack et al. 2009; Argent et al. 2018; Yalew et al. 2022). This raises the notion that an enhanced approach to patient education, one that is more personalised, could increase compliance, an assumption arising from the literature (Gay et al. 2016; Calner et al. 2019).

The Health Belief Model, a psychological framework aimed at understanding and predicting health behaviours, suggests that hesitation on therapy initiation or maintenance often arises from doubts about its effectiveness (Rimer and Glanz 2005; Gold and McClung 2006). Specifically, in Jeddah, the study found that individuals with knee pain were typically informed about intended treatment without additional information on its benefits or their condition in general, an insight captured in theme 2. This educational gap potentially contributes to the observed non-compliance with home exercises, a situation likely aggravated by the limited exercise culture within Saudi society (Althomali et al. 2023). Engaging in detailed education and discussions about their condition and the treatment options available during therapy sessions can alter patients' approach to self-managing their health. Calner et al. (2021) conducted a qualitative study with 11 participants with chronic musculoskeletal pain to explore their physiotherapy experiences in Sweden. These participants highlighted that receiving in-depth information from their physiotherapists about their condition, including triggers and movements that could worsen pain, enhanced their body awareness and led to better activity choices. Therefore, involving individuals with knee pain in informative dialogues during clinic visits has the potential to reshape their care perceptions and promote more proactive and responsible management of their conditions outside the clinical environment (Cheung and Soundy 2021).

4.4.1.3 Individuals' self-led strategies for managing knee pain

In managing chronic knee pain, individuals share a responsibility with their healthcare providers to facilitate sustained improvement and a better quality of life (Calner et al. 2021). However, this study found that physiotherapists in Jeddah minimally involve individuals with knee pain in managing their own condition. Despite this, some of the individuals with knee pain show notable initiative in managing their condition, as seen

in theme 3 ‘Self-initiated strategies to manage knee pain’. These individuals proactively seek information on their knee pain to increase their knowledge, monitor their condition's progression and communicate changes to their physiotherapists. This self-directed approach also includes implementing some strategies to self-manage symptoms at home or work based on the knowledge they gain, demonstrating health literacy. Kwan et al. (2016) define health literacy as the ability to find, understand and apply health information to achieve better health outcomes. Their proactive actions underscore the resilience and adaptability of those individuals in managing their own healthcare, often compensating for the gaps in the healthcare system with personal initiative, particularly with regards to education (Faria et al. 2014; Ghanei Gheshlagh et al. 2016). Resilience, often exhibited by individuals with chronic conditions, enables them to adjust to their evolving health challenges, facilitating a more manageable lifestyle (Ghanei Gheshlagh et al. 2016).

Interestingly, those particular individuals with knee pain expressed a high level of confidence in their physiotherapists in the interviews when discussing their conditions, expectations from physiotherapy and the self-management practices they selected. Such confidence is believed to be a result of a shift in their mindset, transitioning from merely expecting treatment to embracing and accepting their chronic pain's unique nature (Morris 2004; Liddle et al. 2007; Kawi 2014; Ernstzen et al. 2016). These individuals with a deep understanding of their chronic musculoskeletal conditions are more adept at managing and communicating with healthcare professionals about their health (Ernstzen et al. 2016). Nevertheless, this study suggests, in line with Adem (2017), that participants' proficiency in self-monitoring and exercise might stem from improved health literacy but is augmented by their long-lived experience with their condition and frequent engagement with physiotherapists and other healthcare professionals. Notably, individuals with knee pain in this study specifically credited their self-monitoring skills to their physiotherapists' guidance, corroborating with Adem (2017)'s observations. While gaining knowledge can motivate individuals to adopt active management strategies, whether they actually apply these strategies depends upon a complex interplay of factors, as highlighted by the literature and behaviour change theories (Devan et al. 2018; Egerton et al. 2021; Karloh et al. 2023).

However, not all participants in this study showed an interest in active engagement, particularly older individuals and females, who, as reported by physiotherapists, often prioritised immediate pain relief over engaging in educational or active strategies. This is a preference also observed in Alkhatrawi's (2013) study, which revealed a general disinterest among older patients in acquiring health information to manage their lower back pain. Individuals who actively engaged in their care tended to have higher education levels and professional status, consistent with a trend revealed by prior research (Adjei Boakye et al. 2018; Gustafsson et al. 2020; Sylwander et al. 2023). This can be understood through the lens of social cognitive theory, which emphasises the role of self-efficacy and its positive correlation with higher education and income (Bandura 1997; 2001; Yuan et al. 2014). Confirming the findings of this study, individuals of lower socioeconomic status typically exhibit reduced self-efficacy and tend to employ passive and less effective coping mechanisms in knee care (Cano et al. 2006; Christensen et al. 2006). Low self-efficacy correlates with low confidence, reluctance to exercise appropriately, low medication compliance and difficulties managing symptoms, underscoring the focus on enhancing self-efficacy in the self-management program literature (Mirzaei et al. 2017; Yi et al. 2021; Karloh et al. 2023). Effectively engaging those less inclined to practice self-care may require physiotherapists to change their behaviour and offer proper reassurance (Cheung and Soundy 2021). Reassurance in clinical interactions involves establishing rapport, displaying empathy, alleviating anxiety, ensuring individuals feel supported and providing explanations and education to enhance their understanding in order to promote lasting changes in beliefs, improve satisfaction levels and increase self-efficacy (Pincus et al. 2013; Cheung and Soundy 2021).

4.4.2 Discussion of findings related to research question two (Phase 1): How do physiotherapists and individuals with knee pain attending physiotherapy settings in Jeddah, Saudi Arabia perceive digital self-management support initiatives?

In this study, the introduction of the concept of digital self-management support was facilitated through a scenario-based question. Participants were presented with an imaginary website as a potential substitute to current face-to-face physiotherapy sessions. Key findings from the theme 'Connection to technology' and 'Perceptions of digital-based self-management support' answer study question 2.

Overall, most individuals with knee pain expressed support for transitioning from face-to-face sessions to a digital self-management support website, with the male participants being especially convinced. The physiotherapists suggested tailoring the website's use to specific groups, identifying young adults as ideal candidates for this digital approach. To address the challenges faced by those with limited technological skills, the physiotherapists proposed strategies like involving family members, integrating website training into therapy sessions and developing user-friendly manuals or booklets. This consensus between physiotherapists and individuals with knee pain extended to key features of future digital self-management support initiatives, with both groups emphasising educational materials, exercise videos and communication tools.

4.4.2.1 The role technology plays in the life of participants to manage knee pain

In this study, theme 4 titles ‘Connection to technology’ underscores the Internet's central role in the daily lives of the participants. A report from the Saudi Minister of Communications and Information Technology proudly positions Saudi Arabia as seventh globally in terms of Internet quality and speed with fifth-generation networks now widely adopted (Saudi Gazette 2021). This outstanding level of network coverage doubtless leads to the nation's high internet usage rates. Specifically, statistics reveal that there are 36.31 million Internet users in a country with a population of only 32 million, indicating a surplus of approximately 13.47% more devices connected than the total population (Saudi Census 2022; Kemp 2023). It suggests a high level of digital engagement and indicates that a significant portion of the population uses more than one device to access the Internet. This high rate of Internet penetration in Saudi Arabia aligns with trends observed in neighbouring Gulf Cooperation Council countries, which are all known for their wealth, technological advancements and high rankings on the United Nations Human Development Index (UNDP 2019; Alharbi and Csala 2021). The combination of these factors, alongside the region's harsh weather that encourages indoor activities, may explain the high Internet user rates in the region (Al-Khani et al. 2021). In this context, it is not surprising that almost all the participants in the study had Internet access and owned Internet-connected devices.

The Internet has an impact on various aspects of the participants' daily lives, including education and employment. Interestingly, its reach also extends to health management, and participants highlighted its role in managing knee conditions. This finding echoes the broader trend observed in relevant literature, emphasising the Internet's significance as a source of medical knowledge. Notably, a study by AlMuammar et al. (2021), which surveyed 1363 individuals in Jeddah, revealed that a substantial 92.6% of the participants turned to the Internet for health-related information for themselves or their family members. This pattern of behaviour aligns with the earlier findings of Bahkali et al. (2016), who reported that among their sample of 4847 participants across Saudi Arabia, 90.2% had sought medication-related information online at least once, with 68.3% using it regularly for this purpose. These high engagement rates underscore the significant reliance of the Saudi population on the Internet to enhance their health awareness, as demonstrated in the studies by Bahkali et al. (2016) and AlMuammar et al. (2021). This prevalent use suggests that digital solutions, particularly those offering credible educational content like self-management support initiatives, are likely to capture the attention of Saudi users. However, the physiotherapists interviewed expressed concern regarding individuals' reliance on online sources for health information. This concern is grounded in the reality that many online sources, particularly search engines, are not designed to be authoritative or unbiased providers of health-related information (Cai et al. 2021). As highlighted by Ahmad et al. (2006), this reliance on potentially inaccurate or misleading information poses a risk of indirect harm to individuals.

This study further highlights a noteworthy practice among physiotherapists. They were found to be encouraging correct performance of home exercises through the use of mobile phone cameras. In the field of physiotherapy, the use of mobile phones to support exercise therapy has previously been documented in the literature (Bientzle et al. 2021). Physiotherapists from this study identified the mobile camera as a preferred tool of theirs and individuals with knee pain, leveraging its widespread availability among the Saudi population to facilitate this approach (Arab News 2017). The effectiveness of mobile cameras in this context is supported by existing literature, which acknowledges their usefulness in creating instructional exercise videos, offering video feedback and enabling video self-modelling (Reo and Mercer 2004; Coulson et al. 2006; Miller et al. 2009; Rohbanfard and Proteau 2013; Post et al. 2016). The

physiotherapists from this study were found to use mobile cameras for similar purposes, showcasing a trend among Jeddah physiotherapists towards embracing digital solutions to improve the exercise performance and compliance of individuals with knee pain. This practice capitalises on the familiarity and accessibility of mobile technology in the country, integrating it seamlessly into the therapeutic process (Al-Sakran and Alsudairi 2021). While the integration of mobile phone photography and video recording into clinical practice might elicit concerns regarding individual autonomy and privacy, such concerns are mitigated in this study's context. It is explicitly reported that the recordings are made using the individuals' own devices, thus giving them rather than healthcare professionals control of privacy and autonomy (Vearrier et al. 2018).

Additionally, physiotherapists from this study were found to share their personal phone numbers with individuals to facilitate sending exercise-related content, respond to queries and supervise home exercises through video calls. This practice is less documented in the physiotherapy-specific literature but is known to be common practice in the broader healthcare sector, where orthopaedic surgeons, primary care physicians and radiologists adopt it (Dash et al. 2016; Rogero et al. 2020; Kemp et al. 2020). Dillaway (2009) suggests that such direct communication channels might significantly enhance the therapist-patient rapport by facilitating prompt responses to patient concerns. This effort by physiotherapists in Jeddah showcases their commitment to providing personalised, ongoing management and support for individuals with knee pain, thereby promoting a therapeutic relationship rooted in trust and accessibility. Nevertheless, this approach is not without its complications, particularly concerning ethical and professional boundaries. The exchange of personal contact information between healthcare providers and patients might contravene the guidelines of some healthcare institutions. Notably, the Saudi Ministry of Health's Law of Practicing Healthcare Professions (MoH 2017) does not explicitly restrict the sharing of personal contact details during clinical interactions, possibly contributing to its acceptance among physiotherapists interviewed. However, this practice risks blurring professional boundaries, inadvertently changing the nature of interactions from professional to personal. Such shifts could alter patient expectations, undermining the integrity of the professional relationship (Donate-Bartield and D’Angelo 2000). Furthermore, personal contact details are inherently sensitive, and any mishandling

could breach privacy laws, risking patient confidentiality (Sittig and Singh 2015; Virginio and Ricarte 2015). In this context, digital self-management support initiatives emerge as a viable alternative, potentially mitigating the aforementioned risks. They can offer a structured, secure platform for information exchange, exercise demonstration and monitoring, without the need for sharing personal contact information.

4.4.2.2 The potential for individuals with knee pain to take the lead in their care

The physiotherapists and individuals with knee pain interviewed in this study were in agreement that a digital self-management support initiative might be a valuable addition to traditional in-clinic therapy. They mostly envisioned its use as both an educational resource and a part of a hybrid care model, integrating online and face-to-face interactions, rather than as a standalone intervention. This conception is understandable, considering the novelty of digital solutions in physiotherapy within the region at the time of the interviews, which were conducted before the widespread adoption of remote services during the COVID-19 pandemic (Alwashmi 2020; Alharbi et al. 2022a; Alharbi et al. 2022b). The pandemic, which began in 2020, was a catalyst for significant change in terms of the delivery of physiotherapy treatment in Saudi Arabia (Elsayed et al. 2022). Before this, digital solutions were not a part of standard physiotherapy practice. However, the pandemic necessitated the rapid introduction of remote healthcare in order to accommodate global lockdowns and changing healthcare needs (Elsayed et al. 2022). This change suggests that perceptions of digital solutions and self-management in Saudi might be more favourable post-pandemic, as reported in other regions of the world (Morrison et al. 2022). To capitalise on this evolving situation, the integration of self-management support initiatives as a complement to face-to-face care (as toolkits) into existing physiotherapy practices is recommended at this stage. This approach has been increasingly recognised in the literature for its effectiveness in enhancing individual's knowledge and supporting healthcare providers. For example, studies by Choi et al. (2019) and Goff et al. (2023) underscore the ability of these toolkits to facilitate self-management support. Implementing such toolkits in Jeddah would not only complement in-clinic therapy but also serve as a preparatory strategy, gradually acclimating individuals with knee pain and physiotherapists to a more digital-oriented care approach.

In this study, the physiotherapists demonstrated a positive attitude towards the proposed website, which sought to address the challenge of long waiting lists and would be especially beneficial for younger adults. This concurs with Keel et al. (2022), highlighting physiotherapists' selective adoption of digital tools for younger adults due to their familiarity with technology for educational and professional purposes. Nonetheless, the ongoing digitisation of public services in Saudi Arabia has led to increased Internet usage among older generations, suggesting a growing adaptability to such digital health solutions (Brende 2023). To ensure accessibility, digital self-management support initiatives are often designed with a focus on ease of use and clear readability, catering to a broad age spectrum (Chapman et al. 2017; Button et al. 2018). For older adults, the physiotherapists in the current study proposed inclusive strategies like involving family members, in-session training and distributing informative brochures. The involvement of family as support makes good sense in a country like Saudi Arabia, where the culture emphasises familial bonds. A similar strategy was observed in a Nepali study by Bhandari et al. (2021), in which family members helped older adults with low literacy to use mobile health technology. This observation is crucial for communities in countries like Saudi Arabia and Nepal, where family involvement is integral to the healthcare process (Evason 2017; Evason 2022). These strategies underscore the need to tailor digital self-management support initiatives to the specific cultural and demographic needs of the population.

In this study, individuals with knee pain predominantly endorsed the concept of transitioning from traditional in-person therapy to remote self-management support. However, a clear difference between the genders emerged, with male participants more likely to support the replacement of face-to-face sessions with the proposed website. This could be a consequence of men's greater comfort with, and openness to, digital healthcare solutions. Research by Sobieraj and Krämer (2020) sheds light on gender differences in technology usage and acceptance. Their findings suggest that despite men and women being similarly proficient in technology use, women tend to harbour more self-doubt about their technological capabilities. This insight could help explain why women in this study were less inclined to fully embrace a digital health solution for managing their knee pain. Further, the female participants emphasised the importance of physical interaction with their therapist during sessions. This preference highlights the diverse and specific needs of different groups. For these

women, the physical presence of a therapist goes beyond preference; it is an integral part of their treatment, offering essential support, guidance and a sense of comfort in their care journey (Promises 2021).

Further, some individuals with knee pain in this study perceived the self-management support website as a supplement to in-person sessions rather than a complete replacement. This viewpoint resonates with the opinions of many physiotherapists involved in the study. They appreciated a hybrid model that melds the convenience and accessibility of digital platforms with the tangible benefits of face-to-face interactions. This duality is evident in some knee-focused, digital self-management support interventions in the existing literature. For instance, Hinge Health by Smittenaar et al. (2017) incorporates personal coaching for each user, enhancing the digital experience with human interaction. Similarly, the TRAK App suite by Spasić et al. (2015), enables users to engage with their peers in virtual support groups, providing a sense of community and shared experience. In the case of My Dear Knee by Alasfour and Almarwani (2022), supervised exercise sessions that offer direct professional guidance and reassurance are an aspect of the application. These examples from the literature demonstrate the popularity of integrating human interaction into digital self-management support initiatives. Replicating such approaches in future self-management initiatives for individuals with knee pain in Jeddah could be beneficial. Importantly, it would maintain the essential role of physiotherapists in the care process and could address specific needs, such as providing reassurance to females who value direct communication and supervision during their treatment.

4.5 Clinical implications from Phase 1

The study reveals a positive response from both physiotherapists and individuals with knee pain to digital self-management support initiatives. This enthusiasm is rooted in the anticipation that such digital solutions can significantly enhance the understanding of knee conditions and reduce the operational strain on physiotherapy clinics. However, the transition towards a fully digital self-management support model is met with caution, indicating a preference for digital support toolkits that complement the therapeutic journey by enriching individual knowledge and strengthening the rapport between the physiotherapist and the individual with knee pain. This reluctance to fully embrace standalone digital interventions reflects a deeper, systemic problem within the Saudi healthcare system.

In particular, principles integrated into self-management support, such as autonomy, shared decision-making and personalised care, transcend the limits of existing practice in Jeddah physiotherapy clinics. A transformative plan aimed at restoring human dignity in care is a priority, beginning with efforts to elevate the stature of physiotherapy as a recognised profession among healthcare providers, particularly physicians (Al-Eisa et al. 2016). This plan requires a multifaceted approach involving revisions to medical education curricula and the launch of targeted awareness campaigns led by physiotherapists themselves (Alanazi 2020). Such efforts aim to foster mutual respect and understanding between physicians and physiotherapists, enabling the latter to operate with greater autonomy and creative freedom. Liberating physiotherapists from the need to constantly prove their competency to physicians could significantly boost their confidence and effectiveness in patient care (Barrett and Terry 2018).

In Jeddah, individuals with knee pain are generally passive when it comes to making decisions about their treatment within clinic settings. Despite their passivity, they express satisfaction, trusting in the superior knowledge and expertise of physiotherapists to formulate optimal treatment plans. This trust suggests those individuals might be open to embracing self-management support initiatives as a primary method of management if they received enough information and education from physiotherapists. Yet, the variable quality of patient education provided in

Jeddah's clinics presents a significant barrier to this shift. Addressing this issue necessitates the development of educational programs for physiotherapists. These programs should aim to promote a collaborative care model that emphasises the patient's active participation in their treatment journey. Such models aim to enhance decision-making and increase awareness of health maintenance and condition management as well as activate and sustain individual interest in care (Krist et al. 2017). This method not only strengthens the therapeutic alliance but also aligns with the principles of patient-centred care, potentially providing a more favourable context for integrating self-management support initiatives.

4.6 Limitations of Phase 1

Few limitations that warrant attention were identified in this study. Despite efforts to ensure a varied participant pool through the selection of three public hospitals and one private clinic across Jeddah, the study's findings may not fully capture the diverse demographics and healthcare dynamics of the country. Consequently, the applicability of the study's findings to broader populations within and beyond Jeddah may be restricted. Therefore, future researchers are encouraged to broaden the scope of their explorations to include various regions of the country, including rural areas with a high proportion of elderly individuals—a demographic that could offer valuable insights. Although physiotherapy clinics might not be as prevalent in these rural areas, engaging with participants from such locales could unveil perspectives that might be otherwise overlooked. This is particularly relevant due to the unique characteristics of rural settings, potentially affected by limited network services, lower income levels, and a higher proportion of illiterate individuals (Alhowaymel and Alenezi 2022). While similarities might generally persist with the existing work, the surrounding culture could lend new layers of depth to the insights obtained. Moreover, given the study's focus on introducing digital-based healthcare solution, the varying levels of technological literacy and access among participants could influence their perceptions and reported experiences. Participants with limited technological skills, confidence or access may face inherent challenges not adequately addressed by the study.

4.7 Conclusion to the chapter

This study, employing an exploratory descriptive qualitative design, explored how physiotherapy practices for chronic knee pain in Jeddah, Saudi Arabia align with self-management support principles. Additionally, it explored the perceptions of physiotherapists and individuals with knee pain regarding digital self-management support initiatives. To achieve this, 29 participants from four physiotherapy clinics in Jeddah were interviewed using semi-structured interviews. The data analysis thematically generated five key themes, which are ‘Physiotherapy practice in Jeddah’, ‘Focus of physiotherapists in managing knee pain’, ‘Self-initiated strategies to manage knee pain’, ‘Connection to technology’ and ‘Perceptions of digital-based self-management support’. The findings from the themes pointed to a misalignment of existing physiotherapy practices with the core principles of self-management support, highlighting a significant need for a shift towards more patient-centred care. This shift requires emphasising patient education and the more active engagement of individuals in their care journey. A broadly positive approach to digital self-management support initiatives was found amongst both physiotherapists and patients. Nonetheless, the transition to a fully digital model is approached with caution, advocating for digital self-management support initiatives that complement rather than replace face-to-face therapeutic interactions. This situation is a microcosm of the broader Saudi healthcare system, where there is a general need for greater autonomy and shared decision-making in care.

The next chapter provides a comprehensive overview of the journey to tailor TRAK-Saudi platform, detailing the adaptation team, the rationale for adapting an existing intervention, the specific user requirements that guided TRAK-Saudi’s design, the base platforms it is built upon and the functionalities that define its final form.

Chapter 5: The Adaptation of TRAK to TRAK-Saudi, A Web-Based Self-Management Support Platform for Individuals with Chronic Knee Pain in Jeddah, Saudi Arabia

5.1 Introduction to the chapter

This chapter describes the adaptation of the digital intervention TRAK (Button et al. 2018) to make it suitable for the Saudi context (TRAK-Saudi). Incorporating insights from the interviews conducted in Phase 1, TRAK-Saudi, a web-based self-management support platform specifically catering for individuals with chronic knee pain in Jeddah, Saudi Arabia, was tailored. In this scenario, adaptation refers to the intentional modifications applied to an evidence-based intervention to achieve better fit with a new context (Escoffery et al. 2019; Movsisyan et al. 2019). The ADAPT guidance framework by Moore et al. (2021) was followed, though not strictly adhered to, during the adaptation process. This decision was made to enhance the narrative's clarity and accessibility, ensuring that readers could easily grasp the complex process of adapting the original platform. Inspired by the ADAPT guidance framework, this chapter will include information on aspects such as the adaptation team, the rationale for adaptation, user requirements and base platforms and will provide a visual tour of the final functionalities.

5.2 Adaptation team

The primary researcher led the adaptation process, with supervision from the original developers of base platforms for guidance and evaluations (Moore et al. 2021). A senior specialist in information systems from Cardiff University supported the technical modifications. To accommodate the Arab user base of TRAK-Saudi, a professional translator was recruited to ensure accurate and culturally relevant translations of the originally English content in the base platforms, enhancing the accessibility and appropriateness of TRAK-Saudi for the new context. Regular online meetings were held between the adaptation team members to follow up on progress.

5.3 Rationale for adaptation

At this stage of the project, adaptations were applied to ensure that the digital self-management support platform tested in phase 2 closely aligned with the needs of

physiotherapists and individuals with chronic knee pain in Jeddah. My goal for phase 2 was to present a digital platform that realistically mirrored potential real-life usage. Research indicates that the perceived ease of use and relevance of technology significantly influences user intentions regarding acceptance or rejection (Ji et al. 2018; Utomo et al. 2021). Hence, drawing from feedback collected during the phase 1 interviews, TRAK-Saudi was adapted for the phase two participants, ensuring it precisely catered to their expressed needs and preferences.

5.4 Contextual and Theoretical Foundations of the Adaptation process

In reviewing the literature in Chapter 2, it is evident that contemporary global practices in the design and development of self-management support initiatives prioritise three key principles: co-design, patient-centered content, and theory-based interactive features (Eysenbach 2005; Button et al. 2018; Nelligan et al. 2019; Meyerowitz-Katz et al. 2020; Bennion et al. 2020; Barnum 2021). This knowledge brought from the literature informed the final product of TRAK-Saudi for this project.

TRAK-Saudi was co-designed to integrate the expertise of the original TRAK developers, my own experience as a physiotherapist familiar with Saudi culture, and the feedback provided by participants in Phase 1 interviews. This approach aligns with best practices, aiming for a human-centered design that meets user needs, ensures navigational ease, and enhances overall satisfaction (ISO 9241-210, 2018; Slattery et al. 2020). This methodology is consistent with several reviewed DHIs in this study in Chapter 2, including TRAK by Spasić et al. (2015) and Button et al. (2018), My Knee Exercise by Nelligan et al. (2019), Knee OA (MVP) by Mrklas et al. (2020), DETA by Gruner et al. (2021), and My Knee by Goff et al. (2023). Incorporating feedback solely from both healthcare professionals and patients in TRAK-Saudi reflects practices seen in the original TRAK and My Knee by Goff et al. (2023) and was deemed sufficient to inform initial design (Spasić et al. 2015; Button et al. 2018).

Drawing from the interviews, a requirement document covering the needs of and suggestions made by the participants in the interviews was completed myself in September 2020. Both physiotherapists and individuals with knee pain concurred that educational content, exercise videos, connection and reminders on the platform were

necessary, echoing findings from international research on knee pain management (Mrklas et al. 2020; Goff et al. 2023).

1- Education content: The participants expressed a need for detailed information on the causes and triggers of knee pain, effective home-based pain management strategies and dietary information. Prior research, such as the study by Alissa et al. (2020), underscores the impact of dietary habits on knee OA in Saudi women, highlighting the importance of incorporating dietary guidance and dietitian consultations into these initiatives. Furthermore, the feedback from the participants indicates a strong preference for video-based educational materials over traditional text and graphics. This aligns with the evolving digital self-management support for knee pain landscape, wherein video content is increasingly used to enhance user engagement and comprehension (Gruner et al. 2021; Shewchuk et al. 2021; Goff et al. 2023). Opting for video content is a deliberate strategy to mitigate information overload, a notable obstacle in the effective use of digital health resources (Umapathy et al. 2015; Parsons and Adams 2018). For TRAK-Saudi, a multimodal approach that combined videos and text to deliver educational content was chosen.

2- Exercises videos: Participants desired video-based exercise instructions in order to enhance comprehension and execution within the platform. Demonstrating exercises through videos rather than relying on traditional printed materials has been proven to improve both the accuracy of performance of those exercises and adherence to a schedule (Weeks and Anderson 2000; Reo and Mercer 2004). This method not only helps ensure that exercises are carried out correctly but also bolsters users' confidence in their ability to manage their chronic knee pain independently at home (Ouegnin and Valdes 2020). Increased confidence can lead to better adherence to prescribed exercise routines, an essential component in the management of knee pain, as noted by Kingston et al. (2010). For TRAK-Saudi, all exercises are presented in videos and brought from the original TRAK website by Button et al. (2018). They are derived from the TRAK ontology, which is a formal model designed to represent standard care for knee condition rehabilitation (Button et al. 2013).

These exercises were selected based on a systematic literature review and a comprehensive survey of clinical practices across the United Kingdom (Button et al. 2012). The inclusion of these exercises in TRAK-Saudi ensures that users have access to a wide range of evidence-based exercises that are relevant to their specific knee conditions.

3- Being connected: The study participants emphasised the importance of including a communication feature in future initiatives. This desire likely stems from concerns about the loneliness and isolation that can accompany the independent management of chronic conditions like knee pain. Being connected, through direct interactions with healthcare providers or a peer network, is crucial for those dealing with chronic knee pain (Fledderus et al. 2015). The use of communication tools is a well-established practice in the field of chronic knee pain self-management. Successful interventions around the world have employed in-person meetings, phone conversations, emails and instant messaging to support patients (Brooks et al. 2014; Smittenaar et al. 2017; Gruner et al. 2021; Alasfour and Almarwani 2022). For TRAK-Saudi, a messaging system was incorporated into the platform.

4- Reminders: The physiotherapists recommended adding a reminder feature to the platform. This echos findings from both Saudi and international research that highlights the benefits of reminders in supporting compliance to exercise routines at home (Nelligan et al. 2021; Alasfour and Almarwani 2022). The literature suggests that various forms of reminders, such as SMS, on-screen notifications and email alerts, are effective in encouraging regular exercise and symptom monitoring (Spasić et al. 2015; Nelligan et al. 2021; Alasfour and Almarwani 2022). This is supported by the Health Belief Model, which suggests that reminders can motivate health-enhancing behaviours by emphasising the importance of action to mitigate health risks (Ronis 1992). Reminders are not yet part of TRAK-Saudi but will be considered as an update when long-term testing studies are carried out.

5- Physiotherapists' input: Feedback from physiotherapists highlighted their desire to have control over the selection of exercises on the platform. This reflects the

traditional, more paternalistic approach observed in the clinics involved in this study and aligns with practices observed in existing Saudi digital applications like My Dear Knee, which was designed for chronic knee pain management (Alasfour and Almarwani 2022). To accommodate this, TRAK-Saudi was designed to facilitate shared accounts between physiotherapists and patients, encouraging a partnership in care. This feature allows both parties to propose exercises for the treatment plan, encouraging collaboration to foster mutual decisions on the components of the exercise regimen.

Furthermore, TRAK-Saudi facilitates the personalisation of content to align with the specific conditions and goals of individuals experiencing chronic knee pain, embodying a patient-centred approach. The importance of personalisation in self-management support DHIs has been emphasised in the reviewed literature. For instance, potential users in studies on the TRAK App suite, Knee OA (MVP), and My Knee toolkit have highlighted the significance of tailored interventions in areas such as goal setting and exercise selection (Spasić et al. 2015; Shewchuk et al. 2021; Goff et al. 2023). Feedback from these studies underscores the necessity of personalising initiatives to better address users' individual needs, which, in turn, enhances psychological factors like motivation and engagement (Burgers et al., 2015; Hutmacher & Appel, 2022). In TRAK-Saudi, the personalisation process begins at the initial stage, where all new users are asked to complete the Saudi-Arabic version of the Knee Injury and Osteoarthritis Outcome Score (KOOS) questionnaire upon joining the platform and on different time points afterward (Appendix K). The Arabic KOOS is a validated and reliable tool for assessing symptoms, functional limitations, and quality of life in individuals with knee conditions (Roos and Lohmander 2003; Alfadhel et al. 2018). This preliminary step provides physiotherapists with detailed insights into the individual's knee pain experiences, facilitating the creation of personalised exercise and advice plans, as well as monitoring progress over time. Exercise regimens in TRAK-Saudi are specifically tailored to the user’s goals and timelines, with no fixed regimens. Instead, users collaborate with physiotherapists to develop personalised plans that respect and address their unique needs. This approach ensures that the TRAK-Saudi is not only relevant but also adaptable to cope the potential change in subject’s condition over a long time of use, promoting a higher degree of user engagement and satisfaction.

Furthermore, the basis platforms of TRAK-Saudi, LEAP-MS, and the original TRAK (more details in 5.5) are based on a theoretical underpinning that promotes behavioral change among users. Incorporating theoretical principles into TRAK-Saudi was deemed important, despite inconsistent application in the reviewed literature (Gruner et al. 2021; Alasfour and Almarwani 2022). This incorporation addresses the needs identified in user interviews, where participants showed a need for empowerment to take an active step in the self-management process through education and autonomy, as well as motivation via external support and interactive features such as videos and monitoring systems. Behavioral change theories are specifically designed to facilitate these objectives. In TRAK-Saudi, key elements from social cognitive theory and self-determination theory were incorporated to encourage positive health behaviours. Social cognitive theory emphasises the role of observational learning, self-efficacy, and self-regulation in behaviour change, while self-determination theory focuses on promoting intrinsic motivation by supporting autonomy, competence, and relatedness. By embedding these theoretical elements, TRAK-Saudi aims to create an environment that not only educates and empowers users but also sustains their motivation and engagement over time. This theoretically informed approach ensures that TRAK-Saudi is robust and effective in promoting long-term behavioral change.

- By incorporating educational content, exercise videos and personalised feedback from physiotherapists, TRAK-Saudi adopts principles from social cognitive theory. This theory emphasises the significance of observational learning, self-efficacy and social support. The platform enables users to learn through observation (e.g., watching educational videos and exercise demonstrations, learning new skills, and understanding the importance of physical activity and pain management techniques), provides step-by-step exercise videos (Activity suite), facilitates goal setting (Aims), progress tracking (Activity log), and enhances users' confidence in executing exercises correctly and managing their conditions. Additionally, the messaging system (Contact my physio) offers a channel for receiving encouragement and advice from physiotherapists, thereby fostering a supportive community environment (Bandura et al. 1975; Bandura and McClelland 1977; Bandura et al. 1997; Maisto et al. 1999).

- TRAK-Saudi's functionality, which includes goal setting, progress monitoring and receiving personalised exercise plans and advice, aligns with self-determination theory's central tenets: autonomy, competence and relatedness. The platform empowers users to take control of their treatment plans (autonomy), enables them to track their progress and receive tailored exercise recommendations (competence), and provides support from physiotherapists (relatedness). In doing so, TRAK-Saudi effectively promotes intrinsic motivation regarding healthy behaviours (Ryan and Deci 2000; Ryan and Deci 2011).

5.5 Base platforms

TRAK-Saudi evolved out of two DHIs developed to support behaviour change: TRAK, aimed at knee rehabilitation, and LEAP-MS, a Lifestyle, Exercise and Activity Package for people living with progressive Multiple Sclerosis (Spasić et al. 2015; Button et al. 2018; Lowe et al. 2021). TRAK and LEAP-MS align closely with the user requirements identified in this study. TRAK can be accessed at this URL: http://trakphysio.org.uk/Home whilst LEAP-MS can be found in the studies of Lowe et al. (2021) and Busse et al. (2022).

TRAK, described in detail in Chapter 2, was originally developed as TRAK App suite and incorporates four principal functionalities, which are the delivery of information, a knee-specific exercise program, self-monitoring with visual feedback and virtual support through a Facebook-hosted platform (Spasić et al. 2015). Subsequently, TRAK evolved into a standalone website, as depicted in Figure 8, with enhancements that include self-select exercise videos and additional educational resources to facilitate self-management (Button et al. 2018). However, in this iteration, the communication portal was removed to alleviate the work burden on clinicians. Some of the educational materials that relate more for chronic knee pain individuals and all the exercise videos from TRAK were specifically integrated into TRAK-Saudi, with language adaptations to ensure they were contextually appropriate for the Arabic speaking audience.

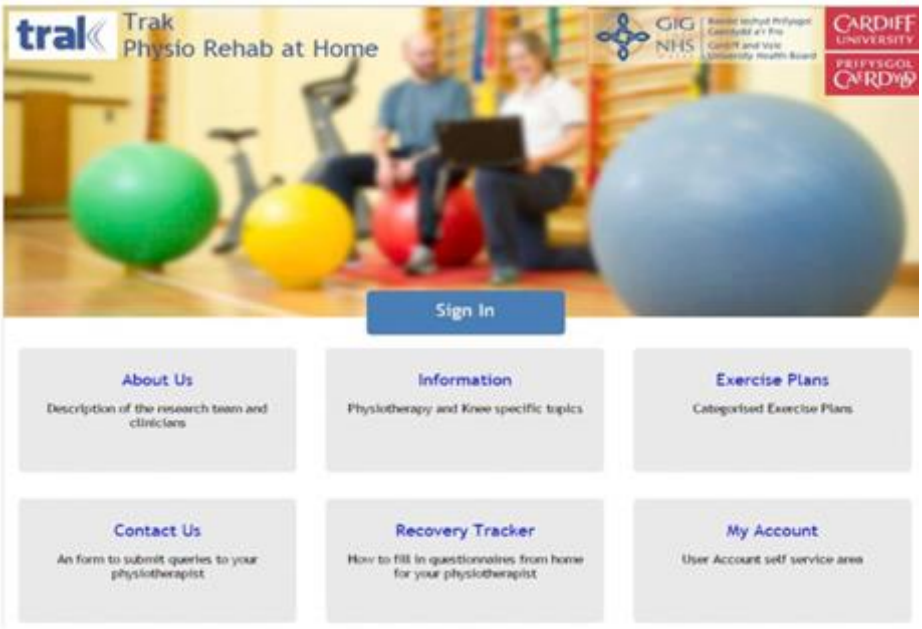

Figure 8: A screenshot of the main page of TRAK website.

LEAP-MS was developed to assist individuals with multiple sclerosis in maintaining consistent physical activity and to facilitate physiotherapists' involvement in self-management practices (Busse et al. 2021). Focusing on behaviour change, LEAP-MS is underpinned by behaviour change theories, mainly social cognitive theory and self-regulation theory (Busse et al. 2021). As an interactive web-based platform, it is compatible with various devices, including computers, laptops, tablets and mobile phones, ensuring accessibility for users (see Figure 9) (Busse et al. 2021). The platform features functionalities, such as an information suite, a physical activity library, a progress tracking tool, goal-setting capabilities, a shared account option, so physiotherapists can monitor progress and provide feedback, and a participant-physiotherapist messaging system. For the development of TRAK-Saudi, LEAP-MS served as the base platform as it was capable of integrating the specific user needs identified in phase 1 along with the educational and exercise content from TRAK.

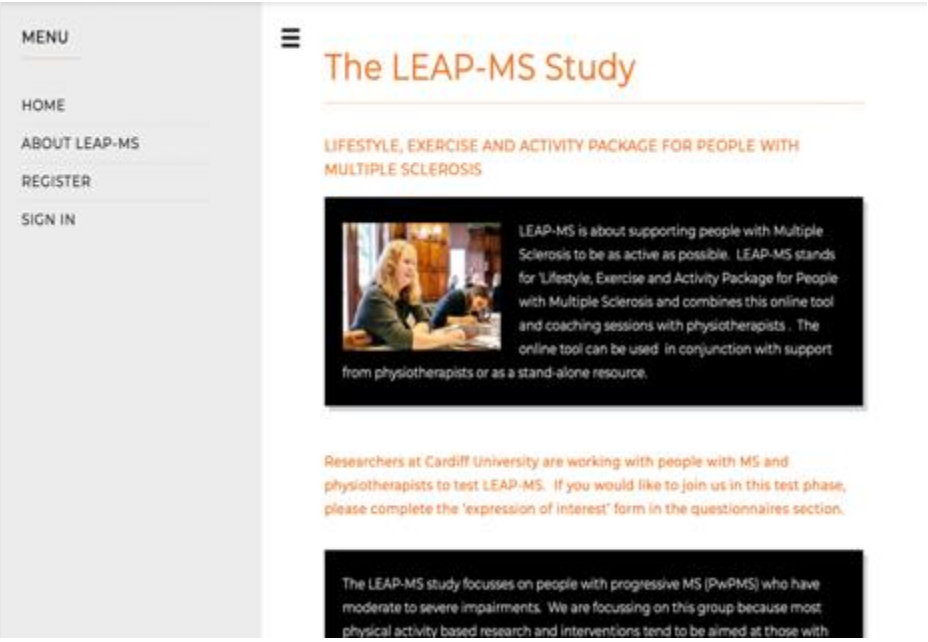

Figure 9: A screenshot of the main page of LEAP-MS website.

5.6 TRAK-Saudi functionalities

The final version of TRAK-Saudi was completed in June 2021 and can be accessed via this URL https://traksa-intervention.uat.ctr.cardiff.ac.uk. TRAK-Saudi is a bilingual interface which supports Arabic and English-speaking users due to these being the two main languages spoken in Saudi. The main functionalities of the web-based platform are:

Homepage serves as the initial landing page of TRAK-Saudi, providing visitors with introductory information about the platform and its content. It is the central point from which users can access and navigate to other sections and pages within TRAK-Saudi. The homepage of TRAK-Saudi, titled *About TRAK Saudi,* contains brief information about the platform and its different functionalities (see Figure 10).

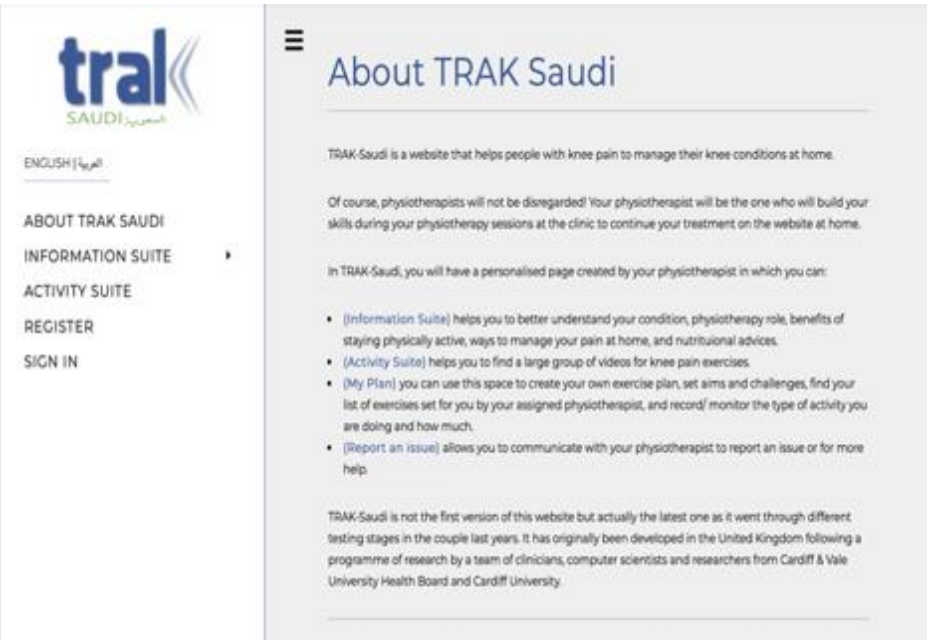

Figure 10*:* A screenshot of the main page of TRAK-Saudi.

Information Suite functions as the central educational resource for TRAK-Saudi users, primarily drawing its content from the TRAK website with additional input from three experts who were consulted to enrich the content creation process (Spasić et al. 2015). This feature covers a wide range of topics, including physiotherapy care practices, knee anatomy, the importance of physical activity, pain management techniques and dietary recommendations. (see Figure 11).

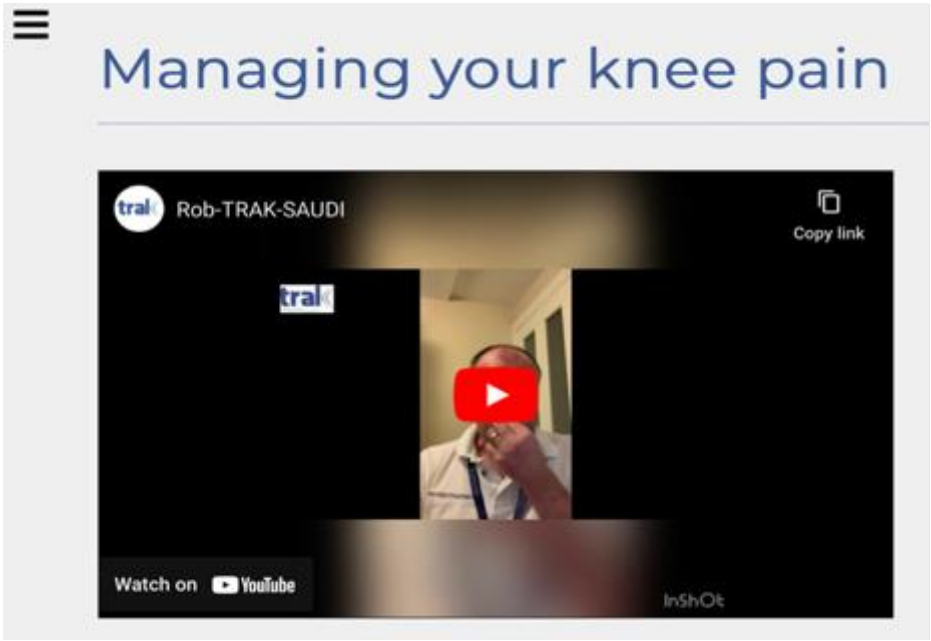

Figure 11: A screenshot of an educational video in the information suite.

Activity Suite includes different categories of exercise videos that can be used by individuals with chronic knee pain with different causes (see Figure 12, 13). The exercise information included in TRAK-Saudi is derived from the TRAK ontology, which is a formal model designed to represent standard care for knee condition rehabilitation (Button et al. 2013). These exercises were selected based on a systematic literature review and a comprehensive survey of clinical practices across the United Kingdom (Button et al. 2012). The inclusion of these exercises in TRAK-Saudi ensures that users have access to a wide range of evidence-based exercises that are relevant to their specific knee conditions.

Figure 12: A screenshot showcasing the exercise categories in TRAK-Saudi.

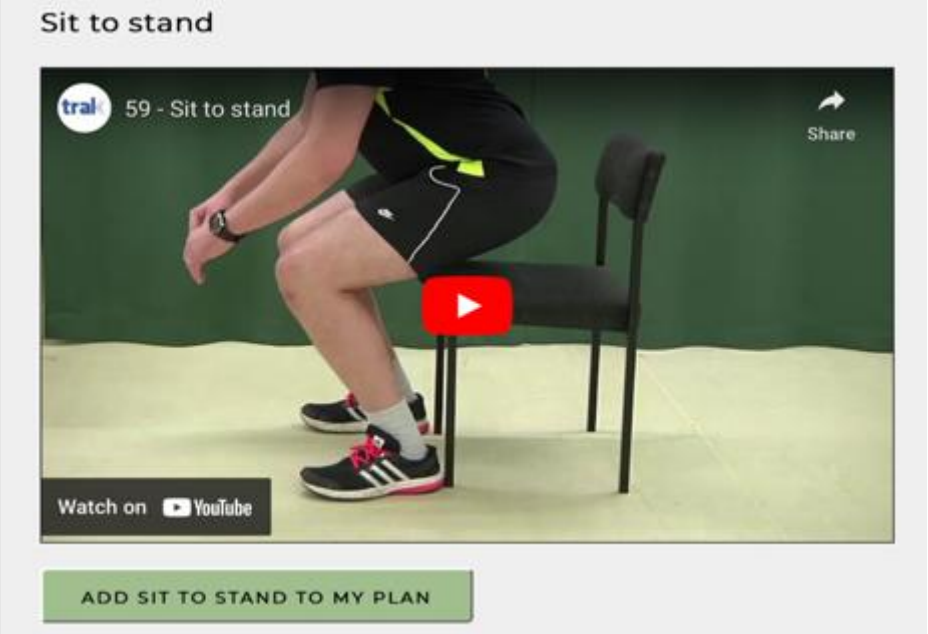

Figure 13: A screenshot showcasing a sample of exercise video available on TRAK-Saudi.

Register is for new users who wish to submit their inquiries to be reviewed by physiotherapists for an eligibility check. Once approved, users can access their personal account via Sign In.

Dashboard can be found in the navigation menu exclusively for registered users. Different functionalities can be found in the dashboard, as follows:

1- My Plan: This is where users can find their self-selected exercises or others recommended by their assigned physiotherapist.

2- Aims: This is where users can set their aims within a planned timeframe. Physiotherapists can assess these aims and give advice.

3- Activity log: This is where users and physiotherapists can track the user's progress and the activity plans completed.

4- My account: This is where users can access their personal information, including name, username and registered email.

5- My questionnaires: This is where users can complete a survey relating to eligibility as a starting point for the eligibility check. Right after joining TRAK-Saudi, individuals with chronic knee pain are required to complete the Saudi-KOOS questionnaire, enabling their assigned physiotherapist to understand the current state of their problem and any progress made overtime. The Arabic KOOS is a valid and reliable tool to assess symptoms, functional limitations and quality of life in individuals with knee conditions (Roos and Lohmander 2003; Alfadhel et al. 2018).

6- Contact my physio: This is the messaging system on TRAK-Saudi via which individuals with knee chronic pain can contact their assigned physiotherapist to make enquires and ask for advice.

7- View emails: This is where physiotherapists can find and respond to the messages sent to them by other individuals with chronic knee pain.

5.7 Conclusion to the chapter

TRAK-Saudi is an adapted platform derived from existing DHIs. The decision to adapt TRAK to TRAK-Saudi was made due to a desire to offer participants in phase 2 a close-to-reality experience in the planned usability study. The adaptation process incorporated feedback from phase 1, ensuring the digital platform met user needs, and integrated evidence-based content from TRAK, supplemented by expert guidance. TRAK-Saudi features a comprehensive suite of functionalities, including education, exercise videos, self-monitoring tools and a messaging system, enabling a collaborative self-management experience for users in Jeddah.

The next chapter details all the information related to the second phase of this research titled with “A remote usability study of the TRAK-Saudi platform with physiotherapists and individuals with chronic knee pain”. It presents methods, results, discussion, clinical implications, study limitations and conclusion to the chapter.

Chapter Six: Phase 2 – A Remote Usability Study of the TRAK-Saudi Platform with Physiotherapists and Individuals with Chronic Knee Pain

6.1 Introduction to the chapter

This chapter outlines phase 2 of this mixed methods research, a remote quantitative usability testing study of the TRAK-Saudi platform (described in Chapter 5) to answer the following research question:

How usable is the "TRAK-Saudi" platform for physiotherapists and individuals with chronic knee pain in Jeddah, Saudi Arabia?

The following sections present the methods, results and discussion, including the clinical implications and limitations of the TRAK-Saudi usability study.

6.2 Research methods for phase 2

As previously explained in Chapter 3, a quantitative usability testing study was conducted in this phase of research. In usability testing, when the digital product being assessed is nearly fully developed like the case with TRAK-Saudi, quantitative measures are best to be adopted to generate data that is replicable over time for precise data for continues enhancements (Barnum 2021). This usability study adopts mixed methods approach, combining think-aloud techniques with questionnaire data. This method is supported by literature suggesting that integrating qualitative insights with quantitative measures offers a more comprehensive understanding of usability issues, enhancing user experience and facilitating healthcare adoption (Zapata et al. 2015; Maramba et al. 2019). Evidence from numerous studies confirms the value of this dual approach in gaining deeper, actionable insights into user-system interaction (Smaradottir et al. 2016; Tielman et al. 2017; Maramba et al. 2019).

6.2.1 Study setting

The original plan was to conduct the usability testing phase of the study in-person. However, due to the pandemic and to ensure continuity of research, the data collection was conducted remotely (Sherwin et al. 2021). This decision was aligned with global

guidelines to reduce physical contact and thus mitigate the spread of COVID-19 (WHO 2021). In the pre-pandemic study Sherwin et al.'s (2021), participants expressed concerns about in-person usability testing, leading the authors to adopt remote testing to fit the participants' schedules and preferences. The results of Sherwin et al. (2021) showed that remote usability testing is a viable option for maintaining research progress, whether necessitated by public health crises, such as the COVID-19 pandemic, or by the needs of the participants.

Recent literature recognises remote usability testing as an effective alternative to lab testing (Tullis et al. 2002; Chalil Madathil and Greenstein 2011; Firjatullah et al. 2021; Bastien and Falzone 2022). Remote testing outperforms lab testing by offering home-based participation and reducing setup costs (Bolt and Tulathimutte 2010). It also enables evaluation across different devices and Internet conditions, a flexibility often lacking in lab tests that typically rely on a single dedicated device (Gardner 2007). Therefore, the shift to remote usability testing in this study was a strategic response to the pandemic, ensuring safety and research continuity while leveraging the method's recognised benefits for flexibility and broader device compatibility.

6.2.2 Outcome variables and associated data collection approaches

In this study, the participants assessed the usability of the TRAK-Saudi platform by evaluating its **perceived usability** and identifying **usability issues** that could disrupt the user experience. A similar approach was used in the studies by Spasić et al. (2015) and Shewchuk et al. (2021) in evaluating their mobile self-management support applications. These studies combined a usability questionnaire with qualitative feedback to pinpoint usability strengths and challenges, informing where to boost support or replicate effective elements for a better future user experience.

Furthermore, this study investigated the likelihood that participants might prefer using the TRAK-Saudi platform over face-to-face in-clinic sessions, guided by the scenario-based question previously posed in Phase 1 interviews (Chapter 4). Research suggests that even brief exposure to health technologies can significantly shape users' willingness and perceptions regarding continued use, offering insights more precise than those from individuals with no prior experience (Cranen et al. 2011; Wade et al.

2012). Consequently, revisiting the scenario question in Phase 2 aimed to assess whether initial willingness to engage with digital self-management support, as reported in Phase 1, would persist or evolve following actual interaction with the platform.

6.2.2.1 The perceived usability of TRAK-Saudi

The participants used TRAK-Saudi during a remote session and evaluated its perceived usability via a questionnaire they were given immediately afterwards, thus providing instant feedback from their direct interaction. The perceived usability refers to the subjective assessment of the ease of use and satisfaction experienced by users when interacting with a digital system (Alghabban and Hendley 2022). Scholars emphasise the importance of perceived usability because it influences users' willingness to use the system, their efficiency while using it and their overall satisfaction, all of which are key to the system's success and acceptance (Brooke 2013; Lewis et al. 2015; Sauro and Lewis 2016). Questionnaires are widely recognised as effective tools for assessing perceived usability in digital-based healthcare, with Maramba et al. (2019) reporting that nearly 79% of 133 online health application studies used them. They provide a quick assessment of perceived overall usability (Brooke 1996; Hornbæk 2006; Assila et al. 2016).

In this study, the participants assessed the perceived usability of TRAK-Saudi using the System Usability Scale (SUS). The selection of the SUS specifically for this study was based on its effectiveness in similar research contexts, thus facilitating an opportunity for future data comparison (Spasić et al. 2015; Shewchuk et al. 2021). The SUS is recognised as a quick, reliable tool for assessing a wide range of products and services, from hardware and software to websites and applications (Brooke 1986; Brooke 2013). The scale is accepted as a usability measure in different health domains, favoured for its concise 10-item structure and free availability (Borsci et al. 2015; Maramba et al. 2019). The SUS consists of ten statements in which 5 are positive statements and the other 5 are negative statements (Hyzy et al 2018) (refer to Appendix L for the list of scale’s statements). Users indicate their agreement or disagreement on a 5-point Likert scale (1 = strongly disagree; 5 = strongly agree). These ten items were chosen from an initial pool of 50, crafted to address the three main usability concepts per ISO 9241–11: effectiveness, efficiency, and satisfaction (ISO 9241-11, 2018). A panel of 20 users evaluated two interactive systems, one

notably easy to use and the other for highly technically skilled users (Brooke 1996). The ten statements with the most extreme responses, demonstrating the greatest discrimination between the systems, were retained.

The decision was further supported by the availability of the validated Arabic version of the SUS (A-SUS) (Erdinç and Lewis 2013; Dianat et al. 2014; Borkowska and Jach 2017; AlGhannam et al. 2018). It is crucial when selecting a questionnaire to ensure that the language used aligns with the cultural and linguistic context of the target audience (Tsang et al. 2017). As noted by AlGhannam et al. (2018), using English-based usability questionnaires in non-English settings may cause misunderstandings and yield inaccurate results. To address this, AlGhannam et al. (2018) translated the SUS into Arabic, using the back-translation method to translate the SUS back into English to ensure semantic consistency (Chen and Boore 2009; AlGhannam et al. 2018). The A-SUS was selected for this study to guarantee that participants could fully comprehend and accurately respond to its items, thus enhancing data reliability and facilitating cross-cultural comparisons (Tsang et al. 2017) (Appendix M). The psychometric properties of the A-SUS are detailed below.

6.2.2.1.1 Psychometric properties of the Arabic System Usability Scale

The A-SUS underwent thorough evaluation to confirm its psychometric properties for usability assessments within Arabic-speaking contexts (AlGhannam et al. 2018). Construct validity, which assesses the scale's ability to measure what it is intended to, was indirectly affirmed through investigating A-SUS’s sensitivity (Deniz and Alsaffar 2013; AlGhannam et al. 2018). AlGhannam et al. (2018) compared two user groups with different levels of familiarity with the tested digital system. The A-SUS effectively distinguished between the groups, indicating its sensitivity and supporting its construct validity. This ability to differentiate user experience levels mirrored findings from other studies where the original SUS effectively discriminated between distinct user groups, such as patients and healthcare professionals (Spasić et al. 2015; Shewchuk et al. 2021). AlGhannam et al.'s (2018) findings thus reaffirmed the A-SUS's capability to detect user group differences, endorsing its applicability and construct validity in the Arabic context.

The reliability of the A-SUS was evaluated through its internal consistency, a key measure indicating the consistency of the questionnaire's results (Hajjar 2018). Reliability, often quantified by Cronbach's alpha coefficient, reflects the degree to which an instrument consistently measures an attribute (Hajjar 2018). An acceptable range for Cronbach's alpha is between 0.7 and 0.95, with values closer to 1.0 denoting higher reliability (Bangor et al. 2008; Ab Hamid et al. 2017). The SUS is noted for its high reliability in over a decade of usability studies, boasting an alpha coefficient of 0.91 (Bangor et al. 2008). In AlGhannam et al.'s (2018) study, the A-SUS displayed a Cronbach's alpha of 0.8, indicating an acceptable reliability that, while slightly lower than the English version's 0.91, comfortably sits within the acceptable reliability range.

6.2.2.2 Usability issues in TRAK-Saudi

In this usability study, another key outcome variable is identifying usability issues in TRAK-Saudi. These issues, as outlined by Alqahtani and Orji (2019), involve challenges faced by users while performing functional tasks, ranging from technical glitches and design obstacles to user support necessities. Unaddressed, these issues can significantly diminish user satisfaction and continued usage, as reported in healthcare contexts (Thach 2018). By pinpointing these issues here, the current study aimed to highlight the enhancements and support structures that would lead to a more autonomous and satisfactory user experience for future users in Jeddah.

For this study, a think-aloud approach was selected to accompany the SUS in assessing the usability of TRAK-Saudi. The think-aloud approach entails participants articulating their cognitive process while engaging with specific tasks, thereby providing insights into user thought patterns that extend beyond mere observational data (Fan et al. 2020). In this study, the participants were instructed to verbalise their thoughts as they navigated their way through predefined tasks on TRAK-Saudi. The theoretical underpinnings of this approach are provided by Ericsson and Simon (1980), who hypothesised that verbal reports could yield reliable data reflective of the cognitive processes involved in task execution (Lewis 2014). The think-aloud approach is acclaimed for its high face validity as it accurately reflects real user interactions with a digital system, unlike methods that rely on post-interaction user judgments (van den Haak et al. 2004). Within the health domain, think-aloud has been recognised as a key

method for uncovering user experiences and identifying usability issues (Nielsen 1993, 2012; Jaspers 2009; Eiring et al. 2017; Ferron et al. 2017). Its effectiveness is highlighted by a global survey where 86% of 197 usability professionals reported using the think-aloud approach in their evaluations, confirming its significant role and acceptance in usability testing practices (Fan et al. 2020). The true strength of think-aloud lies in its ability to uncover the users' perceptions and any hurdles encountered, thereby providing crucial information for improving user interaction with digital systems (Olmsted-Hawala et al. 2010).

In usability research, the think-aloud approach is categorised into two types: concurrent and retrospective (Nielsen 1993; van den Haak et al. 2004; Olmsted-Hawala et al. 2010; Zhao et al. 2014). Concurrent think-aloud, chosen for this study, involves participants verbalising their thoughts in real-time during task completion. In contrast, retrospective think-aloud requires participants to describe their thoughts post-task, often with video assistance (van den Haak et al. 2004; Olmsted-Hawala et al. 2010). The latter approach may introduce bias due to potential memory alterations (Russo et al. 1989; Ericsson and Simon 1993; Teague et al. 2001). For this study, as testing of TRAK-Saudi was to be remote, the participants might more easily forget or misrepresent experiences retrospectively due to the added distractions of remote environments. Additionally, retrospective think-aloud can lead to longer sessions with less spontaneous verbalisation, impacting the depth of collected data (van den Haak et al. 2004; Bowers and Snyder 1990). Therefore, concurrent think-aloud was strategically employed in this study to capture immediate, authentic feedback, ensuring a methodology that accurately reflects user interactions with TRAK-Saudi. The protocol followed during think-aloud sessions to regulate researcher-participant interactions is explained below.

6.2.2.2.1 The selected protocol for regulating interactions during think-aloud usability sessions

A potential limitation of concurrent think-aloud is distraction and performance impact during sessions, which particularly relates to the way evaluators regulate their interaction with participants while they think aloud (Olmsted-Hawala et al. 2010). To mitigate this, three different protocols are discussed in the literature to regulate

evaluator-user interactions in usability testing session (Olmsted-Hawala et al. 2010). These protocols are the traditional protocol by Ericsson and Simon (1996), the speech communication protocol by Boren and Ramey (2000) and the coaching protocol. Each protocol offers a different level of interaction and insight, tailored to the study's needs and the depth of analysis required (see Table 16).

Protocol/ developers	**Probes**	**When to probe**
Traditional Ericsson and Simon (1996)	"Keep talking;"	After 15 seconds of silence
Speech communication Boren and Ramey (2000)	- Feedback tokens such as "Um-hum, uh-hum," and "know…?" - Questioning tone that reflects the last word spoken by the participant.	After 15 seconds of silence
Coaching Dumas and Redish (1999), Krahmer and Ummelen (2004), Nørgaard and Hornbaek (2006), and Hertzum et al. (2009)	Direct questions about different areas of the tested digital system.	- When the participant faces difficulty, pauses or describes an area as confusing or frustrating, assistance or guidance is provided to help overcome the struggle. - May occur even in the absence of an explicit need for help.

Table 16: Existing protocols for think-aloud approach.
Sources: Olmsted-Hawala et al. (2010) and Lewis (2014).

In this study, the speech communication protocol by Boren and Ramey (2000) was chosen for regulating researcher-participant interactions during the think-aloud sessions. This decision was informed by its potential to facilitate a more natural, engaging and reflective dialogue between the researcher and participants. This approach eases the analysis burden by eliciting more natural and explanatory verbalisations from participants, thus providing a clearer and more relevant understanding of the user experience (Olmsted-Hawala et al. 2010; Zhao et al. 2014). Unlike the traditional protocol, which maintains minimal evaluator involvement, the speech communication protocol incorporates feedback tokens and reflective questioning (Olmsted-Hawala et al. 2010; Zhao et al. 2014; Lewis 2014). This method

fosters a more dynamic exchange, encouraging participants to articulate their thought processes and experiences in greater detail. This protocol's relevance is further supported by literature indicating that a more engaged dialogue does not significantly detract from task completion rates or user satisfaction but does enrich the data collection process (Krahmer and Ummelen 2004; Olmsted-Hawala et al. 2010). Evidence that the speech communication protocol could facilitate exploration of the participants' perceptions and interactions with TRAK-Saudi in a way that maintained participant engagement and data integrity supported the decision to use it.

Following Boren and Ramey (2000), efforts were made in this study to naturalise speech during the sessions, aiming to create a listener-focused environment. As highlighted in Table 17, if a participant remained silent for more than 15 seconds, they were prompted with a question such as "What are you doing right now?" to encourage continuous thinking aloud. Comforting acknowledgment tokens like "Mm hmm" were employed to assure participants and maintain a conversational flow. Assistance was offered only when participants explicitly requested help or exhibited clear confusion, always aiming to provide the minimum necessary help to resume the session's flow. These rules were implemented to ensure a structured yet responsive interaction that is characteristic of the speech communication protocol, facilitating the collection of rich, authentic feedback while maintaining the session's natural progression and focusing on the user's perspective.

Action	When to apply
"What are you doing right now?"	To break the silence if it persisted for more than 15 seconds.
A nodding sound “Mm hmm” as an acknowledgment token.	To comfort the participant.
The minimum limit possible of assistance that can assist in resuming the flow of the session.	If verbally asked by the participant.
The minimum limit possible of assistance that can assist in resuming the flow of the session.	If the participant was in a clear state of confusion.

Table 17: Actions employed by the researcher to regulate interactions in think-aloud sessions.

6.2.2.3 Likelihood of participants substituting in-clinic sessions with TRAK-Saudi for self-managing their knee

Participants were asked to use a 5-point Likert scale to rate the likelihood of them substituting TRAK-Saudi for in-clinic physiotherapy sessions by responding to the scenario question below.

> *TRAK-Saudi offers a wide range of knee exercise videos and information to help you manage your knee pain at home. It also allows your physiotherapist to monitor your progress over time and enables you to contact them if needed. If your physiotherapist has trained you on how to use TRAK-Saudi, would you be willing to substitute your clinic sessions with this platform and continue your treatment at home?*

Likert is a self-report scale used to measure people's opinions, consisting of five or more responses, typically labelled as Strongly Disagree, Disagree, Neutral, Agree and Strongly Agree (Leung 2011; Bishop and Herron 2015; Russo et al. 2021). A 5 point Likert scale was chosen rather than other Likert scales with a greater number of responses to maintain consistency in the response format between the scenario question and SUS. It was thought this approach would alleviate the burden on participants in terms of decision-making (frustration level) and increase the quality of the responses (Babakus and Mangold 1992; Sachdev and Verma 2004).

6.2.3 Participants

6.2.3.1 Population

Participants for this study included both physiotherapists and individuals with chronic knee pain, representing two potential groups of users of TRAK-Saudi platform. This selection strategy, informed by literature recommendations, underscores the importance of incorporating a diverse sample of future users in usability research (de Róiste 2013; Mortensen 2020). Such inclusivity is essential for grasping how the system will be employed in real-world settings, revealing various interaction dynamics. This approach ensures that the design and usability of TRAK-Saudi are tailored to meet the needs and preferences of its intended user base, as suggested by Nielsen and Landauer (1993).

6.2.3.2 Sampling technique

This study employed convenience sampling by re-inviting participants from Phase 1, a sampling technique that selects easily accessible individuals (Lavrakas 2008). Those who initially engaged and welcomed future contact in Phase 1 were approached for this usability study. When the original participants were unavailable due to disinterest, non-response or other commitments, purposive sampling was implemented to identify appropriate new participants, mirroring the approach taken in Phase 1 (Hulley et al. 2013; Nikolopoulou 2022). Sampling was guided by a specific set of eligibility criteria, as outlined below.

Physiotherapists

- Inclusion criteria: Physiotherapists who are licensed by the Saudi Commission for Health Specialties, work in outpatient clinics and regularly treat patients with knee conditions, have access to the Internet and are willing to participate.
- Exclusion criteria: Physiotherapists who are in their internship year as they may not yet have the opportunity to practice independently or make autonomous clinical decisions (Clouder and Adefila 2017; Stoikov et al. 2022).

Individuals with chronic knee pain

- Inclusion criteria: Individuals who are aged 18 years or older, have knee pain that persisted 3 months or more (chronic) and visited physiotherapy clinic for knee treatment (Nicholas et al. 2019). They need to be proficient in reading and writing in either Arabic or English, have access to the Internet and are willing to participate.
- Exclusion criteria: Individuals for whom the primary source of pain is not the knee.

6.2.3.3 Sample size

Selecting the right number of participants in usability studies depends on the testing method and the goals of the study (AlRoobaea and Mayhew 2014). This study used the think-aloud approach, more details of which are provided later. Hwang and Salvendy (2010) observed in their comparative analysis of 27 usability studies that the think-aloud approach typically requires an average of 9 participants to effectively uncover approximately 80% of usability issues. However, they noted that different testing methods might necessitate slightly different sample sizes than those generally required for the think-aloud approach (Hwang and Salvendy 2010). To address this variability, Hwang and Salvendy (2010) proposed a flexible "10±2" rule as a general guide for usability studies that can be adapted across various testing methods, including think-aloud.

Despite the guidance, the "10±2" rule is not universally accepted, especially for tests that aim to identify a wider range of issues, including minor or cosmetic faults in the system. AlRoobaea and Mayhew (2014) recommend a more inclusive "16±4" rule to ensure thorough identification of design, navigation and functional problems. In testing TRAK-Saudi, a minimum number of 12 participants was planned to be included in this study, a number that lies within the range suggested by both Hwang and Salvendy (2010) and AlRoobaea and Mayhew (2014). The decision to recruit 12 participants was made to balance thoroughness with manageability, aiming to effectively identify a broad spectrum of usability issues in the design, navigation and key functionalities of the TRAK-Saudi platform.

6.2.3.4 Recruitment procedure

The study's recruitment was managed remotely, using online communication channels. Study invitations and participants' information sheet (Appendices L, M, N) were sent to potential participants using their preferred method, whether that be phone call, text message or email. Those expressing interest in re-participating received a consent form (Appendix Q), which was prepared in accordance with Cardiff University's ethical guidelines. In this remote study, consent involved additional components. Specifically, the participants were required to agree to share their device's screen and allow session recording with the participant's camera offline for analysis purposes. The participants were given the documents at least 72 hours before the scheduled data collection session, providing sufficient time for informed decision-making.

In order to recruit new participants, the process mirrored that of Phase 1. It began by contacting the heads of physiotherapy departments, who served as gatekeepers, using their office numbers. They were tasked with distributing a study poster (Appendix R) and eligibility criteria to their teams. The physiotherapists showing interest contacted the researcher to verify their eligibility and learn more about the study. These physiotherapists also played a key role in informing potential participants with knee pain about the study. Interested individuals were encouraged to contact the researcher directly regarding participation.

6.2.4 Pilot usability testing session

In this study, two pilot sessions were carried out involving one physiotherapist and one individual with knee pain. These selected participants closely matched the characteristics of the actual study participants, enhancing the simulation of real data collection. These pilot sessions aimed to help the researcher become familiar with remote testing, practice the role of a moderator in a think-aloud session, pilot test TRAK-Saudi platform and ensure that all necessary equipment was functioning properly. Valuable insights were gained from the pilot sessions that were used to enhance the overall quality of the study.

One key area addressed was the quality of sound. The actual participants were strongly advised to use earphones to reduce background noise during the recordings, ensuring clearer audio data. Additionally, to minimise distractions, the participants were encouraged to either print their user guide document (more details on this can be found later in section) or open it on a separate device, thus mitigating potential interruptions associated with having multiple windows open on the same screen during task performance. Furthermore, TRAK-Saudi underwent several enhancements based on feedback from the pilot sessions. Spelling mistakes were promptly rectified, mistranslated words were corrected for language accuracy and various textual elements on the platform were revised to enhance overall readability. Additionally, a deactivated button was identified on TRAK-Saudi and subsequently activated to ensure the full functionality of the platform in the actual data collection sessions.

6.2.5 Actual usability testing session procedures and associated tools

Those who consented to participate and filled in a demographics form attended individual online usability testing sessions. During these sessions, they were instructed to think aloud while completing a predefined set of tasks on the TRAK-Saudi platform. This was followed by completing the A-SUS and the scenario-based question to end the session. The specifics of these procedures are detailed under three subsequent subheadings: prior to data collection session, main data collection session and end of data collection session.

6.2.5.1 Prior to data collection session

At this stage, the researcher ensured that all those selected consented to participate before their sessions' time. Accommodating the remote nature of the study, consent forms were prepared using the Microsoft Forms app and completed online by all the participants. Microsoft Forms is known for its survey, quiz and poll creation capabilities along with real-time results and analytics (Microsoft). The app's instant notification feature, alerting researchers upon the submission of each form, was particularly beneficial for this study, enabling prompt data review and efficient management. The participants received a link to the form prior to the usability session, allowing them to complete it when convenient. The responses were easily exportable to an Excel sheet, streamlining data handling.

A similar process was followed to collect demographics in this study, with an online demographics form being prepared using the Microsoft Forms app. The form captures details such as sex, age, education, employment status, Internet-connected device ownership, computer and website usage proficiency and any changes in usage post-pandemic. These demographical factors have been shown to influence users' performance and perception of satisfaction and are thus examined in this study (Mentes and Turan 2012; Mkpojiogu et al. 2016). Links to the consent and demographics forms were emailed to the participants prior to their sessions. Consent forms were sent at least 72 hours before the session, and upon completion, demographic forms were subsequently provided. The participants were consistently reminded of their right to ask questions at any time during their participation.

To arrange the data collection sessions, the participants were asked to suggest their preferred dates and times, considering the researcher's availability to prevent scheduling conflicts. The researcher then emailed invitations for the agreed-upon times, including all essential session details. The participants received notifications about their sessions at least 24 hours beforehand, with reminders sent on the day of their scheduled appointments.

6.2.5.2 Main data collection session

Achieving a laboratory-like testing experience in remote settings necessitates a carefully chosen online platform with comprehensive tools, a principle underlined by Tullis et al. (2002). This study sought a platform offering screen sharing, screen recording, chat functions and media sharing options. The remarkable 1000% increase in virtual events since the onset of COVID-19, as reported by Koetsier (2020), has emphasised the feasibility of such platforms. Recent reports highlight Microsoft Teams, Zoom and Google Meet as popular and effective videoconferencing tools for transitioning to online communication in many education and workplace settings (Dhawan 2020; EHL Insights 2020).

Zoom was selected for this study, capitalising on its global popularity and widespread use during the pandemic, as highlighted by Evans (2020). Its usage peaked with daily meeting participants exceeding 300 million in the first quarter of 2020, and it topped the download charts on Apple devices, surpassing Instagram and YouTube in the

same year (Dooley 2020; Graham 2020; Warren 2020). Zoom's global prevalence made it a suitable choice for this study's UK-based researcher and Saudi-based participants, ensuring a familiar and accessible platform in both geographical regions. In selecting Zoom, reliability and security were also paramount, addressing concerns around remote testing and privacy (Bolt and Tulathimutte 2010). Cardiff University's certification of Zoom as a reliable platform further affirmed its suitability. The platform's user-friendly features, like allowing access to the sessions without downloads or membership, also played a key role in its selection for the study. A visual representation of Zoom's interface is provided in Figure 14.

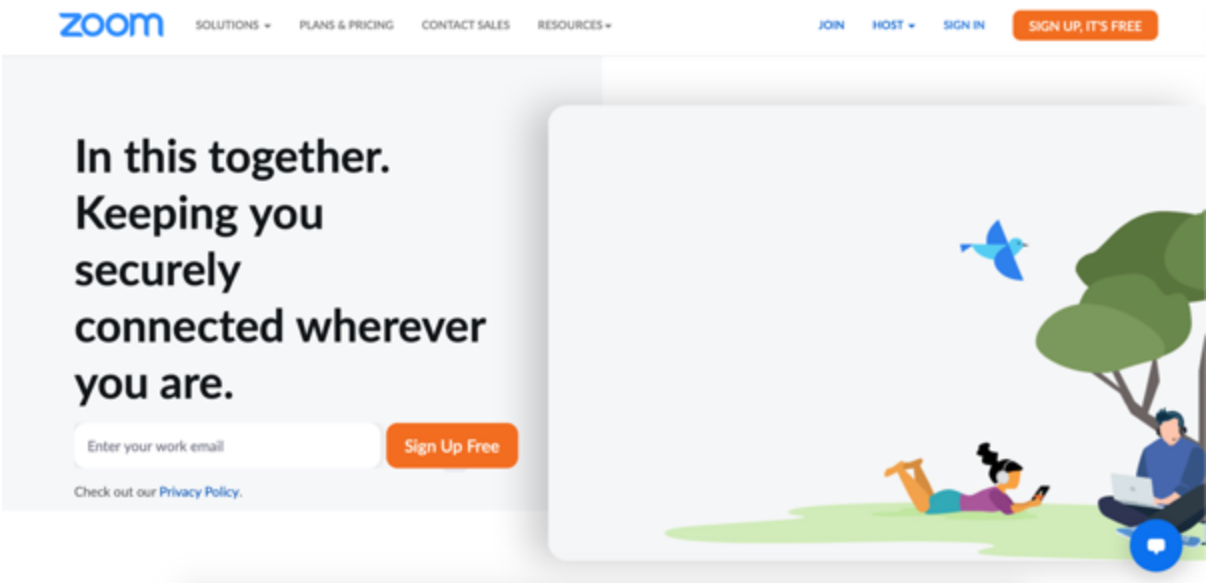

Figure 14: Front page of Zoom.

The participants in this study accessed their online sessions on Zoom using the invitation cards emailed to them by the researcher. Upon joining the session, the researcher greeted the participant and provided a brief introduction to the study, explaining the roles of both the researcher and the participant. The overall data collection procedure, including the correct method of thinking aloud and purpose of screen share and recording was explained to the participant before initiating the session (Schrier 1992). The participant's consent to begin screen recording was confirmed, and they were reminded of their right to withdraw from the study at any point. The participant was then instructed to start performing the selected tasks on the TRAK-Saudi platform, which are detailed at length under the following subheading.

6.2.5.2.1 Tasks performed by participants on TRAK-Saudi during usability sessions

All the participants in the study completed seven tasks on the TRAK-Saudi platform, with tasks varying between individuals with chronic knee pain and physiotherapists to match their different roles on the platform. For each participant type, the researcher prepared a task sheet in the form of a user guide to help them during the testing session (Appendices Q, R). A user guide, typically crafted by those well-versed with the system, such as developers or technical writers, is recommended for reducing user dependence on external support and improving satisfaction (Patel 2021). In this study, the user guides, developed based on feedback from the participants in Phase 1 and those who participated in similar research described in the literature, aimed to encourage broader use of TRAK-Saudi by those with knee pain in Jeddah (Crane et al. 2017). These guides, created with Microsoft Word, were distributed electronically before the session for participant familiarisation. The participants were instructed to either print the guides or display them on a separate electronic device, ensuring they could easily reference the instructions during the sessions. To ensure clarity, the guides were crafted with concise, easy-to-follow instructions, following best practice in user guide creation (Hodgson 2007).

The chosen tasks in this study were fundamental, enabling testing various features and buttons on the platform that users would typically encounter in real-world scenarios (Holmes 2022). These tasks are detailed at length below.

TRAK-Saudi Entry Navigation All the participants were instructed to enter the TRAK-Saudi platform through a specific link provided on the user guides, using their preferred web browser. This prescribed method was the exclusive means of accessing TRAK-Saudi as it has not yet been officially published.

Account Access All the participants were instructed to access the accounts, which had been pre-created by the researcher, using the login information provided on their user guides.

Knee Health Self-assessment The individuals with chronic knee pain were asked to find and independently complete the KOOS survey on the platform (Roos and

Lohmander 2003) (Appendix K). This task aimed to assess participants' ability to locate questionnaires and complete them independently on the platform.

Information Navigation All the participants were asked to find specific information within the Information Suite on the platform. They needed to read through several informational texts to identify the relevant information as specified by the test. This activity was designed to allow the participants to experience the readability and accessibility of the platform's written content.

Patient's Profile Navigation The physiotherapists were instructed to navigate to the page of a specific individual with knee pain, as on their user guides. This step mirrors real-life scenarios where physiotherapists access their assigned individuals' pages on TRAK-Saudi as an important step to track progress and communicate effectively as part of a supported self-management experience.

Goal Setting The individuals with chronic knee pain were asked to type in a goal they wished to achieve during a specific period of a time on the Aims page. Setting goals is a crucial aspect of the self-management journey and was a key feature introduced to participants in the study through the platform (Lorig and Holman 2003).

Exercise Selection All the participants were instructed to navigate to the Activity Suite on the platform and add a particular exercise written on the user guide to the My Plan page. This enabled the individuals with chronic knee pain and their physiotherapists to collaboratively develop activity plans based on mutual decisions. Including this task in the test exposed the participants to the exercise media format available on the platform, allowed them to experience shared control over exercise selection and introduced them to the wide range of knee exercises offered.

Simulated Patient Interaction The physiotherapists were asked to reply to a message in their mailbox sent to them by a fictitious individual with knee pain. The message was sent by the researcher to imitate a real scenario. This task introduced the idea of virtual communication and consultation to the physiotherapists.

Account Exit All the participants, marking the end of thinking aloud and screen recording, were asked to securely log out of their accounts using the designated logout

button, as instructed on their task sheet. This simple, yet vital step, demonstrates the platform's commitment to user privacy and security. See Table 18 for task titles and target participants.

Task	Target participant type
TRAK-Saudi Entry Navigation	Individual with chronic knee pain, Physiotherapist
Account Access	Individual with chronic knee pain, Physiotherapist
Knee Health Self-assessment	Individual with chronic knee pain
Information Navigation	Individual with chronic knee pain, Physiotherapist
Patient's Profile Navigation	Physiotherapist
Goal Setting	Individual with chronic knee pain
Exercise Selection	Individual with chronic knee pain, Physiotherapist
Simulated Patient Interaction	Physiotherapist
Account Exit	Individual with chronic knee pain, Physiotherapist

Table 18: Tasks performed during the usability sessions and target participant type.

6.2.5.3 End of data collection session

After the participants logged out of their TRAK-Saudi's accounts, they were informed that they could stop the screen share since the researcher would also stop recording at this point. Subsequently, the participants received a link to the A-SUS questionnaire and the scenario question via the Zoom chat box on the right-hand side of the screen. The researcher emphasised the importance of promptly filling the questionnaire in to gather real-time usability data for the TRAK-Saudi platform. The participants were informed that they could leave the meeting to complete the questionnaire independently. Once finished, the researcher received a completion receipt via Forms. Following each session, the researcher reviewed the screen recording to ensure the clarity and validity of the collected data for subsequent analysis.

6.2.6 Data analysis

6.2.6.1 Analysis of the demographics

Demographic data collected through the online form were automatically exported to Excel sheets via Microsoft Forms. These Excel sheets underwent an accuracy check performed by the researcher before undergoing statistical analysis, which was conducted using SPSS (Statistical Package for Social Sciences, version 26) software for iOS. The analysis involved the use of descriptive statistics, including the calculation of means, percentile and standard deviations. These statistical measures were applied to the variables of sex, age, education, employment status, proficiency in computer and website usage as well as any changes in usage patterns post-pandemic.

6.2.6.2 Calculation of the Arabic System Usability Scale's scores

Similar to the demographic data, the data from the A-SUS questionnaire were also automatically exported to Excel sheets via Microsoft Forms. These Excel sheets underwent an accuracy check prior to calculation. Two distinct methods for calculating SUS scores have been identified in the literature, which are manual calculation and the application of a specific formula within Microsoft Office Excel (Alathas 2018; Guerci 2020). The selection of the method hinges on whether the participants' responses are recorded manually or electronically. In this study, where the responses were electronically reported, the recommended formula by Guerci (2020) was applied, appearing on the Excel spreadsheet as follows:

SUS = ((B2-1) +(5-C2) +(D2-1) +(5-E2) +(F2-1) +(5-G2) +(H2-1) +(5-I2) +(J2-1) +(5-K2)) *2.5

The cumulative score obtained from the computation serves as the participant's overall perceived usability score for the TRAK-Saudi platform. However, SUS scores cannot be interpreted as such; instead, they require a distinct approach in order to be comprehend by the broader audience. To address this need, the literature presents five methods intended to enhance the understanding of SUS scores among all types of audience. These methods, as detailed in the work of Sauro (2018), include grading systems, percentiles, descriptive adjectives, acceptability scales and the net promoter scale (Bangor et al. 2008; Sauro 2011) (see Table 19). In this study, it was decided

that the scores should be interpreted in percentiles to be more relevant to the general reader. Additionally, although the primary aim of this study is not to compare participant types, a separate analysis of the overall A-SUS scores for individuals with chronic knee pain and physiotherapists was conducted. This analysis aligned with similar studies and aimed to explore whether similar score differences existed between different user types within the Saudi context (Spasić et al. 2015; Shewchuk et al. 2021).

SUS score	Grade	Percentiles %	Adjective	Acceptable	NPS
84.1-100	A+	96-100	Best Imaginable	Acceptable	Promoter
80.8-84.0	A	90-95	Excellent		
78.9-80.7	A-	85-89			
77.2-78.8	B+	80-84			Passive
74.1 – 77.1	B	70 – 79			
72.6 – 74.0	B-	65 – 69			
71.1 – 72.5	C+	60 – 64	Good		
65.0 – 71.0	C	41 – 59		Marginal	
62.7 – 64.9	C-	35 – 40			
51.7 – 62.6	D	15 – 34	OK		Detractor

Table 19: Interpretation methods for the SUS scores.
Source: Sauro (2018).

6.2.6.3 Analysis of the think-aloud data

The participants' verbalisations, spoken in Arabic during the sessions, were transcribed to create a think-aloud protocol for each participant (Jääskeläinen 2010).

Subsequently, these protocols were translated into English by the researcher, with the aid of a professional translator, mirroring the process employed for the interview transcripts in the previous phase to maintain precision and accuracy (Squires 2009; Al-Amer et al. 2015).

For the analysis of the protocols, a quantitative content analysis approach was selected. This type of analysis allows for the examination of qualitative materials, such as transcripts and protocols, to identify predefined terms and their relationships (Boettger and Palmer 2010). Content analysis can be categorised into two main types: conceptual and relational, which can be implemented either quantitatively or qualitatively, depending on the study's objectives (Elo and Kyngäs 2008; Boettger and Palmer 2010). Conceptual content analysis, which is typically quantitative, focuses on identifying the frequency of specific terms within the text to address research questions, whereas relational content analysis, which is typically qualitative, explores the relationships between terms to gain insights into specific phenomena (Carley 1990; Boettger and Palmer 2010). In this study, a quantitative conceptual content analysis was employed to systematically identify and quantify potential usability issues within the TRAK-Saudi platform, effectively contributing to the study's research question.

To maintain the rigour of the content analysis, the study adhered to specific, replicable steps, as outlined by Krippendorff (2004). These steps included identifying a sample, data categorisation, coding and data analysis. The following subheadings offer a detailed explanation of the sequential steps taken in this study to ensure a robust analysis of the think-aloud protocols.

6.2.6.3.1 Identifying a sample

Within the context of content analysis, sampling involves identifying specific qualitative texts for analysis and narrowing the selection to a replicable subset (Boettger and Palmer 2010). In this study, the chosen sample for analysis was the think-aloud protocols.

6.2.6.3.2 Categorising data

Categorisation in content analysis involves pinpointing specific relevant categories within the selected text sample to address the study's research question. The researcher conducted multiple reviews of the protocols to become familiarised with the content, which was essential for creating meaningful categories. These categories were generated to represent distinct aspects or concepts that the researcher intended to explore within the content (Boettger and Palmer 2010).

6.2.6.3.3 Coding data

During this step, the protocols underwent manual coding, following the recommendation of Boettger and Palmer (2010). They recommend that this type of coding is used for conceptual quantitative analysis due to its straightforward nature, especially when dealing with a limited number of codes. This was particularly applicable in this study due to the relatively short length of the protocols. The process involved highlighting sections of text within the think-aloud protocols that conveyed the participants' views on the TRAK-Saudi platform, aligning with predefined categories. Each highlighted text section was then assigned specific codes or terms that accurately represented its content. These generated codes were organised on a coding sheet under their respective categories.

While Neuendorf (2002) recommended the use of a coding sheet to enhance inter-rater reliability in cases involving multiple raters, this study solely involved one rater, the researcher, in the coding process. To maintain reliability despite the single rater, an additional simple computer-assisted method was employed to validate the outcomes of the manual coding. This computer-assisted method includes using the "Find" function in Microsoft Word or PDF documents to search for specific terms within the protocols. This approach expedited the identification of relevant terms and quantified their occurrence in the text, reducing potential challenges related to inter-rater reliability and the necessity for additional raters, as suggested by Boettger and Palmer (2010).

6.2.6.3.4 Analysing data

To identify the usability issues of the TRAK-Saudi platform based on the generated codes, a quantitative descriptive analysis was employed (Boettger and Palmer 2010). This analysis method was chosen to emphasise the frequency of codes within each category, enabling the researcher to pinpoint the most commonly encountered issues during the testing process. The analysis was carried out using SPSS version 26, resulting in a summary table that included mean, median and standard deviations presented later in the results section.

6.2.6.4 Analysis of the 5-Likert responses

Participants' responses on the 5-point Likert scale were descriptively analysed using SPSS to identify median, mode and range.

6.2.7 Ethical and regulatory considerations

6.2.7.1 Ethical approval

In this remote study, there was no need for access to medical venues as all the participants participated in the testing sessions from their own homes. Hence, approval for the commencement of this study was exclusively granted by the School of Healthcare Sciences Research Ethics Committee at Cardiff University (refer to Appendix U) in May 2021.

6.2.7.2 Ethical concerns

In the remote usability sessions, different ethical concerns were addressed to ensure the confidentially, safety and wellbeing of the included participants. Complying with Cardiff University ethical procedures and GDPR Data Protection Act (2018), all data collected in this study were handled with utmost confidentiality. The real names of the participants were replaced with identification numbers to ensure anonymity during storage and analysis. All study-related materials, including consent forms and screen recordings, were securely uploaded to Cardiff University's server. Adhering to the university's research records retention schedule, the data will be retained for 5 years after the study's completion, after which it will be permanently deleted. Furthermore, personal data, such as names and email addresses, will be destroyed one year after the completion of the Ph.D.

In order to safegard the participants' privacy and wellbeing, they were advised to disable their cameras during online sessions to hide their identities, and no third-party was allowed to attend the sessions. Before screen sharing commenced, the participants were instructed to conceal any personal items on their screens, mitigating the risk of unintended exposure. Conducting sessions from their own homes afforded the participants the autonomy to adjust their device settings, including sound levels and screen brightness, to their preference, thereby minimising any discomfort associated with unfamiliar settings.

The research process was designed to be as stress-free as possible. The participants were briefed in detail about the data collection procedure beforehand. Also, they were not limited to a specific amount of time to complete the session, allowing them to work at their own pace. Help was readily available upon request, ensuring the participants felt safe throughout. Furthermore, the researcher's interactions were carefully regulated to avoid influencing the participants' performance, thereby maintaining the integrity of the usability testing. These ethical considerations were essential to conducting a fair and secure remote usability study.

6.2.8 Summary

In this phase, a remote usability testing study was conducted via the Zoom platform in compliance with the COVID-19 restrictions on physical interactions that were in place at the time. The researcher decided to test the TRAK-Saudi platform using 12 participants, half of whom were physiotherapists and half individuals with chronic knee pain, who represented potential users. Key outcome variables of this study were the perceived usability of TRAK-Saudi, its usability issues and the likelihood that potential users would substitute in-clinic sessions with the digital platform. To achieve this, a standardised usability questionnaire (the Arabic SUS), a think-aloud approach and 5-Likert scale were selected. Each participant was assigned seven tasks to be completed on TRAK-Saudi while verbalising their thought process. At the end of the testing sessions, the participants were asked to complete the A-SUS and the scenario question. All the data collected were stored properly and analysed anonymously using quantitative methods.

6.3 Research results for phase 2

This section outlines the results obtained from the usability testing sessions, starting with the demographics of the recruited sample followed by the usability results of TRAK-Saudi.

6.3.1 Demographic results

A total of 12 participants, consisting of 6 individuals with chronic knee pain and 6 physiotherapists, were recruited to assess the usability of the TRAK-Saudi platform. Among these participants, nine (75%) had previously participated in phase one of the study, while the remaining 3 were new individuals with chronic knee pain. The analysis of data collected from the online demographic forms revealed the following information about the cohort of participants (Table 20).

Variable	6 Individuals with Chronic knee pain	6 Physiotherapists	Total of all 12 participants (%)
Age	Mean: 48.17 years (SD ± 16.3) Age range: 25-67 years	Mean: 34.83 years (SD ± 4.4) Age range: 30-42 years	Mean: 41.5 years (SD ± 13)
Sex	3 Females 3 Males	4 Females 2 Males	7 Females (58.33%)
Education	2 Secondary education 2 Undergraduate education 2 Postgraduate education	3 Undergraduate education 3 Postgraduate education	2 Secondary education (16.67%) 5 Undergraduate education (41.67%) 5 Postgraduate education (41.67%)
Employment Status	2 Employed 2 Self-employed 2 Retired		
Proficiency in computer use	3 Moderate proficiency 3 Excellent proficiency	4 Moderate proficiency (66.67%) 2 Excellent proficiency (33.33%)	7 with Moderate proficiency (58.33%) 5 with Excellent proficiency (41.67%)
Proficiency in website navigation	3 Moderate proficiency 3 Excellent proficiency	5 Moderate proficiency (83.33%) 1 Excellent proficiency (16.67%)	8 with Moderate proficiency (66.67%) 4 with Excellent proficiency (33.33%)

Changes in technology usage patterns post-pandemic	3 Increased in use 3 Unchanged use	6 Increased in use	9 with Increased use post-pandemic (75%) 3 with Unchanged use (25%)

Table 20: Demographics of the participants.
Abbreviations: **SD**: Standard Deviation, **%**: percentile.

Among the 12 participants, 7 were female (58.33%) and 5 were male (41.67%). The participants' ages ranged from 25 to 67 years, with mean ages of 48.17 years (SD ± 16.3) and 34.83 years (SD ± 4.4) for individuals with chronic knee pain and physiotherapists consecutively. In terms of education, 2 participants finished a secondary school (16.67%), 5 had an undergraduate education (41.67%), 5 had a postgraduate education (41.67%). Furthermore, among the 6 individuals with chronic knee pain included in the study, 2 were employed, 2 identified as self-employed and an additional 2 reported retired during the study period.

Additionally, participants self-rated their proficiency in computer use and website navigation in the demographic form. Out of the 12 participants, 7 (58.33%) reported a moderate level of proficiency in computer use while the remaining 5 (41.67%) indicated an excellent level of proficiency. A similar situation was observed in relation to the participants' proficiency in website navigation, with 8 participants (66.67%) rating themselves as having a moderate level of proficiency while the remaining 4 (33.33%) rated their proficiency as excellent. Furthermore, when asked about their electronic device usage during the worldwide pandemic, 9 participants (75%) reported an increase in their usage of computers, tablets and mobile phones while 3 individuals with chronic knee pain (25%) mentioned that their level of device usage remained unchanged during this period.

6.3.2 Perceived usability of TRAK-Saudi

The perceived overall usability of TRAK-Saudi was evaluated by the 12 participants using the A-SUS. The analysis revealed that individuals with chronic knee pain rated the platform with a usability score of 77.5, placing it in the 80-84% percentile range (Sauro 2018). Physiotherapists rated the platform higher, with a score of 83.3, positioning it in the 90-95% percentile range (see Table 21).

Participant type	SUS score (corresponding percentile range)
Individuals with knee pain	77.5 (80-84%)
Physiotherapists	83.3 (90-95%)

Table 21: The perceived usability of TRAK-Saudi as obtained from the A-SUS.

6.3.3 Usability issues identified on TRAK-Saudi

In the think-aloud sessions, a total of 64 verbalisations were captured in the recordings of the 12 participants. Content analysis of these verbalisations resulted in the identification of two significant categories related to usability issues encountered by the participants while navigating the TRAK-Saudi platform. These categories include *Help and Guidance*, which identified areas on the platform where participants faced complexity and needed support, and *Bugs and Flaws*, which included verbalisations highlighting technical issues on the platform. The following subheadings present the codes under each category, covering their description and frequency for each task.

6.3.3.1 Help and guidance needed in navigating TRAK-Saudi platform

This category covers instances where the participants sought assistance or requested guidance from the researcher while completing the tasks on the TRAK-Saudi platform. A total of 53 verbalisations were coded and grouped under this category with varying frequencies. The verbalisation counts revealed that the most frequently sought form of help was reassurance, followed by instances where the participants felt lost in the process. Assistance-seeking verbalisations were comparatively less frequent, indicating that the participants predominantly required guidance and reassurance during their interactions with the TRAK-Saudi platform (See Table 22).

Category	Underlying codes	Description	Frequency in data (% out of 53)
Help and Guidance	*Reassurance*	Participants asked for confirmation of their actions while completing the tasks.	24 (45.28%)
	Lost in the process	Participants needed assistance in navigating back to relevant sections of the user guide to resolve any confusion encountered while completing the tasks.	20 (37.73%)
	Assistance	Participants sought real support to overcome specific challenges faced while completing the tasks.	9 (16.98%)

Table 22: Help and guidance categories with underlying codes.

Reassurance in this context pertains to participants seeking confirmation for their actions during task completion. These requests for reassurance accounted for a substantial portion, specifically 45.28% (24 out of 53), of the total verbalisations categorised under Help and Guidance. Reassurance-seeking occurred in all nine tasks performed on the TRAK-Saudi platform, with an average of 2.66 (± 1.22) instances. Among these tasks, *Account Access*, *Exercise Selection* and *Account Exit* had the highest number of reported reassurance-seeking instances while *Information Navigation* and *Simulated Patient Interaction* had the fewest instances (refer to Table 23).

Task	Reassurance-seeking instances
TRAK-Saudi Entry Navigation	2
Account Access	4
Knee Health Self-assessment	2
Information Navigation	1
Patient's Profile Navigation	3
Goal Setting	3
Exercise Selection	4
Simulated Patient Interaction	1
Account Exit	4
Mean (SD)	2.66 (± 1.22)

Table 23: Frequency of reassurance-seeking instances in each task.

Furthermore, the analysis generated codes indicating instances of participants being lost in the process during 7 out of the 9 tasks, with an average of 2.85 (± 2.3) instances per task. These codes constituted a notable portion, comprising 37.73% (20 out of 53) of the verbalisations categorised under Help and Guidance. Lost in the process codes were assigned to instances in which participants encountered difficulties and temporarily lost their way while completing tasks on the TRAK-Saudi platform. It is worth noting that the availability of the user guide helped participants navigate and resolve these situations effectively. Among the tasks, *Account Access* and *Exercise Selection* had the highest number of instances where participants reported feeling lost during task completion, with 5 and 7 occurrences, respectively. In contrast, tasks such as *Simulated Patient Interaction* and *Account Exit* had more straightforward completion processes, resulting in fewer instances of participants getting lost (refer to Table 24).

Task	Lost in the process-reported instances
TRAK-Saudi Entry Navigation	1
Account Access	5
Knee Health Self-assessment	2
Information Navigation	3
Patient's Profile Navigation	1
Goal Setting	1
Exercise Selection	7
Simulated Patient Interaction	
Account Exit	
Mean (SD)	2.85 (± 2.3)

Table 24: Frequency of lost in the process reported instances in each task.

Lastly, a percentage of 16.98% (9 out of 53) of the total verbalisations categorised under Help and Guidance highlighted instances where participants genuinely needed assistance to overcome specific challenges during TRAK-Saudi navigation. This need for assistance was reported in 4 out of the 9 tasks attempted on TRAK-Saudi, with an average of 2.25 (± 0.95) instances. The tasks that predominantly saw participants seeking assistance were *Account Access* and *Knee Health Self-assessment* (refer to table 25).

Task	Assistance-seeking instances
TRAK-Saudi Entry Navigation	1
Account Access	3
Knee Health Self-assessment	3
Information Navigation	
Patient's Profile Navigation	2
Goal Setting	
Exercise Selection	
Simulated Patient Interaction	
Account Exit	
Mean (SD)	2.25 (± 0.95)

Table 25: Frequency of assistance-seeking instances in each task.

6.3.3.2 Bugs and Flaws identified on TRAK-Saudi

This category includes the identification of system faults by participants while navigating TRAK-Saudi. A total of 11 verbalisations were coded and grouped under this category (see Table 26). The verbalisations recorded identified three types of faults, which are a translation flaw, a common technical bug and an unexpected technical bug on TRAK-Saudi.

Category	Types of faults	Description	Location on TRAK-Saudi
Bugs and Flaws	*Translation flaw*	An appearance of mistranslated button or text.	Aims page
	Common technical bug	A technical bug identified by more than one participant.	My plan page
	Unexpected technical bug	Technical glitches appeared in rare cases.	Dashboard

Table 26: Bugs and Flaws category.

All individuals with chronic knee pain identified a translation flaw while attempting the task *Goal setting*. A number of the participants identified an inaccurately translated button on the "Aims" page. The intended label for the button, "Add a new aim", was mistakenly typed in Arabic as "قم بحفظ الهدف," which translates as "save the aim" in English (see Figure 15).

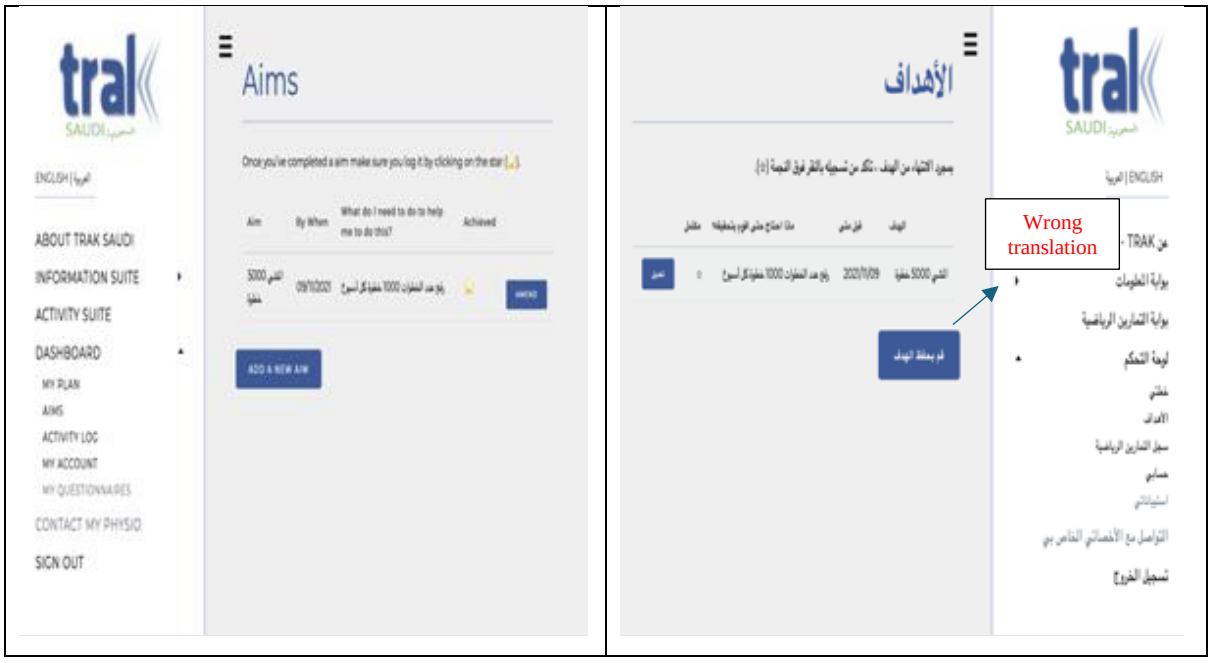

Figure 15: Screenshots of the page “Aims” in both languages.

Furthermore, during the *Exercise Selection* task, four participants encountered a technical bug. Specifically, when they added an exercise to their activity plans, its name became invisible on the "My plan" page (refer to Figure 16).

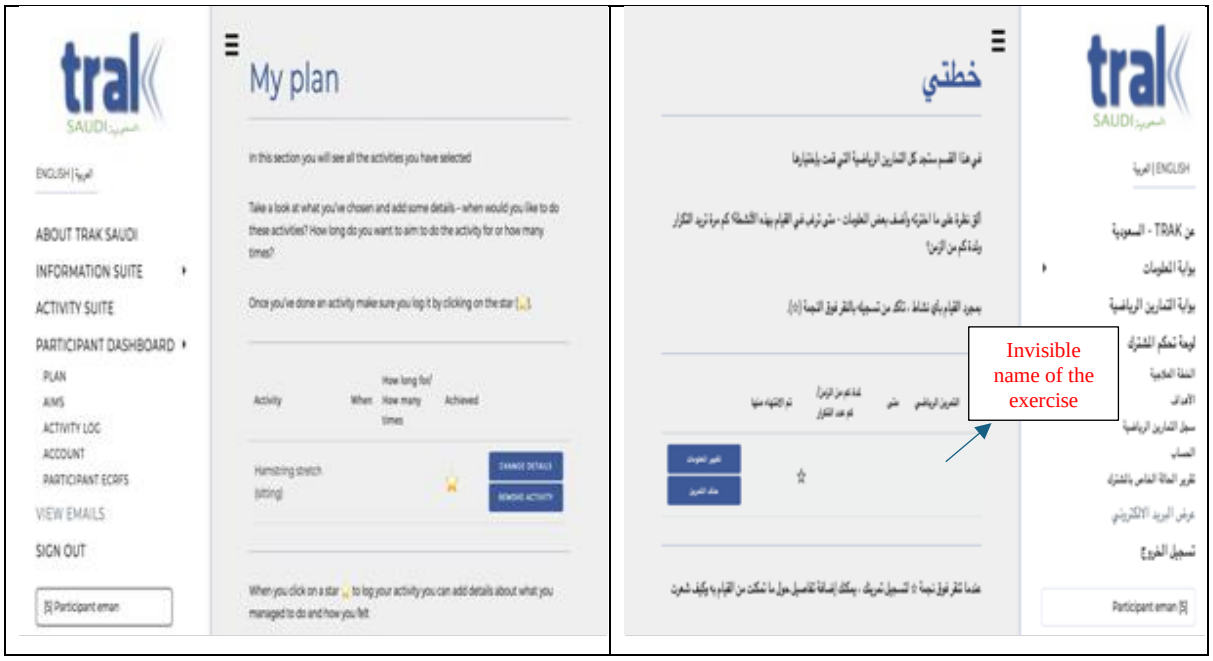

Figure 16: Screenshots of the page “My plan” in both languages.

Lastly, while attempting the *Knee Health Self-assessment* task, one participant encountered an unexpected technical bug on the TRAK-Saudi platform. Typically, clicking on the dashboard in the side menu should open a side list containing sub-sections, including My questionnaires, where the KOOS survey is located. However, in this particular case, clicking the dashboard did not immediately open it as expected, resulting in a brief delay. To address this issue, the participant clicked the dashboard button multiple times, and eventually, the side list appeared as intended.

6.3.4 The likelihood of participants substituting in-clinic sessions with TRAK-Saudi

The participants were asked to rate their willingness to substitute in-clinic sessions with TRAK-Saudi on a scale of 5. As shown in Table 27, the statistical analysis reveals a median of 4.5 for individuals with chronic knee pain and 5 for physiotherapists, indicating a strong preference for substitution, particularly among the physiotherapists. The mode is 5 for both groups, further highlighting this preference. The range of responses varies from 3 to 5 for individuals with chronic knee pain and from 2 to 5 for physiotherapists, suggesting some variability in opinions, though the data is generally skewed towards the upper end of the scale, indicating overall agreement with the idea of substitution.

Statistic	6 Individuals with Chronic knee pain	6 Physiotherapists
Median	4.5	5
Mode	5	5
Range	3-5	2-5

Table 27: Statistical analysis of participants' responses to substituting in-clinic sessions with TRAK-Saudi.

6.3.5 Summary

In this study, a total of 12 participants attended the remote sessions testing the usability of the TRAK-Saudi platform. A diverse group of participants was included, with slightly more females than males, and average age of 48.17 years (SD ± 16.3) and 34.83 years (SD ± 4.4) for individuals with chronic knee pain and physiotherapists consecutively. Their educational backgrounds and employment status varied. Furthermore, all participants in this study claimed having moderate and excellent proficiency in computer and website navigation, with most reporting an increased usage of electronic devices during the pandemic.

The analysis showed that individuals with chronic knee pain rated the platform with a usability score of 77.5 (80-84% percentile), while physiotherapists gave a higher score of 83.3 (90-95% percentile) (Sauro 2018). Content analysis of the think-aloud transcripts identified two main categories: Help and Guidance and Bugs and Flaws. Within the Help and Guidance category, reassurance-seeking was most prevalent, accounting for 45.28% of all verbalisations and being recorded in all nine tasks. Additionally, some participants faced challenges during task completion, leading to instances coded as lost in the process, constituting 37.73% of verbalisations. This category was observed in seven out of the nine tasks, highlighting the need for user support. A smaller portion of verbalisations (16.98%) indicated a genuine need for assistance, reflecting the participants' difficulties in navigating the platform in four out of the nine tasks. The participants also identified three system faults, including a translation flaw, a common technical bug and an unexpected technical bug. Most of the participants indicated agreement to substitute their in-clinic sessions with TRAK-Saudi.

6.4 Discussion of phase 2

Here, key results obtained from the 12 usability testing sessions conducted in this study are discussed in relation to the relevant literature and the study question below.

6.4.1 Discussion of findings related to the research question (Phase 2): How usable is the TRAK-Saudi platform for physiotherapists and individuals with chronic knee pain in Jeddah, Saudi Arabia?

This study recruited a total of 12 participants to test the usability of the adapted TRAK-Saudi. The sample size is aligned with the recommendations in the literature for usability studies that adopt the think-aloud approach (Hwang and Salvendy 2010; AlRoobaea and Mayhew 2014). A relatively similar participant count was also found in other usability testing studies employing the think-aloud approach, validating its sufficiency (Richardson et al. 2017; Alessa et al 2021). In the present study, it was found that the 12 participants were sufficient to discover usability issues in TRAK-Saudi that might impede user experience in the future. The consistency observed in the identification of bugs and flaws by participants in this study might support claims in the literature that testing with as few as 5 users is sufficient to uncover around 85% of a system's problems (Lewis 2006). In the current study, the bugs and flaws discovered remained consistent across participants as early as the third participant onwards, validating the claims of Lewis (2006).

In this study, the mean age of individuals with chronic knee pain was 48.17 years (SD 16.3). Upon comparing these figures with the mean age of the Saudi cohort with chronic knee conditions reported in existing literature, a slight difference emerges, the mean age of the participants of this study being lower than that of the participants of previous studies (Alfadhel et al. 2018; Alasfour and Almarwani 2022; Alotaibi et al. 2023b). However, this does not necessarily suggest that the participant sample fails to faithfully represent the broader population of individuals with chronic knee pain in Saudi Arabia. The divergence arises due to the distinct recruitment criteria employed in other studies, which exclusively focused on recruiting participants aged over 45 years, consequently limiting the exploration of the prevalence of chronic knee pain within younger age groups (Alfadhel et al. 2018; Alotaibi et al. 2023b). This assertion is substantiated by the latest research by Althomali et al. (2023), who broadened their

eligibility criteria to include participants aged 18 years and above to explore knee OA prevalence among the Saudi population. Their findings revealed that prevalence of knee OA is 13% (totalling 1852 subjects) in individuals aged between 18-49 years (Althomali et al. 2023). Considering this, it is reasonable to assume that chronic knee pain in Saudi Arabia is not confined solely to individuals above the age of 45 but instead extends across a broader age range, as observed in the current study. The current study had participants aged between 25 and 67 years, incorporating a subset of the knee pain population that is often underrepresented in Saudi published literature concerning chronic knee pain.

6.4.1.1 User perceptions of the usability of TRAK-Saudi

Overall, the results indicated that TRAK-Saudi effectively fulfilled the participants' expectations and was easy to navigate, earning scores of 77.5 and 83.3 on the A-SUS (Bangor et al. 2008; Sauro 2011). Physiotherapists, in particular, rated TRAK-Saudi with a score of 83.3, indicating excellent usability. According to Sauro (2011), scores exceeding 70 generally reflect above-average usability, while those above 80, are considered excellent. Notably, this score exceeds those reported for interventions within the same context, such as the TRAK App suite and the Knee OA (MVP), which obtained scores ranging from 57.8 to 78 on SUS (Spasić et al. 2015; Shewchuk et al. 2021). The following paragraphs discuss different factors that may have contributed to the high perceived usability of TRAK-Saudi among its potential users in this study.

It appears plausible that the high usability score reported for TRAK-Saudi could be attributed to the participants' digital literacy. Digital literacy includes an individual's ability to navigate, evaluate, summarise, analyse, present and share information within a digital environment (Ananiadou and Claro 2009; Ferrari 2013; Fraillon et al. 2013; Van Dijk and Van Deursen 2014). In this study, the participants claimed to have a moderate to excellent level of proficiency in using everyday technologies and navigating websites, with 75% noting an increase in their digital exposure with the pandemic. This finding aligns with research by Van Deursen and Van Dijk (2011), which suggests that increased or prolonged exposure to the Internet correlates with enhanced operational Internet skills. These operational skills are crucial for Internet

navigation such as browsing, searching and online forms completion (van Deursen and van Dijk 2010; Van Deursen and Van Dijk 2011).

Moreover, the age of the participants in this study likely contributed to the higher perceived usability of TRAK-Saudi. The participants in this study, with average ages of 48.17 years (SD ± 16.3) for individuals with chronic knee pain and 34.83 years (SD ± 4.4) for physiotherapists, were significantly younger than those in Shewchuk et al. (2021), who had an average age of 66.2 years (SD ± 6.9) and reported a lower SUS score.The relationship between age and operational Internet skills, as demonstrated by Özsoy et al. (2020), supports this observation. Their research on a random sample of 400 participants indicated that younger individuals tend to have better operational Internet skills. Young adults, having grown up during a time of rapid technological advancements, have been immersed in technology all their lives, using it extensively for education and social interaction. This generation, often referred to as digital natives, are fluent in the digital language of technology and Internet-connected devices, a concept introduced by Prensky (2001a; 2001b). However, Spiegel (2021) argues that being a digital native does not automatically imply proficiency in technology use. Prensky posits that the technology-rich environment of younger generations might lead to changes in brain structure, affecting how they process information technology and giving them an advantage over older generations who adapted to digital changes later in life (Rosell 2021). This generational divide in digital fluency and processing could be why TRAK-Saudi received scores of 77.5 and 83.3 on the A-SUS, closely aligning with the SUS score of 75 given by physiotherapists in Spasić et al. (2015)'s study, who were closer in age (36.5-40.3 years) to the current study's participants.

Additionally, the few bugs and flaws in TRAK-Saudi identified by the participants could have influenced their perceptions of the platform. A total of three system glitches were discovered by the participants during the sessions, with most encountering only one during their navigation. As argued by Dawood et al. (2019), a link exists between system bugs and users' overall perceived usability and intentions regarding future adoption, a notion that is supported by Ain et al. (2023). However, bugs in online systems are not unusual as these systems are built on codes made by humans, and humans are not perfect (Marfice 2020). Usability testing is mainly conducted to

discover system bugs as early as possible when an online system is newly developed or being adapted to accommodate a new set of users (Niranjanamurthy et al. 2014). TRAK-Saudi was piloted twice before conducting this study and refinements were made multiple times, which may explain the low number of bugs identified by the participants and the high usability score.

Moreover, Spasić et al. (2015) uncovered a notable difference in SUS ratings between participant types, observing that the physiotherapists involved in their research assigned lower SUS ratings to the TRAK App suite compared to the patients. The authors speculated that the physiotherapists might have faced greater difficulties in navigating the system than the patients. Although the primary aim of the current study did not directly address the variance between different types of participants, the findings by Spasić et al. (2015), echoed in Shewchuk et al. (2021), prompted a closer look at user experiences in Jeddah. Intriguingly, the dynamics in Jeddah presented a contrasting scenario, where physiotherapists rated TRAK-Saudi with a slightly higher overall A-SUS score (83.3) than individuals with chronic knee pain (77.5), indicating that physiotherapists in this context found the platform somewhat more navigable. This difference could potentially be attributed to varying levels of digital technology engagement, especially heightened during the pandemic (Pandya and Lodha 2021). Considering the professional backgrounds of the study participants, with four individuals with chronic knee pain being retired or self-employed, it is likely that their daily interaction with digital platforms was less frequent compared to the physiotherapists. Physiotherapists, in contrast, may have been more immersed in digital environments, adapting to virtual modes of patient interaction during the pandemic. Supporting this notion, Elsayed et al. (2022) surveyed 265 Saudi physiotherapists about the COVID-19 pandemic's impact on their practice, revealing that about 30% had adopted digital communication methods to continue providing services remotely. This pivot to digital service delivery, spurred on by the pandemic and the national digitalisation scheme of Saudi Vision 2030, has likely enhanced physiotherapists' familiarity with digital tools, as noted by Salehiya (2021).

6.4.1.2 Users experiences in navigating TRAK-Saudi

Prior research has highlighted the value of employing multiple testing methods in usability studies to uncover issues affecting user experience and explore users' initial reactions to the platform being tested (Thyvalikakath et al. 2009; Khajouei et al. 2018; Zardari et al. 2021). In this study, the participants engaged with TRAK-Saudi while thinking-aloud, a method renowned for its efficacy and prevalence in usability research (Wu et al. 2017; Fischer et al. 2019; Lunde et al. 2023). The analysis of 12 think-aloud protocols through quantitative content analysis not only facilitated the identification of usability issues but also enabled the quantification of these occurrences to explore their impact on the user experience. A key finding from this analysis was that while navigating TRAK-Saudi a considerable number of participants sought validation of their actions (45.28% of 53 inquiries) and experienced feeling lost (37.73%), exceeding their requests to receive actual assistance to complete tasks (16.98%).

Reflecting upon the high A-SUS score and relatively low number of assistance requests, it becomes apparent that TRAK-Saudi, as a platform, was not inherently difficult for the participants to manage. However, the overarching process of familiarising oneself with a new technology, particularly within the confines of a research study, seemed to have introduced a level of confusion for many of these first-time users. This ties in with Button et al. (2018), where physiotherapists found the original TRAK usable with no extra training needed but were initially somewhat challenged by the unfamiliar system. This pattern of user behaviour resonates with the findings of previously published literature in this field (Lyles et al. 2011; Crane et al. 2017). Specifically, a study by Crane et al. (2017) involved a usability assessment of a smartphone application designed to support individuals in reducing their alcohol consumption. Using a think-aloud methodology, their thematic analysis of participant feedback uncovered ‘Feeling lost and unsure what to do next’ as a predominant theme. This finding highlighted a common experience among participants: a sense of confusion when first engaging with a novel technology, leading to recommendations for the development of a user guide to facilitate better understanding of the technology. Despite the provision of a user guide in the current study for navigating TRAK-Saudi, similar patterns of confusion were still reported by the participants.

The confusion reported in this study and other mentioned literature could be explained by the participants' cognitive dynamics during interactions with the technology.

Cognitive dynamics include the intricate interplay of various cognitive processes, such as perception, attention, memory, reasoning and problem-solving, within the human mind, shaping individuals' engagement with tasks, information and stimuli (Colom et al. 2010). The degree of cognitive dynamics required by users to effectively complete specific tasks in usability testing sessions is referred to as cognitive load theory (Sweller 1988; Whitenton 2013). A well-established relationship exists in the literature between cognitive load and usability results, with higher cognitive loads required for task completion correlating with lower usability results and satisfaction rates (Nielsen 1993; Zviran et al. 2006; Hollender et al. 2010; Byun and Finnie 2011; Nielsen 2012). In tasks with high cognitive demands, participants might experience uncertainty and seek assistance to alleviate cognitive strain, enhancing task performance through validation of their steps. Reflecting on the high usability score of TRAK-Saudi, it appears that the frequent requests for reassurance and occurrences of confusion observed in this study may not be directly attributable to TRAK-Saudi itself. Instead, other factors, including the testing tools and methods used in the study, may have been responsible, as will be explained in the following paragraphs.

Firstly, the literature raises concerns about the potential impact of employing the think-aloud approach on the cognitive load experienced by participating individuals (Preece et al. 2002). Thinking-aloud entails multitasking, demanding participants to expend additional mental effort to articulate their internal cognitive processes into coherent spoken language while concurrently accomplishing the task successfully (Preece 1994; Pike et al. 2014; Park et al. 2020). This dual cognitive demand places a higher cognitive load on the participants compared to a scenario wherein they execute tasks silently (Preece et al. 2002). In the context of thinking-aloud, participants must strike a balance between task performance, verbalisation and maintaining focus on the task's objectives. However, this argument contrasts with Vanicek and Popelka's (2023) perspective on cognitive load during thinking-aloud. They contend that participants act naturally, as they would in real-life situations, when performing routine tasks and vocalising their thoughts, with no need for additional interpretation (Vanicek and Popelka 2023). While their standpoint is valid, it is noteworthy that the situation diverges when individuals become aware of being observed, as in testing sessions. This introduces the observer effect, where participants' self-awareness of their actions is heightened, increasing cognitive demand compared to real-life scenarios in which

they might naturally think aloud without the pressure associated with observation or evaluation (Monahan and Fisher 2010).

Secondly, the inclination to seek reassurance and guidance during the completion of certain tasks on TRAK-Saudi could potentially stem from an elevated cognitive load caused by the use of the videoconferencing platform, Zoom. The Zoom meeting might have seemed unfamiliar to participants due to its specific purpose (i.e., participation in an experiment) (Carolli 2023). Notably, the intensity of the call, encompassing instructions to think aloud, follow the user guide and execute tasks under researcher observation, could have potentially caused discomfort among the participants. This has been reported in the literature as Zoom fatigue, a phenomenon that emerged with the intensity of use of videoconferencing platforms during the pandemic as people tried to stay connected remotely (Bailenson 2021). Zoom and similar platforms are classified as multimodal technologies because they use more than one channel (audio, visual, etc.) to transit information simultaneously, requiring the use of more cognitive resources than single modal technologies, thus increasing the cognitive load of the user (Lang 1995; Hinds 1999; Bailenson 2021). In the case of the current study, the participants were asked to turn off their cameras while thinking aloud and to share their screen instead. The act of sharing screens can introduce an element of self-awareness as the participants may become more conscious of how their shared content is being perceived by others, leading to additional mental processing as they strive to present information clearly and effectively (Hinds 1999).

Indeed, the participants of this study were given a user guide to help them complete the tasks on TRAK-Saudi to facilitate independent navigation (Crane et al. 2017). While the user guide may have enhanced the participants' experience with TRAK-Saudi, as reflected by the A-SUS score, it did not eliminate confusion. In fact, it is assumed that the presence of the user guide created an extra burden for the participants in some way. The multitasking involved in following the user guide instructions and simultaneously thinking aloud while executing tasks may potentially have increased cognitive demands and load on the working memory of the participants. Operating within a "task-oriented" framework involves interaction between diverse cognitive processes, such as perception, attention and memory, to accomplish specific tasks, increasing cognitive load, and working memory frequently

becomes taxed during such activities (Budiu 2018). The presence of the user guide can be seen as facilitating navigation for novice users, but according to the results of this study, this was not sufficient. Specifically, there was an apparent preference for expert guidance (from the researcher) during the usability sessions, not necessarily to assist with task execution but to reassure users that their actions during the process were correct. These findings imply that optimal onboarding for future users of digital self-management support might involve preliminary training sessions led by an expert, followed by the distribution of a user guide for ongoing reference. The feasibility of integrating training into therapy sessions is highlighted by the positive response from the physiotherapists in Phase 1, particularly PT5, who expressed readiness to provide training as needed, stating, "*I will train them of course if the platform needs training*". Therefore, it is advisable for future developers to include training for physiotherapists, equipping them to effectively support and deliver these initiatives in clinical settings (Dunphy et al. 2017).

Regarding the need for assistance, the participants indeed sought help during their use of TRAK-Saudi, though less frequently (16.98% of 53 total interactions) than seeking reassurance. An investigation into the moments when assistance was requested revealed an interesting pattern; they were less about the inherent complexity of TRAK-Saudi's interface and more about the participants missing minor yet crucial instructions in the user guide. Overlooked details involved actions like entering the provided URL to access TRAK-Saudi for ‘TRAK-Saudi entry navigation’, using capital letters in login credentials for ‘Account access’ and selecting the correct questionnaire for ‘Knee health self-assessment’. These tasks all necessitated data entry, prompting a need for assistance. Crane et al. (2017) offer insight into why participants may seek help in such scenarios, especially in a supervised research setting. They argue that the concern over inputting incorrect information and its potential consequences on the study's flow may induce a level of worry among the participants who need help (Crane et al. 2017). Yet, in this study, with the presence of a user guide, it seems that instructions in the guide were overlooked, perhaps due to the participants' familiarity with similar digital technologies or the cognitive burden imposed by the multi-tasking process of this research. Following the user guide, verbalising thoughts and performing tasks, participants likely deemed it unnecessary to concentrate on all the minutiae presented in the user guide, a phenomenon known

as "selective attention". This cognitive process involves focusing on information deemed relevant for thorough processing while disregarding what's viewed as irrelevant (Stevens and Bavelier 2012). This suggests that despite the guide's presence, the combination of technological familiarity and the demands of multitasking led the participants to focus their attention on what they considered essential, inadvertently skipping over small but significant details.

6.4.1.3 Integration of TRAK-Saudi into knee care

At the end of the sessions, the participants in this study were asked about the likelihood of their substituting in-clinic physiotherapy sessions with TRAK-Saudi. The results strongly indicated that most participants were inclined to accept digital self-management support to manage knee pain, giving the idea a score of 5, meaning “strongly agree”, on the 5-Likert scale. The participants were also introduced to this idea earlier in Phase 1, and generally they shared positive feelings on it, though with some caution and concern regarding its suitability for different demographics. Revisiting this enquiry in the current phase added valuable depth. The key difference is that the opinions in Phase 1 were speculative, shaped by the anticipated benefits of the digital initiative and the expected digital proficiency of potential users. However, the insights from Phase 2, being grounded in actual user experience, carry more weight and provide a clearer picture of the potential for TRAK-Saudi's integration into Jeddah's physiotherapy practices. This progression from hypothetical to experiential understanding underscores a more concrete and favourable outlook on adopting TRAK-Saudi in clinical settings.

The findings from this phase provide a clearer understanding of potential users' initial acceptance of integrating TRAK-Saudi into their care routines. The term "initial use acceptance" aptly describes this scenario as data were collected following the participants' first interaction with the technology in a controlled environment (Martin et al. 2015; Arbelaez Garces et al. 2016; Distler et al. 2018). In contrast, the opinions formed in Phase 1, prior to engaging with TRAK-Saudi, align more with the concept of "peruse acceptability", reflecting theoretical receptiveness to the technology (Martin et al. 2015). Various models in the literature attempt to elucidate the factors influencing human intentions towards technology acceptability and acceptance, highlighting the

complexity of predicting intentions but identifying key factors that can guide developers in understanding user attitudes (Davis 1985; Connelly 2007; Kim and Park 2012; Dou et al. 2017; Cheung et al. 2019). Specific tools and methods are widely used by scholars to measure acceptance in the literature, including usability questionaries (Nadal et al. 2020).

This study did not delve into measuring acceptance as outlined in existing literature, and consequently, the A-SUS score was not interpreted in this context. The focus was rather on assessing the potential acceptance of TRAK-Saudi as a substitute for in-clinic care, utilising a Likert scale to determine if real interactions with the platform altered any preconceived opinions from earlier phases. The Technology Acceptance Model suggests that user intentions to accept technology are shaped by perceived ease of use (the effort needed to learn and use the technology) and perceived usefulness (the technology's capacity to enhance everyday life and job performance) (Davis 1985). Initial qualitative feedback from phase 1, without direct engagement with digital self-management tools, probably mirrored expectations of the benefits and the platforms' capability to support autonomous management of knee pain and streamline clinical operations. This perspective is echoed in statements from the participants. For instance, PT12 mentioned, "*the number of patients will decrease in the clinic, so we can treat the acute cases*" and IKP8 highlighted, "*it saves time, I mean, because I do not have to come and go every time*". Importantly, while the concept of perceived usefulness can develop without direct interaction, perceived ease of use necessitates first-hand experience (Davis and Venkatesh 2004). Therefore, the affirmative feedback in Phase 2 likely originates from a thorough reassessment of TRAK-Saudi's usefulness and ease of use after the participants had personally interacted with the platform, providing a more grounded perspective on its potential integration into their care practices.

6.5 Clinical implications from phase 2

The results from this usability study have several implications for clinical practice in the Saudi physiotherapy context. The positive reception suggests that digital self-management support platforms can substitute in-clinic sessions in Jeddah, aligning with global trends towards digital health supporting knee pain self-management support (Smittenaar et al. 2017; Button et al. 2018; Nelligan et al. 2019; Mrklas et al. 2020; Gruner et al. 2021; Goff et al. 2023). However, the successful integration of digital initiatives like TRAK-Saudi into physiotherapy services in Jeddah necessitates a proactive approach to address varying levels of digital literacy among target users. The participants in this study were of a moderate to excellent level of proficiency in navigating computer and website, which is a situation that does not necessarily align with the wider target audience. Thus, future adopters should consider offering user education and training programs aimed at enhancing digital literacy, particularly for those with limited proficiency to promote initial acceptance and use, which is a practice observed in the literature concerning the integration of new digital health solutions (Kuek and Hakkennes 2020; Ismond et al. 2021; Shaw 2023).

Indeed, the study's indication of a high incidence of reassurance-seeking behaviours among participants highlights the importance of training sessions for all first-time users. These sessions should be designed to address common challenges and questions, thereby mitigating potential frustrations that may arise from navigating new digital health platforms (Crane et al. 2017). Such initiatives should not only familiarise users with the basic functionalities of the platform but also empower them to navigate its features with confidence, thereby ensuring a smoother transition to digital health services (Alruwaili et al. 2023). These sessions in fact are pivotal not only for individuals with chronic knee pain but also for physiotherapists who are integral to the delivery of the TRAK-Saudi platform. By equipping physiotherapists with the needed knowledge and skills to support individuals in using the platform, the potential for its integration and proper use could be markedly enhanced (Shiferaw et al. 2020; Alruwaili et al. 2023; Shaw 2023). This approach ensures that individuals with chronic knee pain receive the support they need to engage successfully with the proposed technology.

6.6 Limitations of phase 2

The use of convenience sampling in this study primarily attracted participants who were more inclined towards technology. While still effective in generating usability data, this may have left the needs of a significant portion of the target population less comfortable with digital platforms unaddressed. This oversight suggests that the study's findings might reflect the experiences of potential digital adopters, potentially missing critical insights into the needs and opinion of those less familiar with such technologies (Wade et al. 2012). Given this gap in the research, future research should specifically aim to engage with individuals who have limited digital literacy or express reservations about using digital health platforms. This focus is crucial for developing an inclusive understanding of the barriers to and needs of all potential users of digital physiotherapy tools and not just the most technologically adept ones (Toscos et al. 2019).

Furthermore, the decision to employ remote testing for the TRAK-Saudi study, while pragmatic during the pandemic, likely skewed participant inclusivity, favouring those comfortable with videoconferencing platforms like Zoom. This approach may have inadvertently excluded those concerned about virtual interactions, potentially biasing the findings towards a more digitally literate user base. Recognising this limitation, future studies should consider lab-based testing as an alternative. This can mitigate the barriers associated with remote testing, offering direct support and a more accessible experience for all participants, thus ensuring a more inviting environment for a wider spectrum of participants.

6.7 Conclusion to the chapter

This study investigated the usability of the TRAK-Saudi platform by its potential users in Jeddah, physiotherapists and individuals with chronic knee pain. Accommodating the constraints imposed by the global COVID-19 pandemic, the study employed remote testing sessions with a total of 12 participants. It applied mixed methods approach of usability testing, namely, the A-SUS to evaluate perceived usability, the think-aloud approach to identify usability issues with TRAK-Saudi and a scenario-based question to assess the likelihood of potential users substituting in-clinic physiotherapy sessions with the TRAK-Saudi platform. This study's findings demonstrate that potential users of TRAK-Saudi in Jeddah possess adequate digital skills to interact effectively with digital self-management support initiatives, requiring little to no external help. Nonetheless, the results also highlight the need for additional support during initial use to increase familiarity and boost the confidence of future users. Insights gained in this study are of value to future researchers aiming to understand the attitudes and receptiveness of Saudi users towards digital health solutions, thereby aiding in the preparation for broader implementation and seamless integration of such technologies into healthcare practices.

The next chapter discusses findings from both phases of the Ph.D. research. It seeks to contribute to the broader discourse, highlighting insights that have become more meaningful upon the completion of the research. These insights, together with those explored in chapters 4 and 6, establish a foundation for proposing directions for future research.

Chapter Seven: Discussion

7.1 Introduction to the chapter

This Ph.D. research aimed to explore digital self-management support for chronic knee pain within current physiotherapy practices in Jeddah, Saudi Arabia. This chapter integrates and discusses findings from the two phases of the Ph.D. research, both of which aimed to deepen the understanding of the subject matter through insights gained. It is designed to enrich the conversation around the topic, emphasising insights that became more pronounced following the completion of both phases. The discussion is particularly beneficial for future researchers interested in TRAK-Saudi or similar digital self-management support initiatives for chronic knee pain, either within the Jeddah context or in areas with similar healthcare systems and cultural backgrounds. This chapter discusses the relevance of existing practices for chronic knee pain with digital self-management support initiatives, the limitations of digital solutions for those who prefer in-clinic therapy, and the potential for Jeddah's digital infrastructure to support initiatives such as TRAK-Saudi. In addition, recommendations are offered for integrating TRAK-Saudi into local practices. These insights, along with those discussed in Chapters 4 and 6, lay the foundations for making recommendations for future research in this area.

7.2 Current physiotherapy practices for chronic knee pain in Jeddah retain a degree of relevance with the core components of digital self-management support initiatives.

In Phase 1, the themes ‘Focus of physiotherapists in managing knee pain’ and ‘Connection to technology’ provide insight into the practices of physiotherapists in Jeddah. The findings indicate that their existing practices for managing knee pain demonstrate a partial alignment with the core components of digital self-management support initiatives, particularly through their emphasis on exercises, continued support, education and self-monitoring (Button et al. 2018; Nelligan et al. 2019; Mrklas et al. 2020; Gruner et al. 2021; Goff et al. 2023). In particular, their practices were found to be augmented by digital technology. Through video calls and the sharing of video recordings, physiotherapists offer personalised guidance on exercise

programmes, ensuring that individuals continue to receive the support that they need outside of the clinic. This practice implies that physiotherapists perceive value in continuous individual engagement and support, recognising that the management of chronic knee pain extends beyond the clinic to include engaging individuals in care by supporting self-management at home setting (Wu et al. 2022). By using technology for this purpose, physiotherapists' practices not only exemplify their adaptability to the digital revolution but also highlight the natural fit of digital solutions within the existing therapeutic setting.

Moreover, findings from Phase 1 indicate that physiotherapists in Jeddah encourage individuals with knee pain to self-monitor their symptoms and progress, emphasising a broader recognition of the importance to promote self-awareness and the ability to self-manage diseases (Duplaga 2013). This practice aligns with social cognitive theory by fostering self-awareness and reinforcing individuals' belief in their ability to manage their condition (Bandura 1999; Smith et al. 2022). Self-monitoring through increased self-awareness and continuous recording of change is considered to offer a promising behaviour change strategy to reduce the incidence of sedentary behaviours by acknowledging improvement (Michie et al. 2011; Gardner et al. 2016). Self-monitoring skills noticed among individuals in Jeddah signals a capacity to engage more deeply with their health management, making the case for digital solutions which can support these efforts to an even greater degree. Digital self-management support initiatives provide user-friendly tools for tracking symptoms, progress and adherence to exercises, thereby aligning perfectly with this context (Choi et al. 2019; Safari et al. 2020). They not only reinforce the culture of self-management but also ensure that such practices are more impactful, thereby enhancing the relevance of these digital solutions in the Jeddah healthcare setting.

Digital self-management support initiatives emerge as a compelling means of addressing the notable gap in education provision and enhancing current practices. Despite the intention to offer patient education, a disconnect between the planned delivery and actual implementation has been identified in Phase 1, revealing a missed opportunity to empower individuals with the knowledge required for effective self-management (van Berkel et al. 2015; Liu and Jiang 2019; Hong and Oh 2020). This scenario presents digital self-management support as a promising solution that is

capable of providing tailored, accessible and reliable educational content to a digitally adept population, thus effectively bridging this educational gap and catering to the demand for constructive education (Goff et al. 2023). This approach not only satisfies the evolving needs of physiotherapists and individuals with chronic knee pain but also showcases a mutual recognition of its potential to enhance the current care landscape, as highlighted in the theme of 'Perceptions of digital-based self-management support.' Physiotherapists recognise that these digital initiatives potentially offer a solution to reduce their workload by facilitating a shift towards remote monitoring and management (Haleem et al. 2021). For individuals with chronic knee pain who face long commutes and busy schedules, digital self-management support offers a pragmatic solution, enabling them to access therapeutic exercises and professional guidance remotely, thereby alleviating the need for frequent clinic visits. This strategic integration of digital support initiatives not only alleviates clinic workloads but also significantly improves access to and the quality of physiotherapy care for individuals, demonstrating a clear path towards optimising healthcare delivery in Jeddah.

7.3 Digital solutions might not be the optimal choice for those seeing in-clinic therapy as an escape

In the theme 'Perceptions of digital-based self-management support,' the participants displayed a generally positive perception of the concept of digital self-management support initiatives as a substitute for face-to-face care, albeit with varying opinions regarding the delivery methods for future integration. Notably, some resistance was observed among individuals with knee pain, particularly among women, which may stem from concerns regarding their digital capabilities, as discussed in Chapter 4 (Sobieraj and Krämer 2020). However, the subsequent usability study in Phase 2 (see Chapter 6) added a new dimension to this understanding. Interestingly, of the 12 participants who re-joined the study to test the digital platform, 7 (58.33%) were women, thereby prompting a re-evaluation of the initial perceptions. A notable discrepancy emerged between the demographic profiles of the interview participants and those who participated in the usability testing. The interviews in Phase 1 had included housewives, some of whom had not completed high school education and were absent from the usability study. In contrast, the usability study participants all had work experience and at least a high school education, suggesting a greater

openness to technological solutions among this more educated and employed demographic.

This shift indicates a potential preference among housewives for in-person sessions, which could be attributed to several factors, some of which were mentioned in the interviews. Attending these sessions may provide a break from household responsibilities, an opportunity for personal interaction and to have their concerns heard. Alternatively, it may reflect the challenges of dedicating time to self-care amidst a busy home life, often reported among housewives (Radina et al. 2014). Indeed, this insight reveals that the issue is not a simple matter of women being less inclined to engage with digital healthcare solutions; rather, it highlights the importance of active listening to these individuals during therapy sessions. This approach helps to reveal each individual's unique life circumstances and responsibilities, enabling a precise evaluation of such initiatives' suitability (Bischof et al. 2021). Such depth of understanding is fundamental for accurately determining the appropriateness of digital self-management initiatives. Reflecting on the transtheoretical model of change discussed in Chapter 2, the literature underscores the importance of actively listening to the concerns of individuals with chronic conditions to gauge their readiness for change before recommending self-management strategies (Jensen et al. 2003). Effective communication through incorporating motivational interviewing techniques may well increase receptiveness to digital platforms among these individuals, particularly given the high level of trust they place in their physiotherapists, as evidenced by interviews in Phase 1 (Lee and Lin 2009; Thom et al. 2014; Schoenthaler et al. 2014; Arkowitz et al. 2015). This approach is not solely applicable to women but could extend to any individual might experiencing a stressful home environment. For these individuals, in-clinic sessions may serve a dual purpose, not just addressing physical health needs but also providing a form of mental therapy.

7.4 Jeddah's digital infrastructure could facilitate the smooth handling of digital initiatives such as TRAK-Saudi

In the context of introducing digital initiatives such as TRAK-Saudi, the significance of robust digital infrastructure cannot be overstated. Insights from the current research reveal a noteworthy observation. In the theme ‘Connection to technology,’ participants did not report daily struggles with Internet connectivity and nor did they encounter

troubleshooting issues in their neighbourhoods during the interviews which could impede the digital transition. This finding is corroborated by the seamless Internet experience during the usability testing where there were no instances of Internet-related disruptions, delays in video or voice quality issues reported in the recordings. The absence of connectivity issues indicates the readiness and capability of the existing digital infrastructure in Jeddah to support the future integration of digital health initiatives, ensuring uninterrupted access and interaction with digital platforms (UNDP 2019; Alharbi and Csala 2021).

Additionally, it is important to ensure that the target audience can use the proposed technologies (Duplaga 2013). Saudi Arabia, as shown in statistical reports, is a fertile environment for technological contributions (Al Shouli and Mechael 2019; Al-Kahtani et al. 2022). The theme ‘Connection to technology’ from Phase 1 highlights participants' deep engagement with digital technology, reflecting a wider cultural and societal trend of incorporating technology into daily life, including healthcare, even before the pandemic urged a digital acceleration (Aljohani and Chandran 2019). This inclination was reflected in Phase 2 by the minimal requests for assistance with the TRAK-Saudi platform (16.98% of 53 inquiries in total), thereby suggesting both adequate digital literacy among users and the intuitive design of the platform. This is supported by the high usability score for TRAK-Saudi on the A-SUS scale (Sauro 2011). Further supporting this finding, Alasfour and Almarwani (2022) demonstrated that elderly Saudi females were able to navigate the My Dear Knee app without reporting issues, thereby suggesting a general competence in digital skills across the target population. This competence is likely to stem from the country's ongoing digitalisation efforts in public and healthcare services as part of Vision 2030 (VISION2030, 2023b). These findings combined suggest the potential to seamlessly integrate digital health solutions into the participants' routines, facilitated by a national readiness to embrace technology in healthcare.

7.5 Guiding notes for integrating TRAK-Saudi into Jeddah's physiotherapy practices

Across both phases of the research, a consistent theme emerged: the need for reassurance within the digital healthcare experience, highlighting a need for human-centric support. In Phase 1, the theme ‘Perceptions of digital-based self-management support’ revealed a preference among the participants for digital initiatives to complement rather than completely substitute traditional, face-to-face care, thus suggesting a hybrid model for future integration. In Phase 2, interactions with the TRAK-Saudi platform further underscored this need for reassurance; a noteworthy number of inquiries (45.28% of 53 inquiries in total) were directed towards seeking guidance and support, thereby indicating some dependency on the researcher for reassurance during the usability sessions. Although Chapter 6 attempts to rationalise this behaviour through discussions of the methodology, tool selection and the participants' unfamiliarity with the platform, integrating data from both phases reveals an additional layer of justification. Recognising the varied needs among populations regarding digital health technology features, the current research reveals that for users in Jeddah, the appeal of digital solutions does not solely lie in their functionality (Michie et al. 2017; Werntz et al. 2023). These technologies are also valued for their ability to provide continuity and a sense of security through features that emulate the support found during traditional human interactions (Yardley et al. 2016). This continuous mention of reassurance emphasises the need for digital self-management support initiatives to deliver more than merely educational content or exercise routines; they must also mimic the comforting aspects of face-to-face care. The extent and type of human support required differ among various user groups, necessitating future developers to evaluate users' needs to effectively meet these demands (Yardley et al. 2016). For example, in TRAK-Saudi at the current phase, a messaging system was integrated into the platform based on participant suggestions to facilitate communication with their physiotherapists (see Chapter 5).

However, future adopters must be aware user needs identified in this research and digital advances may change over time and, therefore, in order to promote adoption and effectiveness, continuous evaluation and iteration are required on a regular basis (Michie et al. 2017). Gathering user feedback through surveys, focus groups and analysis of usage data will prove crucial for identifying areas for improvement, understanding user satisfaction, and adapting the platform to better meet the needs of potential users and upscale care (Cresswell et al. 2020). This iterative process, rooted

in the principles of user-centred design, will ensure that digital health solutions such as TRAK-Saudi remain relevant, effective and aligned with the evolving landscape of healthcare and technology in Jeddah (de Beurs et al. 2017; Slattery et al. 2020). For now, the data obtained from this mixed methods research has been integrated to provide an overview of TRAK-Saudi which is detailed in Table (28). This reflects the approach taken by Goff et al. (2023) to provide an effective overview of the platform for any future research endeavours.

Item	Description
Brief name of the platform and its description	TRAK-Saudi: A web-based self-management support platform to be used by individuals with chronic knee pain in Jeddah, Saudi Arabia.
Rationale for the platform and the goal of the elements essential to the platform	There is a high prevalence of chronic knee pain in Saudi Arabia and a tendency towards digital technologies and healthcare digitisation in the country. This platform facilitates the self-management of chronic knee pain, primarily through exercises and education; the two key treatment strategies supported by universal clinical guidelines and applied to other populations.
Aim of the platform	
1. Improve the knowledge that individuals with chronic knee pain have about the condition to inform treatment decision-making and self-management	- The platform provides text and video content regarding the causes and triggers of knee pain, effective home pain management strategies, and dietary advice, as recommended in the Phase 1 interviews. - Content was added to the platform to counter misinformation frequently found on the Internet which was a concern raised by physiotherapists in Phase 1 interviews. - Clinical expert interviews feature on the platform to improve the accuracy of the content, depth of information, and adaptability to the Saudi context.
2. Provide tools to facilitate self-efficacy	- The platform offers individuals the opportunity to set their goals so that the subsequent attainment of goals on the activity log reinforces and strengthens the performance mastery aspect of self-efficacy (Bandura et al. 1975; Bandura et al. 1997). - By enabling individuals with chronic knee pain to tailor their exercise regimens, the platform not only supports their autonomy but also enhances their confidence in managing their health (Ryan and Deci 2000). - Videos of a model exercising were included on the platform to facilitate the modelling aspect of self-efficacy (Bandura and McClelland 1977; Maisto et al. 1999).
3- To be used as a comprehensive resource for physiotherapists and individuals with chronic knee pain to facilitate	- Information suite can be used by physiotherapists as an educational resource to be provided at the sessions to increase individuals' awareness of their conditions. - Activity suite can be used by physiotherapists to improve the accuracy of exercise performance during the sessions and at home instead of using personal mobile phones for this purpose.

effective management and care.	- Individuals with chronic knee pain can use the platform as a tool to facilitate communication with their physiotherapists during the sessions by sharing their goals in exercise therapy and preferred exercises to achieve these goals.
Other principles that guided platform adaptation	
Co-design	The platform content and features were added based upon the suggestions and requirements of physiotherapists and individuals with knee pain identified in Phase 1 interviews (Eysenbach 2005; Meyerowitz-Katz et al. 2020; Bennion et al. 2020; Barnum 2021).
Patient-centred	TRAK-Saudi is centred on the goals and preferences of those with knee pain. They are required to complete the KOOS questionnaire to provide physiotherapists with insight into their individualised knee pain experiences, guiding personalised exercise and advice. Exercise plans are tailored to the user's goals and timelines, with no fixed regimens. Instead, users and physiotherapists collaborate to develop personalised plans which respect the user's unique needs.
Theory-based	The platforms of TRAK-Saudi, LEAP-MS and the original TRAK are based on a theoretical underpinning that enhances their effectiveness in driving behavioural change among their users (see Chapter 5). TRAK-Saudi also integrates key elements from behavioural change theories, specifically social cognitive theory and self-determination theory, to encourage positive health behaviours: - By incorporating educational content, exercise videos and personalised feedback from physiotherapists, TRAK-Saudi adopts principles from social cognitive theory. This theory emphasises the significance of observational learning, self-efficacy and social support. The platform enables users to learn through observation (e.g., watching educational videos and exercise demonstrations, learning new skills, and understanding the importance of physical activity and pain management techniques), provides step-by-step exercise videos (Activity suite), facilitates goal setting (Aims), progress tracking (Activity log), and enhances users' confidence in executing exercises correctly and managing their conditions. Additionally, the messaging system (Contact my physio) offers a channel for receiving encouragement and advice from physiotherapists, thereby fostering a supportive community environment (Bandura et al. 1975; Bandura and McClelland 1977; Bandura et al. 1997; Maisto et al. 1999).

	- TRAK-Saudi's functionality, which includes goal setting, progress monitoring and receiving personalised exercise plans and advice, aligns with self-determination theory's central tenets: autonomy, competence and relatedness. The platform empowers users to take control of their treatment plans (autonomy), enables them to track their progress and receive tailored exercise recommendations (competence), and provides support from physiotherapists (relatedness). In doing so, TRAK-Saudi effectively promotes intrinsic motivation regarding healthy behaviours (Ryan and Deci 2000; Ryan and Deci 2011).
Other features	
Presentation	TRAK-Saudi is a bilingual platform which enables users in Jeddah to navigate in English or Arabic. It uses a multimodal blend of video and text to present educational content, specifically selecting videos to tackle the challenge of information overload, a critical issue in digital health (Umapathy et al. 2015; Parsons and Adams 2018).

Table 28: Overview of the TRAK-Saudi platform for future research endeavours.

7.6 Recommendations for future research

Based on the results of this mixed methods research, several recommendations for future research were identified:

- Further exploratory research is warranted to uncover the reasons for the paternalistic approach observed in physiotherapy care within Saudi clinics, deviations from patient-centred care and the barriers to aligning practices with international clinical guidelines, given that existing cross-sectional studies limit the exploration of physiotherapists' thoughts and experiences (Almoajel et al. 2012; Alshehri et al. 2017; Al-Sahli et al. 2021).

- Researchers are recommended to examine the practices of physiotherapists in knee care and the attitudes of individuals with chronic knee pain towards self-management nationwide. This would enable the identification of consistencies and divergences compared to the findings of this research. Specifically, the data from this study could inform the development of research tools aimed at capturing a broad knowledge of the wider Saudi population, assessing the potential for generalising these research findings and evaluating the suitability of TRAK-Saudi beyond Jeddah.

- Future research on TRAK-Saudi may start with explanatory research with the same participants as in Phase 2. This research approach will facilitate a deeper understanding of the challenges encountered by the users when interacted with the platform and the causes of their behaviours, particularly the need for continued assurance. Insights from such research will be crucial in guiding specific improvements to the TRAK-Saudi platform, enhancing its usability.

- Further studies are warranted to assess how TRAK-Saudi can be integrated into actual care practices, identify barriers and facilitators, and explore strategies for broad adoption that consider organisational factors.

- There is a need for a larger evaluation trial to investigate the adoption rates, user satisfaction, and the impact of TRAK-Saudi on clinical outcomes over time. Through extended studies, valuable insights into how engagement with the platform

changes and compares to conventional in-clinic physiotherapy sessions can be obtained. This approach will provide deeper insights into the true attitudes of potential users towards self-managing their knee pain digitally. Such studies should include participants with diverse health and digital literacy levels to enhance the accessibility of the TRAK-Saudi platform, addressing a recognised barrier to the uptake of digital health initiatives (Parsons and Adams 2018). Understanding these perspectives will aid in identifying driving factors and potential obstacles to the acceptance of TRAK-Saudi and similar technologies.

The next chapter provides the conclusion of this Ph.D. research, briefly summarising the research design and methods undertaken to accomplish it and the principal findings. It highlights the meaningful contributions this research has made to the prevailing body of knowledge.

Chapter Eight: Conclusion

This Ph.D. thesis has explored the multifaceted realm of digital self-management support for chronic knee pain within the context of physiotherapy settings in Jeddah, Saudi Arabia. Through two exploratory sequential phases, this mixed methods research has not only provided significant insight but also illuminated pathways for future research and integration into current practice.

In Phase 1, qualitative interviews played a key role in exploring the alignment of Saudi physiotherapy settings with self-management support and the integration of technology to support knee care self-management. The resulting data has contributed substantially to the establishment of a foundational knowledge base which can serve as a guiding signal for future researchers seeking to integrate self-management support initiatives within the Saudi healthcare landscape, specifically for individuals with chronic knee pain. The findings revealed a landscape where the current state of physiotherapy settings presents a challenge to the seamless integration of self-management support. A transformation is required in the existing care model to foster a collaborative environment between physiotherapists and individuals with chronic knee pain. However, the study's findings not only outlined barriers but also showcased the immense potential offered by the digital format for such initiatives within Saudi Arabia. A significant aspect that has been emphasised is the imperative for all stakeholders to receive comprehensive training to ensure a smooth transition to this innovative approach.

In Phase 2, a usability study was conducted, providing insight into Saudi users' experiences with the self-management support platform, TRAK-Saudi. The use of remote testing sessions served as a dynamic method to expose the complexities inherent in the platform's design. The data collected from this phase serves as evidence of the users' satisfactory navigational journey, as corroborated by the high A-SUS score. The study pinpointed technical difficulties and areas of confusion, thereby underscoring the iterative enhancements crucial for refining the platform's user experience. Additionally, this phase gathered genuine feedback from participants on their perceptions of digital self-management support initiatives. Their responses to a scenario-based question post-use shed light on the potential willingness to embrace

TRAK-Saudi as a substitute in-clinic therapy sessions in the context of Jeddah’s physiotherapy practices.

In conclusion, this Ph.D. thesis has navigated through the intricacies of digital self-management support initiatives in Jeddah's physiotherapy clinics, an area previously unexplored by research. The process revealed complexities, barriers and potential solutions, with each phase contributing a different layer to the overarching narrative. This study sets the stage for continued exploration, improvement and integration, promoting a future in which the intersection of technology and healthcare transforms how knee conditions are managed, thereby elevating individual engagement, empowerment and outcomes in the Saudi context and beyond.

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Appendices

Appendix A: Critical Appraisal Checklists

www.casp-uk.net
info@casp-uk.net
Summertown Pavilion, Middle Way Oxford OX2 7LG

CASP Checklist: 11 questions to help you make sense of a Randomised Controlled Trial

How to use this appraisal tool: Three broad issues need to be considered when appraising a trial:

- Are the results of the study valid? (Section A)
- What are the results? (Section B)
- Will the results help locally? (Section C)

The 11 questions on the following pages are designed to help you think about these issues systematically. The first three questions are screening questions and can be answered quickly. If the answer to both is "yes", it is worth proceeding with the remaining questions. There is some degree of overlap between the questions, you are asked to record a "yes", "no" or "can't tell" to most of the questions. A number of italicised prompts are given after each question. These are designed to remind you why the question is important. Record your reasons for your answers in the spaces provided.

About: These checklists were designed to be used as educational pedagogic tools, as part of a workshop setting, therefore we do not suggest a scoring system. The core CASP checklists (randomised controlled trial & systematic review) were based on JAMA 'Users' guides to the medical literature 1994 (adapted from Guyatt GH, Sackett DL, and Cook DJ), and piloted with health care practitioners.

For each new checklist, a group of experts were assembled to develop and pilot the checklist and the workshop format with which it would be used. Over the years overall adjustments have been made to the format, but a recent survey of checklist users reiterated that the basic format continues to be useful and appropriate.

Referencing: we recommend using the Harvard style citation, i.e.: *Critical Appraisal Skills Programme (2018). CASP (insert name of checklist i.e. Randomised Controlled Trial) Checklist. [online] Available at: URL. Accessed: Date Accessed.*

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Paper for appraisal and reference:.....

Section A: Are the results of the trial valid?

1. Did the trial address a clearly focused issue?

Yes ☐
Can't Tell ☐
No ☐

HINT: An issue can be 'focused' in terms of
- the population studied
- the intervention given
- the comparator given
- the outcomes considered

Comments:

2. Was the assignment of patients to treatments randomised?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- how this was carried out
- was the allocation sequence concealed from researchers and patients

Comments:

3. Were all of the patients who entered the trial properly accounted for at its conclusion?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- was the trial stopped early
- were patients analysed in the groups to which they were randomised

Comments:

Is it worth continuing?

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4. Were patients, health workers and study personnel 'blind' to treatment?

Yes ☐
Can't Tell ☐
No ☐

Comments:

5. Were the groups similar at the start of the trial

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
• other factors that might affect the outcome, such as; age, sex, social class

Comments:

6. Aside from the experimental intervention, were the groups treated equally?

Yes ☐
Can't Tell ☐
No ☐

Comments:

Section B: What are the results?

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7. How large was the treatment effect?

HINT: Consider
- what outcomes were measured
- Is the primary outcome clearly specified
- what results were found for each outcome

Comments:

8. How precise was the estimate of the treatment effect?

HINT: Consider
- what are the confidence limits

Comments:

Section C: Will the results help locally?

9. Can the results be applied to the local population, or in your context?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider whether
- the patients covered by the trial are similar enough to the patients to whom you will apply this
- how they differ

Comments:

10. Were all clinically important outcomes considered?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider whether
- there is other information you would like to have seen
- if not, does this affect the decision

Comments:

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11. Are the benefits worth the harms and costs?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- even if this is not addressed by the trial, what do you think?

Comments:

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info@casp-uk.net
Summertown Pavilion, Middle Way Oxford OX2 7LG

CASP Checklist: 10 questions to help you make sense of a Qualitative research

How to use this appraisal tool: Three broad issues need to be considered when appraising a qualitative study:

- Are the results of the study valid? (Section A)
- What are the results? (Section B)
- Will the results help locally? (Section C)

The 10 questions on the following pages are designed to help you think about these issues systematically. The first two questions are screening questions and can be answered quickly. If the answer to both is "yes", it is worth proceeding with the remaining questions. There is some degree of overlap between the questions, you are asked to record a "yes", "no" or "can't tell" to most of the questions. A number of italicised prompts are given after each question. These are designed to remind you why the question is important. Record your reasons for your answers in the spaces provided.

About: These checklists were designed to be used as educational pedagogic tools, as part of a workshop setting, therefore we do not suggest a scoring system. The core CASP checklists (randomised controlled trial & systematic review) were based on JAMA 'Users' guides to the medical literature 1994 (adapted from Guyatt GH, Sackett DL, and Cook DJ), and piloted with health care practitioners.

For each new checklist, a group of experts were assembled to develop and pilot the checklist and the workshop format with which it would be used. Over the years overall adjustments have been made to the format, but a recent survey of checklist users reiterated that the basic format continues to be useful and appropriate.

Referencing: we recommend using the Harvard style citation, i.e.: *Critical Appraisal Skills Programme (2018). CASP (insert name of checklist i.e. Qualitative) Checklist. [online] Available at: URL. Accessed: Date Accessed.*

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Paper for appraisal and reference:

Section A: Are the results valid?

1. Was there a clear statement of the aims of the research?

Yes ☐ Can't Tell ☐ No ☐

HINT: Consider
- what was the goal of the research
- why it was thought important
- its relevance

Comments:

2. Is a qualitative methodology appropriate?

Yes ☐ Can't Tell ☐ No ☐

HINT: Consider
- If the research seeks to interpret or illuminate the actions and/or subjective experiences of research participants
- Is qualitative research the right methodology for addressing the research goal

Comments:

Is it worth continuing?

3. Was the research design appropriate to address the aims of the research?

Yes ☐ Can't Tell ☐ No ☐

HINT: Consider
- if the researcher has justified the research design (e.g. have they discussed how they decided which method to use)

Comments:

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4. Was the recruitment strategy appropriate to the aims of the research?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- If the researcher has explained how the participants were selected
- If they explained why the participants they selected were the most appropriate to provide access to the type of knowledge sought by the study
- If there are any discussions around recruitment (e.g. why some people chose not to take part)

Comments:

5. Was the data collected in a way that addressed the research issue?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- If the setting for the data collection was justified
- If it is clear how data were collected (e.g. focus group, semi-structured interview etc.)
- If the researcher has justified the methods chosen
- If the researcher has made the methods explicit (e.g. for interview method, is there an indication of how interviews are conducted, or did they use a topic guide)
- If methods were modified during the study. If so, has the researcher explained how and why
- If the form of data is clear (e.g. tape recordings, video material, notes etc.)
- If the researcher has discussed saturation of data

Comments:

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6. Has the relationship between researcher and participants been adequately considered?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- If the researcher critically examined their own role, potential bias and influence during (a) formulation of the research questions (b) data collection, including sample recruitment and choice of location
- How the researcher responded to events during the study and whether they considered the implications of any changes in the research design

Comments:

Section B: What are the results?

7. Have ethical issues been taken into consideration?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- If there are sufficient details of how the research was explained to participants for the reader to assess whether ethical standards were maintained
- If the researcher has discussed issues raised by the study (e.g. issues around informed consent or confidentiality or how they have handled the effects of the study on the participants during and after the study)
- If approval has been sought from the ethics committee

Comments:

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8. Was the data analysis sufficiently rigorous?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider
- If there is an in-depth description of the analysis process
- If thematic analysis is used. If so, is it clear how the categories/themes were derived from the data
- Whether the researcher explains how the data presented were selected from the original sample to demonstrate the analysis process
- If sufficient data are presented to support the findings
- To what extent contradictory data are taken into account
- Whether the researcher critically examined their own role, potential bias and influence during analysis and selection of data for presentation

Comments:

9. Is there a clear statement of findings?

Yes ☐
Can't Tell ☐
No ☐

HINT: Consider whether
- If the findings are explicit
- If there is adequate discussion of the evidence both for and against the researcher's arguments
- If the researcher has discussed the credibility of their findings (e.g. triangulation, respondent validation, more than one analyst)
- If the findings are discussed in relation to the original research question

Comments:

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Section C: Will the results help locally?

10. How valuable is the research?

HINT: Consider

- If the researcher discusses the contribution the study makes to existing knowledge or understanding (e.g. do they consider the findings in relation to current practice or policy, or relevant research-based literature
- If they identify new areas where research is necessary
- If the researchers have discussed whether or how the findings can be transferred to other populations or considered other ways the research may be used

Comments:

Appendix B: Study poster for Phase 1 (in English and Arabic)

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

هل لديك ألم في الركبة؟
هل تعالج مرضى يشتكون من ألم في الركبة؟

اذا كانت لديكم الرغبة في المشاركة، سأقوم بدعوتكم لنتحدث عن رأيكم في دور التكنولوجيا في القطاع الصحي، وبذلك ستساعد كثيراً في:

-محاولة تحسين الخدمات الصحية المقدمة للمرضى الذين يعانون من مشاكل في الركبة

-اكتشاف مستوى المعرفة عن الخدمات الصحية الالكترونية لدى المرضى والمعالجين السعودين.

أنت/ي مدعو/ة للمشاركة في بحثي

لمزيد من المعلومات، فضلاً لا أمراً تواصلوا معي أ.شيماء الجحدلي على معلومات التواصل التالية:

الجوال: ٠٥٤٦٠٩٠٣٠٦

الايميل: AljahdaliS@cardiff.ac.uk

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD

هل لديك ألم في الركبة؟
هل تعالج مرضى يشتكون من ألم في الركبة؟

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أنت/ي مدعو/ة للمشاركة في بحثي

لمزيد من المعلومات، فضلاً لا أمراً تواصلوا معي أ.شيماء الجحدلي على معلومات التواصل التالية:

الجوال: [redacted]

الايميل: Al[redacted]

Appendix C: Phase 1 participants' information sheet for physiotherapists (in English and Arabic)

A qualitative study to evaluate the acceptability of technology as a supportive approach to standard physiotherapy treatment for knee pain in Saudi Arabia.

You are being invited to take part in a research study. Before you decide whether to take part it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish.

The first part of the Participant Information Sheet tells you the purpose of the study and what will happen to you if you take part. Then we give you more detailed information about the conduct of the study.

Thank you for reading this.

What is the purpose of this research?

This study aims to explore the possible acceptability of electronic websites for remote care in Saudi patients with knee conditions and physiotherapists through meeting them to explore their thoughts and expectations. Findings could help the researcher to build up a firm idea about the acceptance of this new approach in Saudi Arabia in addition to the modifications required on the existence websites, so it matches the needs of Saudi population.

Why have I been invited?

You have been invited because you are a qualified physiotherapist who treats patients with knee conditions at your clinic.

Do I have to take part?

No, participation is voluntary. If you decide not to take part, you do not have to explain your reasons and it will not affect your position or your legal rights at your medical institution. However, if you do decide to take part, we will discuss the study with you and ask you to sign a consent form. You are free to withdraw your consent at any time, without giving a reason, even after signing the consent form.

What will happen to me if I take part?

You are going to attend one-to-one interview with the researcher that will last approximately 60 to 90 minutes maximum. The interview starts with a discussion between you and the researcher followed by a brief use of one of the electronic health websites and ends with filling in two questionnaires to understand your feedback.

What are the possible benefits of taking part?

There will be no direct advantages or benefits to you from taking part, but your contribution will help us understand more about the acceptance of electronic health websites in Saudi patients with knee problems and physiotherapists. This could help in improving the health services provided to patients in physiotherapy departments.

What are the possible risks of taking part?

No risks have been identified by the researcher.

Will my taking part in this study be kept confidential?

All information collected during the study will be kept strictly confidential in accordance with the General Data Protection Regulation (GDPR) 2016. Your name, address or any other identifying information will not be passed onto anyone. You will not be identified in any published study results.

What will happen to the results of the study?

It is our intention to publish the results of this study in academic journals and present findings at conferences. Participants will not be identified in any report, publication or presentation.

What if there is a problem?

If you wish to complain, or have grounds for concerns about any aspect of the way you have been approached or treated during the course of this research, contact:

Miss Shaima Aljahdali

Email:

Telephone:

If you remain unhappy and wish to complain formally, you can do this by contacting the School of Healthcare Sciences Director of Research Governance at Cardiff University, the United Kingdom.

Dr Kate Button

Email:

Telephone:

Who is organising and funding this research?

The work is part is organised by Miss Shaima Aljahdali to achieve the degree of Doctor of Philosophy in physiotherapy, School of healthcare sciences in Cardiff University, United Kingdom. The research is currently funded by Royal Embassy of Saudi Arabia Cultural Bureau in London.

Who has reviewed this study?

This study has been reviewed and given a favorable opinion by the Research Ethics Committee of the school of healthcare sciences, Cardiff University.

Further information and contact details

Should you have any questions relating to this study, you may contact us during normal working hours Miss Shaima Aljahdali on the following contact details:

Email:

Telephone:

We would like to thank you for considering taking part in this study. If you decide to participate you will be given a copy of the information sheet and a signed consent form to keep.

ورقة معلومات البحث الخاصة بالمشتركين

دراسة بحثية لاكتشاف مدى قبول ادخال التكنولوجيا كعنصر داعم لطرق العلاج التقليدية المقدمة لمرضى مشاكل الركبة في عيادات العلاج الطبيعي بالمملكة العربية السعودية.

أنت مدعو للمشاركة في هذا البحث ولكن قبل أن تأخذ قرارك النهائي في المشاركة من عدمها نرجو منك قراءة هذه الورقة التي ستجاوب الى حد كبير عن كل تساؤلاتك فيما يخص البحث. نرجو منكم أخذ وقتكم الكافي في القراءة وسؤال المقربين منك عن محتويات البحث ان احتجتم ذلك، وسنكون سعداء أيضا للرد على أي سؤال خارج عن المذكور في هذه الورقة يطرأ في بالكم.

ما الهدف من هذه الدراسة؟

تم مؤخرا انتشار تطبيقات الصحة الالكترونية الخاصة بوزارة الصحة والتي تهدف إلى تحسين الخدمات الصحية المقدمة للعامة مثل تطبيق الاستشارات الطبية وتطبيق حجز المواعيد. عالمياً، تم انتشار تطبيقات الكترونية مشابهة لمرضى العظام ولكن الغرض منها هو تحسين مهارات المريض في إدارة حالته الصحية بنفسه بالإضافة الى تعزيز وسائل التواصل مع طبيبه المعالج وكل ذلك لتحسين نتائج العلاج والسماح لعدد أكبر من المرضى لتلقي الاستشارة الطبية. الهدف من هذه الدراسة هي مقابلة الأشخاص المحتمل أن يكونوا مستخدمين لهذا النوع من التطبيقات الإلكترونية لاكتشاف آرائهم حول طرق العلاج التقليدية المستعملة حاليا بالإضافة إلى توقعاتهم عن فائدة دمج التكنولوجيا إليها. نتائج هذه الدراسة ستساعد الباحث كثيراً في بناء صورة توقعيه عن فاعلية هذا النوع من التطبيقات في المجتمع السعودي بالإضافة إلى التعديلات اللازم عملها على التطبيقات المنتشرة عالمياً لتلائم مجتمعنا السعودي.

لماذا تمت دعوتي للمشاركة؟

لأنك تتوافق مع شروط البحث وهي أن تكون أخصائي علاج طبيعي تعالج مرضى يعانون من مشاكل في مفصل الركبة في عيادتك.

هل يجب عليّ المشاركة؟

لا، فمشاركتكم في هذه الدراسة هي اختيارية تماماً حيث ان عدم مشاركتكم لن يؤثر أبداً على منصبكم الوظيفي أو حقوقكم في جهة العمل. أما في حال رغبتم المشاركة، سيتولى القائمين على البحث بمناقشة محتويات الدراسة معكم وتوضيح كل شيء معكم قبل أن تبدأوا بالمشاركة الفعلية وهذا سيتضمن توقيعكم لورقة اتفاقية توضح موافقتكم من عدمها على ما سيحدث خلال المشاركة. يمكنكم الانسحاب من الدراسة في أي وقت ان رغبتم بذلك حتى بعد توقيعكم لورقة الاتفاقية بدون أي أسباب توضيحية سيتم طلبها منكم.

ماذا سيحدث ان قررت المشاركة؟

ستقوم بحضور مقابلة فردية مع الباحث الرئيسي لهذه الدراسة والتي ستستمر لساعة ونصف كحد أقصى. في هذه المقابلة سيتحاور معك الباحث عن بعض النقاط اللي ستساعده في جمع معلومات تخدم الغرض الأساسي للبحث وسوف يلي ذلك استخدامك لفترة قصيرة لواحدة من التطبيقات الالكترونية الخاصة بالصحة والتي هي موجهة لأشخاص في نفس حالتكم الصحية. هذه المقابلة سيتم انهائها بتعبئتكم لاستبيانات توضح آرائكم عن التطبيق الالكتروني المستخدم من قبلكم خلال المقابلة.

ما الفائدة من مشاركتي؟

مشاركتكم في البحث لن تعود عليكم بفائدة ملحوظة، ولكن مساهمتك ستساعدنا على فهم المزيد حول قبول المواقع الإلكترونية الصحية في المرضى السعوديين الذين يعانون من مشاكل في الركبة وأخصائيين العلاج الطبيعي. هذا بدوره يمكن أن يساعد في تحسين الخدمات الصحية المقدمة للمرضى في أقسام العلاج الطبيعي.

ما الأضرار المحتملة من مشاركتي؟

لا توجد أضرار محتملة تم كشفها من قبل الباحث.

هل ستُعامل مشاركتي في البحث بسريّة؟

أي معلومات تتعلق بمشاركتكم في البحث بدأ من معلوماتكم الشخصية وانتهاءً بالمعلومات المجمّعة من المقابلة سيتم التعامل معها بسريّة قصوى وفقا لقانون حماية المعلومات الخاص بعام ٢٠١٦.

ماذا سيحدث لنتائج البحث؟

من المحتمل أن نتائج البحث سيتم نشرها في مجلات علمية أو مؤتمرات طبية، في حال حدوث ذلك، سيتم التعامل مع بياناتكم بصورة المجهول ولن يتم ذكر أي شيء يوضح هويتكم.

من هم القائمين على هذا البحث؟

هذا البحث منظم من قبل أ. شيماء الجحدلي كمتطلب رئيسي للحصول على درجة الدكتوراه في تخصص العلاج الطبيعي من جامعة كارديف في المملكة المتحدة. تم تمويل هذا البحث مادياً من الملحقية الثقافية السعودية في لندن.

هل تمت مراجعة محتويات البحث من جهة رسمية؟

نعم، هذا البحث مر بعدة مراحل قبل أن يتم تطبيقه رسميا. تمت مراجعته اولاً من قبل وحدة اخلاقيات البحث العلمي في جامعة كارديف ومن ثم المديرية العامة للشئون الصحية بمنطقة مكة المكرمة.

ماذا لو اردت التواصل مع شخص بخصوص البحث؟

إذا كانت لديكم شكوى، تساؤلات، او مررتم بشيء غير مرضي خلال مشاركتكم لا تترددوا في التواصل مع:

أ. شيماء الجحدلي

البريد الالكتروني:

الهاتف:

إذا كنت لا تزال غير سعيد وترغب في تقديم شكوى رسميًا ان وجد، يمكنك القيام بذلك عن طريق الاتصال بمدير إدارة البحوث بكلية العلوم الصحية بجامعة كارديف بالمملكة المتحدة.

د. كيت بوتن

البريد الالكتروني:

الهاتف:

أخراً وليس أخيراً، نود شكركم لقراءة هذه الورقة ونأمل منكم توضيح رغبتكم بالمشاركة او عدمها للباحث ليتم تزويدكم بنسخة من هذه الورقة بالإضافة الي نسخة من ورقة الاتفاقية.

Appendix D: Phase 1 participants' information sheet for individuals with knee pain (in English and Arabic)

A qualitative study to evaluate the acceptability of technology as a supportive approach to standard physiotherapy treatment for knee pain in Saudi Arabia.

You are being invited to take part in a research study. Before you decide whether or not to take part it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish.

The first part of the Participant Information Sheet tells you the purpose of the study and what will happen to you if you take part. Then we give you more detailed information about the conduct of the study.

Thank you for reading this.

What is the purpose of this research?
This study aims to explore the possible acceptability of electronic websites for remote care in Saudi patients with knee conditions and physiotherapists through meeting them to explore their thoughts and expectations. Findings could help the researcher to build up a firm idea about the acceptance of this new approach in Saudi Arabia in addition to the modifications required on the existence websites, so it matches the needs of Saudi population.

Why have I been invited?
You have been invited because you are aged over 18 years old and attending physiotherapy sessions to treat your knee problem.

Do I have to take part?
No, participation is voluntary. If you decide not to take part, you do not have to explain your reasons and it will not affect your physiotherapy sessions or your legal rights. However, if you do decide to take part, we will discuss the study with you and ask you to sign a consent form. You are free to withdraw your consent at any time, without giving a reason, even after signing the consent form.

What will happen to me if I take part?
You are going to attend one-to-one interview with the researcher that will last approximately 60 to 90 minutes maximum. The interview starts with a discussion between you and the researcher followed by a brief use of one of the electronic health websites and ends with filling two questionnaires to understand your feedback.

What are the possible benefits of taking part?
There will be no direct advantages or benefits to you from taking part, but your contribution will help us understand more about the acceptance of electronic health websites in Saudi patients with knee problems and physiotherapists. This could help in improving the health services provided to patients in physiotherapy departments.

What are the possible risks of taking part?
No risks have been identified by the researcher.

Will anyone look at my medical records?
The researcher might access your medical records to confirm that you are eligible to participate in the study. However, any information approached for the purposes of this study, with your consent, will be treated as strictly confidential.

Will my taking part in this study be kept confidential?

All information collected during the study will be kept strictly confidential in accordance with the General Data Protection Regulation (GDPR) 2016. Your name, address or any other identifying information will not be passed onto anyone. You will not be identified in any published study results.

What will happen to the results of the study?
It is our intention to publish the results of this study in academic journals and present findings at conferences. Participants will not be identified in any report, publication or presentation.

What if there is a problem?
If you wish to complain, or have grounds for concerns about any aspect of the way you have been approached or treated during the course of this research, contact:
Miss Shaima Aljahdali
Email:
Telephone:

If you remain unhappy and wish to complain formally, you can do this by contacting the School of Healthcare Sciences Director of Research Governance at Cardiff University, the United Kingdom.
Dr Kate Button
Email:
Telephone:

Who is organising and funding this research?
The work is part is organised by Miss Shaima Aljahdali to achieve the degree of Doctor of Philosophy in physiotherapy, School of healthcare sciences in Cardiff University, United Kingdom. The research is currently funded by Royal Embassy of Saudi Arabia Cultural Bureau in London.
Who has reviewed this study?
This study has been reviewed and given a favourable opinion by the Research Ethics Committee of the school of healthcare sciences, Cardiff University.

Further information and contact details
Should you have any questions relating to this study, you may contact us during normal working hours Miss Shaima Aljahdali on the following contact details:
Email: AljahdaliS@cardiff.ac.uk
Telephone: 00966546090306

We would like to thank you for considering taking part in this study. If you decide to participate you will be given a copy of the information sheet and a signed consent form to keep.

ورقة معلومات البحث الخاصة بالمشتركين

دراسة بحثية لاكتشاف مدى قبول ادخال التكنولوجيا كعنصر داعم لطرق العلاج التقليدية المقدمة لمرضى مشاكل الركبة في عيادات العلاج الطبيعي بالمملكة العربية السعودية.

أنت مدعو للمشاركة في هذا البحث ولكن قبل أن تأخذ قرارك النهائي في المشاركة من عدمها نرجو منك قراءة هذه الورقة التي ستجاوب الى حد كبير عن كل تساؤلاتك فيما يخص البحث. نرجو منكم أخذ وقتكم الكافي في القراءة وسؤال المقربين منك عن محتويات البحث ان احتجتم ذلك، وسنكون سعداء أيضا للرد على أي سؤال خارج عن المذكور في هذه الورقة يطرأ في بالكم.

ما الهدف من هذه الدراسة؟

تم مؤخرا انتشار تطبيقات الصحة الالكترونية الخاصة بوزارة الصحة والتي تهدف إلى تحسين الخدمات الصحية المقدمة للعامة مثل تطبيق الاستشارات الطبية وتطبيق حجز المواعيد. عالمياً، تم انتشار تطبيقات الكترونية مشابهة لمرضى العظام ولكن الغرض منها هو تحسين مهارات المريض في إدارة حالته الصحية بنفسه بالإضافة الى تعزيز وسائل التواصل مع طبيبه المعالج وكل ذلك لتحسين نتائج العلاج والسماح لعدد أكبر من المرضى لتلقي الاستشارة الطبية. الهدف من هذه الدراسة هي مقابلة الأشخاص المحتمل أن يكونوا مستخدمين لهذا النوع من التطبيقات الإلكترونية لاكتشاف آرائهم حول طرق العلاج التقليدية المستعملة حاليا بالإضافة إلى توقعاتهم عن فائدة دمج التكنولوجيا إليها. نتائج هذه الدراسة ستساعد الباحث كثيراً في بناء صورة توقعيه عن فاعلية هذا النوع من التطبيقات في المجتمع السعودي بالإضافة إلى التعديلات اللازم عملها على التطبيقات المنتشرة عالمياً لتلائم مجتمعنا السعودي.

لماذا تمت دعوتي للمشاركة؟

لأنك تتوافق مع شروط البحث وهي أن يكون عمرك ١٨ سنة أو أكثر، تجيد استخدام الأجهزة المحمولة كالكمبيوتر والجوال، وتحضر لجلسات العلاج الطبيعي لمعالجة مشكلة في مفصل الركبة.

هل يجب عليّ المشاركة؟

لا، فمشاركتكم في هذه الدراسة هي اختيارية تماماً حيث ان عدم مشاركتكم لن يؤثر أبداً على جلسات العلاج المقدمة لكم أو حقوقكم كمرضى. أما في حال رغبتم المشاركة، سيتولى القائمين على البحث بمناقشة محتويات الدراسة معكم وتوضيح كل شيء معكم قبل أن تبدأوا بالمشاركة الفعلية وهذا سيتضمن توقيعكم لورقة اتفاقية توضح موافقتكم من عدمها على ما سيحدث خلال المشاركة. يمكنكم الانسحاب من الدراسة في أي وقت ان رغبتم بذلك حتى بعد توقيعكم لورقة الاتفاقية بدون أي أسباب توضيحية سيتم طلبها منكم.

ماذا سيحدث ان قررت المشاركة؟

ستقوم بحضور مقابلة فردية مع الباحث الرئيسي لهذه الدراسة والتي ستستمر لساعة ونصف كحد أقصى. في هذه المقابلة سيتحاور معك الباحث عن بعض النقاط اللي ستساعده في جمع معلومات تخدم الغرض الأساسي للبحث وسوف يلي ذلك استخدامك لفترة قصيرة لواحدة من التطبيقات الالكترونية الخاصة بالصحة والتي هي موجهة لأشخاص في نفس حالتكم الصحية. هذه المقابلة سيتم انهائها بتعبئتكم لاستبيانات توضح آرائكم عن التطبيق الالكتروني المستخدم من قبلكم خلال المقابلة.

ما الفائدة من مشاركتي؟

مشاركتكم في البحث لن تعود عليكم بفائدة ملحوظة، ولكن مساهمتك ستساعدنا على فهم المزيد حول قبول المواقع الإلكترونية الصحية في المرضى السعوديين الذين يعانون من مشاكل في الركبة وأخصائيين العلاج الطبيعي. هذا بدوره يمكن أن يساعد في تحسين الخدمات الصحية المقدمة للمرضى في أقسام العلاج الطبيعي.

ما الأضرار المحتملة من مشاركتي؟

لا توجد أضرار محتملة تم كشفها من قبل الباحث.

هل سيقوم أحد من أعضاء البحث بالاطلاع على ملفي الطبي؟

نعم، هناك احتمالية بأن الباحث سيطّلع على بعض من معلوماتكم الشخصية والطبية وذلك فقط للتأكد من ملائمتكم لشروط الانضمام للبحث.

هل ستُعامل مشاركتي في البحث بسريّة؟

أي معلومات تتعلق بمشاركتكم في البحث بدأ من معلوماتكم الشخصية وانتهاءً بالمعلومات المجمّعة من المقابلة سيتم التعامل معها بسريّة قصوى وفقا لقانون حماية المعلومات الخاص بعام ٢٠١٦.

ماذا سيحدث لنتائج البحث؟
من المحتمل أن نتائج البحث سيتم نشرها في مجلات علمية أو مؤتمرات طبية، في حال حدوث ذلك، سيتم التعامل مع بياناتكم بصورة المجهول ولن يتم ذكر أي شيء يوضح هويتكم.

من هم القائمين على هذا البحث؟
هذا البحث منظم من قبل أ. شيماء الجحدلي كمتطلب رئيسي للحصول على درجة الدكتوراه في تخصص العلاج الطبيعي من جامعة كاردف في المملكة المتحدة. تم تمويل هذا البحث مادياً من الملحقية الثقافية السعودية في لندن.

هل تمت مراجعة محتويات البحث من جهة رسمية؟
نعم، هذا البحث مر بعدة مراحل قبل أن يتم تطبيقه رسميا. تمت مراجعته اولاً من قبل وحدة اخلاقيات البحث العلمي في جامعة كاردف ومن ثم المديرية العامة للشئون الصحية بمنطقة مكة المكرمة.

ماذا لو اردت التواصل مع شخص بخصوص البحث؟
إذا كانت لديكم شكوى، تساؤلات، او مررتم بشيء غير مرضي خلال مشاركتكم لا تترددوا في التواصل مع:
أ. شيماء الجحدلي
البريد الالكتروني:
الهاتف:

إذا كنت لا تزال غير سعيد وترغب في تقديم شكوى رسميًا ان وجد، يمكنك القيام بذلك عن طريق الاتصال بمدير إدارة البحوث بكلية العلوم الصحية بجامعة كاردف بالمملكة المتحدة.
د. كيت بوتن
البريد الالكتروني:
الهاتف:

أخراً وليس أخيراً، نود شكركم لقراءة هذه الورقة ونأمل منكم توضيح رغبتكم بالمشاركة او عدمها للباحث ليتم تزويدكم بنسخة من هذه الورقة بالإضافة الي نسخة من ورقة الاتفاقية.

Appendix E: Phase 1 participants' consent form (in English and Arabic)

Title of study: A qualitative study to evaluate the acceptability of technology as a supportive approach to standard physiotherapy treatment for knee pain in Saudi Arabia.

Name of Chief/Principal Investigator: Shaima Aljahdali

Please Initial box

1- I confirm that I have read the information sheet dated 20th, September 2017, version 1.0 for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2- I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my legal rights being affected. ☐

3- I understand that the interview will be recorded, and audios will be stored securely for a maximum of 5 years following the end of the study. ☐

4- I do allow the use of anonymised data or quotations from my interviews for:

A. Teaching and Research Presentation ☐

B. Research Publications ☐

5- I agree to take part in the above study ☐

Name of Participant	Date	Signature
Name of Person taking consent	Date	Signature

Subject Identification Number for this Investigation: .....

عنوان البحث: دراسة بحثية لاكتشاف مدى قبول ادخال التكنولوجيا كعنصر داعم لطرق العلاج التقليدية المقدمة لمرضى مشاكل الركبة في عيادات العلاج الطبيعي بالمملكة العربية السعودية.
اسم الباحث الأساسي: شيماء الجحدلي

يرجى وضع الحرف الأول من اسمك واسم العائلة في هذه المربع في حال الموافقة

١- أقر بأني قرأت ورقة المعلومات الخاصة بالبحث المؤرخة بتاريخ () نسخة رقم () وأنّي ناقشت جميع تساؤلاتي مع الباحث ولم يتبق لدي أي أسئلة لم احصل على إجابات لها. ☐

٢- أقر بعلمي أن مشاركتي في هذه الدراسة هي اختيارية تمام ويحق لي الانسحاب في أي وقت اردت دون أن اوضح أسباب ذلك وأن ذلك لن يؤثر على الخدمات الطبية المقدمة لي. ☐

٣- أقر بعلمي أن المقابلة ستكون مسجلة صوتياً وأن التسجيلات ستكون محفوظة في مكان آمن لمدة ٥ سنين بعد الانتهاء من البحث قبل تدميرها نهائيا. ☐

٤- أقر بسماحي باستخدام البيانات الصادرة مني او الاقتباسات المباشرة من كلامي إذا تم استخدامها بصورة المجهول دون ذكر معلوماتي الشخصية في:

أ- التدريس والعرض المرئي لنتائج البحث. ☐

ب- النشر العلمي. ☐

٥- <u>أقر برغبتي في المشاركة في هذا البحث.</u> ☐

اسم المشترك	التاريخ	التوقيع

اسم الشخص المؤول	التاريخ	التوقيع

Appendix F: Interview guide for physiotherapists

A qualitative study to evaluate the acceptability of technology as a supportive approach to standard physiotherapy treatment for knee pain in Saudi Arabia.

Interview Guide

- Researcher introduces herself to the interviewee.
- Researcher introduces her study to the interviewee.
- Researcher explains the interview aims and components to the interviewee.
- Researcher asks for permission for audio recording.
- Researcher asks for the motivation behind the interviewee's participation.

Discussion themes for physiotherapists

- **Clinical practice and patient demographics**

What types of knee conditions do you often treat in this clinic?
ما هي حالات مشاكل الركبة التي تعالجها غالبًا في هذه العيادة؟

Can you tell me about the type of patients you deal with on a daily basis?
هل يمكن أن تخبرني عن نوع المرضى الذين تتعامل معهم بشكل يومي؟

- **Treatment strategies and patient adherence**

Can you tell me about the treatment options you often offer to your knee patients?
(prompts: home program – patient adherence)
هل يمكن أن تخبرني عن خيارات العلاج التي تقدمها غالبًا لمرضاك الذين يعانون من مشاكل في الركبة؟
(التلميحات: برنامج منزلي- كيف هو التزام المرضى به؟)

- **Therapist-patient relationship and engagement**

How would you describe the nature of relationship between you and your patients?
(prompts: honesty - level of agreement)
كيف تصف طبيعة العلاقة بينك وبين مرضاك؟
(التلميحات: الواقعية في المعلومات المقدمة لهم – نسبة التوافق بينك وبينهم)

Could you tell me to what extent your patient is involved in their treatment plan?
(prompts: goals, aims, and treatment decision)
هل يمكن أن تخبرني إلى أي مدى يشارك المريض في خطة علاجه؟
(التلميحات: الأهداف وقرار العلاج المقدم)

- **Treatment plan design and patient empowerment**

What are the areas you often consider in designing treatment plan for your patient?
(prompts: tailored treatment plan – willingness to adhere)
ما هي المجالات التي تفكر فيها كثيرًا عند تصميم خطة العلاج لمريضك؟

(التلميحات: هل يتم تصميم الخطة العلاجية بناءً على الشخص ومدى التزامه بها)

How do you empower your patients to take care of their health condition?
(prompts: comprehensive information – self-care strategies)
كيف يمكنك تمكين مرضاك لرعاية حالتهم الصحية؟
(التلميحات: هل تزودوهم بمعلومات كافية عن حالتهم؟ - كيفية العناية بحالتهم الصحية)

- **Technology in healthcare**

Do you have internet access at your clinic?
هل لديك اتصال بالإنترنت في عيادتك؟

How familiar are you with technology and internet in general?
(prompts: social media, use of technology in practice/in the treatment of patients, such as digital agenda, YouTube videos, digital questionnaires etc.)
ما مدى معرفتك بالتكنولوجيا والإنترنت بشكل عام؟
(التلميحات: استخدام وسائل التواصل الاجتماعي- استخدام التقنية في عملك بالعيادة مثل الاجندة الالكترونية، مقاطع اليوتيوب، أو الاستبيانات الالكترونية)

From your experience, how much is your patient reliant on the internet to get external help?
(prompts: bring you information from the internet)
من خبرتك، إلى أي مدى يعتمد المريض على الإنترنت للحصول على مساعدة خارجية؟
(التلميحات: هل يطلعون على معلومات من الانترنت عن حالتهم الصحية)

How do you ensure that your patient is doing his exercises correctly and regularly at home?
(prompts: videos – papers)
كيف يمكنك التأكد من قيام المريض بتمارينه بشكل صحيح ومنتظم في المنزل؟
(التلميحات: هل تزودهم بفيديوهات او أوراق مساعدة؟)

(before the following question, the researcher will give a brief information about the e-health services launched by the Ministry of Health)
What is your opinion about e-health services launched by the Ministry of Health?
(prompts: its effectiveness- its appropriateness to the society)
ما رأيك في خدمات الصحة الإلكترونية التي أطلقتها وزارة الصحة؟
(التلميحات: مدى فعاليتها ومدى ملائمتها للمجتمع)

If there was a website that is dedicated to physiotherapy in general and to patients with knee pain specifically, what aspects would you like it to cover and why?
(prompts: accurate diagnosis, better treatment solutions, good patient relationship, patient. satisfaction, ability to treat more patients)

إذا كان هناك موقع ويب مخصص للعلاج الطبيعي بشكل عام وللمرضى الذين يعانون من آلام في الركبة على وجه التحديد، ما هي الجوانب التي ترغب في أن يغطيها، ولماذا؟
(التلميحات: تشخيص دقيق- طرق علاج أفضل- علاقة أفضل مع المرضى- رضى المرضى- المقدرة على علاج عدد مرضى أكثر)

What challenges do you believe might affect the smooth introduction of such a service?

ما هي التحديات التي تعتقد أنها قد تؤثر على التقديم السلس لمثل هذه الخدمة؟

What are the solutions in your opinion?

ما هي الحلول في رأيك؟

What do you think of remote care?
(prompts: replacing traditional care "Face to face contact" with remote care partially, benefits, challenges)

ما رأيك في الرعاية عن بعد؟
(التلميحات: استبدال طرق العلاج التقليدية التي تتم عن طريق مواعيد العيادات بمواقع تقدم رعاية عن بعد- ماهي الفوائد والصعوبات)

Appendix G: Interview guide for individuals with knee pain

Discussion themes for individuals with knee pain

- **Perceptions of physiotherapy**

Please tell me your thoughts about physiotherapy before and after attending treatment sessions?
(prompts: effectiveness of exercise therapy)
ما هي آراؤك حول العلاج الطبيعي قبل وبعد حضور جلسات العلاج؟
(التلميحات: فعالية العلاج بالتمارين)

- **Treatment plan and adherence**

Please describe your current treatment plan to me?
(prompts: pros and cons)
هل يمكنك من فضلك وصف خطة العلاج الحالية الخاصة بك لي؟
(التلميحات: الإيجابيات والسلبيات)

How would you describe your adherence to the treatment plan set by your therapist?
(prompts: performance – frequency- reasons of lack of adherence if the interviewee describes himself as non-adherent)
كيف تصف التزامك بخطة العلاج التي وضعها لك المعالج؟
(التلميحات: الأداء - التكرار - أسباب عدم الالتزام إذا وصف المشارك نفسه بأنه غير ملتزم)

- **Therapist-patient relationship**

How would you describe the nature of relationship between you and your therapist?
(prompts: honesty - level of agreement)
كيف تصف طبيعة العلاقة بينك وبين معالجك؟
(التلميحات: الصدق - مستوى الاتفاق)

How would you describe your therapist's openness in discussing with you your condition, possible treatment solution, and expected outcomes in the first session?
كيف تصف مدى انفتاح معالجك في مناقشة حالتك، والحلول العلاجية الممكنة، والنتائج المتوقعة في الجلسة الأولى؟

Could you tell me to what extent you were involved in the treatment decision?
(prompts: goals – willingness to adhere)
هل يمكنك أن تخبرني إلى أي مدى كنت مشاركًا في اتخاذ قرار العلاج؟
(التلميحات: الأهداف – الرغبة في الالتزام)

What is your opinion about the prescribed treatment?
(prompts: understands its purposes - matches your goals)
ما رأيك في العلاج الموصوف؟
(التلميحات: فهم فائدته - يتوافق مع أهدافك)

Has your therapist ever asked you about your satisfaction of the prescribed treatment?
هل سألك معالجك من قبل عن مدى رضاك عن العلاج الموصوف؟

Do you feel you can share your concerns regarding the treatment plan with your therapist?
(prompts: why is that?)

هل تشعر أنه يمكنك مشاركة مخاوفك بشأن خطة العلاج مع معالجيك؟
(التلميحات: لماذا؟)

- **Self-management and problem-solving**

How good do you think you are at setting and achieving self-goals?
(prompts: short or long-term goals)

ما مدى ايمانك في قدرتك على تحديد وتحقيق الأهداف الشخصية؟
(التلميحات: الأهداف قصيرة المدى أو طويلة المدى)

How good do you think you are at solving your daily life issues?
(prompts: asking for help)

ما مدى ايمانك في قدرتك على حل مشاكلك اليومية؟
(التلميحات: طلب المساعدة)

What do you do to manage your symptoms, so it does not interfere with your daily life activities?
(prompts: following the treatment- exploring other methods)

ماذا تفعل لإدارة ألام ركبتك حتى لا تؤثر على أنشطتك اليومية؟
(التلميحات: اتباع العلاج - استكشاف طرق أخرى)

How good are you at adhering to doing the exercises as regularly as the therapist has prescribed (eg twice a day or three times per week)?
(prompts: seek assistance- what makes this better?)

ما مدى قدرتك على الالتزام بأداء التمارين بانتظام كما وصفها المعالج (مثل مرتين في اليوم أو ثلاث مرات في الأسبوع)؟
(التلميحات: طلب المساعدة - ما الذي يجعل ذلك أفضل؟)

How good do you think you are at noticing the change in your health condition?
(prompts: improvement - no change)

ما مدى ايمانك في قدرتك على ملاحظة التغير في حالتك الصحية؟
(التلميحات: التحسن - عدم التغير)

- **Technology in healthcare**

Do you have internet access at home?

هل لديك اتصال بالإنترنت في المنزل؟

How familiar are you with technology and internet in general?
(prompts: seeking information- social media... etc)

ما مدى معرفتك بالتكنولوجيا والإنترنت بشكل عام؟
(التلميحات: البحث عن المعلومات - وسائل التواصل الاجتماعي... إلخ)

When you need more expert advice about your health, what do you do?
(prompts: websites, friends, other doctors, books… etc)

عندما تحتاج إلى نصيحة أكثر خبرة بشأن صحتك، ماذا تفعل؟
(التلميحات: مواقع الويب، الأصدقاء، أطباء آخرون، الكتب... إلخ)

How likely are you going to visit a website prescribed to you by your therapist that has an information about your condition and videos of your exercises?
(prompts: and why?)
ما مدى احتمالية زيارتك لموقع ويب يوصي به معالجك ويحتوي على معلومات عن حالتك وفيديوهات لتمارينك؟
(التلميحات: ولماذا؟)

(before the following question, the researcher will give a brief information about the e-health services launched by the Ministry of Health)
What is your opinion about e-health services launched by the Ministry of Health?
(prompts: its effectiveness- its appropriateness to the society)
ما رأيك في خدمات الصحة الإلكترونية التي أطلقتها وزارة الصحة؟
(التلميحات: فعاليتها - ملاءمتها للمجتمع)

If there was a website that is dedicated to physiotherapy in general and to your case in specific, what aspects would you like it to cover and why?
(prompts: includes exercise videos, online chat with your therapist, information regarding your condition and methods of self-management)
إذا كان هناك موقع ويب مخصص للعلاج الطبيعي بشكل عام ولحالتك بشكل خاص، ما الجوانب التي ترغب في أن يغطيها ولماذا؟
(التلميحات: يتضمن فيديوهات للتمارين، دردشة عبر الإنترنت مع معالجك، معلومات حول حالتك وطرق إدارة الذات)

What do you think of remote care?
(prompts: Replacing traditional care "Face to face contact" with remote care completely, benefits, challenges)
ما رأيك في الرعاية عن بُعد؟
(التلميحات: استبدال الرعاية التقليدية "الاتصال المباشر" بالرعاية عن بُعد تمامًا، الفوائد، التحديات)

Appendix H: Ethical approval from Cardiff university for Phase 1

School of Healthcare Sciences
Head of School and Dean Professor David Whittaker

Ysgol Gwyddorau Gofal Iechyd
Pennaeth yr Ysgol a Deon Yr Athrawes David Whittaker

09 May 2019

Cardiff University
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Shaima Al Jahdali
Cardiff University
School of Healthcare Sciences

Dear Shaima

A qualitative study to evaluate the acceptability of technology as a supportive approach to standard physiotherapy treatment for knee pain in Saudi Arabia.

I am writing to inform you that the Chair of the Research Ethics Committee has, following consultation, **approved** your revised research proposal. The Committee will ratify this decision at its meeting on 14 May 2019.

Please note that if there are any major amendments to the project you will be required to submit a revised proposal form. You are advised to contact me if this situation arises. In addition, in line with the University requirements, the project will be monitored on an annual basis by the Committee and an annual monitoring form will be despatched to you in approximately 11 months' time. If the project is completed before this time you should contact me to obtain a form for completion.

Please do not hesitate to contact me if you have any questions.

Yours sincerely

Appendix I: Ethical approval from the Saudi Ministry of Health for Phase 1

وزارة الصحة
Ministry of Health

المملكة العربية السعودية
Kingdom of Saudi Arabia
مديرية الشؤون الصحية بمحافظة جدة
Directorate of Health Affairs - Jeddah
(٢٠٢/٢٧٥)

Research and studies Department- Jeddah Health Affairs إدارة البحوث والدراسات بصحة جدة

IRB registration Number with KACST, KSA: H-02-J-002
Date:18/09/1440 Research Number: 01049

Initial Approval with Conditional - الموافقة المبدئية المشروطة للجنة الأخلاقية

The Principle Investigator (PI)	Shaima Ghazi Aljahdali	اسم الباحث الرئيسي
Submission Date	17/09/1440	تاريخ التقديم
Research Title	A qualitative study to evaluate the acceptability of technology as a supportive approach to standard physiotherapy treatment for knee pain in Saudi Arabia.	عنوان البحث

The above titled research / study proposal has been examined with the following end closures: The study Protocol, ethics and Questionnaire.

The IRB recommended granting permission of approval to conduct the project along the following terms:

1. The PI and investigators are responsible to get permission from the head of department or unit in the institution to commence data collection.
2. The Investigator will conduct the study under the direct supervision by **Supervisor of nursing research unit in nursing administration**
3. Provide IRB "Continuing Review Progress Report" every **6 month**
4. Any amendments to the Approved Protocol or any element of the submitted documents should NOT be under taken without prior re-submission to, and approval of the IRB for prior approval.
5. Monitoring: The Project may be subject to audit or any other form of monitoring by the IRB.
6. The PI is responsible for the storage and retention of original data of the study for a minimum period of five years.
7. The PI is expected to submit a final report at the end of the study.
8. The PI must provide to IRB a conclusion abstract and the manuscript before Published.
9. The PI and researchers are required to have current and valid certificate on protective human research subjects.
10. The final approval letter with the IRB number will be given to the IP after he complete all the above terms and conditions.
11. To follow all regulation issued by the National Committee of bio med ethics – King Abdul Aziz city for science and technology.

The organization and operating procedures of the research and study Administration – Directorate of health Affairs – Jeddah – Institutional review board (IRB) are based on the good clinical Practice, (GCP) Guidelines.

PLEASE NOTE THAT THIS APPROVAL IS VALID FOR ONE YEAR COMMENCING FROM THE DATE OF THIS LETTER.

√ I Read and Agree to the Above and take full responsibility
Signature : Shaima ghazi Aljahdali

تمت مراجعة المشروع المذكور للمحتويات الاتية: البروتوكول، الاستبيان واخلاقيات البحث العلمي.

توصي لجنة اخلاقيات البحث العلمي بالموافقة لإجراء المشروع على أساس الشروط التالية:

١. على الباحث الرئيسي والباحثين المشاركين الحصول على اذن من رئيس المنشأة للبدء بجمع البيانات المطلوبة للمشروع.
٢. سيقوم الباحثين بإجراء الدراسة تحت اشراف مباشر من مشرف وحدة البحوث بإدارة التمريض بصحة جدة
٣. يقوم الباحث بتقديم تقرير كل ٦ **أشهر** عن اخر ما تم تنفيذه في المشروع.
٤. أي تعديل على بروتوكول المشروع او أي من الوثائق المقدمة مسبقا يجب الحصول على موافقة اللجنة قبل البدء في التنفيذ.
٥. **المراقبة:** ممكن للمشروع ان يخضع للمراجعة او أي نوع من المراقبة من قبل اللجنة الأخلاقية اثناء تنفيذ المشروع
٦. الباحث الرئيسي هو المسؤول عن حفظ البيانات الاصلية لمدة لا تقل عن **خمس سنوات** من اجراء المشروع
٧. المتوقع من الباحث ان يقدم تقريرا نهائيا في نهاية المشروع.
٨. يجب على الباحث تقديم ملخص الدراسة ونسخة من المخطوطة قبل القيام بالنشر في المجلات العلمية.
٩. يجب على الباحث الرئيسي والباحثين المشاركين الحصول على شهادة اخلاقيات البحث العلمي حديثة وسارية.
١٠. **يحصل البحث على خطاب الموافقة النهائي ورقم الموافقة من اللجنة الأخلاقية بعد قيام الباحثين باستكمال الشروط السابق ذكرها.**
١١. على الباحثين اتباع الأنظمة والقوانين الصادرة من اللجنة الوطنية لأخلاقيات الطب الحيوي بمدينة الملك عبد العزيز للعلوم والتقنية.

ان اللوائح التنظيمية والتشغيلية للجنة الأخلاقية التابعة لإدارة البحوث والدراسات في صحية جدة تستند على الممارسة السريرية الجيدة، (GCP) Guidelines

ملاحظة: هذه الموافقة المبدئية صالحة لمدة عام من تاريخ الصدور.

أقرأت وأوافق على ما سبق وأتحمل كامل المسئولية.
التوقيع : شيماء غازي الجحدلي

[redacted]d view Board

الرقم: / ٤٧/ج التاريخ: / /

هاتف: ٠١٢-٦٩٧٠٠٠٦ / ٠١٢-٦٨٣١٣٧٧ فاكس: ٠١٢-٦٦٢٢٩٦١ ص.ب: جدة: ٢١١٧٦
Tel.: 012-6831377, 012-6970006 Fax : 012-6622961 P.O. Box : 12493 Jeddah 21176
www.mohj.gov.sa : موقع إلكتروني

Appendix J: Ethical approval from the private clinic of Health for Phase 1

[redacted]

To Whom It May Concern

The principle Investigator (PI): Shima Ghazi Aljahdali

Research Title:

A qualitative study to evaluate the acceptability of technology as a supportive approach to standard physiotherapy treatment for knee pain in Saudi Arabia

We approved her start for the study at [redacted] from **September 1, 2019** for one year.

This letter was given upon her request without any liability / responsibility on the center.

Dr. [redacted] **an;**

[redacted]

[redacted] **Medical Director**

[redacted]

Appendix K: The Arabic Knee injury and Osteoarthritis Outcome Score questionnaire (KOOS)

استبانة الإلتهاب المفصلي العظمي وإصابات الركبة

تاريخ اليوم: _____/_____/_____ تاريخ الميلاد: _____/_____/_____

الاسم: _____

التعليمات: هذه الاستبانة صممت لمعرفة رأيك حول ركبتك. معلومات هذه الاستبانة سوف تساعدنا في معرفة شعورك بركبتك وكيف ستكون قادراً على أداء نشاطاتك الاعتيادية.

أجب عن كل سؤال بوضع علامة في المربع المناسب. اختر مربع واحد فقط لكل سؤال. إذا كنت غير متأكد من الإجابة اختر أقرب اجابة مناسبة.

الأعراض:

يجب أن تكون الإجابة على هذه الأسئلة بناء على أعراض ركبتك خلال **الأسبوع الماضي**

S1 هل يوجد تورم في ركبتك؟

أبداً	نادراً	أحياناً	غالباً	دائماً
□	□	□	□	□

S2 هل تشعر بصرير أو تسمع طقطقه أو أي صوت في ركبتك عند تحريك الركبة؟

أبداً	نادراً	أحياناً	غالباً	دائماً
□	□	□	□	□

S3 هل ركبتك تتصلب عند الحركة؟

أبداً	نادراً	أحياناً	غالباً	دائماً
□	□	□	□	□

S4 هل تستطيع مدّ ركبتك بشكل كامل؟

دائماً	غالباً	أحياناً	نادراً	أبداً
□	□	□	□	□

S5 هل تستطيع ثني ركبتك بشكل كامل؟

دائماً	غالباً	أحياناً	نادراً	أبداً
□	□	□	□	□

التصلب: الأسئلة التالية تتعلق **بمقدار تصلب** المفصل الذي عانيت منه **الأسبوع الماضي** في ركبتك.
التصلب هو الإحساس بتقييد أو بطء في سهولة تحريك مفصل الركبة.

S6 كيف تكون شدّة التصلب في ركبتك بعد الاستيقاظ صباحاً؟

لا يوجد تصلب	خفيفة	متوسطة	شديدة	شديدة جداً
□	□	□	□	□

S7 كيف تكون شدّة التصلب في ركبتك بعد الجلوس أو الاستلقاء أو الراحة في نهاية اليوم؟

لا يوجد تصلب	خفيفة	متوسطة	شديدة	شديدة جداً
□	□	□	□	□

الألم

P1 كم مره تشعر بألم في الركبة؟

أبداً	شهرياً	اسبوعياً	يومياً	دائماً
□	□	□	□	□

ما هو مقدار **ألم** الركبة الذي عانيته **الأسبوع الماضي** أثناء أداء الأنشطة التالية:

P2 الإلتواء/اللف على ركبتك

لا يوجد ألم	خفيف	متوسط	شديد	شديد جداً
□	□	□	□	□

P3 مدّ الركبة بالكامل

لا يوجد ألم	خفيف	متوسط	شديد	شديد جداً
□	□	□	□	□

P4 ثني الركبة بالكامل

لا يوجد ألم	خفيف	متوسط	شديد	شديد جداً
□	□	□	□	□

P5 المشي على سطح مستوي

لا يوجد ألم	خفيف	متوسط	شديد	شديد جداً
□	□	□	□	□

P6 صعود أو نزول الدرج

لا يوجد ألم	خفيف	متوسط	شديد	شديد جداً
□	□	□	□	□

P7 في فراشك أثناء الليل

لا يوجد ألم	خفيف	متوسط	شديد	شديد جداً
□	□	□	□	□

P8 الجلوس أو الإستلقاء

لا يوجد ألم	خفيف	متوسط	شديد	شديد جداً
□	□	□	□	□

P9 الوقوف باستقامة

لا يوجد ألم	خفيف	متوسط	شديد	شديد جداً
□	□	□	□	□

الوظائف، أنشطة الحياة اليومية

الأسئلة التالية تتعلق بالوظائف البدنية، ونعني بذلك قدرتك على التنقل والاعتناء بنفسك.
لكل نشاط من الأنشطة التالية يرجى تحديد **درجة الصعوبة** التي واجهتها **الأسبوع الماضي** بسبب الركبة.

A1 نزول الدرج

لا يوجد صعوبة	خفيفة	متوسطة	شديدة	شديدة جداً
□	□	□	□	□

A2 صعود الدرج

لا يوجد صعوبة	خفيفة	متوسطة	شديدة	شديدة جداً
□	□	□	□	□

لكل نشاط من الأنشطة التالية يرجى تحديد درجة الصعوبة التي واجهتها **الأسبوع الماضي** بسبب الركبة.

A3 القيام من وضع الجلوس	لا يوجد صعوبة ☐	خفيفة ☐	متوسطة ☐	شديدة ☐	شديدة جداً ☐
A4 الوقوف	لا يوجد صعوبة ☐	خفيفة ☐	متوسطة ☐	شديدة ☐	شديدة جداً ☐
A5 الإنحناء لإلتقاط شيء من الأرض	لا يوجد صعوبة ☐	خفيفة ☐	متوسطة ☐	شديدة ☐	شديدة جداً ☐
A6 المشي على سطح مستوي	لا يوجد صعوبة ☐	خفيفة ☐	متوسطة ☐	شديدة ☐	شديدة جداً ☐
A7 الصعود أو النزول من السيارة	لا يوجد صعوبة ☐	خفيفة ☐	متوسطة ☐	شديدة ☐	شديدة جداً ☐
A8 الذهاب للتسوق	لا يوجد صعوبة ☐	خفيفة ☐	متوسطة ☐	شديدة ☐	شديدة جداً ☐
A9 لبس الجوارب (الشرابات)	لا يوجد صعوبة ☐	خفيفة ☐	متوسطة ☐	شديدة ☐	شديدة جداً ☐
A10 النهوض من الفراش	لا يوجد صعوبة ☐	خفيفة ☐	متوسطة ☐	شديدة ☐	شديدة جداً ☐
A11 خلع الجوارب (الشرابات)	لا يوجد صعوبة ☐	خفيفة ☐	متوسطة ☐	شديدة ☐	شديدة جداً ☐
A12 الاستلقاء على السرير (التقلب على أحد الجانبين أو الحفاظ على وضع ثابت للركبة)	لا يوجد صعوبة ☐	خفيفة ☐	متوسطة ☐	شديدة ☐	شديدة جداً ☐
A13 الدخول والخروج من حوض الإستحمام	لا يوجد صعوبة ☐	خفيفة ☐	متوسطة ☐	شديدة ☐	شديدة جداً ☐
A14 وضع الجلوس	لا يوجد صعوبة ☐	خفيفة ☐	متوسطة ☐	شديدة ☐	شديدة جداً ☐
A15 الجلوس أو القيام من المرحاض (قضاء الحاجة)	لا يوجد صعوبة ☐	خفيفة ☐	متوسطة ☐	شديدة ☐	شديدة جداً ☐

لكل نشاط من الأنشطة التالية يرجى تحديد **درجة الصعوبة** التي واجهتها **الأسبوع الماضي** بسبب الركبة.

A16 الأعمال المنزلية الثقيلة (نقل الصناديق الثقيلة، ونظافة أرضيات المنزل...الخ)

لا يوجد صعوبة	خفيفة	متوسطة	شديدة	شديدة جداً
□	□	□	□	□

A17 الأعمال المنزلية الخفيفة (الطبخ وتنظيف الغبار...الخ)

لا يوجد صعوبة	خفيفة	متوسطة	شديدة	شديدة جداً
□	□	□	□	□

الوظائف، الأنشطة الرياضية والترفيهية

الأسئلة التالية تتعلق بوظائفك البدنية عندما تمارس أنشطة عالية الجهد، يجب أن تكون الإجابة على هذه الأسئلة بناء على **درجة الصعوبة** التي واجهتها **الأسبوع الماضي** بسبب الركبة.

SP1 وضعية القرفصاء (الجلوس على المرحاض العربي)

لا يوجد صعوبة	خفيفة	متوسطة	شديدة	شديدة جداً
□	□	□	□	□

SP2 الجري

لا يوجد صعوبة	خفيفة	متوسطة	شديدة	شديدة جداً
□	□	□	□	□

SP3 القفز

لا يوجد صعوبة	خفيفة	متوسطة	شديدة	شديدة جداً
□	□	□	□	□

SP4 الإلتواء أو اللف على ركبتك المصابة

لا يوجد صعوبة	خفيفة	متوسطة	شديدة	شديدة جداً
□	□	□	□	□

SP5 الارتكاز على الركبتين (الجلوس بين السجدتين)

لا يوجد صعوبة	خفيفة	متوسطة	شديدة	شديدة جداً
□	□	□	□	□

جودة الحياة

Q1 كم مره تدرك وتتذكر أن لديك مشكلة في الركبة؟

أبداً	شهرياً	اسبوعيًا	يومياً	باستمرار
□	□	□	□	□

Q2 هل قمت بتعديل نمط حياتك لتجنب الضرر المحتمل من بعض الأنشطة على ركبتك؟

لا على الإطلاق	بشكل بسيط	بشكل متوسط	بشكل كبير	بشكل كُلي
□	□	□	□	□

Q3 ما مدى تضايقك بسبب ضعف ثقتك في ركبتك؟

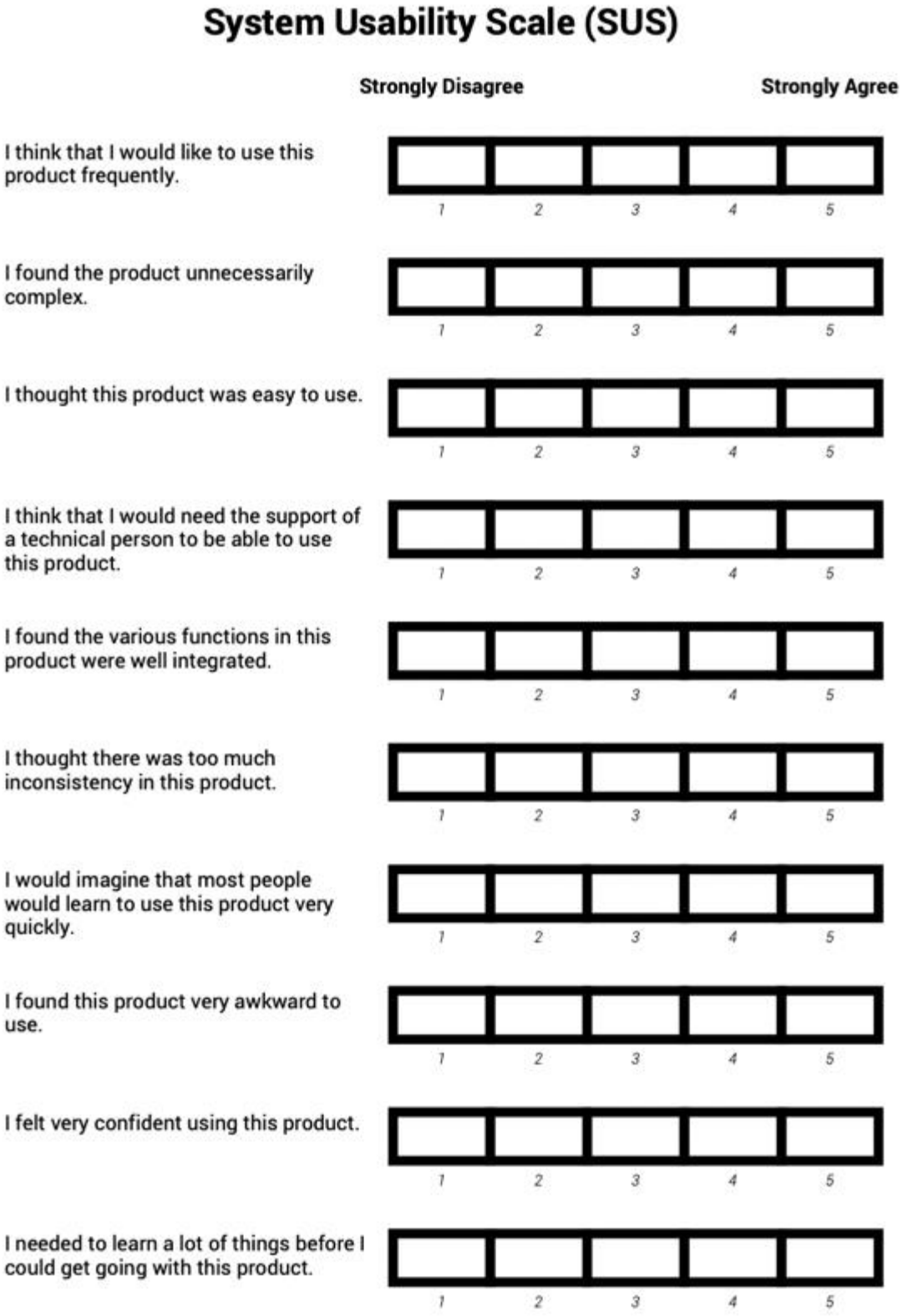
لا على الإطلاق	بشكل بسيط	بشكل متوسط	بشكل كبير	بشكل كُلي
□	□	□	□	□

Q4 بشكل عام، ما مقدار الصعوبة التي تواجهها مع ركبتك؟

لا يوجد صعوبة	خفيف	متوسط	شديد	شديد جداً
□	□	□	□	□

شكراً جزيلاً لإجابتك على كل الأسئلة في هذه الاستبانة.

Appendix L: The System Usability Scale (English)



Appendix M: The Arabic System Usability Scale

System Usability Scale (SUS)*

استبيان لقياس سهولة استخدام النظام (A-SUS)**

التعليمات: أمام كل عبارة من العبارات التالية، اختر الرقم الذي يصف بدقة رأيك عن الموقع بعد استخدامه اليوم.

العبارات	لا أوافق =1 بشدة	2	3	4	أوافق =5 بشدة
1- اظن انني أحب ان استخدم هذا النظام باستمرار.	☐	☐	☐	☐	☐
2- وجدت هذا النظام معقد أكثر من اللازم.	☐	☐	☐	☐	☐
3- أظن أن هذا النظام سهل الاستخدام.	☐	☐	☐	☐	☐
4- اعتقد بأنني احتاج مساعدة شخص من تخصص تقني لاستخدام هذا النظام.	☐	☐	☐	☐	☐
5- وجدت الوظائف المتعددة في هذا النظام منسجمة فيما بينها.	☐	☐	☐	☐	☐
6- ظننت ان هناك الكثير من التضارب في استخدام هذا النظام.	☐	☐	☐	☐	☐
7- اتخيل بأن الكثير من الناس سوف يتعلمون استخدام هذا النظام بسهوله.	☐	☐	☐	☐	☐
8- وجدت هذا النظام غريب للاستخدام.	☐	☐	☐	☐	☐
9- شعرت بالثقة التامة عند استخدام هذا النظام.	☐	☐	☐	☐	☐
10- يجب معرفة أمور كثيرة لتسهيل استخدام هذا النظام.	☐	☐	☐	☐	☐

* (Brooke, 1996)

** (AlGhannam, et al. 2018)

Appendix N: Study invitation for Phase 2 (in English and Arabic)

A request to join a study

Dear Sir/Madam,

We are a research group that you already honored us by joining Miss Shaima Aljahdali's doctoral research in the period between October and December 2019. As a reminder, the study consisted of one-to-one interviews that were conducted with you by Miss Shaima at one of these physiotherapy departments of the following medical centers: [redacted]

And because your previous participation had a great benefit in understanding the physiotherapy services provided in the Kingdom of Saudi Arabia and strengthened the results of Miss Shaima's research study, we invite you to participate in a new study that is complementary to the previous study you joined, and its results will help in the possibility of adding new advanced physical therapy services to the Kingdom.

Because of the current world situation and to keep you safe, the study will consist of an individual online interview that takes a maximum of 45 minutes, so, you do not have to leave your home. During this interview, you will perform certain tasks that will be asked of you by the researcher on the "Track-Saudi" website to assess its readiness for use in physiotherapy clinics with people suffering from chronic pain in the knee joint. If you have no problem joining the study, we will provide you with detailed information about the interview itinerary.

Please reply to this message with rejection or acceptance so that we can provide you with all the required information. Note that if you refuse to participate, you will not be contacted again in this regard, and we thank you for your active participation in advance.

Your sincerely,

Shaima Aljahdali

PhD researcher at Cardiff University in the United Kingdom and a member of the faculty at King Abdulaziz University in Jeddah.

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طلب انضمام لدراسة

عزيزي/عزيزتي المشترك/ة

نحن فريق عمل بحثي سبق وان شرفتنا بانضمامك لبحث الدكتوراه الخاص بالأستاذة شيماء الجحدلي في الفترة ما بين أكتوبر الى ديسمبر ٢٠١٩. وللتذكير، الدراسة كانت عبارة عن مقابلات فردية تم عملها معكم في احدى هذه عيادات العلاج الطبيعي [redacted]

ولأن مشاركتك السابقة كان لها نفع كبير في فهم خدمات العلاج الطبيعي المقدمة في المملكة العربية السعودية وعززت من نتائج الدراسة البحثية القائمة حاليا، ندعوك للمشاركة في دراسة أخرى تُعتبر مُكملة للدراسة السابقة ونتائجها ستساعد في إمكانية إضافة خدمات جديدة متطورة للعلاج الطبيعي في المملكة.

بسبب الوضع الراهن ولحمايتك، الدراسة ستكون عبارة عن مقابلات عن طريق الانترنت تستغرق ٤٥ دقيقة كحد أقصى ولن يكون هناك أي حاجة لمغادرة منزلك من أجلها. خلال هذه المقابلة ستقوم بعمل مهام معينة ستُطلب منك من قبل الباحث على موقع "تراك-السعودية" لدراسة فعاليته للاستخدام في عيادات العلاج الطبيعي مع أشخاص مصابين بألام مزمنة في مفصل الركبة. ان لم تكن لديكم مشكلة في الانضمام، سنقوم بتزويدكم بمعلومات مُفصلة عن خط سير المقابلة.

الرجاء الرد على هذه الرسالة بالرفض أو القبول ليتسنى لنا تزويدكم بكل المعلومات المطلوبة. علماً بأنه في حال رفضكم المشاركة، لن يتم التواصل معكم مجدداً بهذا الخصوص ونشكر لكم مشاركتكم الفعالة مُسبقاً.

تقبلوا تحياتي،

شيماء الجحدلي

باحثة دكتوراه في جامعة كارديف بالمملكة المتحدة وعضو هيئة تدريس بجامعة الملك عبد العزيز بجدة.

Appendix O: Phase 2 participants' information sheet for physiotherapists (in English and Arabic)

TRAK-Saudi a web-based approach to support self-management in patients with chronic knee pain in Saudi Arabia: A usability study

You are being invited to take part in a research study. Before you decide whether or not to take part it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish.

The first part of the Participant Information Sheet tells you the purpose of the study and what will happen to you if you take part. Then we give you more detailed information about the conduct of the study.

Thank you for reading this.

What is the purpose of this research?
This study aims to explore the usability of an electronic website called "TRAK-Saudi" for online care. This website targets patients with knee conditions and physiotherapists in Saudi Arabia. Findings could help the researcher to build up a firm idea about the readiness of this new website to be used in its new environment in addition to the modifications required so it matches the needs of users in Saudi Arabia.

Why have I been invited?
You have been invited because you are a qualified physiotherapist who has an experience dealing with knee conditions in a physiotherapy department in Saudi Arabia.

Do I have to take part?
No, participation is voluntary. If you decide not to take part, you do not have to explain your reasons and it will not affect your physiotherapy sessions or your legal rights. However, if you do decide to take part, we will discuss the study with you and ask you to sign a consent form. You are free to withdraw your consent at any time, without giving a reason, even after signing the consent form.

What will happen to me if I take part?
You are going to attend one-to-one online meeting with the researcher that will last approximately 45 minutes maximum. The interview starts with a brief use of the electronic website and ends with filling two questionnaires to understand your feedback. You will be asked to complete simple tasks on the website and describe what you are doing while your screen is recorded, no need to turn on your camera on this meeting.

What are the possible benefits of taking part?
There will be no direct advantages or benefits to you from taking part, but your contribution will help us understand more about the opinion of Saudi patients with knee problems and physiotherapists of this new website. This could help in improving the health services provided to patients in physiotherapy departments.

What are the possible risks of taking part?
No risks have been identified by the researcher.

Will my taking part in this study be kept confidential?
All information collected during the study will be kept strictly confidential in accordance with the General Data Protection Regulation (GDPR) 2016. Your name, email, your IP address or any other identifying information will not be passed onto anyone. You will not be identified in any published study results. All data collected in this work will be stored in a secure place for 5 years then destroyed.

What will happen to the results of the study?
It is our intention to publish the results of this study in academic journals and present findings at conferences. Participants will not be identified in any report, publication or presentation.

What if there is a problem?
If you wish to complain, or have grounds for concerns about any aspect of the way you have been approached or treated during the course of this research, contact:
Miss Shaima Aljahdali
Email:

If you remain unhappy and wish to complain formally, you can do this by contacting the School of Healthcare Sciences Director of Research Governance at Cardiff University, the United Kingdom.
Dr Kate Button
Email:

Who is organising and funding this research?
The work is part is organised by Miss Shaima Aljahdali to achieve the degree of Doctor of Philosophy in physiotherapy, School of Healthcare Sciences in Cardiff University, United Kingdom. The research is funded by the Saudi Cultural Bureau in London.

Who has reviewed this study?
This study has been reviewed and given a favourable opinion by the Research Ethics Committee of the School of Healthcare Sciences, Cardiff University.

Further information and contact details:
Should you have any questions relating to this study, you may contact us during normal working hours Miss Shaima Aljahdali on the following contact details:
Email:

We would like to thank you for considering taking part in this study. If you decide to participate you will be given a copy of the information sheet and a signed consent form to keep.

ورقة معلومات البحث الخاصة بالمشتركين

دراسة لتحديد مدى قابلية استخدام موقع تراك-السعودية الخاص لدعم الإدارة الذاتية للمرضى الذين يعانون من الام الركبة المزمنة

أنت مدعو للمشاركة في هذا البحث ولكن قبل أن تأخذ قرارك النهائي في المشاركة من عدمها نرجو منك قراءة هذه الورقة التي ستجاوب الى حد كبير عن كل تساؤلاتك فيما يخص البحث. نرجو منكم أخذ وقتكم الكافي في القراءة وسؤال المقربين منك عن محتويات البحث ان احتجتم ذلك، وسنكون سعداء أيضا للرد على أي سؤال خارج عن المذكور في هذه الورقة يطرأ في بالكم.

ما الهدف من هذه الدراسة؟
تهدف هذه الدراسة إلى استكشاف إمكانية استخدام موقع إلكتروني يسمى "تراك-السعودية" المخصص بتقديم خدمات العلاج الطبيعي عبر الإنترنت. يستهدف هذا الموقع المرضى الذين يعانون من أمراض الركبة وأخصائيين العلاج الطبيعي في المملكة العربية السعودية. يمكن أن تساعد النتائج الباحث في تكوين فكرة ثابتة حول جاهزية هذا الموقع الجديد لاستخدامه في بيئته الجديدة بالإضافة إلى التعديلات المطلوبة بحيث يلبي احتياجات المستخدمين في المملكة العربية السعودية.

لماذا تمت دعوتي للمشاركة؟
لقد تمت دعوتك لأنك أخصائي علاج طبيعي مؤهل يتعامل مع حالات الركبة في قسم العلاج الطبيعي في المملكة العربية السعودية.

هل يجب عليّ المشاركة؟
لا، فمشاركتكم في هذه الدراسة هي اختيارية تماماً حيث ان عدم مشاركتكم لن يؤثر أبداً على جلسات العلاج المقدمة لكم أو حقوقكم كمرضى. أما في حال رغبتم المشاركة، سيتولى القائمين على البحث بمناقشة محتويات الدراسة معكم وتوضيح كل شيء معكم قبل أن تبدأوا بالمشاركة الفعلية وهذا سيتضمن توقيعكم لورقة اتفاقية توضح موافقتكم من عدمها على ما سيحدث خلال المشاركة. يمكنكم الانسحاب من الدراسة في أي وقت ان رغبتم بذلك حتى بعد توقيعكم لورقة الاتفاقية بدون أي أسباب توضيحية سيتم طلبها منكم.

ماذا سيحدث ان قررت المشاركة؟
ستحضر مقابلة فردية عبر الإنترنت مع الباحث والتي ستستغرق حوالي 45 دقيقة كحد أقصى. تبدأ المقابلة باستخدام موجز للموقع الإلكتروني وتنتهي بملء استبيانين لفهم رأيك حوله. استخدامك للموقع سيكون عن طريق عمل مهام معينة ستطلب منك من قبل الباحث وسيتم تسجيل شاشتك خلال ادائك لهذه المهام، لا تقلق! لن يطلب منك تشغيل الكاميرا خلال هذه المقابلة.

ما الفائدة من مشاركتي؟
مشاركتكم في البحث لن تعود عليكم بفائدة ملحوظة، ولكن مساهمتك ستساعدنا على فهم المزيد حول قبول المواقع الإلكترونية الصحية في المرضى السعوديين الذين يعانون من مشاكل في الركبة وأخصائيين العلاج الطبيعي. هذا بدوره يمكن أن يساعد في تحسين الخدمات الصحية المقدمة للمرضى في أقسام العلاج الطبيعي.

ما الأضرار المحتملة من مشاركتي؟
لا توجد أضرار محتملة تم كشفها من قبل الباحث.

هل ستُعامل مشاركتي في البحث بسريّة؟
أي معلومات تتعلق بمشاركتكم في البحث بدأ من معلوماتكم الشخصية وانتهاءً بالمعلومات المجمّعة من المقابلة سيتم التعامل معها بسريّة قصوى وفقا لقانون حماية المعلومات الخاص بعام ٢٠١٦. علماً بأن جميع المعلومات الخاصة بهذه الدراسة سيتم الاحتفاظ بها لخمسة سنوات ومن ثم اتلافها.

ماذا سيحدث لنتائج البحث؟
من المحتمل أن نتائج البحث سيتم نشرها في مجلات علمية أو مؤتمرات طبية، في حال حدوث ذلك، سيتم التعامل مع بياناتكم بصورة المجهول ولن يتم ذكر أي شيء يوضح هويتكم.

من هم القائمين على هذا البحث؟

هذا البحث منظم من قبل أ. شيماء الجحدلي كمتطلب رئيسي للحصول على درجة الدكتوراه في تخصص العلاج الطبيعي من جامعة كاردف في المملكة المتحدة. تم تمويل هذا البحث مادياً من الملحقية الثقافية السعودية في لندن.

هل تمت مراجعة محتويات البحث من جهة رسمية؟

نعم، هذا البحث مر بعدة مراحل قبل أن يتم تطبيقه رسميا. تمت مراجعته اولاً من قبل وحدة اخلاقيات البحث العلمي في جامعة كاردف ومن ثم المديرية العامة للشئون الصحية بمنطقة مكة المكرمة.

ماذا لو اردت التواصل مع شخص بخصوص البحث؟

إذا كانت لديكم شكوى، تساؤلات، او مررتم بشيء غير مرضي خلال مشاركتكم لا تترددوا في التواصل مع:

أ. شيماء الجحدلي

البريد الالكتروني:

إذا كنت لا تزال غير سعيد وترغب في تقديم شكوى رسميًا ان وجد، يمكنك القيام بذلك عن طريق الاتصال بمدير إدارة البحوث بكلية العلوم الصحية بجامعة كاردف بالمملكة المتحدة.

د. كيت بوتن

البريد الالكتروني:

أخراً وليس أخيراً، نود شكركم لقراءة هذه الورقة ونأمل منكم توضيح رغبتكم بالمشاركة او عدمها للباحث ليتم تزويدكم بنسخة من هذه الورقة بالإضافة الي نسخة من ورقة الاتفاقية.

Appendix P: Phase 2 participants' information sheet for Individuals with knee pain (in English and Arabic)

TRAK-Saudi a web-based approach to support self-management in patients with chronic knee pain in Saudi Arabia: A usability study

You are being invited to take part in a research study. Before you decide whether or not to take part it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish.

The first part of the Participant Information Sheet tells you the purpose of the study and what will happen to you if you take part. Then we give you more detailed information about the conduct of the study.

Thank you for reading this.

What is the purpose of this research?
This study aims to explore the usability of an electronic website called "TRAK-Saudi" for online care. This website targets patients with knee conditions and physiotherapists in Saudi Arabia. Findings could help the researcher to build up a firm idea about the readiness of this new website to be used in its new environment in addition to the modifications required so it matches the needs of users in Saudi Arabia.

Why have I been invited?
You have been invited because you are aged over 18 years old, have knee pain for more than 12 weeks and it is there with movements in most of the days in the last month.

Do I have to take part?
No, participation is voluntary. If you decide not to take part, you do not have to explain your reasons and it will not affect your physiotherapy sessions or your legal rights. However, if you do decide to take part, we will discuss the study with you and ask you to sign a consent form. You are free to withdraw your consent at any time, without giving a reason, even after signing the consent form.

What will happen to me if I take part?
You are going to attend one-to-one online meeting with the researcher that will last approximately 45 minutes maximum. The interview starts with a brief use of the electronic website and ends with filling two questionnaires to understand your feedback. You will be asked to complete simple tasks on the website and describe what you are doing while your screen is recorded, no need to turn on your camera on this meeting.

What are the possible benefits of taking part?
There will be no direct advantages or benefits to you from taking part, but your contribution will help us understand more about the opinion of Saudi patients with knee problems and physiotherapists of this new website. This could help in improving the health services provided to patients in physiotherapy departments.

What are the possible risks of taking part?
No risks have been identified by the researcher.

Will anyone look at my medical records?
No. However, any information approached for the purposes of this study, with your consent, will be treated as strictly confidential.

Will my taking part in this study be kept confidential?

All information collected during the study will be kept strictly confidential in accordance with the General Data Protection Regulation (GDPR) 2016. Your name, email, your IP address or any other identifying information will not be passed onto anyone. You will not be identified in any published study results. All data collected in this work will be stored in a secure place for 5 years then destroyed.

What will happen to the results of the study?
It is our intention to publish the results of this study in academic journals and present findings at conferences. Participants will not be identified in any report, publication or presentation.

What if there is a problem?
If you wish to complain, or have grounds for concerns about any aspect of the way you have been approached or treated during the course of this research, contact:
Miss Shaima Aljahdali
Email:

If you remain unhappy and wish to complain formally, you can do this by contacting the School of Healthcare Sciences Director of Research Governance at Cardiff University, the United Kingdom.
Dr Kate Button
Email:

Who is organising and funding this research?
The work is part is organised by Miss Shaima Aljahdali to achieve the degree of Doctor of Philosophy in physiotherapy, School of Healthcare Sciences in Cardiff University, United Kingdom. The research is funded by the Saudi Cultural Bureau in London.

Who has reviewed this study?
This study has been reviewed and given a favourable opinion by the Research Ethics Committee of the School of Healthcare Sciences, Cardiff University.

Further information and contact details
Should you have any questions relating to this study, you may contact us during normal working hours Miss Shaima Aljahdali on the following contact details:
Email:

We would like to thank you for considering taking part in this study. If you decide to participate you will be given a copy of the information sheet and a signed consent form to keep.

ورقة معلومات البحث الخاصة بالمشتركين

دراسة لتحديد مدى قابلية استخدام موقع تراك-السعودية الخاص لدعم الإدارة الذاتية للمرضى الذين يعانون من الام الركبة المزمنة

أنت مدعو للمشاركة في هذا البحث ولكن قبل أن تأخذ قرارك النهائي في المشاركة من عدمها نرجو منك قراءة هذه الورقة التي ستجاوب الى حد كبير عن كل تساؤلاتك فيما يخص البحث. نرجو منكم أخذ وقتكم الكافي في القراءة وسؤال المقربين منك عن محتويات البحث ان احتجتم ذلك، وسنكون سعداء أيضا للرد على أي سؤال خارج عن المذكور في هذه الورقة يطرأ في بالكم.

ما الهدف من هذه الدراسة؟

تهدف هذه الدراسة إلى استكشاف إمكانية استخدام موقع إلكتروني يسمى "تراك-السعودية" المخصص بتقديم خدمات العلاج الطبيعي عبر الإنترنت. يستهدف هذا الموقع المرضى الذين يعانون من أمراض الركبة وأخصائيين العلاج الطبيعي في المملكة العربية السعودية. يمكن أن تساعد النتائج الباحث في تكوين فكرة ثابتة حول جاهزية هذا الموقع الجديد لاستخدامه في بيئته الجديدة بالإضافة إلى التعديلات المطلوبة بحيث يلبي احتياجات المستخدمين في المملكة العربية السعودية.

لماذا تمت دعوتي للمشاركة؟

لقد تمت دعوتك لأن عمرك يزيد عن 18 عامًا، وتعاني من آلام في الركبة لأكثر من 12 أسبوعًا ولاتزال تشعر به مع الحركة في معظم أيام الشهر الماضي.

هل يجب عليّ المشاركة؟

لا، فمشاركتكم في هذه الدراسة هي اختيارية تماماً حيث ان عدم مشاركتكم لن يؤثر أبداً على جلسات العلاج المقدمة لكم أو حقوقكم كمرضى. أما في حال رغبتم المشاركة، سيتولى القائمين على البحث بمناقشة محتويات الدراسة معكم وتوضيح كل شيء معكم قبل أن تبدأوا بالمشاركة الفعلية وهذا سيتضمن توقيعكم لورقة اتفاقية توضح موافقتكم من عدمها على ما سيحدث خلال المشاركة. يمكنكم الانسحاب من الدراسة في أي وقت ان رغبتم بذلك حتى بعد توقيعكم لورقة الاتفاقية بدون أي أسباب توضيحية سيتم طلبها منكم.

ماذا سيحدث ان قررت المشاركة؟

ستحضر مقابلة فردية عبر الإنترنت مع الباحث والتي ستستغرق حوالي 45 دقيقة كحد أقصى. تبدأ المقابلة باستخدام موجز للموقع الإلكتروني وتنتهي بملء استبيانين لفهم رأيك حوله. استخدامك للموقع سيكون عن طريق عمل مهام معينة ستطلب منك من قبل الباحث وسيتم تسجيل شاشتك خلال ادائك لهذه المهام، لا تقلق! لن يطلب منك تشغيل الكاميرا خلال هذه المقابلة.

ما الفائدة من مشاركتي؟

مشاركتكم في البحث لن تعود عليكم بفائدة ملحوظة، ولكن مساهمتك ستساعدنا على فهم المزيد حول قبول المواقع الإلكترونية الصحية في المرضى السعوديين الذين يعانون من مشاكل في الركبة وأخصائيين العلاج الطبيعي. هذا بدوره يمكن أن يساعد في تحسين الخدمات الصحية المقدمة للمرضى في أقسام العلاج الطبيعي.

ما الأضرار المحتملة من مشاركتي؟

لا توجد أضرار محتملة تم كشفها من قبل الباحث.

هل سيقوم أحد من أعضاء البحث بالاطلاع على ملفي الطبي؟

لا. ومع ذلك، فإن أي معلومات يتم الوصول لها لأغراض هذه الدراسة بموافقتك، سيتم التعامل معها بسرية تامة.

هل ستُعامل مشاركتي في البحث بسريّة؟

أي معلومات تتعلق بمشاركتكم في البحث بدأ من معلوماتكم الشخصية وانتهاءً بالمعلومات المجمّعة من المقابلة سيتم التعامل معها بسريّة قصوى وفقا لقانون حماية المعلومات الخاص بعام ٢٠١٦.

علماً بأن جميع المعلومات الخاصة بهذه الدراسة سيتم الاحتفاظ بها لخمسة سنوات ومن ثم اتلافها

ماذا سيحدث لنتائج البحث؟

من المحتمل أن نتائج البحث سيتم نشرها في مجلات علمية أو مؤتمرات طبية، في حال حدوث ذلك، سيتم التعامل مع بياناتكم بصورة المجهول ولن يتم ذكر أي شيء يوضح هويتكم.

من هم القائمين على هذا البحث؟
هذا البحث منظم من قبل أ. شيماء الجحدلي كمتطلب رئيسي للحصول على درجة الدكتوراه في تخصص العلاج الطبيعي من جامعة كاردف في المملكة المتحدة. تم تمويل هذا البحث مادياً من الملحقية الثقافية السعودية في لندن.

هل تمت مراجعة محتويات البحث من جهة رسمية؟
نعم، هذا البحث مر بعدة مراحل قبل أن يتم تطبيقه رسميا. تمت مراجعته اولاً من قبل وحدة اخلاقيات البحث العلمي في جامعة كاردف.

ماذا لو اردت التواصل مع شخص بخصوص البحث؟
إذا كانت لديكم شكوى، تساؤلات، او مررتم بشيء غير مرضي خلال مشاركتكم لا تترددوا في التواصل مع:
أ. شيماء الجحدلي
البريد الالكتروني:

إذا كنت لا تزال غير سعيد وترغب في تقديم شكوى رسميًا ان وجد، يمكنك القيام بذلك عن طريق الاتصال بمدير إدارة البحوث بكلية العلوم الصحية بجامعة كاردف بالمملكة المتحدة.
د. كيت بوتن
البريد الالكتروني:

أخراً وليس أخيراً، نود شكركم لقراءة هذه الورقة ونأمل منكم توضيح رغبتكم بالمشاركة او عدمها للباحث ليتم تزويدكم بنسخة من هذه الورقة بالإضافة الي نسخة من ورقة الاتفاقية.

Appendix Q: Phase 2 participants' consent form (in English and Arabic)

CARDIFF UNIVERSITY
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Consent Form (Physiotherapists)

Title of study: TRAK-Saudi a web-based approach to support self-management in patients with chronic knee pain in Saudi Arabia: A usability study

Name of Chief/Principal Investigator: Shaima Aljabdali

Please Initial box

1- I confirm that I have read the information sheet dated 10th March 2021, version 1.1 for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2- I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my job being affected. ☐

3- I agree to participate in a virtual interview with a TRAK-Saudi study team member. I understand that my screen will be shared and recorded during the interview time only for research purposes. ☐

4- I understand that the interview will be recorded and sent for professional transcription. ☐

5- I understand that I do not have to answer particular interview questions. ☐

6- I understand that my words may be quoted in research reports, web pages, and other academic/research outputs or publications - but that this will be anonymised. ☐

7- I understand that my personal data [contact details], this consent form and the interview data I give will be stored on Cardiff University secure servers - accessible only to the TRAK-Saudi research team. ☐

8- I agree to take part in the above study ☐

Name of Participant	Date	Signature
Name of Person taking consent	Date	Signature

Subject Identification Number for this Investigation: .....

Version 1.0 10 March 2021

Consent Form (Physiotherapists)

عنوان البحث: دراسة لتحديد مدى قابلية استخدام موقع تراك-السعودية الخاص لدعم الإدارة الذاتية للمرضى الذين يعانون من الام الركبة المزمنة
اسم الباحث الأساسي: شيماء الجحدلي

	يرجى وضع الحرف الأول من اسمك واسم العائلة في حال الموافقة
١- أقر بأني قرأت ورقة المعلومات الخاصة بالبحث المؤرخة بتاريخ (مارس ٢٠٢١) نسخة رقم (١.١) وأنني ناقشت جميع تساؤلاتي مع الباحث ولم يتبق لدي أي أسئلة لم احصل على إجابات لها.	☐
٢- أقر بعلمي أن مشاركتي في هذه الدراسة هي اختيارية تمام ويحق لي الانسحاب في أي وقت اردت دون أن اوضح أسباب ذلك وأن ذلك لن يؤثر على مهنتي.	☐
٣- أوافق على اشتراكي في المقابلات الافتراضية مع أفراد فريق البحث لـTRAK-Saudi ، وأعلم أنه سيتم مشاركة شاشتي وتسجيلها أثناء وقت المقابلة فقط، وذلك لأغراض بحثية.	☐
٤- أوافق على اشتراكي في المقابلات الافتراضية مع أفراد فريق البحث لـTRAK-Saudi ، وأعلم أن المقابلات ستكون مسجلة صوتيًا، وستُرسل للتفريغ الكتابي لأغراض بحثية.	☐
٥- اعلم انه باستطاعتي عدم الإجابة على كل أسئلة المقابلة.	☐
٦- أعلم أنه قد يتم اقتباس كلامي في تقارير البحث، وصفحات الموقع الإلكتروني، وغيرها من وسائل النشر الأكاديمية والبحثية، وذلك مع الحفاظ على سرية هويتي.	☐
٧- أوافق على مشاركة معلومات مقابلتي – مع الحفاظ على سرية هويتي- مع باحثين آخرين والاستعانة بها لإجابة أسئلة بحوث أخرى	☐
٨- أقر برغبتي في المشاركة في هذا البحث	☐

اسم المشترك	التاريخ	التوقيع
اسم الشخص المسؤول	التاريخ	التوقيع

رقم تعريف المشترك لهذا الدراسة: .....

Appendix R: Study poster for Phase 2 (in English and Arabic)

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PRIFYSGOL CAERDYDD

Are you interested in trying tech solutions to help with knee pain?

YOU ARE INVITED TO PARTICIPATE IN A RESEARCH STUDY.

For more information, please do not hesitate to contact me, Miss Shaymaa AlJahdali, using the following contact information:

If you're interested in participating, I will invite you to try out a website from the comfort of your home. The website has been designed by physiotherapists to help people with knee pain. Your participation will help gather valuable information that aids in refining the website more accurately to align with the needs of users in Jeddah to enhance quality of care provided

هل مهتم بتجربة حلول تقنيه مساعدة في علاج آلام الركبة؟

اذا كانت لديكم رغبة في المشاركة، سأقوم بدعوتكم الى تجربة موقع الكتروني من راحة منزلكم. الموقع تم تصميمه من قبل اخصائيين علاج طبيعي لمساعدة هؤلاء الذين يعانون من آلام في الركبة. مشاركتكم ستساعد في جمع معلومات قيّمه تساعد تحسين الموقع بشكل ادق وتحسن من جودة الرعاية المقدمة في عيادات العلاج الطبيعي في جدة.

انت/ي مدعو/ة للمشاركة في بحث علمي

لمزيد من المعلومات، فضلاً لا أمراً التواصل معي انا أ. شيماء الجحدلي على معلومات التواصل التالية:

الجوال:

الايميل:

Appendix S: User guide for physiotherapists (in English and Arabic)

User Manual

Task #1: Accessing Trak-Saudi website from search engines

1- Enter any internet browser you currently have on your device (Safari, Chrome, Firefox).
2- Write in the site bar located at the top of the page the following link http://traksa-intervention.uat.ctr.cardiff.ac.uk

Task #2: Log in to your personal account on the website

1- Convert the website into English language by clicking on the word "**English**" in the top corner of the website.
2- Click on **"Sign in"** on the left-hand bar of the site.
3- First, enter the following information:
username:
password:
Then click on **"Sign in"**.

Task #3: Reaching information on the website

1- Click on **"Information suite"** on the left-hand side of the website.
2- Select **"Physical activity with knee pain"**
3- Scroll to the bottom of the page until you reach the side heading **"Do I need to set goals?".**

4- Read the text under this section and tell us if the website allows the user to be in contact with a physiotherapist or not.

Task #4: Loading participant information

1- Click on **“Select a participant”** on the left-hand side of the website.
2- Select **“Name of the participant”** from the list of names.
3- press on **“Load participant”** to load the participant information.

Task #5: Add exercise to the participant’s plan

1- Click on **“Activity suite”** on the left-hand side of the website.
2- Select the **"Flexibility (stretching)“** icon at the bottom of the page.

3- Select the **"Chair Exercises"** icon.

4- Click on **"Add Hamstring stretch (Sitting) to my plan"** to add the exercise to the participant's plan.

5- Once you done, select **"Dashboard"** on the left-hand side of the website.

6- Choose **"Plan"** from the control panel sub-bar.

7- Look for the exercise **"Hamstring stretch (Sitting)"** in the plan.

Task #6: Respond to an email

1-Click on **"View emails"** on the left-hand side of the website.

2-Click on **"View details"** that is on the first email received"

3-Write any sentence you like in the blank space of "**Respond to participant"**

4-Once you done, click on **"Send message"** to send it.

Task #7: Signing out

1- Select **"Sign out"** on the left-hand bar of the website.

دليل الاستخدام

المهمة الأولى: الدخول لموقع تراك-السعودية من محركات البحث

- قم بالدخول الى اي متصفح انترنت تملكه على جهازك حاليا (سفاري، كروم، فايرفوكس).
- قم بالكتابة في شريط الموقع الموجود في اعلى الصفحة الرابط التالي

http://traksa-intervention.uat.ctr.cardiff.ac.uk

المهمة الثانية: تسجيل الدخول لحسابك الشخصي بالموقع

- قم بتحويل الموقع للغة العربية عبر الضغط على كلمة "**العربية**" في زاوية الموقع العُليا.
- قم بالضغط على "**تسجيل الدخول**" في الشريط الايمن للموقع.
- قم اولاً بإدخال المعلومات التالية:

اسم المستخدم:

كلمة المرور:

ومن ثم قم بالضغط على "**تسجيل الدخول**"

المهمة الثالثة: الوصول الى معلومة في الموقع

- قم باختيار" **بوابة المعلومات** "في الشريط الايمن للموقع.
- قم باختيار" **التمارين الرياضية وألام الركبة**"
- قم بالنزول الى أسفل الصفحة حتى تصل الى العنوان الجانبي" **هل يجب وضع اهداف؟** ".

- قم بقراءة النص تحت هذا القسم وأخبرنا إذا يمكن مناقشة الأهداف مع اخصائي العلاج الطبيعي ام لا.

المهمة الرابعة: عرض معلومات مشترك

- قم بالضغط على" **اختر مشترك** "في الشريط الايمن للموقع.
- قم باختيار" اسم **المشترك** "من القائمة التي ستظهر لك.
- قم بالضغط على" تحميل **معلومات المشترك** "لعرض معلومات المشترك الذي قمت باختياره.

المهمة الخامسة: اضافة تمرين رياضي لخطة المشترك

- قم باختيار "**بوابة التمارين الرياضية**" في الشريط الايمن للموقع.
- قم باختيار ايقونة "**تمارين المرونة**" في أسفل الصفحة.

- قم باختيار ايقونة "**تمارين الكرسي**".

- قم بالضغط على "**أضف إطالة عضلة الفخذ الخلفية (أثناء الجلوس) لخطتي**" لإضافة التمرين الى خطة المريض.
- قم باختيار "**لوحة تحكم المشترك**" في الشريط الايمن للموقع.
- قم باختيار "**الخطة العلاجية**" من الشريط الفرعي للوحة التحكم.

تأكد من وجود التمرين "إطالة عضلة الفخذ الخلفية (أثناء الجلوس)" في خطة المشترك.

المهمة السادسة: الرد على بريد الكتروني

- قم باختيار "عرض البريد الالكتروني" في الشريط الايمن للموقع.
- قم بالضغط على "عرض التفاصيل" لأول بريد الكتروني مُرسل لك.
- قم بكتابة أي جملة في خانة "الرد على المشترك"
- قم بالضغط على "ارسال"

المهمة السابعة: تسجيل الخروج

- قم باختيار "**تسجيل الخروج**" في الشريط الايمن للموقع.

Appendix T: User guide for individuals with chronic knee pain (in English and Arabic)

User Manual

Task #1: Accessing Trak- Saudi website from search engines

1- Enter any internet browser you currently have on your device (Safari, Chrome, Firefox).
2- Write in the site bar located at the top of the page the following link http://traksa-intervention.uat.ctr.cardiff.ac.uk

Task #2: Log in to your personal account on the website

1- Convert the website into English language by clicking on the word "**English**" in the top corner of the website.
2- Click on "Sign in" on the left-hand bar of the site.
3- First, enter the following information:
username:
password:
Then click on "Sign in".

Task #3: filling out questionnaires

1- Select "My questionnaires" on the left-hand side of the website.
2- Select the latest questionnaire named "demographics"
3- Fill out the whole questionnaire by selecting the suitable answers for you.
4- When done, click on the word "Save" at the bottom of the page.
5- Then, select the third questionnaire called "Knee injury and Osteoarthritis questionnaire"
6- Fill out the whole questionnaire by selecting the suitable answers for you.
7- Upon completion, click on the word "Save" at the bottom of the page.

Task #4: Reaching information on the website

1- Select "Information suite" on the left-hand side of the website.
2- Select "Physical activity with knee pain"

3- Scroll to the bottom of the page until you reach the side heading "Setting aims and challenges".

4- Read the text under this section and tell us if the website allows the user to be in contact with a physiotherapist or not.

Task #5: Setting a goal

1- Select “Dashboard” on the left-hand side of the website.
2- Select “Aims” from the dashboard sub-bar.
3- Select “Add a new aim” to add your new goal.
4- Write “Walk 10,000 steps” in the “Describe your aim” box.
5- Write “within a month from now” in the “When do you want to achieve this aim” box.
6- Write “Increase the number of steps 1000 steps every 3 days” in the “What do you need to help you do this” box.
7- After completing, click on “Save your aim”.

Task #6: Add exercise to your plan

1- Select the “Activity suite” on the left-hand side of the website.
2- Select the "flexibility (stretching)“ icon at the bottom of the page.

3- Select the "Chair Exercises" icon.

4- Click on “Add Hamstring stretch (Sitting) to my plan” to add the exercise to your plan.
5- Select “Dashboard” on the left-hand side of the website.
6- Choose “My Plan” from the control panel sub-bar.
7- Look for the exercise “Hamstring stretch (Sitting)” in your plan.

Task #7: Signing out
1- Select “Sign out” on the left-hand bar of the website.

دليل الاستخدام

المهمة الأولى: الدخول لموقع تراك - السعودية من محركات البحث

١- قم بالدخول الى اي متصفح انترنت تملكه على جهازك حاليا (سفاري، كروم، فايرفوكس).
٢- قم بالكتابة في شريط الموقع الموجود في اعلى الصفحة الرابط التالي
http://traksa-intervention.uat.ctr.cardiff.ac.uk

المهمة الثانية: تسجيل الدخول لحسابك الشخصي بالموقع

١- قم بتحويل الموقع للغة العربية عبر الضغط على كلمة "**العربية**" في زاوية الموقع العُليا.
٢- قم بالضغط على "**تسجيل الدخول**" في الشريط الايمن للموقع.
٣- قم اولاً بادخال المعلومات التالية:
اسم المستخدم:
كلمة المرور:
ومن ثم قم بالضغط على "**تسجيل الدخول**"

المهمة الثالثة: تعبئة الاستبيانات

١- قم باختيار "**استبياناتي**" في الشريط الايمن للموقع.
٢- عند الانتهاء، قم بالضغط عل كلمة "**حفظ**" في أسفل الصفحة.
٣- قم باختيار الاستبيان الثالث والمسمى "**استبانة الالتهاب المفصلي العظمي وإصابات الركبة**"
٤- قم بتعبئة الاستبيان كاملاً عبر اختيار الاجابات المناسبة لك.
٥- عند الانتهاء، قم بالضغط عل كلمة "**حفظ**" في أسفل الصفحة.

المهمة الرابعة: الوصول الى معلومة في الموقع

١- قم باختيار" **بوابة المعلومات** "في الشريط الايمن للموقع.
٢- قم باختيار" **التمارين الرياضية وألام الركبة**"

٣-قم بالنزول الى أسفل الصفحة حتى تصل الى العنوان الجانبي" **هل يجب وضع اهداف؟** ".

٤-قم بقراءة النص تحت هذا القسم وأخبرنا إذا يمكن مناقشة الأهداف مع اخصائي العلاج الطبيعي ام لا.

المهمة الخامسة: تحديد هدف رياضي

١- قم باختيار "**لوحة التحكم**" في الشريط الايمن للموقع.
٢- قم باختيار "**الأهداف**" من الشريط الفرعي للوحة التحكم.
٣- قم باختيار "**اضف هدف جديد**" لإضافة هدفك الرياضي.
٤- قم بكتابة "المشي ١٠٠٠٠ خطوة" في مربع "قم بوصف هدفك".
٥- قم بكتابة "خلال شهر من الان" في مربع "متى ترغب بتحقيق هذا الهدف".
٦- قم بكتابة "رفع عدد الخطوات ١٠٠٠ خطوة كل ٣ أيام" في مربع "ماذا تحتاج حتى قوم بذلك".
٧- بعد الانتهاء، قم بالضغط على "**قم بحفظ الهدف**".
قم بحفظ الهدف غلط
ولما اضغط عليه تجي صفحة بيضا

المهمة السادسة: اضافة تمرين رياضي لخطتك

١- قم باختيار "**بوابة التمارين الرياضية**" في الشريط الايمن للموقع.
٢- قم باختيار ايقونة "**تمارين المرونة**" في أسفل الصفحة.

٣- قم باختيار ايقونة "**تمارين الكرسي**".

٤- قم بالضغط على "**أضف إطالة عضلة الفخذ الخلفية (أثناء الجلوس) خطتي**" لاضافة التمرين الى خطتك.
٥- قم باختيار "**لوحة التحكم**" في الشريط الايمن للموقع.
٦- قم باختيار "**خطتي**" من الشريط الفرعي للوحة التحكم.
٧- تأكد من وجود التمرين "إطالة عضلة الفخذ الخلفية (أثناء الجلوس)" في خطتك.

المهمة السابعة: تسجيل الخروج
١- قم باختيار "**تسجيل الخروج**" في الشريط الايمن للموقع.

Appendix U: Ethical approval from Cardiff university for Phase 2

CARDIFF UNIVERSITY
PRIFYSGOL CAERDYDD
School of Healthcare Sciences
Ysgol y Gwyddorau Gofal Iechyd

Interim Head of School and Dean /Pennaeth yr Ysgol Dros Dro a Deon Professor David Whitaker

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13 May 2021

Shaima Al Jahdali
Cardiff University
School of Healthcare Sciences

Dear Shaima

Research project title: TRAK-Saudi a web-based approach to support self-management in patients with chronic knee pain in Saudi Arabia: A usability study

SREC reference: REC625

The School Of Healthcare Sciences Research Ethics Committee reviewed the above application via its proportionate review process.

Ethical Opinion
The Committee gave:

> a favourable ethical opinion of the above application on the basis described in the application form, protocol and supporting documentation.
>
> Please address the issues below:

Some comments on the PIS have not been actioned and need addressing:

The risks have not been identified.

More detail is needed as to where the data is stored i.e. CU server.

More detail needed on What if there is a problem - in line with the guidance document.

Check the PIS and consent forms as consent forms refer to interviews, and the information sheet refers to 2 questionnaires about opinions.

What are the possible benefits of taking part?

"There will be no direct advantages or benefits to you from taking part, but your contribution will help us understand more about the opinion of Saudi patients with knee problems and physiotherapists of this new website. This could help in improving the health services provided to patients in physiotherapy departments".