An exploration of the potential contribution of a medication management app in heart failure outpatients' care: the experiences of staff and older patients

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Declaration

I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy is entirely my own work, and that I have exercised reasonable care to ensure that the work is original, and does not to the best of my knowledge breach any law of copyright, and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

Signed:  ___________

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List of Abbreviations

ARCH	Applied Research for Connected Health
App	Mobile application
CCIO	Council of Clinical Information Officers
CIO	Chief Information Officer
CVD	Cardiovascular diseases
DHI	Digital Health Intervention
ECME	Eastern Corridor of Medical and Engineering Centre
eHealth	Electronic Health
EHR	Electronic Health Record
EU	European Union
GP	General Practitioners
HF	Heart Failure
HFpEF	Heart Failure with preserved ejection fraction
HFrEF	Heart Failure with reduced ejection fraction
HSE	Health Service Executive
ICU	Intensive Care Unit
ICT	Information and Communication Technology
mHealth	Mobile Health
NHS	National Health Service
NPT	Normalisation Process Theory
RCT	Randomised Control Trial
TILDA	The Irish Longitudinal Study on Ageing
WHO	World Health Organisation

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Published abstract

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Abstract

"An exploration of the potential contribution of a medication management app in heart failure outpatients' care: the experiences of staff and older patients in a heart failure clinic"

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Background: Managing the care of older adults with Heart Failure (HF) largely centres on symptom and medication management. Medication management in patients with HF is challenging due to frequent medication adjustments in response to changes in their symptomatology and polypharmacy. Some patients with HF typically take on average 10-25 tablets daily. Given the complexity of HF self-management, assisting older adults in managing their own care at home is critical to the success of HF management.

Aim: To explore the role of a medication management app in supporting the care of older adults attending a HF outpatients 'clinic and the impact of this new intervention on staff working practices.

Methods: Mixed methods sequential design to test the feasibility of a medication app with HF patients. Observations of clinical practice were conducted followed by semi-structured interviews with healthcare professionals (HCPs) and patients pre- and post-intervention. Interviews were transcribed and analysed using thematic analysis, the Normalisation Process Theory (NPT) framework was used to capture challenges and facilitators to technology use in phase three. A systematic search of apps was also conducted to identify commercially available apps with a medication functionality, followed by an evaluation of apps using a validated tool. The optimal app was selected and implemented in a three-month intervention with patients attending the HF clinic. A case study strategy was used to present the experiences and opinions of HCPs and patients using the app.

Findings: Patients normalised the use of the app and found it easy to use after training for medication self-management at home. HCPs found the use of the app to empower patients and to assist them in maintaining an up-to-date medication list and concluded that the use of the app was beneficial to both HCPs and patients. However, several challenges need to be overcome before implementing and scaling up this intervention. Some of the barriers to technology uptake identified in this study were: HCPs attitudes towards older people using technology, lack of managerial support and the need for training and ongoing technical support for older adults

Conclusion: The use of the NPT framework captured individual and organisational barriers and facilitators to the normalisation of the use of the medication app with HF older patients. These barriers need to be overcome to enable the implementation and scaling up of this intervention. The findings of this feasibility study are encouraging and warrant further investigation to test the effectiveness of a medication app with HF older adults at a larger scale in future studies.

Chapter 1: Contextual background

In this chapter the relevant background to the research will be described. It includes a discussion of the demographic trends in Ireland and information related to the current understanding of HF, policy responses to HF and the challenges of poly-pharmacy for HF patients. The chapter also defines the term mobile health (mHealth), mobile applications (apps), and the potential benefits mHealth offers to older people, specifically during the COVID-19 pandemic. Finally, the setting, aim of this study and the research questions were provided and an outline for this thesis was summarised.

1.1 Background of this study

Life expectancy is growing faster in Ireland than anywhere else in Europe (Health Service Executive 2018). Within the over 65 populations, cardiovascular disease (CVD) is the leading cause of death and the cost associated with treatment is increasing rapidly (Department of Health and Children 2010). There has been growing interest regarding the ability of mHealth to reduce the increasing burden of chronic diseases, including HF, on healthcare systems. The potential for transformational change comes from patients using digital tools to self-manage their condition outside of hospitals, promoting adherence to treatment and lifestyle changes. To date however cardiac care, including rehabilitation, remains hospital centred. Moreover, mHealth has not been widely used with older patients. Evidence suggests HCPs remain concerned about the ability of technology to monitor patients' conditions and adherence (Deloitte 2015).

This study forms part of a four-year, INTERREG VA-funded initiative, the Eastern Corridor Medical Engineering Centre (ECME). The Eastern Corridor Medical Engineering Centre is a collaborative research initiative focused on improving cardiovascular health. The ECME is a partnership between 5 leading academic research centres based in Ireland, Scotland and Northern Ireland, and the Southern Health & Social Care Trust. The goal of the ECME initiative is to create better models of heart disease care through research (via 24 PhD students) and developing generic solutions for the remote patient monitoring market with a specific focus on:

- developing cardiac big data databases within the region
- enhancing user ready sensor technology
- improving smart wearables
- reducing the complexity and cumbersomeness of point of care diagnostics
- improving smart clinically relevant monitoring in the AAL and rehabilitation environments (Eastern Corridor of Medical and Engineering Centre n.d.).

The study is led by the NetwellCASALA Research Centre in Dundalk Institute of Technology. The aim of this study is to explore the role of mHealth medication management apps in supporting the care of older HF outpatients and the impact that mHealth has on staff working practices. The HF team, at Our Lady of Lourdes Hospital, Drogheda, Co. Louth, collaborated in this research (please see Appendix A, letter of support from Dr. Murphy, consultant cardiologist).
The PhD candidate and primary researcher is a registered general nurse with over 20 years of experience, with an MSc in Ageing, Health and the Environment completed in 2013.

1.2 Introduction and rationale for the study

1.2.1 Demographic trends

In Ireland, the proportion of the population aged over 65 years is increasing by 20,000 each year, with the largest proportional increase occurring in the oldest-old (i.e. people aged 85 years or over). By 2026, one quarter of Ireland's population will be aged over 85 years (Houses of the Oireachtas 2017b). This age group has the most complex care needs due to a greater prevalence of multi-morbidity[1] (Central Statistics Office 2017).

Similar demographic trends are being witnessed in developed countries around the world. According to data from the World Population Prospects 2017, the number of people aged 60 years or over is expected to more than double by 2050 and more

[1]Multimorbidity refers to the coexistence of two or more chronic conditions.

than triple by 2100, rising from 962 million globally in 2017 to 2.1 billion in 2050 and to 3.1 billion in 2100 (United Nations, Department of Economic and Social Affairs, Population Division 2017). Within the European Union (EU), evidence that the old-age dependency ratio – the number of people aged over 65 relative to the working age population – will rise by 20% between 2016 and 2070 to reach 52% by 2070, has raised concerns for the sustainability of health care systems (European Commission 2018a).

1.2.1.1 The trend towards mobile technology in health care

There is an increase of the number of people using mobile technologies, particularly mobile phones (Pew Research Centre 2015). An information and communications technology (ICT) survey conducted in Ireland in 2018 showed that most internet users (90%) owned a smartphone (Central Statistics Office 2018). Likewise, the Global Mobile Consumer Survey 2019 report found that 96% of Irish people owned a mobile phone and from those, 91% owned a smartphone (Deloitte 2019). In 2018, another Deloitte report stated that the use of computer tablets by those aged 65 and over increased from 57% in 2017 to 70 % in 2018 (Deloitte Ireland 2018). Furthermore, a TILDA report found that Irish older adults utilisation of technology also increased during the COVID-19 pandemic (The Irish Longitudinal Study on Ageing 2021).

Several studies point to the changes in lifestyle and patterns brought about by restrictions imposed of society during the global pandemic. As an identified vulnerable group at risk of the most severe adverse outcomes associated with the SARS-CoV-2 virus, older adults were encouraged to make more use of technologies to stay in contact with family and friends (White et al. 2020).

1.3 Heart failure

While increasing longevity is a welcome development, suggesting better lifestyles and living standards, inevitably an ageing population will mean a corresponding increase in demands for care. This is particularly true for the management of chronic illness, chief of which is cardiovascular disease (CVD), the leading cause of death worldwide[2]. One of the most rapidly growing cardiovascular diseases globally is HF, and it is the only major cardiovascular disease on the increase in Europe (The Heartbeat Trust, Irish Heart Foundation and NUI Galway 2015). Heart failure is a chronic condition characterised by the heart's incapacity to pump blood efficiently. A cluster of symptoms accompanies the condition such as dyspnoea (difficulty breathing), fatigue (extreme tiredness/loss of energy) and oedema (swelling of the ankles and/or abdomen) (Health Service Executive 2018), resulting in significant personal, social and occupational impairment. Moreover, HF with preserved ejection fraction (HfpEF), the most common type of HF in older adults, remains without definitive treatment (Butrous and Hummel 2016).

While it can develop at any age, HF becomes more common with increasing age. It is estimated that around 1% of people under 65 years of age have HF, rising to 10% of 75-84-year olds and to 15% in people 85+ (Heartbeat Trust, Irish Heart Foundation and NUI Galway 2015). Heart failure is one of the most common causes of hospitalisation in older patients, accounting for an estimated 20,000 hospital admissions in Ireland each year, 90% of which are emergency admissions. Indeed, HF-related admissions are thought to account for approximately 4% of all inpatient admissions, 7% of all inpatient bed days and approximately 5% of all emergency and acute admissions (ibid).

When older patients are treated for HF, they tend to spend relatively long periods of time in hospital, reflecting the gravity of the condition. The average length of stay in hospital is 11.1 days (The Heartbeat Trust, the Irish Heart foundation and NUI Galway 2015). It is the lengthy and repeated hospital stays required by patients with HF that typically account for most of the economic cost of HF, estimated to be €660 million annually. Moreover, a diagnosis of HF carries substantial risk of mortality. The Framingham Heart Study, a long-term, ongoing cardiovascular

[2] CVD includes all the disorders of the heart and blood vessels, of which there are four main types: coronary heart disease (caused by a reduced flow of oxygen-rich blood to the heart, leading to angina, heart attacks or heart failure), strokes and TIAs - transient ischaemic attacks-   (caused when the blood supply to part of the brain is cut off damaging the brain or causing death), peripheral arterial disease (caused by a blockage in the arteries to the limbs, usually the legs, resulting in a dull or cramping leg pain or persistent ulcers) and aortic diseases (caused by a bulging, weakened aorta which could burst and cause life-threatening bleeding).

cohort study (n= 5,209) which began in 1948 and is now on its third generation of participants, found a 30-day mortality rate of around 10%, 1-year mortality is 20–30%, and 5-year mortality is 45–60% (Lloyd-Jones et al. 2010).

In addition, multimorbidity is the rule rather than the exception among older patients with HF. Consequently, managing the care of older patients with HF is largely about managing the symptoms of HF, alongside other cardiovascular and non-cardiovascular comorbidities (Shakib and Clark 2016). Evidence suggests up to half of all patients with HF have five additional comorbid conditions (Saczynski et al. 2013), such as hypertension, dyslipidaemia, diabetes mellitus, visual impairments, depression and dementia. Furthermore, patients with multimorbidity have worse prognoses as the presence of multimorbidity in patients with HF increases the risk of polypharmacy, readmissions and death (ibid). For the oldest-old care is often further complicated by frailty, a decline in cognitive ability and/or polypharmacy (i.e. the chronic use of five or more medications). The presence of one or more of these factors has been shown to strongly and independently predict hospital admission as well as in-hospital and post-discharge mortality of older patients (Chaudhry et al 2013).

1.3.1 Heart failure and polypharmacy

The progressive use of multiple drugs is common and recommended by international guidelines for HF patients (Ponikowski et al. 2016; McMurray et al. 2012; Dickstein et al. 2008). Therefore, in addition to the medication patients are prescribed for symptom management of HF, such as diuretics, the recommended medical therapy for HfrEF includes beta blockers (BB), angiotensin-converting enzyme inhibitors (ACEI) or angiotensin receptor blockers (ARB), and mineralocorticoid antagonists. In consequence, polypharmacy has been identified as an underestimated challenge in the management of older patients with HF (Butrous and Hummel 2016). Notwithstanding this, the distinction between ‘appropriate’ and ‘inappropriate’ polypharmacy is an important one. ‘Appropriate polypharmacy’ is “prescribing for an individual for complex conditions or for multiple conditions in circumstances where medicines use has been optimised and the medicines are prescribed according to best evidence" (Duerden et al. 2013, p1). The overall intent for the combination of medicines prescribed is to maintain good quality of life, improve longevity and minimise harm from drugs. In contrast, 'problematic polypharmacy' occurs where "multiple medications are prescribed inappropriately, or where the intended benefit of the medication is not realised" (ibid).

Polypharmacy often leads to poor adherence to pharmacological therapies, drug interactions, inappropriate drug prescription, and adverse effects (Butrous and Hummel 2016). Part of the challenge, particularly for older persons set in their daily routines and chronically ill older persons, is the difficultly in making consistent change (Lam et al. 2013). This is compounded by the fact that many older patients may assume that the multiple healthcare professionals (HCPs) involved in treating their health conditions are aware of the medications they are taking, when this is often not the case. In practice, care for older patients has been seen to be characterised by poor communication and coordination and a system not designed around the needs of older patients (NHS England 2014). This draws attention to the need for new models of care to improve the management of older patients with HF, including a model which promotes and supports better self-care and greater patient empowerment. In addition, there is an urgent and growing need for the multiple complex interactions in the care of older HF patients to be better delineated and more fully integrated into routine clinical decision-making and medication management for older patients with HF (Schwartz et al. 2018).

1.4 Policy responses to heart failure amongst older adults

Policy responses to population ageing increasingly promote interventions that enable people to be active participants in their "care", reflecting the concerns of government to address the twin challenges of chronic illness and population ageing through greater self-management and patient empowerment. The "Living Well with a Chronic Condition: Framework for Self-Management Support", for example, highlights the Health Service Executive's (HSE) vision for patients with non-communicable diseases to self-manage their illness (Chronic Conditions Working Group 2017). Outlining actions, interventions and resources the HSE use to support patients to self-manage their illness at home, it draws attention to the need for patients to avoid heavy reliance on the healthcare system and to adopt an autonomous approach by taking more responsibility for self-management of their chronic illness(es). It also emphasises the importance of HCPs listening to the lived experiences of patients self-managing at home, their preferences and challenges and recognising how social contexts and relationships may affect behaviour. Similarly, shifting HF care from hospital-based to community-based care is one of the recommendations of the National Cardiovascular Health Policy to improve the interface between primary, secondary and tertiary care (Department of Health and Children 2010). This is seen to offer the potential to facilitate effective communication channels between GPs and cardiologists based on the community HF specialist nurse role, which includes visiting patients in their own homes. Shifting care, where possible, out of hospitals and into the community is seen to be in the best interests of patients since, given the choice, most people would prefer to live at home (Roy et al. 2018). It is however noteworthy that the HSE plans to undertake this transition in care while experiencing the longest period of funding constraint in its history, even before the COVID-19 outbreak. Collectively, these drivers contribute to a renewed context for care directed at older people living with chronic conditions in Ireland.

1.5 Mobile health (mHealth) and COVID-19 context

Given the complexity of HF self-care, assisting older patients to manage their own care at home is central to the success of HF management. Emerging evidence suggests that mHealth, particularly mobile technologies, can serve as a form of support for patients with HF and may enhance patient-provider collaboration for self-management (Torous et al. 2020; Athilingam and Jenkins 2018). By their nature, mobile devices, such as phones are carried by people and therefore are always with them, offering opportunities beyond simple remote monitoring towards assisting with the management of care. In the context of the COVID-19 pandemic, when the community (and especially older adults) were requested to maintain social distancing, the public health landscape is changing and mHealth has never been so important for treatment (Torous et al. 2020; Ting et al. 2020; Greenhalgh et al. 2020).

For older adults, social isolation and loneliness increases the risk of anxiety, depression symptoms, heart disease, reduction of activities of daily living, morbidity and mortality (Santini et al. 2020; Shankar et al. 2017; Steptoe et al. 2013; Holt-Lunstad et al. 2010; Barth et al. 2010). Government recommendations to self-isolate during this pandemic has undoubtedly had a detrimental effect on older adults, including those that previously had a wide social connection ties with the community and relatives (Marston et al. 2020; Armitage and Nellums 2020). Older patients previously attending the HF clinic have seen their access restricted. Also, during the COVID-19 pandemic in Ireland, the Health Service Executive website noted that all out-patient appointments are postponed until further notice (Health Service Executive 2020). Clinicians working at the HF clinic were seeing a much-reduced number of patients, with most consultations taking place over the phone, bar medical emergencies. In Ireland, McGlynn (2020) has drawn attention to the sharp decline in cardiac outpatients' appointments during the period March to April 2020 (300,000 appointments) compared to the same period in 2019. Therefore, the need for new models of care in this changed environment to support older adults at home to alleviate their mental and physical burden as well as providing medical care are especially timely (Torous et al. 2020; Greenhalgh et al. 2020).

In America, a ten-fold increase in virtual consultations in the space of just a few weeks was described as, 'as big a transformation as any ever before in the history of US health care' (Webster 2020, p. 1180). Likewise, Canada, South Africa, India and UK shifted to virtual consultations at an exponential rate. This shift was described as *"incredible. [COVID-19] has done what we couldn't do until now, because, suddenly, it's not just the patient who might die— now it's the doctor who might. So, the doctors are highly motivated. The risk–benefit ratio for virtual health care has massively shifted and all the red tape has suddenly been cut."* (ibid p. 1181). The COVID-19 crisis prompted patients and clinicians to use technology, bypassing previous uncertainty and personal concerns towards technology adoption. *"The regulatory barriers that have held virtual health care back for all these decades were never justifiable" … "[COVID-19] is an opportunity to blow all these barriers away*" (ibid). This suggests that for older adults with HF unable to physically access the HF clinic, a medication app can potentially support them to remotely manage their medication regimen, one of the key components of HF self-management.

1.6 mHealth and apps

The term electronic health (eHealth) was first coined by Eysenbach almost 20 years ago and refers to *"health services and information delivered or enhanced through the Internet and related technologies"* (Eysenbach 2001). It is an umbrella term that encompasses many subtypes for example, mobile health (mHealth), telemedicine, digital health and telehealth. For the purpose of this study, the focus is on mHealth and the use of mobile communications technologies for health and in particular the use of apps.

Health and wellness apps offer health-related services on smartphones, tablet computers and other communication devices. Health apps are defined as any commercially available health or fitness apps with capacity for self-monitoring and improving patient compliance with treatment recommendations (World Health Organization 2011). The distinction between a health and fitness app (sometimes called a wellness app) and a medical app is not clear. Apps that support users' wellbeing (e.g., support smoking cessation, mindfulness or levels of physical activity) are considered to be health or wellness apps (Health Products Regulatory Authority 2017). However, if an app is designed to support users to track their vital signs or to receive medical advice, then it is considered to be a medical app and thus deemed a medical device (ibid). Medical apps are created for the healthcare sector (Mulder 2019) although several apps are listed under the medical app category in the app stores and are not considered medical devices. To add to the confusion, health apps are also known as mobile health applications (mHealth apps), but this term should only be used when HCPs are using the app concomitantly with users to enhance their treatment and care (Monsenso ApS 2018).

The European Commission's eHealth Strategy promotes the use of mHealth to deliver cost-effective, sustainable person centred care (European Commission

2018a). In 2017, a pilot study was conducted in the UK to test the feasibility and acceptability of prescribable apps and, in 2019, the pilot was rolled out nationally in England (MobiHealthNews 2019). English HCPs can now download the "AppScript" to access the National Health Service (NHS) App library for a list of all recommended apps for prescription (Byambasuren et al. 2018). In contrast to this, Irish HCPs are not able to recommend health apps. Plans on digital healthcare in Ireland were announced in 2019 for the start of the Individual Health Identifier [IHI] and trial of telehealth projects (Department of Health 2019) but only a small number came to fruition. However, the Irish mHealth landscape may be set to improve following the Government announcement in 2019 of €20 million funding for 122 eHealth projects under the "Sláintecare Integration Fund." Sláintecare is a government of Ireland 10-year policy commitment that aims to transform the health and social care of Irish citizens. One of the strands, the Integration Fund, is concerned with the testing and scaling up of projects providing a new way of care, including mobile health technologies (Government of Ireland 2020).

Evidence from elsewhere suggests that many patients are tracking their health data with wearables and through wellness apps and willing to share their data to improve their health or the device's performance (Deloitte 2015). However, while mHealth has considerable potential to reshape healthcare delivery, there is limited evidence base supporting the role that apps may play in healthcare (Torous et al. 2018; Miner et al. 2014). Clinicians are calling for better understanding on how apps work before recommending them to their patients (Rowe and Sauls 2020; Hempel et al. 2018; Boudreaux et al. 2014). The findings from this study, which is based on older patients attending a HF clinic, will contribute to a better understanding of the potential contribution apps can make to the care of the growing number of older patients with HF. This is the first study in Ireland to test a medication app with older adults with HF.

1.7 Aim of Study

The aim of this study is to explore the role of a medication management app in supporting the care of older adults attending a HF outpatients 'clinic and the impact of this new intervention on staff working practices.

Phase 1 aimed to answer the following research questions:

- What are HF HCPs' attitudes towards technology in care of older patients?
- What factors affect job satisfaction and technology acceptance among HF HCPs?
- What are the barriers and facilitators for the adoption of a medication app in the care of HF older patients?

Phase 2 aimed to review commercially available apps with a medication functionality in order to identify a medication management app for inclusion in Phase 3 of this study.

Phase 3 aimed to implement a three-month intervention (use of the app identified in phase 2) with patients attending the HF clinic. It also elicited opinions, perspectives and experiences of older people using the medication app and of HCP working in the HF clinic, pre-and-post intervention.

Phase 4 aimed to produce four case studies to compare the experiences and opinions of HCPs and HF patients about the medication app and to present the findings.

1.8 The setting for this study

The fieldwork for this study was based on patients aged over 65 years attending the HF Clinic at Our Lady of Lourdes Hospital, Drogheda. The HF team at Our Lady of Lourdes Hospital includes a consultant cardiologist, three clinical nurse specialists, and supportive help from a pharmacist, dietician, physiotherapist and medical social worker. The goal of the HF team is to optimise the management of patients with heart failure admitted to hospital. The work which takes place in the clinic is designed to:

- improve the post-discharge management of patients.

- educate patients and families on how best to manage HF.
- improve patients' quality of life and reduce hospital readmissions.

The daily work practices in the clinic involve:

- reviewing prescribed medications to ensure patients receive appropriate medications in effective doses.
- reviewing clinical status and blood chemistry after any changes are made to medications/doses.
- providing tailored education, advice, and support to families.
- providing advice to patients on lifestyle changes.
- providing reviews by dietician, pharmacist, physiotherapist and other members of the HF multidisciplinary team, as necessary.
- providing access to a specialist nurse for patients/carers so that early clinical deterioration is detected and treated before symptoms become severe.

On discharge, patients receive a weekly telephone calls for 3 months and attend the HF clinic on 3 occasions during this period (or more frequently if required). Patients are encouraged to 'phone-in' a weight gain of 2kgs/2days so that adjustment to their diuretic regime may be made over the phone.

1.9 Overview of the thesis

Chapter 2 presents a literature review related to the current scientific understanding on issues related to technology in care, with an emphasis on barriers and facilitators and the impact of mHealth interventions.

Chapter 3 presents a discussion on the theoretical frameworks used in this study and a rationale for other theories that were considered at the start but discarded at a later stage.

Chapter 4 outlines the overall design of the thesis and was divided into four sections (phases): section one explored the views and experience of HCPs about technology use in the care of older patients attending a HF clinic. In section two, a systematic search and review of commercially available apps with a medication functionality was conducted, followed by a comprehensive literature search and review of medication apps. Section three of chapter 4 presents a discussion of the trial of the app with HF patients and in section four, four case studies were formulated to compare the experiences and opinions of the HCPs and HF patients about the use of medication app.

Chapter 5 follows, presenting the results and chapter 6 discuss the interpretation of the results, strengths and limitations and the conclusions of this study.

Chapter 2: Review of the Literature

2.1 Introduction

Heart failure is the chief cardiovascular condition leading to hospitalization and rehospitalisation in older adults, with significant cost implications for the State and quality of life of older patients and their families. TILDA, The Irish Longitudinal Study on Ageing, found medications used to treat cardiovascular conditions (mainly high blood pressure and heart disease) are the most common medications contributing to polypharmacy (Richardson et al. 2012). In addition, although one in three people aged over 65 years report polypharmacy, they are responsible for more than half of hospital outpatient and inpatient visits in this age group.

Medication nonadherence is a common, complex, and costly problem that contributes to poor treatment outcomes and consumes health care resources. Yet, despite the prevalence of the problem, clinical recognition of non-adherence remains poor. The TILDA report draws attention to the need for regular medication reviews by health professionals managing the care of older patients taking five or more medications (ibid). The growing emphasis in healthcare systems on maximising value from spending on medicines also makes it imperative that older HF patients take their medicines as directed. Apart from this, adherence to medication is first and foremost about patients because it results in better health outcomes for patients.

Medication apps for an android or iPhone allow patients to track their medications and set up reminders so they do not miss a dose. A recent report by the World Health Organization (WHO) argues technology could improve both patient experience and medication adherence and highlights the potential for enabling patients to be active participants in medication reviews (WHO 2019). However, it points out more research is required to evaluate strategies for integrating health apps and other technology into clinical practice to ensure they meet their potential in improving patient outcomes and creating value for all users. In addition, while there have been some interventions that have used apps for adult medication management of chronic conditions including heart failure (Anglada – Martinez et al. 2016; Goldstein et al. 2014), use with older adults has been limited and specifically linked to tele monitoring pilots. The influence of apps on enhancing medication management for older adults therefore remains largely unexplored (Conway et al. 2018).

The primary objective of this literature review is to identify and discuss literature that informs debates on the role of medical apps to enhance HF care and medication management for older patients. The literature reviewed was generated from a search of scholarly articles, books and other sources (e.g. conference proceedings).

2.1.1 Search methods for identification of studies

A literature search of peer reviewed articles was conducted in 2019. The key search terms used were: heart failure OR heart disease, older people OR older adults, healthcare professionals OR healthcare staff, healthcare professionals' attitudes towards technology, job satisfaction, patient satisfaction, technology barriers AND technology facilitators, mHealth, mobile health, mobile health applications and medication apps.

Databases included eBook Collection & eBook Academic Collection (EBSCOhost), Complementary Index, Academic Search Complete, CINAHL Plus with Full Text, Business Source Complete, and ScienceDirect. Manual searches were also conducted in Google Scholar. Articles included were written in English and most of the articles were written from the year 2000 onwards reflecting the availability and use of mobile health technologies.

2.2 Healthcare professionals' attitudes to mHealth

While some studies have explored the uptake of health technologies and perceptions of HCPs, further work is required to examine the attitudes and perceptions of HCPs in Ireland regarding mHealth in care practice. According to Jacob et al. (2019), several studies established how crucial the attitudes of physicians are towards the adoption of mHealth. In Spain, Asua et al. (2012) found HCPs were reluctant to utilise health technologies, with subsequent negative implications for uptake by patients. In Canada, Gagnon et al. (2003) found self-awareness of technology among physicians directly influenced the level of usage in care practices. In Hong Kong, perceptions of effectiveness and efficacy were found to be critical factors for adoption in care practice (Chau and Hu 2014) and in the UK the importance of trust and a sense of security have been highlighted (Sharma et al. 2010). In Germany, a mHealth study reported that the less experienced HCPs were more inclined to accept mHealth solutions than their counterparts (Grass et al. 2018) more details overleaf. In Ireland, a study was conducted to explore the attitudes of HCPs towards electronic data sharing using the Electronic Health Record (EHR) system. According to the findings, while Irish HCPs are supportive of the EHR system and found it to be beneficial for patient outcomes and safety, they are concerned about patient confidentiality and data security (O'Malley et al. 2010). However, as noted earlier, there is a dearth of literature on HCPs attitudes and perceptions towards mHealth in Ireland.

More recently, the Applied Research for Connected Health (ARCH; a collaboration with University College Dublin and the National University of Limerick) in conjunction with the HSE conducted research to explore healthcare personnel views on readiness to adopt eHealth. The participants interviewed were Council of Clinical Information Officers (CCIO). CCIO's were described as "HSE clinical staff who have direct experience or a particular interest in using eHealth within clinical practice" (Applied Research for Connected Health n.d., p.1). Preliminary conclusions reported that the majority of CCIOs agreed that their organisations are ready to implement mHealth (ibid). However, the participants' responses do not represent the Irish HCPs working on the frontline, as CCIOs are staff with direct experience or interested in using mHealth in clinical settings, however, they are not frontline workers (those who will be exposed to mHealth on a daily basis). Therefore, in Ireland, there is a dearth of information on the readiness of HCPs working in the front-line to adopt mHealth. Very few studies were found exploring the views of Irish HCPs towards mHealth (Lolich et al. 2019; Murphy et al. 2017a; Murphy et al. 2017b; Doyle et al. 2016; MacFarlane et al. 2006).

2.3 Barriers and enablers to technology in care

Barriers to technology in care are multifactorial and can be experienced at different levels: including technology adoption (Lee and Coughlin 2015), implementation

(Ramsey et al. 2016), and at organisational (Harst et al. 2019) and individual (i.e. lack of digital skills; Göransson et al. 2018). This section will focus on barriers affecting technology in care adoption from the individual level from the clinician's perspective.

Despite mHealth promises of delivering better quality of care and alleviating pressure points in healthcare systems, clinicians remain cautious on mHealth adoption. Research highlights personal concerns such as increased costs of equipment, internet ubiquity, increased workload, interoperability and awareness of mHealth (Jacob et al. 2020; Carayon et al. 2019; Cowan et al. 2019; Klocek et al. 2019; Keyworth et al. 2018; Gagnon et al. 2016). Clinicians are concerned about the costs of software, hardware and maintenance of equipment, the poor or unreliable internet connectivity and how mHealth might affect their already overstretched working hours. Another barrier is HCPs different levels of eHealth and ICT preparedness and readiness. De Rosis and Seghieri (2015) reported on 31 European countries basic level of ICT use in primary care and found Czech Republic to be a laggard compared to Northern European countries. The low rate of adoption in the Czech Republic was confirmed four years later in a cross sectional study by (Klocek et al. 2019). Klocek et al. (2019) conducted a cross sectional mixed methods study in the Czech Republic and found ICT adoption rates by GPs practices low compared to other European countries. In Czech Republic, a single-GP practice is commonplace and according to the findings, ICT tools are less used in single-GP practice than in GP cooperatives, a practice more common in Ireland (ibid). The study highlighted the digital divide between young and older age GP's, with older GPs less likely to embrace ICT tools in their practice and appeared to be concerned with technology substituting HCPs face to face care, lack of digital literacy, technical support and infrastructure. Another personal barrier is that most of GPs in the Czech Republic are not motivated to use ICT tools to provide patient care, beyond administration purposes (ibid).

On the other hand, the adoption and use of care technologies depended on personal views and opinions of HCP (Safi et al. 2018). Perceived usefulness and prior experience of technology are cited in the literature as facilitators supporting and enhancing the adoption of technology in care by HCPs (Jacob et al. 2020; Pan et al.

2019; Abbas et al. 2018; Gagnon et al. 2016). Clinicians consider using technology if they perceive it to be advantageous and if it provides accurate clinical information in a timely manner (Pan et al. 2019; Safi et al. 2018; Ganasegeran et al. 2017). Furthermore, they will “buy in” if they consider that technology will support their clinical practice, freeing time to attend other non-clinical tasks (Grassl et al. 2018; Sweeney et al. 2018). Jacob et al. (2019) investigated the role of HCPs in the adoption of a clinical decision app. Interviews were conducted with HCPs from several European countries (including Ireland). Participants agreed that by using the app their clinical practice was more efficient, less time consuming and their patients had better outcomes. This was echoed by another study where physicians perceived telemedicine as an opportunity to reduce their workload and allowing them to attend patients presenting with medical emergencies (Grassl et al. 2018). Interestingly, the authors reported that less experienced healthcare staff were more inclined to accept eHealth solutions than their counterparts. A number of studies have found that younger (Hofer and Haluza 2019; Olok et al. 2015; Kuhn et al. 2014) and less experienced HCPs (Grassl et al. 2018, Kayyali et al. 2017) are more likely to use mHealth in clinical practice than their older and more experienced counterparts. This finding has also been observed in a number of countries, including Uganda (Olok et al. 2015), Austria (Hofer and Haluza 2019, Germany (Grassl et al. 2018) United States of America (Kuhn et al. 2014) and England (Kayyali et al. 2017). Grassl et al. (2018) also reported that having previous knowledge or feeling comfortable with the use of smartphones and technology facilitated technology use and adoption. Hofer and Haluza (2019) also described how younger and digitally proficient Austrian clinicians were comfortable using medical apps when consulting patients.

Likewise, an RCT investigated HCPs’ experiences and perceived usefulness of an app supporting pregnant women (Garnweidner-Holme et al. 2018). The app allowed pregnant women to access health information at their own convenience after consultations and record their blood glucose levels. Overall, the app was well accepted by HCPs and most of them had participated in previous mHealth projects. Another study from United States reported similar findings. Kuhn et al. 2014 investigated mental health practitioners’ opinions towards a novel approach using an app to treat patients with post-traumatic stress disorder. Clinicians with previous experience of using apps for medical care purposes found the app to be very beneficial and stated they were willing to use the app in their own medical practice. In Australia, implementing e-mental health services for the Aboriginal and Torres Strait Islander community is one of the key priorities of government. Interviews with stakeholders (managers, director of services, health and social care practitioners) were conducted to investigate their opinions and views on e-mental health programs (Puszka et al. 2016). Findings emphasized that previous exposure and experience of clinicians on mHealth projects is a facilitator for adoption of care technology, and that barriers to the uptake of e-mental health services by Australian HCPs remain (ibid). Concerted efforts are necessary to change policy and practice to imbed the use of mHealth into routine care (Hofer and Haluza 2019) while responding to HCP concerns on technology adoption.

2.4 Job satisfaction and technology in care

The use of digital technology may influence job satisfaction and staff retention (Simon et al. 2019; Sweeney et al. 2018; Lopez and Fahey 2018; Tiwari and Bhagat. 2018). A large body of evidence has reported HCPs high levels of stress, anxiety and burnout (Mufarrih et al. 2019; Simon et al. 2019; White et al. 2019; Sulaiman et al. 2017; Khamisa et al. 2015; Rama-Maceiras et al. 2012). This has been linked to job dissatisfaction, poor communication, staff retention and lower levels of patient care, outcomes and safety (Bridgeman et al. 2018; Rama-Maceiras et al. 2012). The link between job satisfaction and technology in care has been observed in several countries, including Ireland (Sulaiman et al. 2017), South Africa (Khamisa et al. 2017; Munyewende et al. 2014), Germany (Brattig et al. 2014), United States (Waddimba et al. 2019; Randolph and Johnson 2005), Indonesia (Margahana and Haryono 2018) and Australia (Scanlan and Hazelton 2019). Job satisfaction and technology has also been explored in nurses (for a cross sectional study see Khamisa et al. 2017), physicians (for an observational study using secondary analysis data from a quasi-experiment see Waddimba et al. 2019), physiotherapists (for a cross-sectional study see Brattig et al. 2014), occupational therapists working in mental health services (for a quantitative study see Scanlan and Hazelton 2019), anaesthetists (for a cross sectional study see Chiron et al. 2010), primary health care clinic nursing managers (for a cross sectional study see

Munyewende et al. 2014) rehabilitation professionals (Randolph and Johnson 2005) and paramedics (for a quantitative research which developed a research instrument of job motivation and satisfaction see Margahana and Haryono 2018).

According to the findings of a recent study conducted in a hospital setting with resident physicians, technological advances improved HCP job satisfaction and intention to stay (Sweeney et al. 2018). Tablet computers enabled patients' data to be accessed remotely by physicians while visiting inpatients in the ward. Using the tablet, physicians were able to access medical records of their patients, write notes, access laboratory test results and share patient updates with other clinicians (ibid). The physicians reported high levels of job satisfaction (84 %) with the new system, with decreased overtime hours and increased intention to stay also observed. Radiologists are a particular group of HCPs at high levels of burnout and job dissatisfaction (Simon et al. 2019) due to their work overload. Before the introduction of Picture Archiving and Communication Systems (PACS) in the 1990's, radiologist had the support of technical staff completing noninterpretive duties, for example, transcribing or typing reports. PACS arrival meant computerising all tasks (interpretative and noninterpretative) so all the technical support staff eroded over time (Simon et al.2019). Consequently, radiologist's workload has increased, and they often spend working hours away from their interpretative tasks to fulfil other tasks, occupying up to 45%of their working hours. Simon et al. (2019) argues digital technologies have the potential to decrease radiologists' workload and increase job satisfaction levels. This is supported by Zember et al. (2018) who tested the efficacy of a teleconsultation intervention on 17 occasions between a radiology department and a neonatal and paediatric intensive care unit in 2016. The innovative approach allowed radiologists to remotely assess and diagnose patients. Post-intervention, ICU staff reported an increased level of confidence in radiologist diagnoses (up to a 90% confidence) and radiologists reported higher levels of engagement with the ICU clinical team and greater knowledge of patient cases (ibid). Overall, the virtual meetings improved interdisciplinary communication, enhanced patient care and improved job satisfaction among radiologists. Radiologists are particular important for HF as chest radiographs are used for diagnosing certain types of heart disease (Tailor et al. 2017) and congestive heart failure (Seah et al. 2019).

Bhattacharya and Ramachandran (2015) found that the use of digital technologies can positively influence HCPs retention and job satisfaction. This cross-sectional study was conducted in 20 hospitals in urban India and respondents included doctors, nurses, paramedics and hospital administrators. Most respondents agreed that adoption of health technology was crucial for upskilling staff, raising organisation standards, increasing self-efficacy, reducing costs, helping to make practice more efficient and improving patient satisfaction (ibid). Likewise, Hwang et al. (2016) highlighted how HCP commitment and IT self-efficacy predicted higher levels of job satisfaction. The increase of digital technology use in healthcare may generate significant advantages to HCP including an increase on job satisfaction and retention (Lopez and Fahey 2018; Tiwari and Bhagat 2018).

More recently, Terry and Matthews (2021) investigated the impact of technology usage and perceived usefulness of technology on job satisfaction. The results indicate that perceived usefulness is positively associated with job satisfaction. Notably, this study was conducted amongst HCPs working in rural areas during the COVID-19 pandemic. HCPs working in remote areas are dependent on access to technology to provide healthcare to patients i.e. virtual consultations and accessing information. Thus this study is very timely and arguably lends support to an argument that technology can potentially reduce HCPs burnout and increase job satisfaction, at least for those HCPs working in rural communities.

Most studies investigating a correlation between job satisfaction and the adoption of technology in care employ larger sample than the present study, for example, n=300, n=151 and n=586 (Ofori and Wang 2022; Terry and Matthews 2021; Bhattacharya and Ramachandran 2015) respectively. However, a small pilot RCT study with a sample size of 25 participants investigated job satisfaction of HCPs working in residential settings implementing a new assistive technology intervention (Lauriks et al. 2020). The findings of Lauriks et al. study suggest that job satisfaction was not affected by the uptake of technology. Similarly, a doctoral dissertation with a sample of 5 participants investigated job satisfaction among nurses during the COVID-19 pandemic (Gonzalez 2022). Moreover, another study with a sample of 5 participants employed a mixed methods approach, quantitative to explore job satisfaction and qualitative to provide a deeper understanding of the findings (Malik and Nawar 2018).

2.5 Medication management apps and older people with HF

Managing the care of older patients with HF largely centres on symptom management and medication management (Athilingam and Jenkins 2018). As noted earlier, HF patients typically take a range of medications (polypharmacy) which is associated with poor adherence to pharmacological therapies, drug interactions, inappropriate drug prescription, and other adverse effects. Polypharmacy has been identified as an underestimated challenge in the management of older patients with HF (Butrous and Hummel 2016). A recent report by the World Health Organization (WHO) argues that technology could improve patient experiences and medication adherence and enable patients to become active participants in medication reviews (WHO 2019) potentially reducing the risk of poor adherence. Mobile apps offer the potential to augment care for HF patients. Apps can potentially support older people to find information on the medications (i.e. drug interactions, track their medication, facilitate up-to-date lists of medications, communicate with healthcare providers and record daily blood pressure and weight measurements).

There are several apps supporting HF self-management, but none specifically for management for patients with HF. Most of the self-management apps provide medical advice, allows for daily entry of symptoms and focus on behavioural change. However, as noted earlier, medication management in older adults is challenging (Athilingam and Jenkins 2018; Butrous and Hummel 2016) offering a potential opportunity for self-management apps supporting medication management and keeping an up to date medication list among their purposes. Furthermore, there is a dearth of mHealth research on HF medication management apps. Systematic reviews and evaluations have been conducted exploring apps supporting HF self-care with little or no attention to medication management (Wali et al. 2019; Athilingam and Jenkins 2018; Creber et al. 2016). Also, a HF app proof of concept study (Wei et al. 2018) and RCT (Athilingam et al. 2017) focused entirely on self-management and not medication. Therefore, increased attention from the mHealth research community on HF medication management apps is urgently warranted.

Phase 2 of the present study contributes to the literature with a review of commercially available apps with a medication list functionality using the MARS tool and subsequent intervention (trial of the app with HF patients) in Phase 3.

There are several apps for medication management but there has been no review of medication apps with a medication list functionality specifically for older adults with HF. Goldstein et al. (2014) conducted an RCT with HF older patients to investigate medication adherence using two approaches: telehealth (electronic pillbox) and mHealth (medication app). The authors report an increase in medication adherence rates using both approaches and state that the app intervention was favoured by participants. Most of the participants mastered the use of the devices after training was provided (ibid). Anglada-Martinez et al. (2016) conducted a feasibility study of a medication self-management platform (Medplan) for patients with chronic conditions, including HF. Medication adherence was measured by using two methods: proportion of days covered with medication (PDC) and the self- reported Simplified Medication Adherence Questionnaire (SMAQ). No difference in medication adherence was observed in terms of the PDC at follow-up, however an increase on medication adherence and a decrease of missed doses per day was observed on the SMAQ. According to the authors, this was due, in part, to participants displaying high levels of medication adherence before using Medplan (ibid). The app was widely accepted by participants, with many stating that they would continue to use the app and recommend it to others. Similarly, an RCT investigating the use of apps in care management, focused on patients with coronary heart disease (not specifically HF) and adherence to medication (Santo et al. 2019). Patients were assigned to one of three groups: usual care (no app), basic medication reminder app (My heart, my life app) and advanced medication reminder app (Medisafe app). The trial concluded that both apps were generally well accepted, and participants perceived the apps to be useful to improve medication-taking behaviour and medication adherence. The most useful app features cited by participants were medication reminders and keeping an up-to-date list of medication in an electronic format rather than relying on notes written down on paper.

Evidence suggests that older people with HF and other conditions including cardiovascular diseases are receptive to the use of apps to manage complex medication regimen (Santo et al. 2019; Morrissey et al. 2018). However, there is a dearth of research on medication apps reviews specifically for HF patients. The influence of apps on enhancing medication management for older adults therefore remains largely unexplored (Conway et al. 2018).

2.6 Impact of mHealth interventions

Developing new integrated service models in which hospital and community care work closely together is considered essential for sustainability and affordability of health care systems. In particular, evidence points to the potential benefits of digital health interventions to deliver care effectively and efficiently outside traditional in-person models (Houses of the Oireachtas 2017a). Research suggests that digital health interventions can allow patients to effectively self-monitor chronic illnesses at home in conjunction with health professionals (Deloitte 2015). However, in practice as alluded to above, technology adoption in healthcare continues to lag behind other industries, for example, media and sports. Available evidence from a report suggests that while health professionals appreciate the potential clinical value of digital health interventions, many are not convinced about patient use for monitoring purposes (Deloitte 2015). Consequently, cardiac care remains hospital-centred in Ireland, despite the increasing prevalence of cardiac conditions.

There are potential advantages of mHealth interventions to address care challenges, for example, contacting patients in a timely manner and increased availability of HCPs (Whittaker et al. 2019); promoting patient empowerment in self-management, increasing medication adherence, ubiquitous healthcare provision and maximising treatment for patients (Saner and van der Velde 2016). According to Marcolino et al. (2018) mHealth is commonly perceived as an effective intervention that can be scaled up at a low cost and providing a better healthcare experience for patients. However, challenges to mHealth interventions have also been reported: e.g., poor communication between stakeholders (Saner and van der Velde 2016), increased workload and workflow (Hamine et al. 2015) and users not being proficient in technological advances and refusing to buy into the new care pathway

(Gurupur and Wan 2017). The present study will contribute to the gap in the literature in a number of important ways. It is the first study to take place in a HF outpatients' clinic in Ireland and with older patients in particular. The trial of the app draw attention to how older patients manage their medication with an app and the impact on clinical consultations e.g. quantification of medication errors.

2.7 Impact of mHealth on patient satisfaction

mHealth interventions have been shown to improve patient quality of life, engagement with their treatment, satisfaction and to positively modify behaviour (Payne et al. 2015). Hamine et al. (2015) note how the use of mHealth actively engaged a group of patients that otherwise would not have been motivated to avail of face-to-face health services. mHealth has also been shown to have a positive impact on patients' outcomes including HF patients. A review of systematic reviews reported a reduction of HF symptomatology, a reduction in hospitalisation, death rates and an overall improvement in quality of life (Marcolino et al. 2018). This is a very positive result as patients with symptomatic HF find it hard to cope with activities of daily living and participating in hobbies and interests. However, it is important to explore their satisfaction with mHealth interventions in order to plan for future care delivery and to inform policy and practice.

Results from a cross sectional survey conducted in Italy with over 1,700 participants reported that patient dissatisfaction with healthcare service delivery was a motivation for patients to take up digital health (De Rosis and Barsanti 2016). The study described how many respondents (patients using the public primary healthcare system) would turn to the internet to seek health information material online because they were not satisfied with the health service. Despite that, patients still trusted their family doctor, visited them when needed and shared health information found on the internet with their doctor. This gave patients a sense of empowerment as they were involved in the decision-making process (ibid)

Another mHealth RCT found high levels of patient empowerment and satisfaction (Merchant et al. 2018). The intervention increased patients' awareness of the importance of medication management, they were able to monitor their symptoms daily, educate themselves on their illness, identify triggers and learn how to respond. Patients also felt empowered as they were more confident discussing issues with clinicians. This is echoed by the findings of a systematic review on apps used to modify health behaviours which found that apps were well accepted by users to modify health behaviours and consequently modify health outcomes (Payne et al. 2015).

In United States, a pilot RCT was conducted on an mHealth intervention to improve self-management in HF patients (Athilingam et al. 2017). The primary outcomes measured included patient engagement and self-reported confidence using the app. The authors hypothesised the higher the patient engagement with the app, the less likely it would be that they reported symptom burden. Their results showed that the app improved self-management, confidence in self-care and knowledge about HF. Participants also reported high levels of contentment and satisfaction with the app. The authors called for more research to evaluate strategies for integrating health apps into clinical practice to ensure they meet their potential to improve patient engagement, satisfaction and outcomes (Lefler et al. 2018; Athilingam et al. 2017).

2.8 Summary

This literature review presents a discussion of the pertinent issues for technology in care. Technology is increasingly seen to offer opportunities to develop better integrated service models of care in which hospital and community care work closely together. This is considered essential for the sustainability and affordability of health care systems faced with challenges linked to the growing number of people living with chronic illnesses and the growing older population.

Patients are increasingly showing more willingness to engage with technologies to support them to self-manage their care particularly using health apps. Evidence shows patients using technology to monitor health parameters feel more empowered and satisfied. In addition, the conversations between patients and HCPs is seen to be two ways when patients are empowered and feel confident to ask questions and to seek explanations. From a policy perspective, having HCPs fully engaged with patients in the management of their own health is important in improving care delivery not just at a practice but also at a systems level. However, despite evidence pointing to the potential benefits of mHealth interventions to deliver care efficiently outside of traditional in-person models, cardiac care remains hospital centred in Ireland. Some clinicians remain cautious about incorporating mHealth into care, with concerns about internet access, increased workload, interoperability and support resources.

Managing the care of older patients with HF largely centres on symptom management and medication management. Polypharmacy has been identified as an underestimated challenge in the management of older patients with HF. While there are several apps supporting HF self-management, there are none specifically for medication management for patients with HF. Therefore, there is a gap in the literature in terms of mHealth research on medication management apps for older people with HF.

Chapter 3: Theoretical Framework

Attention now turns to the theoretical lens through which this study was conceived and can be understood. Firstly, a rationale for discarding other theories was provided, followed by a brief background about sociomateralism and how it has been used in research studies to date. Thereafter the main components of the sociomateralism are mapped out and an interpretation of the theory in relation to the present study is provided to illustrate how it was used as a practical tool. The section concludes with a discussion on Normalisation Process Theory (NPT) and its constructs, how is interconnected with sociomaterialism and an example of interview questions that guided the analysis and the report of the results.

3.1. Technology acceptance model (TAM)

The technology acceptance model (TAM) is widely used in the ICT field and was one of the theories considered for this study. The model was adapted from the Theory of Reasoned Action (Fishbein and Ajzen 1975) by (Davis 1986). TAM proposes that technology acceptance is determined by two attitudinal variables, perceived usefulness of a system and perceived ease of use and how their relation influence users' behaviour (Davis 1989). This theory is widely used by researchers when testing or developing new technology (e.g. a new app released to the market) or when consulting users to fine tune or improve a product or service. However, a critique of this theory was made by a meta-analysis study of the TAM literature (Lee et al. 2003). The findings concluded that many TAM studies were self-reported, limiting the ability to measure actual usage of the technology. Another limitation raised by Lee at al. study is the limited time users were exposed to the technology. Furthermore, Salovaaraa and Tamminen (2009) posits that TAM does not recognise that users' sense making have a significant impact on technology acceptance and adoption and that often, users are a heterogeneous group. The present study was designed to explore how patients and HCPs made sense of their new experience using a medication app, which Salovaaraa and Tamminen (2009) argue, TAM is unable to capture. Also, the present study wanted to employ a theoretical framework that allowed for the identification of barriers and enablers to technology adoption for both groups (HCPs and HF patients) recognising similarities but also differences. For all these reasons, the theory of TAM was not a fit with the aim and design of this study.

3.2 The Capability, Opportunity, Motivation-Behaviour (COM-B)

As noted earlier, despite technology increasingly seen to offer opportunities to develop better integrated service models of care and efficiency, concerns about the scaling up of mHealth interventions remain (Greenhalgh and Papoutsi 2019). To this end, the field of 'implementation science' is gaining momentum amongst researchers exploring the challenges associated to the implementation of interventions by HCPs. One of the implementation theories, the Capability, Opportunity, Motivation-Behaviour (COM-B) model of behaviour change was also considered for the present study. It incorporates Capability, Opportunity, and Motivational behavioural barriers and enablers and the Behaviour Change Wheel framework, into a theoretical lens widely used in healthcare intervention development. The framework proposes that in order to change behaviour there should be an interaction between one or more of the associated elements: capability, opportunity and motivation (Michie et al. 2011). The COM-B framework has been used previously to explore HCPs perceptions towards evidence practice (Lewis et al. 2021; Wakida et al. 2018; Fleming et al. 2014) and HCPs and patients diagnosed with HF (Whittal et al. 2021). However, this framework was rejected as the present study was focused on understanding the opinions and lived experiences of those using the medication app from not only a behavioural but also from a social standpoint. Furthermore, the present study was also concerned about the social organisation of healthcare practices and investigate if the new intervention was 'normalised' or not in practice.

3.3 Sociomaterialism

Sociomaterialism is a theoretical approach which considers how materials influence human activity. Its development has been influenced by the work of organizational theorists, Wanda Orlikowski and Suzan Scott. They challenged the "taken-for-granted assumption" that organisations, work, people, and technology are separate entities, and argued they should be conceptualised as mutually involved in everyday activities (Orlikowski and Scott 2008). Orlikowski held that all work practices at an organisational level are an "*entanglement of the social and the material in everyday life*" (Orlikowski 2007, p. 1435) with limited consideration of human relationships. Thus, whenever technology is introduced as a material element of social life and social contexts, there is some recognition of rules and their entanglement in technology artefacts as scripts. For example, material elements (use of technology) have a pivotal role in transforming a practice (medication management and medication review process) modifying material arrangements (patients and HCPs understanding the meaning of their actions and responsibilities while using the medication app).

Sociomaterial research in healthcare is relatively recent and largely dominated by the work of Bleakley (2010, 2012) and investigations of ways to improve health care practice, including among a surgical team as well as developing practitioners' awareness of the dynamics of health care systems on their complex everyday work (2010, 2012). When applied to the study of care for patients with a complex condition such as HF and the use of a medication app, sociomaterialism considers health care teams to be composed of both humans and nonhumans i.e. health care teams and the structures, systems, and culture (Bleakley 2012). In addition, it recognises that while complex patient care is fundamentally a team-based issue, 'team-based care' is comprised of more than health care professionals. It is also comprised of administration staff, management, patients and families, and it considers how the use of technology (material) adds to the creation of social practices and social contexts (Orlikowski and Scott 2008) while presenting an opportunity to reshape working practices.

The sociomaterial focus for the present study is concentrated on the function and influence of actions and materials on the everyday working activities of the HF team, made up of health professionals, administration staff, patients and families. It recognizes the importance of the social (i.e., relational) and material (i.e., medication management strategies) aspects of everyday activities and their influence on our understanding of reality. A key part of the work of the team is to get an up to date list of current medicines prescribed for each patient.

The challenges for older patients with HF in managing their use of multiple medications is well recognised, especially co-existing multi-morbid illness, polypharmacy, cognitive impairment, and frailty (Butrous and Hummel 2016). These challenges affect the physical and functional status of many patients with HF. They also affect long-term clinical outcomes and therefore add to the pressure on staff responsible for ensuring medication lists are up to-date while at the same time working under pressure in the clinic. The sociomaterial approach recognises that medication management strategies, as a physical (material) task, combined with human (social) endeavours, serves to include, exclude and regulate actions. As an example of organisational practice and the role sociomateriality plays, below is a description of one of the observations conducted at the HF outpatient's clinic by the researcher in 2019.

At 8 am in the morning, before consultation starts, the nurses have gathered in their team room to have a discussion about: how many patients they are seeing today; if any of the clinic patients were admitted to hospital, and to allocate roles and responsibilities for the day. The room is adjacent to the consultation room where they see patients and the door is closed. Outside, patients are arriving, sitting in the waiting area located outside the team room where nurses are meeting. They knock on door number ten, where the admin staff collect the appointment letter before taking a seat outside the clinic door. New patients sometimes do not know to do this. Consequently, some new patients knock the door where nurses are having their meeting, a source of disruption. A pager belonging to one of the nurses is going off, another source of interruption in addition to constant incoming phone calls.

The clinic starts at 9 am and the consultation commences with the nurse checking the patient's medication list against the computer record they have of the medication list at the last visit to the clinic. Some patients bring their medications with them, others bring a medication list, or have it memorised, and some do not bring anything. Unfortunately, the internet network is down today, so the nurse checks must rely solely on medication notes in the patient's medical record. Patients and relatives are asking why the consultation is taking so long and the nurse apologises and explains the network is down. After taking vital signs and weight, the nurse conducts a blood test to monitor the patient's HF. Once the consultation with the nurse is over, the patient who need to be seen by the doctor are advised to take a seat in the waiting area and wait to be called.

This example illustrates the social (nurses and patients' actions) and material (computer, medical records, pager, lab equipment for blood test) elements and how they shape the routine practice. There are other invisible material elements present such as data of patients, fire alarms, life support equipment and electricity that do not receive much attention as we tend to focus only on the digital elements and neglect the overall workplace (Orlikowski and Scott 2008). This example also highlights how this framework provides a theory to understand and reflect on teamwork and how this might be changed with the introduction of a medication app. Figure 1, below, illustrates how different methods of data collection i.e. observation and interviews were included to incorporate actions and materiality in the present study.

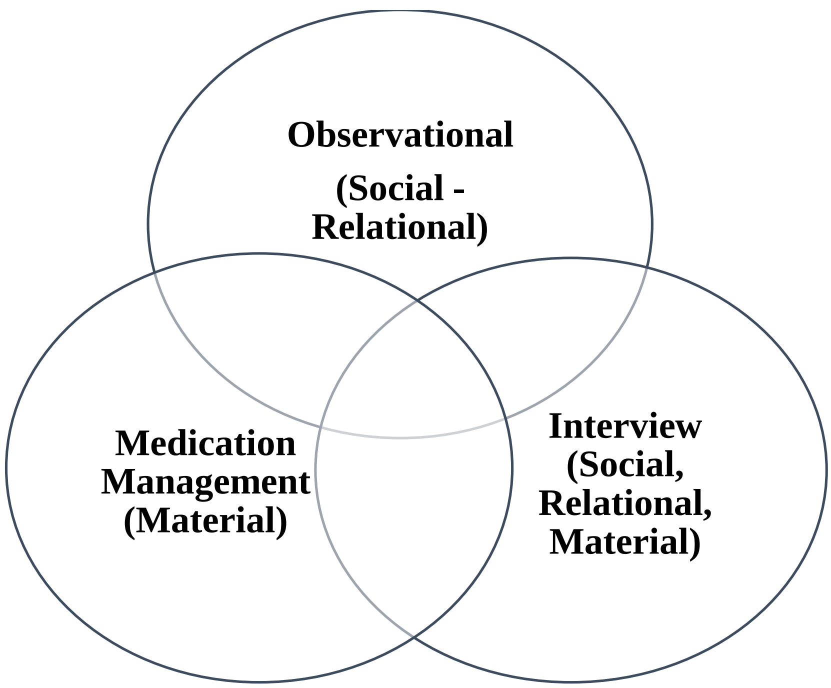

Figure 1: Socio-materiality approach to the study

3.4 Normalisation Process Theory (NPT)

NPT was developed by May (2006) to help understand how new technologies can become routinely embedded in everyday work practices in healthcare organisations. Normalisation process theory is concerned with the social organization of work, with making practices routine elements of everyday life, with embedding practices and sustaining this - in other words, integrating work practices. In the present study, NPT focuses on the interaction between context (healthcare practice, medication management and review process), actors (individuals – HF patients or groups - HCPs) and objects (medication list, medication boxes, digital technology) (May 2006). In addition, there are four core constructs representing the different kinds of work that people involved in an intervention undertake. These include coherence; cognitive participation; collective action; and reflexive monitoring (see Appendix B NPT construct (May and Finch 2009; May et al. 2015).

The NPT has been used in numerous healthcare settings, including mental health services, community and residential settings (McEvoy et al. 2014) and employed in multiple interventions (May et al. 2018) to evaluate feasibility. For example, the implementation of a large-scale digital health programme (Devlin et al. 2016), the implementation of remote monitoring technologies in dementia residential settings (Hall et al. 2017) and an asthma mHealth intervention in a community pharmacy setting (Kosse et al 2020). In addition, NPT was used as a theory in four RCTs (Taft et al. 2022; Hoskins et al. 2016; Buckingham et al. 2015; Blickem et al. 2014) and in two RCTs study protocol (Mukherjee et al. 2022; Kelly et al. 2021). All studies aforementioned concluded that the NPT framework was a rigorous and valid framework to investigate factors that enabled or impeded the sustainability and scaling up of the new intervention.

NPT is interconnected with sociomaterialism because, like sociomaterialism, NPT is concerned with social material practices i.e. “the things that people do to perform certain acts and meet specific goals” (May and Finch 2009, p. 539) in social contexts, such as healthcare practice settings. Furthermore, NPT enables researchers to inform policy and practice for digital healthcare by identifying how and why interventions work (or not). Therefore, while sociomaterialism was used to reflect on health care teams, the structures, systems, and culture in the HF clinic in Phase 1, NPT was used as a continuity in Phase 3 to analyse how the medication management app becomes embedded into practice [or not] – see figure 2 below. Shulver et al. (2016) used NPT to explore HCP views and experiences on telehealth services for older adults in the community setting. The study concluded that the use of telehealth in healthcare service provision for older people was more likely to be normalised in rural areas where services were limited. Another study used the NPT framework to evaluate the implementation of remote monitoring technology in a dementia residential setting (Hall et al. 2017). The study found that the adoption of remote monitoring technology could be facilitated if the intervention is perceived to improve the safety of residents (ibid).

For Phase 3 of this study, NPT was used to inform both the interview guide (baseline and later the app implementation) and the interpretation of results (thematic analysis). Semi-structured interview questions informed by NPT captured HCPs understanding on how the medication app impacted patients and the structured activities in the clinic. Interview questions for patients focused around their experiences using the app, effectiveness of the app on medication management and continuity of use. See Figure 3, below, for further examples of interview questions. Questions for staff focussed on the purpose and benefits of the app, motivation to use it and the skills needed to use the app.

In terms of the interpretation of results, as noted earlier, NPT has four core constructs. Each of these constructs is further divided in four sub-components which explore different elements of implementation in greater detail. For example, the construct coherence (concerned with the sense-making work that people do), has the following four sub-components: i) differentiation–understanding how a set of practices are different from each other; ii) communal specification–how people work together to build a shared understanding of the aims and potential benefits of a set of work practices; iii) individual specification–how individuals understand their tasks around a set of practices; iv) and internalization–understanding the potential value and importance of a set of practices. An inductive approach was used for the analysis, in order to extrapolate NPT constructs to explore the data collected. Results are reported under the four NPT constructs: Coherence (sense making), cognitive participation (enrolment), collective action (enactment), and reflective monitoring (appraisal). O'Reilly et al. (2017) utilised the same approach for an integrative review of interdisciplinary team working in primary care conducted by a team of Irish researchers. Likewise, a mixed methods feasibility cluster pilot trial of a nurse-led intervention for adults with asthma (Hoskins et al. 2016), used the NPT constructs to analyse and interpret the data. Both studies highlight the benefit of NPT in terms of its robustness and elucidating barriers and enablers to implementation.

NPT has been used to understand and evaluate implementation processes of new or modified practices and to provide recommendations for future implementation (MacFarlane and O'Reilly-de Brún 2012; Foster et al. 2011). A qualitative systematic review of qualitative studies also concluded how effective NPT is to highlight the gaps, challenges, and facilitators of new healthcare interventions (McEvoy et al. 2014). Most studies using the NPT framework tend to focus on exploring the implementation of interventions, for example, evaluating the trial of a nurse led HF clinic intervention (May et al. 2017). Other examples at the organisational level are (Ervin et al. 2021; Kosse et al 2020; Knowles et al. 2019; Hall et al. 2017; O'Donnell and Kaner 2017; de Brún et al. 2016; McEvoy et al. 2014; Pope et al. 2013). To a lesser extent, it has been utilised at the individual level to explore the burden related to self-care in patients with HF (Gallacher et al. 2011) and patients' illness experiences (Mäkelä et al. 2020). Some studies point to the benefit of incorporating the experiences of both groups (Clarke et al. 2021; Knowles et al. 2021; Ong et al. 2020; Farr et al. 2018; Taylor 2018). In the present study, NPT is used to understand the implementation of a medication app from the HCPs perspective, as well as the experiences of the users.

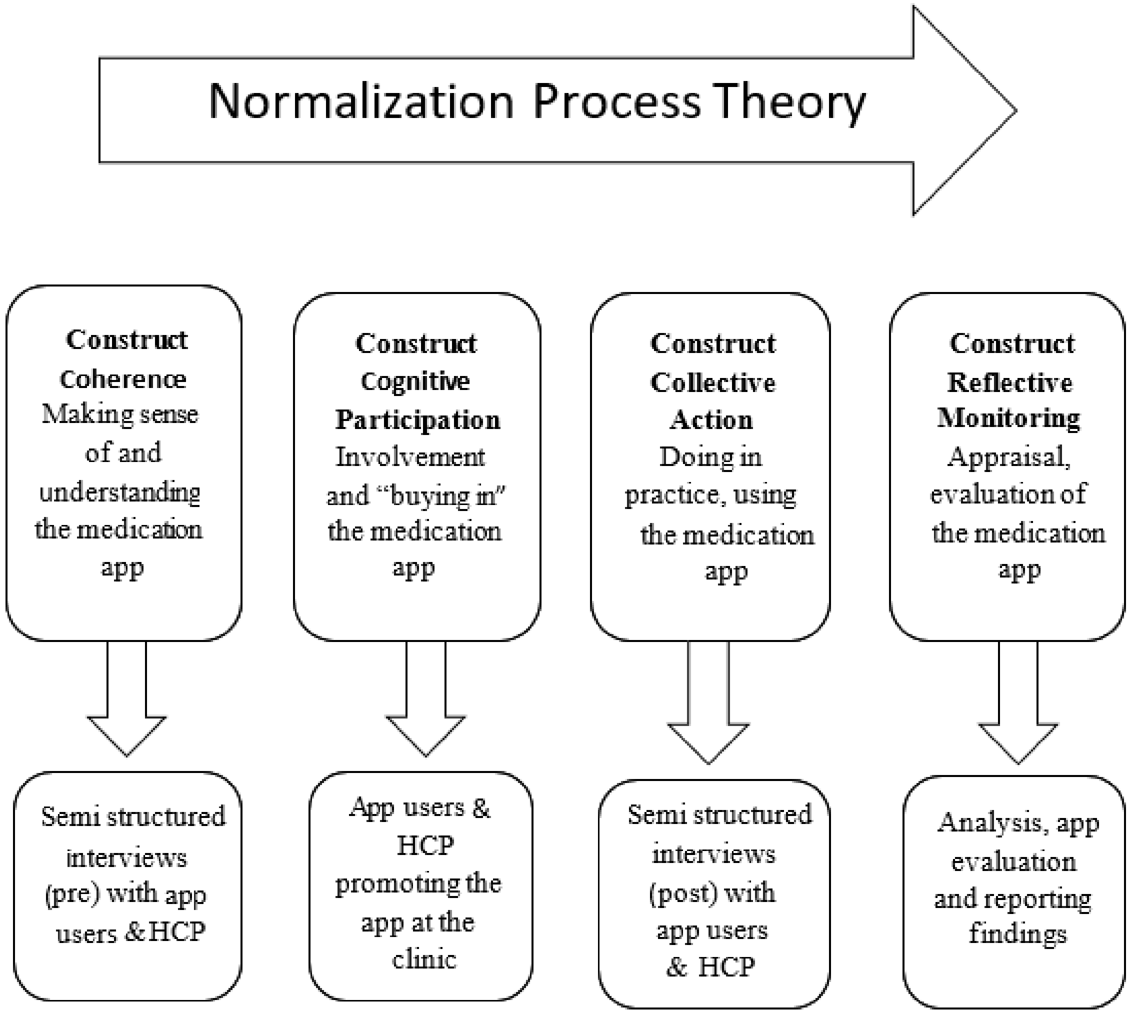

Figure 2: Normalization Process Theory and use of medication app in HF clinic

Construct Coherence (understanding, making sense of the new intervention)	
Pre-intervention	Post-intervention

Patients

Do you have a clear understanding of how the medication app works?	Comparing the methods for medication management – Is the app making a difference to consultations?

Healthcare Professional	
Are you aware of the purposes of the medication app?	Is the medication app a good fit with the overall goals and activities of the HF clinic?

Construct Cognitive Participation (involvement)	
Pre-intervention	Post-intervention

Patients

What will motivate you to start using the medication app?	**Do you feel this app will benefit your medication management?**

Healthcare professionals	
Why would you promote the use of the medication app with your patients?	**Would you promote the use of the app among HF patients?**

Construct Collective Action (doing in practice)	
Pre-intervention	Post-intervention

Patients

Can you tell me about the skills you feel you need before using the app?	**Do you trust the app to support your medication management?**

Healthcare professional	
Do you think promoting the app will fit easily within your work practice?	**How easy was it to promote the use with your patients?**

Construct Reflective Monitoring (Appraisal)	
Pre-intervention	Post-intervention

Patients

Do you think the app will be good to help you manage your medication?	**Do you feel supported to use the app? Will you continue using it?**

Healthcare professional	
Do you feel the app is an effective way to support medication management?	**Has any of your patients provided you with feedback from the app?**

Figure 3: The four construct of the NPT framework guiding pre- and post- interview questions for patients and HCPs

Chapter 4: Methodology

This chapter presents the overall methodological design of this research. This study employed a mixed methods sequential design to test the feasibility of a medication app with HF patients conducted across four phases. A description of the methods used to address each phase are provided with a discussion of the background and justification for their use.

Phase 1 focused on gaining HCPs views and experience towards technology use in the care of HF older patients. In order to identify the technology (medication app), a systematic search of apps was conducted in phase 2, followed by an evaluation of apps.

Phase 3 involved HF older patients using the medication app for three months and observations of the interactions between patients and the HCPs during the consultation. Semi structured interviews pre- and post-intervention were also conducted with HCPs and patients in phase 3.

A qualitative case study approach was used in phase 4 to compare the experience of patients using the medication app and to present the findings. An overview of the study design is presented below in Figure 4. Finally, the ethical issues associated with this study and the impact that the Covid-19 pandemic restrictions had on the present study are discussed.
The use of the NPT framework captured individual and organisational barriers and facilitators to the normalisation of the use of the medication app with HF older patients.

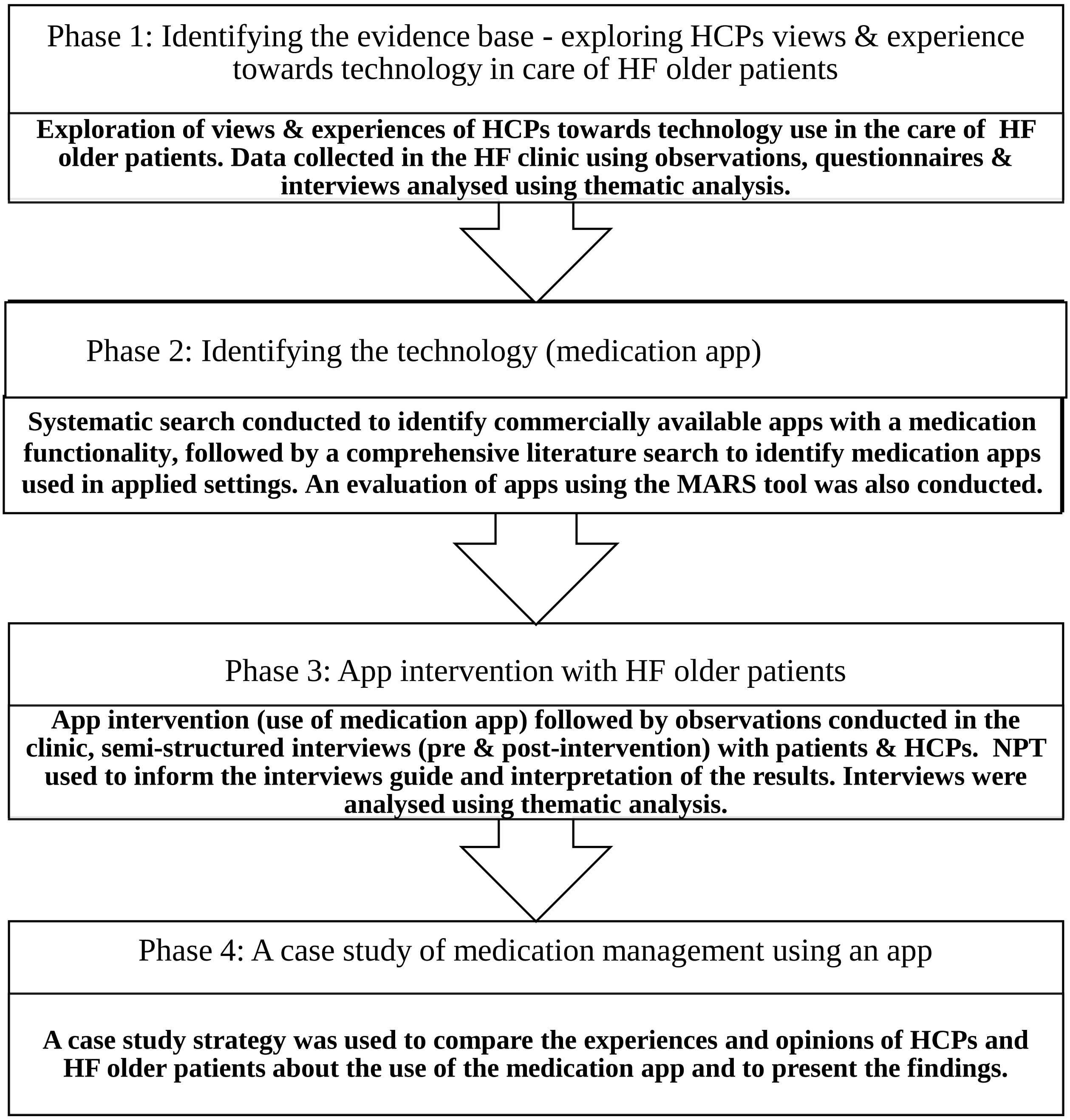

Figure 4: Mixed methods sequential design

Chapter 4: Phase 1 - Identifying the evidence base - exploring HCPs views and experience towards technology in care of HF older patients

As noted earlier, the objective of phase 1 was to explore the views and experience of HCPs working in the HF clinic about technology use in the care of older patients attending the clinic. Data were collected in a specialist HF clinic using structured questionnaires, observations and semi-structured interviews analysed using thematic analysis (presented below). Previous to phase 1, a literature review on barriers and facilitators to technology and staff attitudes towards technology in care of older patients was conducted (presented above).

4.1.1. Approach to phase 1

This section (4.1.1) provides a rationale for the selection of a qualitative approach and a justification of its appropriateness for exploring the views and experience of HCPs working in the HF clinic about technology use in the care of older patients attending the clinic. Semi-structured interviews were selected for data collection for several reasons. Interviews are commonly used for exploring views (Braun and Clarke 2006) and to learn about those things that we cannot directly observe, such as feelings, beliefs, perceptions, behaviours that may be too difficult or sensitive to observe (Bentley et al. 1994). Also, semi-structured interviews allowed the researcher to cover a set of topics whilst providing the opportunity to cover other topics that may arise as the conversation flows and to seek clarification (Lune and Berg 2017; McIntosh and Morse 2015). In the present study, semi-structured interviews were selected to search for answers to two of the research questions: What are the HCPs' attitudes towards technology in care of older patients? and What are the barriers and facilitators for the adoption of a medication app in the care of HF older patients? The interviews were conducted prior to the ethnographic element (see below) as it was important for the researcher to interact with the health professionals at the clinic before conducting observations in order to build rapport and avoid negative reactions from an unfamiliar person observing their behaviour.

In addition to interviews, a participant observation method was used within this study. Ethnography is widely used in qualitative research and involves collecting data via observations which can be triangulated with data from interviews and document analysis (Reeves et al. 2013). The reasons for using observations was to get a sense of the working routines in the clinic. Also to allow the researcher to become immersed in the clinical setting to observe what works and what does not work and to identify day-to-day challenges for HCPs delivering care (Blandford et al. 2015).

4.1.2 Semi-structured interviews with staff in a specialist HF clinic

Semi-structured interviews were conducted with all members of the cardiac team in the HF specialist clinic in Our Lady of Lourdes Hospital, Drogheda. This included: a consultant cardiologist (n=1), heart failure specialist nurses (n=3), registrar (n=1) and dietitian (n=1). Semi-structured interviews involve asking a series of open-ended questions, followed by probing questions[3]. The purpose of the interviews was to explore the views and experience of HCPs working in the HF clinic about technology use in the care of older patients attending the clinic. Interviews also provided context to the care of HF outpatients in an Irish setting to gain an in-depth understanding of staff practices.

The female interviewer was a qualified nurse, had trained in qualitative research and had previous experience conducting semi-structured interviews with older people. She did not have any prior relationship with the participants, beyond communication involved in arranging the interview. All participants were informed about the purpose of the interviews and wider thesis (please see Appendix C Participant Information Leaflet). An interview guide (please see Appendix D) was developed to address the research questions of the wider project, and a list of questions was developed focusing on the main themes that emerged from the literature review. The domains covered included: general background of the clinic, daily routine care practices, personal experience using ICT in care and perceived challenges, changes in traditional care brought by a digital intervention, concerns

[3] Open-ended questions allow for an unlimited number of possible answers to emerge; provide an opportunity to gain in-depth information, including feelings, attitudes and understanding on a particular subject; and provide an insight into the participant’s thinking process and frame of reference. Probes allow the researcher to clarify statements, retrieve additional information and eliminate misunderstandings.

and personalised care. All interviews were conducted in a private room in the HF clinic, at times that suited the participants. Interviews were audio-recorded, with participants' consent, anonymised by the researcher and subsequently transcribed verbatim by a professional transcription company. Each interview lasted between 45 and 60 minutes. Data collection took place between March and May 2019.

The data were analysed using thematic analysis. Thematic analysis is a method to organise and identify themes or patterns in a qualitative data set before analysis (Braun and Clarke 2012). Consistent with Braun and Clarke (2006), a 6-step framework was used in this study, with transcripts uploaded to NVivo v.12 (QSR International, Melbourne, Australia). Pertinent verbatim comments were selected for quotation and illustration creating a narrative of each theme. In line with Braun and Clarke (2006), the first step in the analytical process was concerned with familiarisation with the data. Audio-recorded interviews were listened to several times; transcriptions were re-read and reviewed to increase familiarity with the data; initial thoughts, opinions and ideas were noted as they emerged. The second step was concerned with generating initial codes. Braun and Clarke (2006) refers to this as an analytical and methodical review of the data to identify codes to start to take the shape of ideas, concepts and meanings related to the research questions. The research questions were used to support the identification of data extracts for coding. The fourth step was concerned with searching for themes, with codes divided into themes/subthemes and subsequently reviewed to determine their relevance to the study research questions. Codes that were similar or described a similar concept were grouped under the same theme. Themes were further scrutinised to understand their meaning and sub-themes were arranged within overarching themes. This reviewing step was an analytic and iterative process and a critical one as Braun et al. (2016) point out.

> "*The process is about checking two things: first, whether your analysis 'fits well' (or well enough) with the data and you are not misrepresenting them, inadvertently, through poor coding; and second, whether the story you're telling is compelling and coherent way of addressing your research question."* (Braun et al. 2016, p.11).

The fifth step in data analysis was concerned with defining and naming themes. For this, themes were linked to the research questions and the data within each theme was analysed. For the sixth and final step, extracts related to the research questions and literature were selected for presentation in this thesis.

4.1.3 Observations

As a complement to the semi-structured interviews and structured questionnaire with staff, observations were carried out in clinic to get a sense of the working routines in the clinic. Observations have been shown to enhance understanding of clinical practice and care in a number of settings including hospitals (Dixon-Woods et al. 2013; Tzeng et al. 2010), nursing homes (Bergland and Kirkevold 2005, 2008), and day care centres (Nagington et al. 2021; Øye et al. 2021). For the present study the observations allowed the researcher to become immersed in the clinical setting to identify day-to-day challenges for HCPs delivering care (Blandford et al. 2015). The observations conducted in the clinic confirmed the medication challenges for older patients and staff managing their care. A series of five observations were conducted in the clinic. The first observation was exploratory in nature to facilitate rapport building and allow the researcher to become familiar with the clinical setting and its operations. An observational framework (please see Appendix E) was developed and used to record information on each visit. Before the observations took place, staff were advised that the observations were not targeted at critiquing their individual practice, procedures or patients. They were advised that the purpose was to observe how the clinic operated daily and to highlight the potential for a technological intervention to aid and enhance caring tasks.

The five observations took place on the following days[4]:

- Monday 15 April 2019 (9am–1pm)
- Wednesday 24 April 2019 (2pm –5pm)
- Monday 29 April 2019 (9am–5pm),

[4] Observations took place over a period of time allowing the researcher to observe aspects of the clinical practice on a continued manner and not in an expedient way (Kiyimba et al. 2019).

- Wednesday 08 May 2019 (9am–5pm),
- Wednesday 11 September 2019 (9am–5pm). Thus a total of 28 hours of observation was conducted by the researcher.

Wednesdays are typically the busiest days in the clinic; hence, most observations were scheduled for Wednesdays[5]. The clinic operates Monday to Friday, 8.30am–5pm. On Mondays, medication titration occurs in the morning and, in the afternoon, the consultant sees new patients and referrals. On Wednesdays, a medical review clinic takes place. Specialist nurses assess patients and their observations are subsequently reviewed by the registrar, deciding if any necessary changes on patients' treatment or medication are warranted.

Examples of observational data collected included:

- times the patient entered and exited the consultation room,
- issues related to patient care, specifically if it impacted staff workload (e.g. if the nurse had to leave the consultation room to contact the patient's pharmacy in order to corroborate a patient's medication), and
- interactions amongst staff and between HCPs and patients (e.g. nurses interacting with the cardiologist during patients' clinical reviews, HCPs and patients during the consultation).

Reflexive experiences and opinions of the researcher conducting the observations were not recorded. The researcher only engaged with the patient in terms of greeting and thanking them for consent and participation. No clinical conversations occurred between HF patients and the researcher. Field data was recorded in an observation protocol developed for this study. Themes were categorised and used to describe the setting and to get a sense of the working routines in the clinic (Creswell 2003).

[5] Observations were not scheduled for Tuesdays (medication titration clinic and symptom review with long term patients), Thursdays (medication titration clinic and symptom deterioration) and Fridays (inpatients visit and educational sessions). Instead, observations were scheduled for Wednesdays when medical reviews take place, as clinicians gather information on patients and it is more likely to observe issues arising, for example, poor drug compliance, poor compliance with fluid restriction and medication errors (over or underutilisation).

4.1.4 Structured questionnaires with staff in a specialist HF clinic

On completion of semi-structured interviews, all members of the cardiac team were asked to complete a structured questionnaire[6]. The questionnaire (see Appendix J), contained sections on demographics and validated measures of job satisfaction and technology acceptance - was completed using paper and pen.

4.1.5 Demographics

All participants were asked to provide information (please see Appendix F Staff demographic information questionnaire) on their age, gender, level of education, level of experience, number of days/ hours worked per week, years of clinical experience working at the HF clinic and previous use of technology in care.

4.1.6 Job satisfaction Survey (JSS)

Job satisfaction is paramount in the healthcare industry as it can create staffing issues i.e. staff turnover and also may affect employee productivity (Trivellas et al. 2013; Rouleau et al. 2012). While the benefits of digital technologies implementation in healthcare have been largely explored (Jacob et al. 2020; Pan et al. 2019; Abbas et al. 2018; Grassl et al. 2018), rates of satisfaction and technology uptake amongst HCPs varied (Maillet et al. 2015; Hoonakker et al. 2013). Therefore, investigating HCPs levels of job (dis)satisfaction was deemed important as a predictor of digital health technology uptake in this study.

In the present study, job satisfaction was measured using the Job Satisfaction Survey (JSS; Spector 1985) (please see Appendix G). The JSS includes 36 items which measure nine dimensions of job satisfaction: pay, promotion, supervision, benefits, contingent rewards, operating procedures, co-workers, nature of work and communication. Responses were scored on a six-point rating scale, (1 = disagree very much, 2 = disagree moderately, 3 = disagree slightly, 4 = agree slightly, 5 = agree moderately and 6 = agree very much). Higher scores indicate greater job

[6] Five HCP completed the questionnaires after the interviews, one of the interviewees declined completing the questionnaires.

satisfaction. Due to the lack of variance in responses and the small sample size, responses were recoded into binary variables (responses 1, 2 or 3 = disagree, responses 4, 5 or 6 = agree) (cf. Grassi et al. 2007). Negatively worded items were reverse coded before calculating overall dimension and total scores. The scale has nine subscales targeting different aspects of employees' job satisfaction. Given the small size of the cardiac team, the Ethics Board considered a priori that there was a risk of identification (and threat to data accuracy). Therefore, the JSS was truncated to remove four potentially problematic items where the participants were required to express an opinion about their supervisor (item 3: 'My supervisor is quite competent in doing his/her job'; item 12: 'My supervisor is unfair to me'; item 21: 'My supervisor shows too little interest in the feelings of subordinates'; and item 30: 'I like my supervisor'). In this study, Cronbach's coefficient alpha (α) for the eight subscales ranged from 0.92 to 0.33, and the overall alpha value was 0.92.

The JSS is one of the most popular measures of job satisfaction in the literature. It was originally developed for human resource organizations (Spector 1985), however it has been widely used to assess job satisfaction in a variety of professional groups such as case managers (Cosentino et al. 2017), substance abuse treatment employees (Tsounis, Niakas and Sarafis 2017), nurses (Tagoe and Quarshie 2017; Abualrub and Alghamdi 2012; Rouleau et al. 2012); and physicians (Ruggieri et al. 2014). The JSS has been translated and validated in German and Norwegian (Rosta et al. 2009), Urdu (Rauf et al. 2013), Portuguese (de Souza, Alexandre and de Brito Guirardello 2017), Lituanian (Astrauskaite et al. 2011), Arabic (Abdulla et al. 2011), Greek (Tsounis and Sarafis 2018) and used in several high- and middle-income countries including the USA and Singapore (Spector and Wimalasiri 1986), Turkey (Yelboğa 2009), Pakistan (Ali and Ali 2014), Taiwan (Chou et al. 2011), Iran (Akbaritabar et al. 2013), Czech Republic (Franěk and Večeřa 2008), Greece (Trounis and Sarafis 2018) and Nepal (Batura et al. 2016).

4.1.7 Technology Acceptance Model (TAM)

Technology acceptance was assessed using the extended Technology Acceptance Model (TAM; Asua et al. 2012) (please see Appendix H). It is based on the Theory of Reasoned Action (David, 1993) and is one of the most widely used psychological frameworks for understanding acceptance of ICT systems in various professional areas (Marangunić and Granić 2015). The extended TAM includes 27 items assessing perceived ease of use (PEU; n=6 items), perceived usefulness (PU; n=6 items), compatibility (n=4 items), subjective norm (n=4 items), facilitators (n=3 items), intention (n=3 items) and habit[7] (n=1 item). Participants indicate their level of agreement with each of the 33 items on a 7-point Likert (1 = strongly disagree, 2 = somewhat disagree, 3 = disagree, 4 = neither agree nor disagree, 5 = agree, 6 = somewhat agree, 7 = to strongly agree). In the present study, due to a lack of variance on responses and the small sample size, responses were recoded into binary variables (responses 1, 2, 3 or 4 = all others vs. responses 5, 6 or 7 = agree) (Grassi et al. 2007). The construct validity of the model was evaluated using interitem correlation analysis. Descriptive statistics were conducted to examine the mean and standard deviation of each dimension. In this study, Cronbach's coefficient alpha (α) for the subscales ranged from 0.50-0.95 and the overall alpha value was 0.84.

4.1.8 Ethical considerations

The primary ethical concerns raised by the data collection in this study related to confidentiality and anonymity and informed consent. Both ethical concerns were addressed as follow:

Confidentiality & anonymity

Confidentiality is one of the core ethical principles in research and represents the duties of the researcher to protect and not to share with third parties the participant's identity, personal information and their responses (Anderlik and Rothstein 2001). The agreement is usually made via the inform consent process and read and signed by both parties. According to Wiles et al. (2008), confidentiality is associated with anonymity as anonymity is one of the methods used to guarantee confidentiality. As the present study involved qualitative data collection, securely

[7] This construct was measured by using a yes/no response format ('I have already used a DHI to monitor my patients').

managing the data was of particular importance. The interviews were recorded using digital recording equipment and the data were transcribed verbatim and de-identified before being saved to a password protected computer. Data collected was stored under each participant's unique study ID code and did not contain names or other identifiable data. A separate password-protected key file was maintained to link unique study ID code to participant names. In line with Article 89(1) of the GDPR legislation (Directive 95/46/EC 2016), pseudonymisation allows the researcher to process personal data in a manner that the data subject cannot be easily identified. Participants were pseudonymised during transcription, and these transcripts and questionnaires were stored in a secure location. As with the interviews, questionnaires were stored under each participant's unique study ID code and did not contain names or other identifiable data. Any other potentially identifying information was not reported.

Informed consent

Informed consent is underpinned to the right to self-determination and refers to the process of providing comprehensive information about the nature of the research to the participants and disclosing the participants' involvement, ensuring the potential participant fully understand what is required from their part and offering a voluntary choice to participate (The Nursing and Midwifery Board of Ireland 2007).

One of the most effective means of facilitating informed consent is with a participant information leaflet. Thus in the present study, a comprehensive information leaflet was developed to inform participants what the study aims were, what participants were being asked to do, what could happen with their data and their right to withdraw. According to Article 5(1)(b) GDPR, participants were informed and received a clear and accurate explanation on the purpose of the research (Directive 95/46/EC 2016). Participants were asked to provide written consent to take part in this study and they were informed they were in charge of the process and could accept or decline participation (ibid). The written consent form stated the purposes of data collection and explicitly explained that the data was necessary to achieve the objectives of the study and that processing the data was not going to have any detrimental effect on any participants (Government of Ireland 2018). All participants were provided with two weeks' time to read and sign the written informed consent. Also, they were reminded that they could stop the interview at any time without providing a reason if they wish to do so.

4.1.9 The Impact of the Covid-19 Pandemic Restrictions

On February 29th, 2020 the first case of Covid-19 was confirmed in Ireland and very soon afterwards, on March 11th, 2020 the World Health Organization declared Covid-19 as a pandemic. On March 12th, the Irish Government advised all schools, colleges and childcare facilities to close and urged workers to work from home if possible (Department of Education and Skills 2020). On March 27, a national lockdown was announced and the Government recommended all citizens to self-isolate during the pandemic, especially older people with HF as they were considered extremely vulnerable. This meant that for over a year the research project advanced at a slower pace and the deadline for the conclusion of the PhD programme was fast approaching (6 months). During lockdown, in person data collection was greatly affected as explained in the ethical consideration section above. Originally, it was intended that the researcher would meet patients at the clinic and train them on how to use the app and collect data in the clinic. However, the methodology for phase three and four had to be changed and an amendment for ethical approval was submitted to the HSE, Louth/Meath Research Ethics Committee and to the Ethics Committee for the School of Health and Science at DkIT. Training and data collection was subsequently conducted in person in patients' homes.

Ethical approval for this study was granted before the COVID-19 pandemic. However, in 2021 it was deemed necessary to make an amendment to the ethics to reflect changes brought about the restrictions associated to COVID-19 and a letter was sent to the HSE Northeast Research Ethics Committee (please see Appendix K).

In the revised ethics application, it was explained how older people attending outpatients' appointments in the clinic had seen their access restricted because of COVID-19. The HF clinic was seeing a much-reduced number of patients, with most consultations taking place over the phone, bar medical emergencies and they were to continue this practice for the foreseeable future. Therefore, the probability of meeting patients in person at the clinic was significantly curtailed. Also, the recruitment process[8] was very slow as some nurses were redeployed to other services to deal with the COVID-19 crisis and they were unable to recruit participants for the study. Only two nurses remained working in the HF clinic dealing with large volumes of patients and dealing with emergencies, impacting negatively on recruitment for this study. The added burden to clinical staff was another factor taken into consideration.

For those reasons, the following amendments were made:

- The sample size changed from (n=6) to (n=3). A greater amount of qualitative data was collected weekly to explore and document the experiences, feelings and opinions of the participants about self-managing their medication at home using the app. Ultimately, this facilitated a more detailed analysis of the lived experience of the participants.

- Depending on COVID-19 regulations, the researcher visited participants at home to deploy the equipment and train them on how to use it, followed by weekly telephone calls. In the event that the equipment was not working properly, the researcher revisited participants to provide IT support.

- Pre- and post-intervention questionnaires were administered at home. Interviews took place in participants' home or by phone to minimise patients travelling to the clinic.

[8] Recruitment of patients: Participants were older patients recently diagnosed with Heart Failure and this cohort might be difficult to recruit. Therefore, the researcher liaised with the nurses working in the clinic to assist with the recruitment.

The revised ethics application was submitted to the HSE Ethics Committee in June 2021 and ethical approval was obtained in October 2021. Ethical approval from the Ethics Committee for the School of Health & Science, DkIT, the HSE Northeast Research Ethics Committee together with the amendments can be seen in appendices I, J and K.

Ethical approval for this study was sought in 2019 and approved by the Ethics Committee for the School of Health & Science, DkIT (please see Appendix I) and the HSE Northeast Research Ethics Committee (please see Appendix J).

Chapter 4: Phase 2 - Identifying the technology base (medication app)

The objective of Phase 2 was to conduct a systematic search and review of commercially available apps with a medication functionality, followed by a comprehensive literature search and review of medication apps used in applied settings. The Mobile App Rating Scale (MARS) and the IMS Institute for Healthcare Informatics Functionality Score were used as part of the review process.

4.2.1 Search strategy

A systematic search of apps, accessible in Ireland, was conducted in June 2019 using the Google Play StoreTM and iTunes App StoreTM. The purpose was to identify apps with a medication list functionality. The search term "medication list" was used to identify apps with a medication list functionality. The term "medication app" was excluded from the search because it identifies apps with a different primary purpose (e.g., medication alarm, medication tracker, medication reminder, apps providing educational information only, medical decision support systems for clinicians, medication adverse effect, pharmacy locator and prescription refills). After initial identification of apps containing a medical list function, the apps were tabulated. If the same app was available on different platforms (iOS or Android), both versions were retained for analysis as apps behave differently depending on the platform (cf. Nicholas et al. 2015). Inclusion and exclusion criteria (see below) were applied to each app to determine whether it should be retained for further analysis.

Apps were included for evaluation if they:

- included a medication list function;
- had strict privacy policy written in their website or app store[9];
- included an update in the last two years;
- were free of charge, reflecting popular trends in app downloads (Subramanian 2015; Azar et al. 2013; Technobuffalo n.d.);
- were available in English.

Apps were excluded from evaluation if they:

- were a game (rather than an information app);
- were not available in Ireland;
- were not available in English;
- focused solely on a particular medical condition (COPD);
- were a mobile clinical decision support system;
- were designed primarily to support patients in understanding their medication regimen and adherence;
- were designed primarily for self-care management of a condition (e.g. COPD, asthma);
- were not available for patients to use at home; or,
- had a barcode scanner that did not recognise medication used in HF treatment in Ireland.

4.2.2 Data extraction

Scientific support provides information on the app's reliability as apps which are not supported by evidence are associated with decrements in quality and safety

[9] Safeguarding: privacy policy was not an ultimate standard. However, given the sensitivity nature of health information and the vulnerability of the patient group (older people) using the app, the presence of a transparent privacy policy was deemed important to safeguard them (Nicholas et al. 2015).

(Buijink et al. 2013). Issues relating to patient confidentiality, conflicts of interests and malfunctioning could negatively impact patient health (Moral-Muñoz et al. 2018). The following information for each app with a medication list function was, therefore, downloaded: developer, price, the number of downloads of the app, description of the app in the App store and scientific support.

As noted earlier, apps which fulfilled the inclusion criteria were evaluated using the Mobile App Rating Scale (MARS)[10] and the IMS Institute for Healthcare Informatics Functionality Score. Both tools are explained further in the app evaluation section 4.2.7. No published studies using the MARS to assess the quality of apps with a medication list functionality was found.

4.2.3 Search strategy

A comprehensive literature review of published, peer-reviewed papers was conducted by the researcher in January 2020 to identify studies that applied apps with a medication list functionality. The key search terms included: “medication adherence”, “medication management”, “apps”, “mobile health application”, “older people” and “chronic diseases”. Inclusion and exclusion criteria are presented below. Databases searched included: Complementary Index, Business Source Complete, Academic Search Complete, Medline, CINAHL Plus with Full Text, ScienceDirect and EBSCOhost.

Papers were included in the review if they:

- reported the use of apps to improve medication adherence or medication management;
- were written in English;
- were peer reviewed; and,
- were published in the last 10 years (2010 – 2020).

Papers were excluded if they:

[10] Mobile App Rating Scale (MARS) is a framework developed by (Stoyanov et al. 2015). This tool is used worldwide to evaluate the effectiveness and quality of mobile health applications.

- reported on an app intervention that was not related to medication management related;
- reported an intervention which was not delivered using a smartphone or a tablet (e.g. text messaging or web-based);
- included participants who were not older adults;
- reported on an app which focused solely on self-care/self-management; and,
- reported on apps for HCP use (e.g., a mobile clinical decision support system).

4.2.4 Data extraction

For each paper the following data was recorded: author and country, year of study, sample size, condition declared by participants, study design and patients' evaluations of the app. The primary outcome measures of interest included: improvement in standard practice and user satisfaction. Secondary outcome measures included: medication adherence, usability and feasibility of the apps as well as benefits and challenges.

4.2.5 Data analysis

Papers were organised into two categories: (1) studies where app interventions were efficacious and positively rated by participants, and (2) studies where the app intervention reported minimal or inconclusive results and participants were not motivated to maintain use.

4.2.6 App evaluation

The apps were subject to in-depth analysis and evaluation using the Mobile App Rating Scale (MARS)[11]. MARS was developed by a team of researchers at the University of Queensland, Australia, to provide a systematic means of assessing, classifying and rating the quality of mHealth apps (Stoyanov et al. 2015).

[11] Mobile App Rating Scale (MARS) is a framework developed by (Stoyanov et al. 2015). This tool is used worldwide to evaluate the effectiveness and quality of mobile health applications.

Within this framework, apps are rated according to four objective measures (engagement, functionality, aesthetics, information quality) and one subjective measure (please see Appendix L MARS tool). More specifically, *engagement* involves determining whether the app is fun, interesting, customisable, interactive and well-targeted to its audience. *Functionality* assesses whether the app is easy to learn, navigate, flow logically. The *aesthetics* category evaluates the graphic design, overall visual appeal, colour scheme, and stylistic consistency of the app. *Information quality* involves evaluating whether the app contains high quality information from a credible source. Subjective quality reflects *user satisfaction*, app endorsement and continuity of use (ibid).

The MARS is one of the most widely used tools to evaluate the quality of mobile health applications in various health domains: mental health (Terhorst et al. 2018), physical health (Knitza et al. 2019; Creber et al. 2016), occupational health (LeBeau et al. 2019) and social care (Larco et al. 2018). It has also been validated (Terhorst et al. 2020) and translated in Italian (Domnich et al. 2016), German (Messner et al. 2019) and Spanish (Pavo et al. 2019).

In the present study, apps were independently reviewed by four reviewers (i.e., the PhD student (YD), a senior psychometrician (NC), a senior researcher in ageing (LC) and a senior software technician (DM) using a five-point scale (1 = inadequate, 2 = poor, 3 = acceptable, 4 = good, 5 = excellent). Scores for each category were obtained by calculating the mean of the ratings for each question according to the five measures described above. The total score for each app was determined by the average of the four objective measures. The total score for the subjective measure (subjective quality, worth recommending, repeat use of the app and overall satisfaction) was also calculated. The internal consistency of the subscales (engagement, functionality, aesthetics and information quality) and total quality score were calculated using Cronbach's alpha coefficient. The reviewers carefully read the MARS instructions, independently reviewed the apps and provided a rationale for their ratings. Subsequently, they compared results and reached a consensus on each of the ratings for each of the MARS subscales (Stoyanov et al. 2015).

To complement the MARS quality assessment, the IMS Institute for Healthcare Informatics Functionality Score tool was used to independently evaluate app functionalities (Aitken and Gauntlett 2013). This evaluation focused on the scope of functions and the potential role that each functionality plays in supporting self-management for patients with HF. Unlike MARS, this tool only assesses objective quality and has been used previously to evaluate app capabilities to support HF management (Mortara et al. 2020; Creber et al. 2016). The functionality score consists of 7 functionality criteria and 4 functional subcategories. If a function was present in the app, it was coded as 1; otherwise, it was coded as 0. Functionality scores ranging from 0 to 11 were generated for each app.

4.2.7 Literature search to identify use of Apps with a medication functionality

In addition, to the search for commercially available apps, a comprehensive literature search was conducted to identify where medication apps have been used in practice. The aim was to investigate their intended use and report the outcomes. Other studies employed this approach (literature review and current applications of apps). Sobnath et al. (2017) carried out a literature review to identify digital tools supporting patients with Chronic Obstructive Pulmonary Disease (COPD), followed by a search in the app stores to identify apps related to the condition and their features. Likewise, Haddad et al. (2019) investigated the role of apps designed to be used by HCPs during antenatal care provision. They conducted a systematic review of the literature followed by a detail analysis of the apps identified.

Chapter 4: Phase 3 - App intervention with HF older patients

The objective of Phase 3 was to implement a three-month intervention of the app identified in the evaluation completed in phase 2, with patients attending the HF clinic. As discussed earlier, observations were also conducted by the researcher in the clinic of patients use of the app in clinical consultations. In addition, weekly field notes were collected by the researcher through regular phone calls and visits to participants' homes. Semi-structured interviews were conducted with HCPs and HF patients using the app pre- and post- intervention. The data was analysed using thematic analysis.

4.3.1 Intervention - Trial of app with HF patients

Based on the evaluation of the apps, the optimal app was selected and implemented in a three-month intervention with patients attending the HF clinic. HCPs in the clinic acted as gatekeepers and after much consideration referred three patients for the app trial. Participants were provided with an iPad with the medication app and received a training session, followed by ongoing support (when/if needed) from the researcher during the intervention.

4.3.1.1 HF Clinic observations using the medication app

As discussed earlier, observations were conducted by the researcher in the HF clinic. The purpose of the observations was to observe the social aspects (i.e. interaction between patients and HCPs) and material aspects (i.e. use of the medication app during the medication review process) of the clinical practice. Participants were asked to share the day of their next appointment at the HF clinic with the researcher and advised to bring the iPad while attending the HF clinic appointment. HCPs were also informed the day observations were carried out beforehand. The researcher explained both, HCPs and patients, that observations were carried out with two aims: (1) to observe how the medication review process was carried out with the support of the app and (2) to identify and quantify medication errors.

Before the observations took place, staff were advised that the observations were not intended to critique their individual practice, procedures or patients. They were advised that the purpose was to observe participants use of the medication app during the consultations. Participants were also explained the purpose of the observations and were asked to share with the researcher the date and time of their next visit to the HF clinic, for the observation to take place.

4.3.2 Eligibility criteria

Knowledge and/or experience of computer tablets or apps was not necessary for participation in the trial of the app, the eligibility criteria were as follows:

- patients diagnosed with HF,
- over 65 years of age,
- taking five or more medications daily
- residing in the community setting,
- attending the HF clinic, and,
- residing in the Louth – Meath geographical area

The HF clinical team reviewed their patients list and given the COVID related issues around access and staff, subsequently identified three older patients for the app intervention.
Three outpatients aged over 65 years were recruited to participate in the 12-week intervention[12]. The participants were provided with a computer tablet and trialled the medication app. A face to face meeting was scheduled in participants' home to download and set up the medication app. Ongoing support was provided by the researcher to participants during the intervention. Due to the COVID-19 outbreak, all interactions with staff and patients observed the use of PPE and social distancing measures as per public health guidelines. During the initial home visit the researcher demonstrated:

- how to compile a medication list in the app and update it according to any changes in medication
- how the app works so that participants were familiar with it and could take it to their appointments with HCPs in the HF clinic.

[12] As noted earlier, the planned number of participants for the technology intervention was revised down due to the onset of the pandemic. COVID-related restriction lead to severe delays in accessing patients and changes in how the HF clinic conducted consultations. The necessary amendments included a reduced sample (N=3), regular home visit and follow telephone calls by the researcher to provide a richer picture of patients' experiences.

Patients were invited to provide a mobile phone number to be contacted by the researcher at regular intervals throughout the intervention to ensure there were no difficulties with the app and/or if any issues or questions arose.

4.3.3 Medication discrepancies

As discussed earlier, polypharmacy, medication nonadherence and medication errors are common features in the care of older people with HF (Butrous and Hummel 2016; Fialová and Onder 2009), therefore, keeping an accurate and up-to-date medication list is crucial. Medication discrepancies were monitored during the observations conducted in the clinic in 2022 during the intervention. This was achieved by comparing the medication history compiled in the app (by the patient[13] and the researcher) and the list compiled by the nurse in the clinic. Any discrepancies were quantified and classified as follows:

- omission: when a patient used a medication that was not recorded in the medical record at the HF clinic;
- commission: when a patient stopped taking a medication that was prescribed by the clinicians at the HF clinic;
- dosage: when there was a discrepancy in dosage or frequency of a medication prescribed by clinicians at the HF clinic; and,
- switch: when there was a difference in the same medication category (e.g., a generic drug).

This method of quantifying medication errors has been previously used in a proof of concept study investigating the usability and reliability of a medication list app on a medical setting (Buning et al. 2016). It was found to be a reliable way to reduce medication discrepancies and to increase patient safety (ibid).

[13] Ethical approval (HSE & DkIT) has been granted for this phase.

4.3.4 System Usability Scale

Upon completion of the intervention, the System Usability Scale (SUS) was used to understand problems HF patients faced when using the app (please see Appendix M: System Usability Scale). It is a simple and short tool for researchers and participants to obtain a general overview about a product's usability. The SUS was originally developed for engineering of electronic office systems (Brooke 1986) but has been widely used to measure usability of technological products, including, apps (Kaya et al. 2019; AlGhannam et al. 2018), digital technology interventions on clinical settings (Hvidt et al. 2019) and websites (Katsanos et al. 2012). It has been demonstrated to be a reliable and validated tool with good internal consistency (Hvidt et al. 2020; Sevilla-Gonzalez et al. 2020; Orfanou et al. 2015). The tool has been translated and validated into Spanish (Sevilla-Gonzalez et al. 2020), Danish (Hvidt et al. 2020), Indonesian (Sharfina and Santoso 2016), Portuguese (Martins et al. 2015), Greek (Orfanou et al. 2015) and Slovene (Blažica and Lewis 2015).

The SUS is a 10-item, mixed-tone questionnaire whereby odd-numbered items have a positive tone and even-numbered items have a negative tone. Responses are indicated on a five-point scale, ranging from 1 (anchored with "strongly disagree") to 5 (anchored with "strongly agree) (Brooke, 1986). Upon completion, items score contribution are calculated (scores from 0 to 4). For positively worded items (items 1, 3, 5, 7, and 9), the score contribution is the scale position minus 1. For negatively worded items (items 2, 4, 6, 8, and 10), the score contribution is 5 minus the scale position. The overall SUS score is generated by multiplying the sum of the item scores by 2.5. Accordingly, SUS scores will range from 0 (very poor usability) to 100 (excellent usability) in 2.5-point increments.

A SUS score provides a measure of user-friendliness according to the following seven categories (Bangor et al. 2009, p. 117):

- Worst imaginable: SUS score 0–12.5
- Awful: SUS score >12.5–20.3
- Poor: SUS score >20.3–35.7
- OK: SUS score >35.7–50.9

- Good: SUS score >50.9–71.4
- Excellent: SUS score >71.4–85.5
- Best: SUS score >85.5–100

4.3.5 Health-related quality of life (HRQoL)

Prior to the intervention and upon completion of the intervention, HF patients' HRQoL were assessed using the 5-level version of the European Quality of Life-5 dimensions (EQ-5D-5L) tool (please see Appendix N). The EQ-5D-5L is part of the EQ-5D, a suite of HRQoL instruments that have been used in clinical trials and epidemiological studies for more than three decades and are available in 98 unique languages (EuroQol Research Foundation 2020). The EQ-5D-5L in contrast to the EQ-5D-3L allows to track small changes in health status (Herdman et al. 2011).

The EQ-5D-5L includes a descriptive section and a single index to indicate perceived health status (EQ-VAS). The descriptive section covers five dimensions (mobility, self-care, usual activities, pain/discomfort and anxiety/depression) with responses indicated on a five-point Likert scale (no problems, some problems, and extreme problems). Participants[14] are asked to indicate their health status by selecting the most appropriate statement for each dimension. The resulting health profile is defined by a 5-digit number that combines the levels from each dimension (where '11111' represents the best possible health state and '55555' represents the worst possible health state). The EQ-VAS reflects a patient's perceived health status on a scale ranging from 0 ('worst imaginable health state' to 100 ('best imaginable health state').

The EQ-5D is a reliable and validated tool and has shown good internal consistency Cronbach's alpha 0.72 (Bekairy et al. 2018), 0.75 (de Graaf et al. 2020) and .86 (Bilbao et al. 2018). The tool has been used in clinical trials and population surveys (Rabin and Charro 2001) and clinical and economic evaluation of medical interventions (Brooks 1996). It is also used to measure quality of life of patients with

[14] As mentioned earlier, a cluster of symptoms accompanies HF (Health Service Executive 2018), impacting significantly on patients personal, social and occupational performance thus reducing their quality of life.

diseases, for example, stroke (Hunger et al. 2012), cardiovascular disease (Schweikert et al. 2006) and depression (Günther et al. 2008). It has been translated and validated in Indonesian (Luo et al. 2003), German (Hunger et al. 2012), Arabic (Bekairy et al. 2018) and Spanish (Bilbao et al. 2018). This tool has been previously used in small sample studies, (n=25) qualitative study (Matza et al. 2015) and (n=10) mixed methods study (Notiar et al. 2021).

4.3.6 Semi – structured interviews pre- and post – app use

Upon completion of the intervention, semi-structured interviews were conducted with patients to evaluate their: (1) general attitudes towards the medication app and their expectations, including their reasons for participation in this study, (2) acceptance of the app, and (3) adherence to the app. Semi-structured interviews were also conducted with HCPs to examine the role of the app in the medication review process, benefits of using the app and experiences while using digital technologies in the clinical practice (please see Appendix O, interview guide). The interviews were transcribed verbatim, and transcripts were subjected to theory-led qualitative analysis. The NPT framework was used to capture individual and organisational barriers and facilitators to the normalisation of the use of the medication app with HF older patients. The interview topic guide was developed using the NPT constructs to prompt, guide and structure the questions of the topic guide, and to reflect some of the research questions.

4.3.7 Data analysis

The same process of data analysis (thematic analysis by Braun and Clarke 2006) described in section 4.1.2 was followed. However, they are summarised on the table below to highlight a new element incorporated in step 5. The themes and subthemes were mapped to the NPT framework key constructs and components.

Table 1: Phases of thematic analysis after Braun and Clark (2006)

Steps	Process
1) Familiarise with the data	This included reading and re-reading the data, writing down initial ideas, for example, noticing

	an awkward silence from a participant while listening to the digital audio recording.
2) Generation of initial codes	Coding interesting features across the data set in a systematic way, organising data into the relevant codes
3) Search for themes	Collating codes, organising codes into potential themes
4) Review themes	Reviewing the themes to ensure they captured the coded data, creating a thematic map of the analysis
5) Define the themes and link them to explanatory frameworks, models and concepts	Refining the names for each theme, refining themes into main themes and sub-themes. Making a contribution to theory, reflecting on the validity of different socio-material approaches. In this study, key constructs and components of the NPT framework were applied and themes were refined and sorted into main themes and subthemes accordingly.
6) Produce the report	Selecting representative themes related to the research questions and literature to produce the written report of the analysis. Use of quotes to illustrate the experiences and opinions of interviewees.

The primary researcher and PhD candidate YD transcribed the interviews verbatim and read the transcriptions repeatedly whilst listening to the digital audio recordings. Coding was partially conducted (25 percent random selection of the transcript n=4) with one member of the supervisory team (LC). Data coding and analysis of the four transcripts was reviewed by YD and LC for inter-coder reliability purposes (Pope et al. 2000). A third researcher (NC) was available to resolve any disagreement. All members of the team are from a different professional backgrounds, YD (nursing), NC (psychology) and LC (social policy and ageing), the latter with a vast experience analysing qualitative data. Similarities of codes and points of disagreements were discussed during a meeting with (YD, NC and LC) until a consensus was reached.

Transcriptions were analysed by YD using inductive thematic analysis (Braun and Clarke 2006) - (please see Appendix P for the initial coding), the codes describing common experiences were consequently organised into potential themes (please see Appendix Q). QSR NVivo12® qualitative data management software was used to organise the data and code the transcripts to facilitate the analysis and comparison of relationships between the codes. Themes were reviewed to ensure they captured the coded data associated to them. Subsequently, the initial themes were mapped onto the key constructs and components of the NPT framework (please see table 2 below and Appendix R). Applying the NPT framework to the subthemes was crucial to understand the relationship between the themes that emerged from the thematic analysis. The final phase of the thematic analysis involved selecting participants' quotes to illustrate their experiences and opinions (Braun and Clarke 2012; 2006).

Table 2: NPT coding framework used for the qualitative analysis - Adapted from Mair et al. 2012)

Coherence (Sense-making work)	**Cognitive participation** (Relationship work)	**Collective action** (Enacting work)	**Reflexive monitoring** (Appraisal work)
Differentiation Is there a clear understanding of how using the medication app differs from the traditional medication management strategy?	**Enrolment** Do individuals "buy into" the idea of using the medication app?	**Skill set workability** How does using the app affect individuals' roles & responsibilities and/or training needs?	**Reconfiguration** Do individuals try to modify the way they have been using the medication app?
Communal specification Do individuals understand the aims & expected benefits of using the medication app?	**Activation** Are individuals committed to use the medication app? Can they sustain their involvement?	**Contextual integration** Is there any support (organisational or from relatives) for individuals using the app or those supporting the use the medication app?	**Communal appraisal** How both groups – HCPs and patients - evaluate the contribution of the medication app?

Individual specification	Initiation	Interactional workability	Individual appraisal
Do patients have a clear understanding of their specific tasks and responsibilities while using the medication app?	Are main individuals ready and willing to use the medication app?	Does the medication app make medication self-management easier?	How do patients appraise the effects of the app on them and their medication self-management? How do HCPs appraise the effects of the medication app on their work practice?
Internalization	**Legitimation**	**Relational integration**	**Systematization**
Do individuals have an understanding of the value, benefits and importance of using the medication app?	Are individuals certain that it is right for them to be involved in using the medication app?	Do individuals have confidence in the new medication management strategy – the medication app?	How are app benefits measured and problems with the medication app identified?

Chapter 4: Phase 4 - A case study of medication management using an app

The objective of Phase 4 was to use a multiple case study strategy to compare the experiences and opinions of the HCPs and HF patients about the use of medication app. The case studies were also formulated to answer one of the research questions; What are the barriers and facilitators for the adoption of the medication app in the care of older patients?

A case study can be used as a methodological approach or design for doctoral thesis. However, in the present study, case studies were used as a strategy or method to study how participants' experienced the medication app (Creswell 2007). The case study method was used to present the findings because case studies in medicine and social research, offer the opportunity to present findings and conclusions in qualitative studies (Elsahn et al. 2020; Harwati 2019; Yin 2003). In the present study, case studies were useful for understanding and comparing opinions and experiences from both groups (HCPs and HF older patients). As Lewis (2012) state:

> *"The term case study is used in varied ways, but the primary defining features of a case study are that it draws in multiple perspectives (whether through single or multiple data collection methods) and is rooted in a specific context which is seen as critical to understanding the researched phenomena. The study may involve a single case but more commonly in applied research involves multiple cases, selected carefully to enable comparison."* (p.76).

4.4.1 A case study approach

A case study is an "empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially where the boundaries between the phenomenon and context are not clearly evidenced" (Yin 1994, p. 13). In the present study, the purpose of these case studies the use of a medication app by HF patients self-managing medication at home, by asking how and why questions and capturing the whole context. A multiple case study design was employed (Yin 2019), with three HF patients being the unit of analysis, the fourth case study was an organisation: the HF clinic.

4.4.2 Participants

The case studies present a more holistic understanding of participants in real world contexts across the 12 weeks of the intervention. They were based on HF patients (n=3) using a medication app for 12 weeks, the fourth case study is based on the HF clinic and the implementation of the app. Participants were sampled purposefully and were chosen for multiple reasons: Firstly, they are all HF patients attending the HF clinic, have a complex medication regimen and self-manage their medication at home and lastly, they reported having very little experience to none using a medication app.

4.4.3 Data collection

Semi-structured interviews were conducted with HCPs (n=3) and HF patients (n=3). Observations of practice were conducted when patients visited the HF clinic appointment to observe the interaction between patient and HCP using the app during the medication review process. In addition, the researcher made weekly home visits or telephone calls to patients during the 12 weeks of the intervention.

4.4.4 Data analysis and interpretation

The present study employed an exploratory case study strategy. Thus data from interviews, observations and weekly telephone calls and home visits were presented as case studies.

Data was analysed using thematic analysis (described in phase 3 methodology) and was conducted in parallel to ongoing data analysis and discussion of phase 3. A detailed description of the setting (HF clinic) and individuals (HF patients) was provided. The three HF patient’s case studies were analysed individually and later compared in a summary table to look for similarities and differences (themes). Themes were categorised and described (Creswell 2003).

4.4.5 Case study validity - triangulation of sources

The context of the case studies was outlined in detail to identify similarities between them (Holliday 2004). As recommended by Yin (1994), the information used to describe and build the case studies came from different sources. The first source was the literature review (presented in chapter 2) on HCPs and patients attitudes towards mHealth and barriers and facilitators to technology in care adoption. Another source of information was the semi-structured interviews conducted with HCPs and patients and the observations of clinical practice while using the medication app. Lastly, weekly telephone calls and home visits to patients allowed the researcher to obtain a greater amount of qualitative data. This was very useful to document their experiences, feelings and opinions about self-managing their medication at home using the app.

Chapter 5: Results

Identifying the evidence base - exploring HCPs views and experience towards technology in care of HF older patients

5.1 Semi-structure interviews

Semi-structured interviews were conducted with five HCPs. Demographic information was collected pre-interview. All participants were female, ranging in age from 30 to over 60 years, all stated working between 18 hours to 39 hours a week. Their level of education ranged from bachelor's degree to doctoral degree. Their clinical experience working at the HF clinic ranges from four years to more than ten years. Most interviewees had no previous use of technology in care and reported not feeling comfortable with ICT use.

Four themes emerged from the data: (1) staff attitudes towards older patients use of technology, (2) factors that affect patient technology uptake, (3) technology potential to enhance practise and (4) patient care and challenges experienced by HCP. These themes are described further below.

5.1.1 Theme 1: Staff attitudes towards older patients' use of technology

Overall, the five HCPs agreed that older people attending the clinic were receptive to the use of mobile phones and digital technologies. However, many patients do not use smartphones. As one of the clinicians remarked: *"about 60% would have smartphones and a few of them have the old Nokia."*

According to this participant, technology (such as Fitbits) is more popular among younger patients (around 50 years of age). On the other hand, there was some acknowledgement that while some older patients might find technology challenging, others were motivated and able to use technology: *"some of them are very on top of things and would love to have that information monitored more closely."*

5.1.2 Theme 2: Factors affecting patient technology uptake

Although the HCPs reported that many of their patients would be receptive to mHealth interventions, they predicted some challenges to mHealth uptake by older patients due to age-related problems (e.g., cognitive decline, mobility issues, eyesight deterioration):

> *"some of them definitely, I know they won't* [use mHealth], *especially if they have issues with sight or even with their mobility …and of course, some of them do forget quite easily."*

The lack of a support network around the patient (i.e. relatives or health care assistants visiting the patient at home) was also cited as another potential barrier to mHealth uptake. Interestingly, the HCPs acknowledged that many carers were themselves older adults and not necessarily comfortable using technology:

> *"age and the support systems they have at home; those would be huge factors to embrace* [mHealth] *... even carers as a rule are an older generation …* [they] *might be afraid of it as well."*

One of the HCPs queried whether older people would be able to cope with technological advances: *"the only thing I have to say about digital equipment is for the older people, will they be able to use it?... Will they be able to understand?"*

Compliance with technology was cited as another potential obstacle to mHealth uptake: *"if you are considering using iPads and if the patient had to upload information themselves … I think compliance could be an issue."*

This was echoed by another HCP: *"I'm all for it, but like any technology, it's only as good as the person using it."*

5.1.3 Theme 3: Technology potential to enhance practise and patient care

All five HCPs agreed that mHealth had the potential to facilitate greater efficiency in the clinic, and were willing to adapt their practice and adopt mHealth if it improved the management of older patients with HF and promoted medication compliance and self-care. As one of the HCPs pointed out, patients who experience an exacerbation of symptoms will consider any methods to avoid feeling so unwell again:

> *". . . if they've experienced the acutely decompensated* [episode of disease] *… that awful sense of gasping for air, they never forget it and they'll buy into anything that'll prevent that happening again."*

HCPs were aware of the short-falls in paper-based systems as this comment suggest:

> *"sometimes it is not clear if they are not on a beta-blocker and why they are not on it, it* [information] *gets lost in these paper files. I have seen that a few times."*

mHealth can also support patients with HF who experience frequent hospital readmissions:

> *"*[for] *the more advanced and more unstable patient or the patient who has red flags* [meaning] *they are in a decline. . . it might help intensive their treatment."*

One of the HCPs pointed out that it would be beneficial if patients from the HF outpatient clinic had all their medical information (relating to treatment, medication etc.) on an electronic device. She remarked that typically, patients are very ill when they present to emergency departments and having their medical information clearly articulated and at hand could support clinicians in making crucial clinical decisions in a timely manner, adding: *"... if they had their iPad with basic information that would be helpful."*

Understanding a patient's blood circulation (i.e., hemodynamic) is fundamental for titrating medication. At present, blood pressure is measured in the HF clinic, but often this measurement is influenced by a number of factors (e.g. stress, temperature, time of last food intake). The comments of the HCPs suggest an appreciation for the potential benefits of an app that allows the patient to record their blood pressure daily to facilitate a more accurate overview of blood pressure status over time and enable patients to present this data at the clinic to support clinical decisions by HCPs. Also, the benefits of the information recorded on symptomatology and quality of life on a daily or weekly basis gives a good overview of the patient's medication self-management, as the comment below suggest:

> *"once a week they tapped* [input the information on the app] *how they felt,* [their] *quality of life score was and their symptoms and then you could see on week to week. . .* [if they note their] *symptoms are mild, moderate, severe,* [and] *quality of life is good, average, bad, you might get a trend about well how they are actually doing."*

5.1.4 Theme 4: Challenges experienced by HCPs

Nurses provide educational sessions to recently diagnosed patients. Guidelines recommend that each patient receives three hours of education but this is a challenge for nurses to deliver alongside their other tasks and demanding working schedule:

> *"when they're an inpatient, we should, according to the National Heart Failure Programme, give them three hours on their admission, one hour initially, then the second hour in the middle and then an hour when they're going home and just reinforce those symptoms. But we don't ... We might be lucky if we give them an hour or an hour and a half."*

Emerging tasks also added an additional burden to the HCPs' caseloads:

> *"we have a new drug now that's replacing Ramipril*[15] *on selected patients called Entresto … and* [that requires] *more education for us."*

Some of HCPs remarked that consultation times are time-limited and they are unable to spend the time they would like with patients due to a heavy caseload:

> *"she* [a patient] *needed time because she was very upset, but … other people* [are] *waiting outside … it would be lovely to be able to have that time to spend with them"* and "*you're rushing them in and rushing them out and all they want to do is have a chat, to tell you*

[15] Ramipril is medication used to treat high blood pressure, heart failure, and diabetic kidney disease.

how they are and how they feel … it's sad if we can't give … older people a little bit of extra time."

Patients react in different ways to a HF diagnosis, including feeling fearful and anxious about their symptoms, the future and the impact on their family. Often the HCPs felt that they were ill-equipped in terms of psychological resilience and psychological knowledge to deal with the concerns and problems of patients:

> "*I'm not a psychologist. I'd like to think I'm a good listener and I'd like to think that I can offer advice, but sometimes it's very hard to know what to say … you don't want to say the wrong thing … how much do you say? You don't want to frighten them either … the psychological aspect of things, it's massive. massive*."

Similarly, another HCP remarked:

> *"they're just so traumatised and they just needed that time and unfortunately we don't have a psychologist. So, the psychological care is coming from us."*

Nurses acknowledged how important is for HF patients to be engaged with a psychological service. On reflection on the need for psychological services in the clinical setting one nurse noted: *"it would be fantastic if you could get a psychologist, even once every couple of months, just to come down and see people."*

5.2 Observations

Clinical observations took place for a total of 32 hours and included observations of 76 consultations with patients. Observations focussed on how the clinic operated daily, to enable the researcher to identify the potential role of technology in the clinic to support efficiency in consultations and better outcomes for patients. The results of the observations are presented below within the key areas covered by the observation protocol (Appendix E).

The clinic context (observable behaviour, conversations, general mood of HCP & patients alike).

- Observations were conducted over the spring/summertime; the weather was largely good. Conversations between HCPs and patients were very friendly and the hot weather was a source of delight for patients. Nurses, on the other hand, had to open all windows as the consultation room got very hot at certain periods of the day.

Clinical environment (clinic and waiting room layout, check in procedure, time patients spent at consultations, patient seen at the time given in the appointment letter, greetings).

- HCPs greeted all patients and addressed them by their name, often nurses asked patients about their relatives showing the rapport they built over time. The waiting room which was narrow, had room to sit 16 people. It contained leaflets and support advice on HF for patients to read while waiting to be seen. The check-in procedure at the clinic was very simple (for those that have previously attended the clinic). Patients were advised to avoid knocking the consultation door, instead, to go directly to the administration room, where the clinic secretary answered the door and collected the appointment letter. The secretary took their appointment letters into the consultation room and placed them on a counter for the nurses. Patients were not seen at the time stated on the letter but at the time of arrival. The appointment letter clearly requested that patients arrive 15 minutes before the appointment time. The consultation room was very small, including two cubicles where patients were seen by the HCPs, separated by curtains. The nurse introduced the researcher to the patient prior to clinical review, consent was obtained for the researcher to remain in the room, but clinical examination was undertaken behind closed curtains.

- The curtains were fully closed during the consultations to ensure (physical) patient privacy; however, all sounds and conversations could be overheard. Both consultation rooms were used simultaneously, however, if a patient was symptomatic and needed specialised treatment (i.e. intravenous therapy), they were treated in a consultation room. For patients presenting to the clinic showing signs of HF deterioration, there was no facility allocated for them to receive ambulatory treatment.

- Time patients spent on the consultation room was recorded. The average visiting time was 24 minutes (SD 8.3), 9 minutes the shortest consultation time and 45 the longest. During the observations, 76 patients were seen by HCPs. The visiting time for each patient was recorded, except for four patients that were very symptomatic, and the consultation stopped.

During consultation (consultation procedure, HCPs explaining tests results, HCPs providing health promotion and health education, HCPs allocating time for patients to ask questions, how HCP responds to questions, interruptions during consultation, use of medical jargon).

- Consultations started with the HCPs taking vital signs, weight and a review of medication. The nurses were very patient, explained in clear and simple, easy to understand language the test results and responded to each question posed by patients. However, there were frequent interruptions (e.g., doctors requested information on patients or nurses were bleeped). In all consultations, nurses reiterated the importance of a good diet, daily weight, salt intake reduction and medication compliance. Follow up appointments were sent via post by the clinic secretary.

Newly diagnosed patients first visit to clinic (explaining the diagnosis / prognosis of disease, cause & treatment of disease to the patients, side effects of medication).

- Newly diagnosed patients were seen on an afternoon when the clinic was not busy (typically Wednesday), HCPs allocated sufficient time to provide explanation of the disease, treatment, side-effects and answer any questions by the patient and sometimes relatives (where applicable). The HCPs also asked the patients and their relative if they understood the discussions to avoid any misunderstandings.

The primary objective of the observations was to get a sense of how the clinic operates and day-to-day challenges for HCPs delivering care. During the observations, one of the challenges HCPs faced involved the medication review. Those patients who failed to bring their medication or an updated medication list negatively impacted the ability of the HCPs to complete this task in a safely and timely manner. Patients at the clinic were actively encouraged to bring their current medication (blister pack) or an updated medication list (this instruction was printed in their appointment letter and HCPs repeatedly emphasised the importance of bringing their medication to appointments).

A correct medication list optimises the medication review process avoiding medication errors, ad hoc clinic visits and rehospitalisation. The medication review, therefore, is central to guide patient pharmacological therapy. In the case of HF, frequent changes in medication and the dose taken by HF patients, makes the medication review process more complicated. Therefore, when patients attend the clinic and fail to produce the medication list, nurses must pause the consultation and ring the pharmacist to obtain an accurate list of medication, delaying the consultation process and disrupting the clinic efficiency.

5.3 Results from questionnaires with HCPs

Job satisfaction survey. All HCPs (100%, n=5) were satisfied or very satisfied with the nature of their work, stating their job was extremely enjoyable (100%, n=5). Participants also indicated their satisfaction with their colleagues, i.e. having a good and collegial relationship with colleagues. Payment was one of the least satisfying aspects of participants' jobs, with more than half of participants (60%, n=3) not feeling satisfied with their salary and unhappy with the pay raises. Promotion was also viewed negatively, with HCPs reporting little chance of promotion in their job and feeling that they were unable to advance as quickly as their peers in other clinical settings (60%, n=3).

Technology acceptance of digital health interventions. All the HCPs (100%, n=5) thought that digital interventions could be useful but most (80%, n=4) did not have previous experience of using digital technologies in a clinical setting. All the HCPs (100%, n=5) agreed it would be easy for them to acquire the skills necessary to use digital tools. In addition, all HCPs also reported their intention to use digital technologies.

Identifying the technology (medication app)

5.4 Apps with medication functionality

Google play and iOS app stores searches identified 483 potential apps (292 Android stores and 191 Apple stores) (see Figure 5). Following application of the exclusion criteria, nine apps (five in Google Play and four in the Apple Store) were included in the review and were subject to further analysis. A description of the nine apps is presented in Table 3.

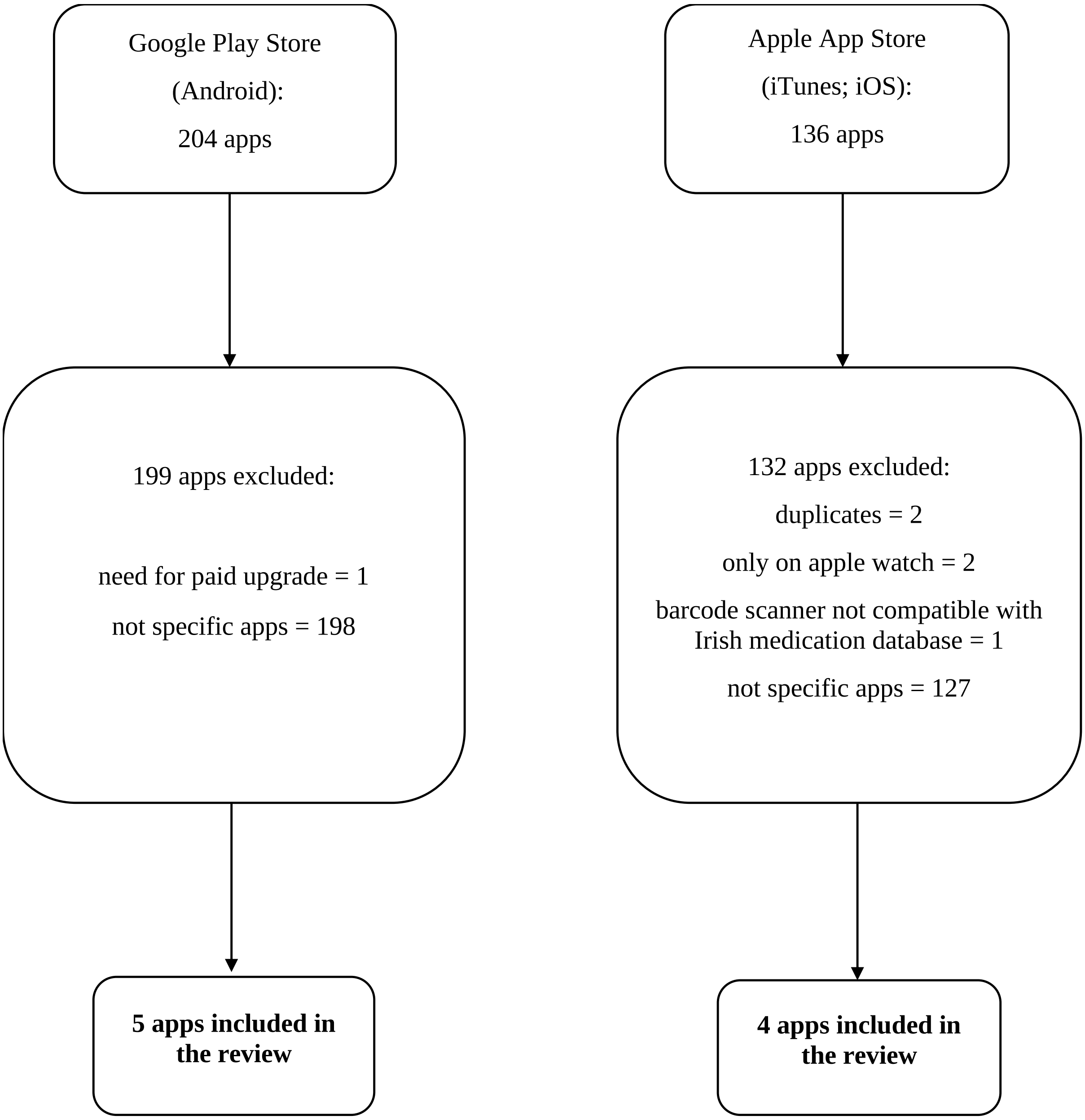

Figure 5: Apps with medication functionality in Google Play & Apple App Stores

Table 3: Name of app, app store, country of development and functionality of the app

<table>
<tr><th>App name</th><th>App store</th><th>Country of development</th><th>Functionality</th></tr>
<tr><td rowspan="2">My Therapy</td><td>Google play</td><td>USA</td><td rowspan="2">• Allows user to input daily health status, symptoms and mood.
• Prints health report to share with others.
• Works on PCs, tablets and smartphones.
• Web dashboard tools to allow HCPs to view and analyse treatment plan, adherence, and self-tracked measurements.</td></tr>
<tr><td>iTunes</td><td>USA</td></tr>
<tr><td rowspan="2">Medisafe</td><td>Google play</td><td>USA</td><td rowspan="2">• Allows user to track 20 + health measurements (e.g. weight, blood pressure).
• Allows user to track their medication and share their medication report with HCPs.
• Provides alerts on drug interactions.</td></tr>
<tr><td>iTunes</td><td>USA</td></tr>
<tr><td>Medication List & Medical Records</td><td>Google play</td><td>USA</td><td>• Display medications prescribed by a doctor.
• Able to take pictures of medication and prescription bottle labels to show HCPs.
• Allows sharing of the user’s medication list with others.
• Tracks blood pressure and weight measurements.
• Keeps a medical record information for use in times of emergency (e.g. attending the emergency department).</td></tr>
<tr><td rowspan="2">Dosecast</td><td>Google play</td><td>USA</td><td rowspan="2">• Able to collate and email medication history to others.
• Sends medication reminders with, or without, an internet connection.
• Pre-populated medication database facilitates easy input medication.
• Tracks the prescribing doctor or dispensing pharmacy.</td></tr>
<tr><td>iTunes</td><td>USA</td></tr>
</table>

			• Medication information is encrypted when in transit to ensure confidentiality.
Pill reminder – All in one	iTunes	Not stated in website	• Medication reminder option. • Allows the user's medication list or administration history to be emailed and shared. • Provides the option of adding photos to each medication for easy identification. • User friendly interface.
MedList Pro	Google play	USA	• Medication list reminder with the option of sharing the medication list with others. • Secure, password protected, and medication data is stored on the local device. • No account creation necessary. • Tracks health measurements.

5.5 App evaluation

The aims of the review were twofold: to review apps with a medication list functionality and to assess the quality of the apps included in the review using the Mobile App Rating Scale (MARS) and the IMS Institute for Healthcare Informatics functionality scale. The Medisafe app achieved the highest objective and subjective overall MARS scores and featured all the IMS Institute for Healthcare Informatics functionalities. One of the distinctive features of this app was the ability to educate users on how and when to take their medication, drug-drug interaction information, and medication side effects. This information was presented in videos using a clear and concise language and text format. In addition, there is evidence of effectiveness, as the Medisafe app has been previously tested in 2 randomized controlled trials, as a medication adherence tool using scheduled reminders and as a medication reminder related to patients' intention to use the app. The app is discussed in more detail below.

The evaluation conducted on the apps identified with a medication list functionality was published in JMIR Mhealth Uhealth journal (Diaz-Skeete et al. 2021).

5.6 The Medisafe app

Medisafe is a free app commercially developed in 2012 and available to Irish consumers. It is a medication reminder app with the ability to produce a medication history log. It also has the ability to share the medication report with others (with HCPs and/or friends and relatives) and track vital parameters.

In a study evaluating apps with a medication list functionality (Diaz-Skeete et al. 2021), the app was found to be effective at communicating to users, offering an educational component about medication, the medical condition associated with each medication and alert about possible drug-drug interaction. Furthermore, the data (daily medication and vital parameters tracking) are displayed in a clear and colourful graphical representation format, as shown in the figures 6, 7 and 8 below.

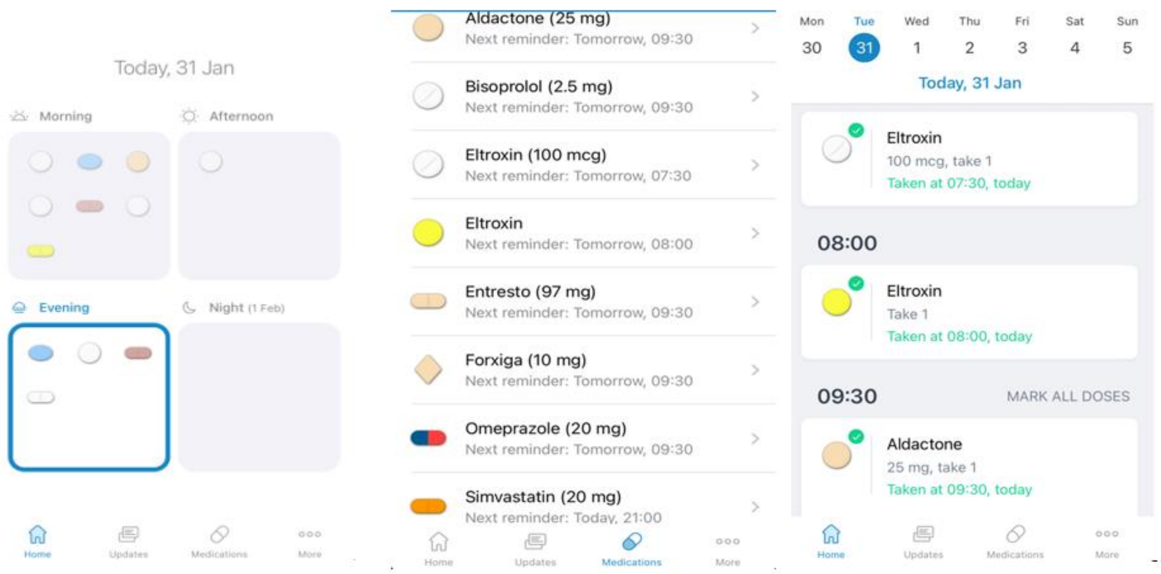

Figure 6: Screenshots of the Medisafe app (daily medication representation) as seen by participants

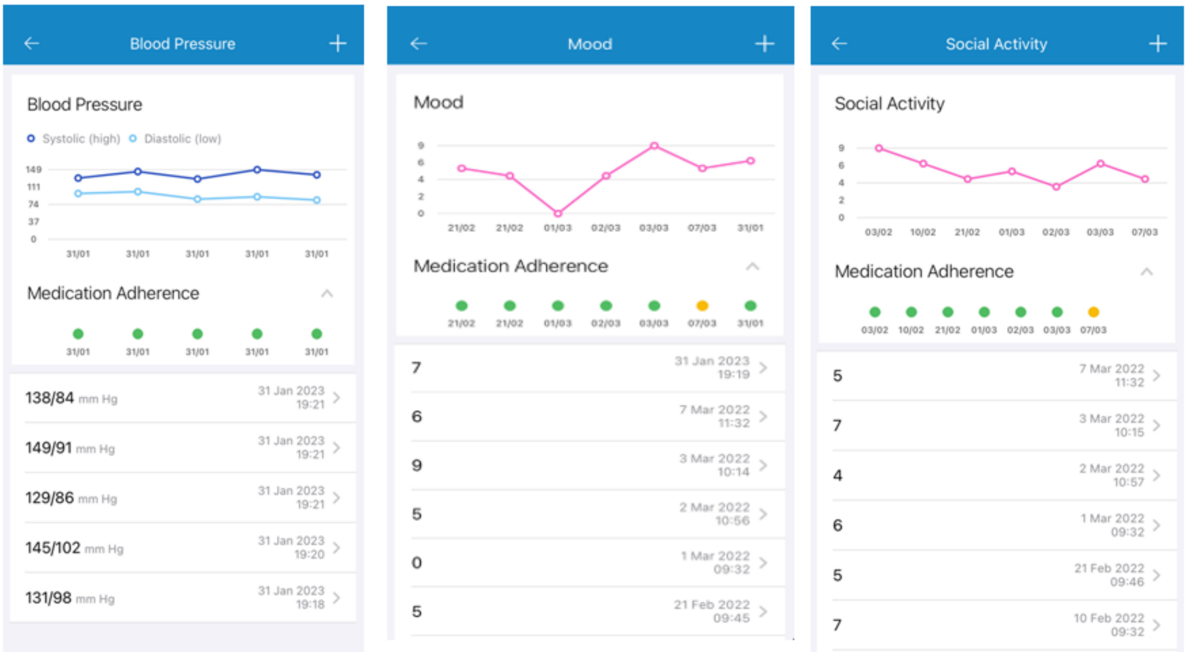

Figure 7: Screenshots of the Medisafe app (daily measurements) as seen by participants

Alongside the weekly medication report complied in the app, it also sends a medication adherence report weekly via email to users.

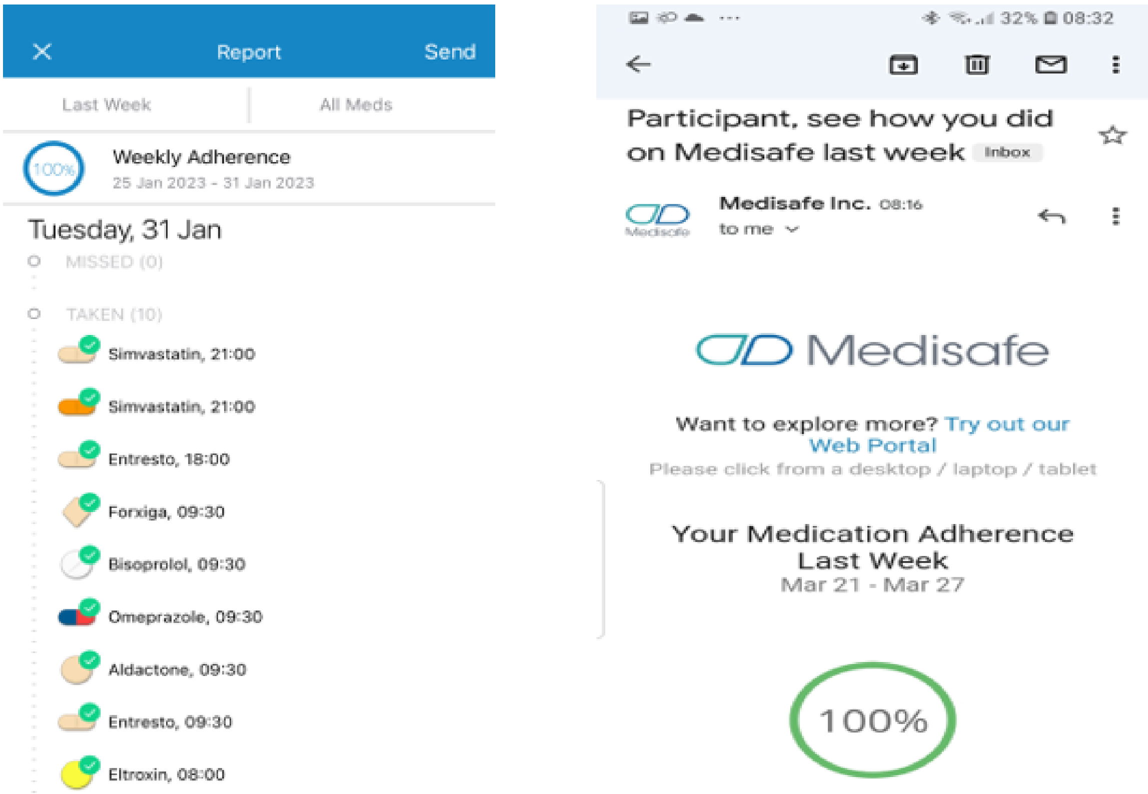

Figure 8: Screenshots of the Medisafe app (medication report that can be exported and shared with others and weekly medication adherence report sent via email) as seen by participants

Medisafe users can access a "Help Center" section for questions and answers on the Medisafe app website (https://www.medisafeapp.com). The "Help Center" link also provides detailed instructions on how to use the app. A screenshot of the help centre and an example of a question can be seen in figures 9 and 10 below. Examples of questions found on the Help Center are "Why did my medication reminders stop working" and "How to add or delete a medication dose".

However, it may be challenging for an older person to find the information they are looking for in a website (i.e. what link should be followed, scrolling down to find the pertinent answer for their question). In addition, reading the answer and following the instructions might also be difficult for an older person with limited technological knowledge. Grindrod et al. 2014 point out the information on the Medisafe app is presented in sections with a large quantity of text without visual aids and argues that it is not very intuitive. Most websites and apps are designed to be used by younger people, without taking into consideration the needs of older adults. Some of the factors negatively affecting technology adoption by older adults are decline in health, dexterity problems, cognitive impairment and hearing and vision impairment (Toschi and Munshi 2020). Age friendly refers to designing websites, apps and digital devices in an inclusive way, making it more accessible for older adults (Van Hoof et al. 2018).

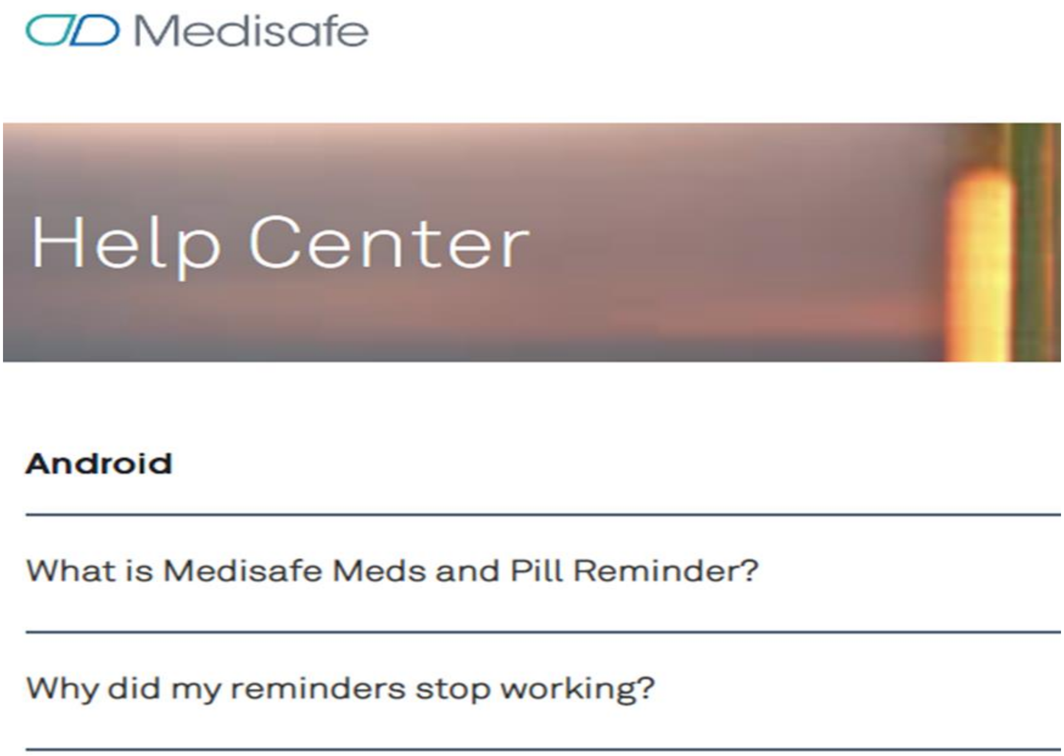

Figure 9: Medisafe website section with FAQ (Medisafe 2022)

Medisafe

How do I add a medication dose?

Android 5.0 or higher:

1. Tap "Medications" on the bottom menu
2. Long press on the medication to add a dose
3. Alternatively, tap "Home" on the bottom menu, tap on the '+' on the bottom right and tap "Add dose"

Below Android 5.0:

1. Tap on the "Side Menu" on the top left
2. Tap on "Medications"
3. Long press on the medication to add a dose
4. Alternatively tap on the '+' on the bottom right and tap "Add dose"

Figure 10: Medisafe app help centre example of a FAQ "How to add or delete a medication dose" (Medisafe 2022)

As the Medisafe website is not age-friendly, a hand-written guide was developed by the researcher to support patients to record their vital parameters (please see Appendix S) during the second week of the intervention. The guide provided support to those patients with limited knowledge and experience using the medication app, allowing them to work independently.

Towards the end of the intervention, a manual (please see Appendix T) was developed by the researcher to guide participants to add/update/delete a medication independently post-intervention. The manual was created using pictures of the app as patients are more familiar with it. It was crucial to avoid information overload, so all instructions were written in a simplified way, avoiding technical jargon and all kept in a single document. For example, in figure 10 (screenshot of instructions in the website on how to add a medication dose) can be seen. In the figure presented below, figure 11, a screenshot of the manual developed, shows how arrows were used to guide the user, using pictures of the app they are familiar with.

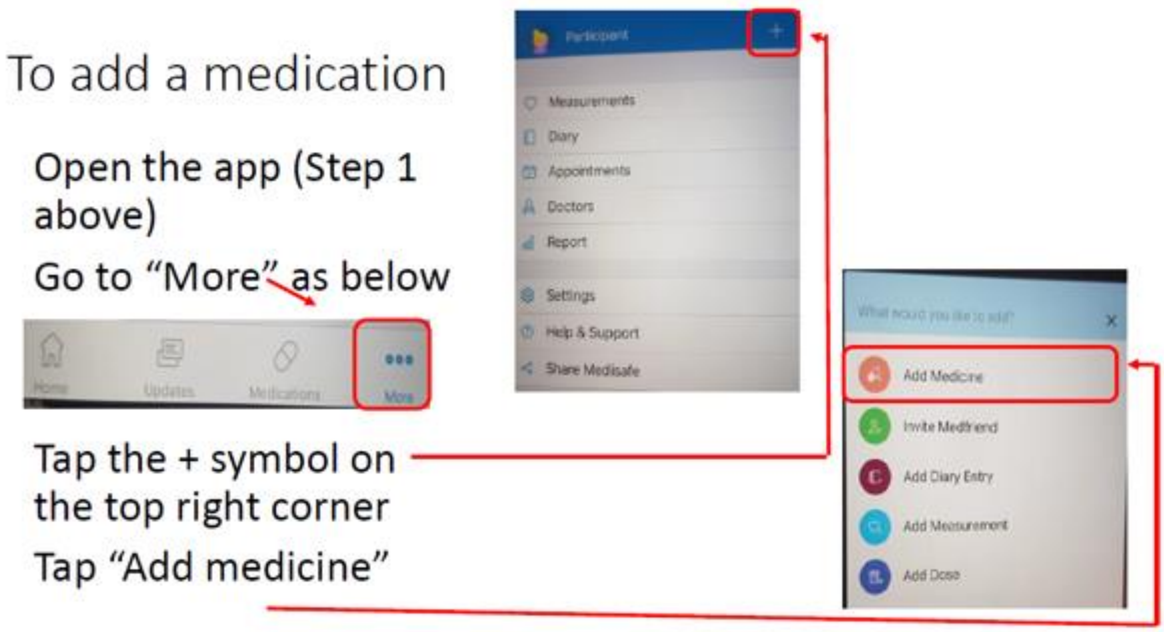

Figure 11: Screenshot of the manual developed for participants

5.7 Literature search to identify use of Apps with a medication functionality

A total of 6,289 articles were identified in the literature search. Of these, 6,270 articles were excluded as they did not meet the inclusion criteria. In total, 19 articles were included in the review of medication management apps (see figure 12: Search results for apps with a medication list functionality used in applied settings, below).

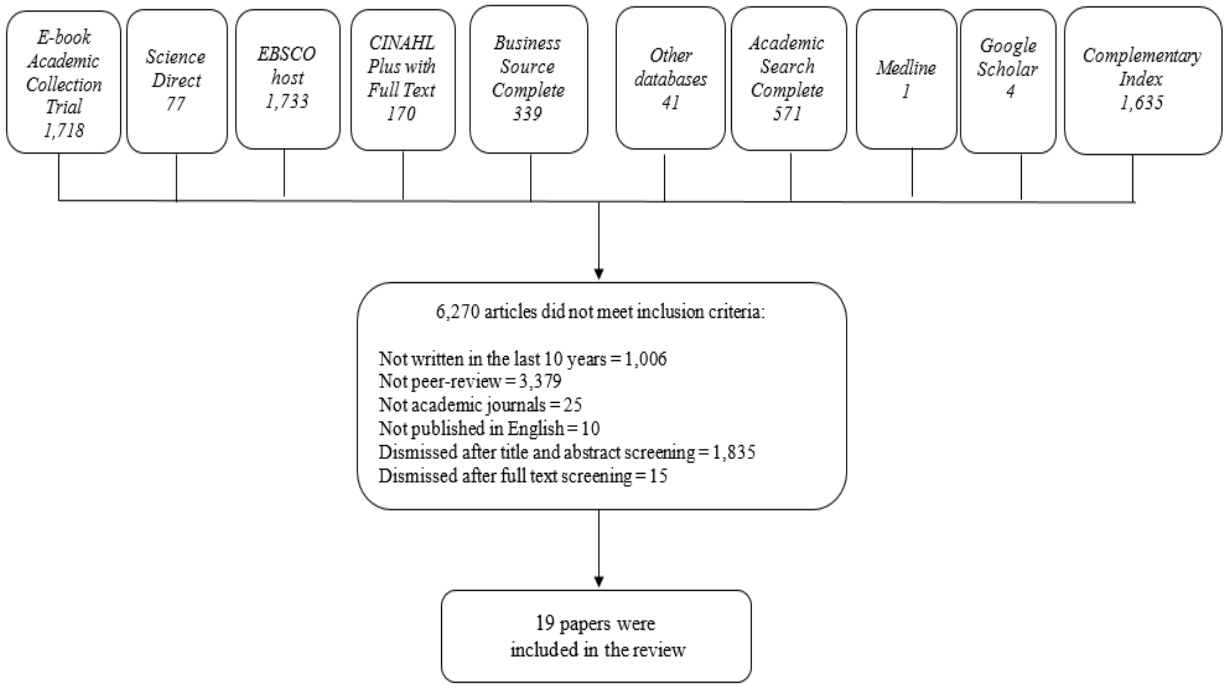

Figure 12: Search results for apps with a medication list functionality used in applied settings

Of the 19 articles, 13 had a sample of less than 100 participants. Becker et al. (2013) had the largest sample (n=11,688) and involved a trial of a medication app involving patients with multi-morbidities. Corden et al. (2016) had the smallest sample (n=11) and involved evaluating the feasibility of a digital intervention to improve the treatment of depression amongst patients during the first eight weeks of starting therapy with a new antidepressant medication. Most studies (n=10) were feasibility and usability studies, five were RCTs and one was a qualitative study describing the experiences of patients using an app. The remaining three studies involved an app effectiveness evaluation, a description of a medication adherence app implementation and the analysis of captured data of patients using a medication app. The intervention timeframe ranged from a 2-hour participation in a usability session (Grindrod et al. 2014) to a 12-months clinical trial (Steinert et al. 2018).

Most of the studies tested one app though Santo et al. (2019) tested two apps (a basic and an advanced medication reminder app) and (Grindod et al. 2014) tested four apps. Some apps were specifically designed and developed for a particular study (Fallah and Yasini 2017; Patel et al. 2013) and were unavailable in app stores.

Some apps were available in the app stores but developed in languages other than English[16], including the Medication Plan app which was developed in German (Mertens et al. 2016; Becker at al. 2015: 2013), the ALICE app in Spanish (Mira et al. 2014), the Hypertension Management app in Korean (Kang and Park 2016) and the MyMedication app in Dutch (Buning et al. 2016).

In the case of Santo et al. (2019), both medication reminder apps were available in the Australian app stores. Apps that were available in the Irish app stores included: MyTherapy (Steiner et al. 2018) Medisafe (Morawski et al. 2018), my BP (Morrisey et al. 2018), MyMedRec, DrugHub, Pillboxie, PocketPharmacist (Grindrod et al. 2014) and iRx Reminder app (Goldstein et al. 2014).

As stated earlier in the literature review, medication to treat cardiovascular conditions are the most common medications contributing to polypharmacy. Interestingly, most of the studies included in the review related to evaluations of medication apps among patients with cardiovascular disease. Specifically, five studies focused on medication adherence of patients with cardiovascular disease (two for HF). Six studies included participants with hypertension and lipid management (good medication compliance for both conditions prevents morbidity and mortality from cardiovascular disease) and one study involved patients taking anticoagulation medication, a treatment used to treat some HF patients with reduced ejection (Mehra et al. 2019).

The majority of mHealth interventions reviewed were widely accepted among older people and most were advantageous for medication adherence and management (Santo et al. 2019; Morrisey et al. 2018; Buning et al. 2016; Johnston et al. 2016; Mertens et al. 2016; Anglada-Martinez et al. 2016; Mira et al. 2014; Patel et al. 2013). However, Grindrod et al. (2014) reported that participants were not motivated or interested in using apps for medication management and in Steinert et al.'s study (2018) 43% of participants never used the app. Other studies also reported inconclusive results (Morawski et al. 2018; Goldstein et al. 2014).

[16] Although these apps were not in English, the papers were written in English and were included in the review. The interest was not on the app itself but how the app was used in a clinical setting and the evaluation and outcomes reported.

Consistent with the findings of a systematic review of mobile apps (Payne et al. 2015), very few studies have applied apps in a clinical setting, despite the exponential rate of apps available to modify health outcomes. Thus, of relevance in this review, is the study by Buning et al. (2016) which is concerned with the efficacy and usability of an app to allow patients to maintain an accurate list of medication. Prior to elective surgery, 17 patients were asked to enter their medication list into the app and email it to the hospital. Upon admission, the patient medication list was compared to the list compiled by their pharmacist and discrepancies were noted. The results suggest the app was effective in supporting patients' medication regimen and in reducing medication errors, with users reporting high levels of empowerment (ibid). Table 4 provides an in-depth summary of each of the 19 articles included in this review.

Table 4: Summary of papers included in the literature review of medication management apps

Author, Country & Sample size	**Conditions declared by participants**	**Study design**	**Patient evaluations**
Becker et al. (2013) Germany Size 11,688 smartphone users	CVD (74%, n=1,697) Transplant history (13%; n=292) Cancer (9%, n= 205) Impaired renal function (7%, n= 168) Diabetes mellitus (7%, n=161) Lung disease (5%, n=105) Liver disease (5%, n=105) Gastrointestinal tract diseases (3%, n=61)	Implementation of an app to support drug adherence among chronically ill users	Of the 11,688 users, 1,095 were identified as regular users (i.e., they used the app at least once a week for at least 28 days): • 124 of 530 (23%) users aged <50 years and 156 of 565 (28%) users aged >50 years were still using the application at least once a week 28 days after downloading the app. • App use significantly declined over time: at 165 days after download, 46 of the 530 users (9%) aged <50 years and 82 of the 565 users (15%) aged >50 years used the app. After 365 days, only 6 of the 530 users (1%) aged <50 years and 4 of the 565 users (1%) aged >50 years regularly used the app. • Feedback on further development of the app was provided by 134 users. The most frequent suggestion (n=60) related to the need for further specification of the user's drug plan.
Patel et al. (2013) USA Size 50 patients	Hypertension (100%, n=50) Diabetes mellitus (54%, n=27)	Sequential study design assessing medication adherence by review of pharmacy refill rates using an app.	Of the total sample, (96%, n=48) of participants completed the study. During the activation phase (first 12-week of the study) participants reported: • Taking their scheduled medication 60% of the time. • Taking their medication an average of 63% in week 1,

			decreasing over time to 54% by week 12. • Satisfaction with the medication reminder app was high (4.6 out of 5.0). More females (65%) than males (46%) reported higher levels of app usage.
Mira et al. (2014) Spain Size 99 older adults	Diabetes mellitus (7%, n=161) Depression (9%, n=9) Hypercholesterolemia (52%, n=52) Hypertension (78%, n=78) CVD 43%, n=43) Chronic obstructive pulmonary disease (19%, n=19) Renal failure (14%, n=14) Arthrosis (20%, n=20).	A single-blind RCT. ALICE (app) for personalization of medical advice and prescription with alerts and reminders.	51 participants used the app (experimental group). Of these: • 88% (n=45) reported the app increased their awareness on medication management. • 59% (n=30) found the app to be useful for medication management, 29.4% (n=15) found the app to be of some use, and 11.8%. (n=6) found the app of no use at all. • 55% (n=28) without ICT experience reported better adherence, fewer missed doses and medication errors. • 45% (n=23) with some ICT experience did not reported a reduction in the number of missed doses. • More than half of the participants (59%, n=30) required basic support to learn how to use the app.
Goldstein et al. (2014) USA Size 60 outpatients	Heart failure (100%, n=60)	RCT evaluating feasibility & effectiveness of an electronic pill box (telehealth) and an app (mHealth) for medication adherence.	Participants using the telehealth device adhered to medication 80% of the time and those using the smartphone adhered 76% of the time. In relation to devices, the smartphone was greater accepted by participants (mean score 48.7) than the telehealth medication container device (mean score 33.4).

			Approximately 25% of participants showed a poor medication adherence and the reminders for medication was not efficient. All participants (100%, n=60) mastered the use of devices after training.
Grindrod et al. (2014) Canada Size 35 participants aged >50 years and over.	Heart disease (20%, n=7) Cholesterol (40%, n=14) High blood pressure (43%, n=15) Thyroid disease (14%, n=5) Bone & joint problems (17%, n=6) Cancer (6%, n=2) Diabetes mellitus (20%, n=7) Kidney disease (11%, n=4) Lung disease 2 (6%, n=2) Other (29%, n=10)	Mixed-methods approach to examine usability and user perceptions of commercially available mHealth apps.	Participants were asked to describe their experiences using medication apps and encapsulated in one word. Some used the following words: • Participants vocalised their negative experiences using the words: frustrating (n=5), challenging (n=3), overwhelming (n=2) and stressful (n=2). • For positive experiences they used the words: fascinating (n=2), fun (n=2), useful (n=1) and informative (1). Overall, participants were not motivated to use medication management apps. They highlighted the need for age friendly interfaces with simpler instructions and buttons describing the capability or functionality of the app for first time users.
Becker et al. (2015) Germany Size 1,799 app users**.** Analysis based on those who provided complete data (n=1,708).	CVD (52%, n=894) History of transplantation (e.g. kidney or liver) (14%, n=243) Diabetes mellitus (7%, n=125)	Captured data from the use of a medication adherence app.	69% (n=1,183) of participants used the app for more than one day and almost three quarters were male (74%). Participants with specific diseases (CVD and those with a history of organ transplantation) were associated with longer usage of the app (on average 50% longer) compared to participants with other chronic conditions.

	Lung disease (5%, n=86) Liver disease (5%, n=90)		Participants taking prescribed medications (>7 a day) had higher daily usage (on average 3.71 uses per day) than participants taking less medication.
Johnston et al. (2016) Sweden Size 174 patients Of these, 8 were excluded from analysis	Myocardial infarction (100%, n=174) Diabetes (12.7%, n=21) Hypertension (47%, n=78) Dyslipidaemia (22.2%, n=37) Asthma (4.8%, n=8) Chronic kidney disease (1.8%, n=3) Prior myocardial infarction (8.4%, n=14) Prior percutaneous coronary intervention (9.6%, n=16)	RCT evaluating the impact of an app intervention on drug adherence in patients with myocardial infarction.	A total of 166 patients (active group n=86) and (control group n=80) were included in the analysis: · Most participants (68.4%) in the active group stated that they would continue using the interactive support tool and were willing to recommend to other patients with the same condition (97.5%). · Participants reported higher levels of satisfaction using the interactive patient support tool compared to the e-diary.
Anglada-Martínez et al. (2016) Spain Size 42 patients	Hypertension (40.4%, n=17) Dyslipidaemia (28.6%, n=12) Hypertension & Dyslipidaemia (12%, n=5) HIV (19%, n=8)	6-month single-arm, pre- and post-intervention study. Pre-intervention (usual care); Intervention Medplan - Medication Self-Management Platform.	Overall, participants showed satisfaction with the app intervention: · 71.4% stated they would recommend the app to relative and friends. · 38.1 % of patients found the app to be beneficial to improve medication adherence. · 88.1 % stated their willingness to continue using the app.

			• Half of the participants (50%, n=21) reported having problems with the reminder feature of the app.
Kang & Park (2016) South Korea Size 38 participants	Hypertension (100%, n=38)	Development of an app and it's evaluation on effectiveness, satisfaction and medication adherence.	From the total sample, (n=38), 76% (n=29) participated in the medication adherence assessment phase: • Participants reported they were satisfied with the app's blood pressure feature (mean score 4.3) and medication recording function (mean score 3.8). • They also highlighted the educational and medication information section on the app to be of benefit to them.
Mertens et al. (2016) Germany Size 24 patients	Coronary heart disease or myocardial infarction (100%, n=24) Hypertension (58.3%, n=14) Dyslipidaemia (37.5%, n=9) Diabetes mellitus (37.5%, n=9) Liver disease (8.3%, n=2) Lung disease (8.3%, n=2)	Crossover design with 3 sequences: initial phase, intervention phase and comparative phase.	Most participants (92%, n=22) indicated their willingness to continue using the medication app daily after the study concluded and stated they would not require further assistance using the app after initial training. Greater medication adherence was reported for those using the medication app compared to those using the paper and pen system.
Buning et al. (2016) Netherlands Size 17 patients	Elective surgery patients (100%, n=17)	Investigation of the usability & reliability of an app for medication reconciliation at care transitions.	Discrepancies between the medication list compiled by the participant in the app and the medication history compiled by a pharmacy practitioner were reported:

			• Discrepancies in dose and frequencies (n=27), medication recorded in the app (n=15) were observed. • The total mean number of medication discrepancies reported was 2.5 errors per patient. • Participants rated the app 68 out of 100 in terms of usability.
Corden et al. (2016) USA Size 11 patients	Taking anti-depressant medication (100%, n=11)	Pilot study evaluating the feasibility of a digital intervention designed to improve pharmacological treatment for depression.	Overall, participants showed a high medication adherence recorded by the system (82%). The system was launched an average of 23.8 times per participants during the study (8 weeks). Most participants (91%, n=10) agreed that the system provided guidance for better communication with their clinicians.
Lee et al. (2016) USA Size 18 older adults	Taking anticoagulation medication (100%, n=18)	Pilot study with a single-arm experimental pre–post design to test the feasibility of an app to enhance anticoagulation therapy.	Participants' anticoagulation medication knowledge significantly improved over time (median baseline 62% to 74% (3-month follow-up). Participants found the app easy to use.
Fallah & Yasini (2017) France Size 60 participants (30 aged <50 years and 30 aged >50 years)	None declared	2 phases study: (1) designing a medication reminder app, (2) usability and efficacy testing.	Both groups (those aged <50 years and >50 years of age) reported the medication reminder app to be effective. Significant differences in usability and efficacy items between both groups were reported, the >50 years of age group rated the app more favourably. The items with higher score from the >50 years of age were "I thought the app was easy to use" (4.7 out of 5) and "I think that I would like to use this app frequently" (4.6 out of 5).

Morawski et al. (2018) USA Size 411 patients	History of heart attack (2.1%, n=9) History of stroke (4.3%, n=18) Diabetes (23.3%, n=96) Dyslipidaemia (42.8%, n=176)	A 2-arm RCT intervention group (209 participants) and control group (202).	Participants in the intervention group showed a small improvement in self-reported medication adherence. • The mean medication adherence for the intervention group at baseline was 6.0 with a slightly increase of 0.4 after 12 weeks. • Medication adherence remained unchanged in the control group.
Morrissey et al. (2018) Ireland Size 24 patients	Hypertension (100%, n=24)	A qualitative descriptive study. Data was analysed using thematic analysis.	Participants reported the app to be beneficial and empowering in terms of understanding their condition and interacting with their HCP. Some concerns were raised by participants about increasing health-related anxiety while using technology and sustainability of the technology over time.
Steinert et al. (2020) Germany Size 100 patients	Lipid metabolism disorder (100%, n=100)	Use of a medication app (My therapy) for 12 months, followed by an online questionnaire with questions regarding their use and changes in medication adherence.	63 participants completed a questionnaire on app usage at the end of the study (12 months). Of these: • n=23 (41.1%) indicated they will continue to use the app. • Participants (58.7%, n=37) reported using the app (38.1%, n=24) frequently; (3.2%, n=2) occasionally and (17.5%, n=11) rarely. 41.3% (n=26) of the participants reported never using the app. • Some participants did not perceive the app to be useful (34.4%, n=21, 2 missing) and that it was too much effort involved

			in using it (23%, n=14, 2 missing). Medication adherence increased from 16.2% to 29.7% in the user group (58.7%, n=37).
Santo et al. (2019) Australia Size 163 patients Medication adherence was measured for 152 participants (93.3% of total sample).	Coronary heart disease (100%, n=163) Hypertension (58.9%, n=96) Diabetes mellitus (33.7%, n=55) Dyslipidaemia (69.9%, n=114)	Parallel, prospective, single blind RCT with follow-up at 3 months. Group (i) usual care, (ii) App - My Heart My Life, (iii) Medisafe App.	Three months into the study, participants in the app user group reported a higher medication adherence (mean score 7.11) compared with those in the usual care group (mean score 6.63). There was no significant difference between those using the basic or advanced apps.
Holden et al. (2020) USA Size 23 patients aged ≥60 years.	None declared	Summative, task-based usability testing of Brain Buddy (app designed to inform about the risks and benefits of medication).	Participants rated the usability of the app to be ‘good’ to ‘excellent’ (mean score of 78.8). All participants (100%, n=23) felt better informed about the risk of harm from anticholinergic medication after using the app 94% stated their willingness to contact the HCP to discuss their medication related risk. Upon follow-up, 82% had already talked to their HCP. Some issues related to app usage were raised by participants (i.e. high rates of errors when they entered their information and the need for assistance).

5.8 App intervention with HF older patients

5.8.1 Trial of App with HF older patients

As noted earlier, HCPs in the clinic acted as gatekeepers and after much consideration referred three patients for the app trial. After the three patients consented to participate in this study, the researcher visited the participants' homes to deploy the equipment. An iPad with the Medisafe app downloaded was given to participants. Also, during the initial visit, the researcher set up the iPad to their Wi-Fi modem and showed the participants how to turn on and off the iPad, and how to launch the Medisafe app. Participants provided the researcher with their most up-to-date medication list to populate the medication list section in the app. All their medication was entered in the app and medication reminders were set up accordingly. This was followed by a training session where participants were shown how to launch the app independently, how to indicate in the app whether a medication was taken, skipped or snoozed and how to locate the medication list section on the app. In subsequent visits, the researcher taught participants other functions in the app, for example, how to input measurements such as their daily weight, blood pressure and mood.

Participants received ongoing support (when/if needed) from the researcher during the intervention. This was considered of vital importance as all participants had no previous knowledge on how to use a medication app. One of the priorities was the ability to independently locate the medication list on the app because participants were asked to bring the iPad to their HF clinic appointment to show their medication. All participants used the medication app during the 12 weeks' intervention.

5.8.1.1 HF Clinic observations using the medication app

A total of seven observations were conducted in the HF clinic during March and June 2022. Examples of observational data collected included:

- interactions amongst HCPs and patients (e.g. nurses interacting with the patient using the app during the medication review process during the consultation)

- number of medication discrepancies identified (if any)

The researcher met each participant in the sitting room outside the HF clinic the day of their appointment. The researcher engaged in conversation with the patients in terms of greeting and general chat while awaiting to be called for their appointment. No clinical conversations occurred between the researcher and the HF patients during the consultation. Medication discrepancies (when detected) were collected in the form presented in Table 7 below. The observations highlighted how patients mastered the use of the medication app after just one week despite the lack of technological skills reported when they joined the study. They also highlighted some medication discrepancies between the medication list contained in the app and the information kept in the medical file in the HF clinic.

5.8.2 Medication discrepancies

During the initial home visit, the researcher and the participant populated the medication list in the app using a hand-written medication list compiled by them. As stated in the section above, participants were instructed to bring the iPad while attending the HF clinic appointment to identify medication errors between the list compiled in the app and the list of their medical record compiled by HCPs. Discrepancies identified during the observations conducted in the HF clinic between the medication list compiled by the patient (contained in the app) and the medication list compiled by the HCPs are reported below in table 5. Discrepancies on their medication were also detected at home during the initial visit.

Table 5: Medication discrepancies detected at home and the HF clinic setting

Error classification	Omission	Commission	Dosage	Switch
Number of times detected while conducting observations	3	0	0	0
Number of times detected at home	1	0	1	2
Total medication discrepancy	4	0	1	2

5.8.3 System Usability Scale

The System Usability Scale (SUS) was administered to HF patients to explore usability and acceptance of the medication app. Participants were given a paper version of the tool and were asked to complete the questionnaire, aiming to understand problems HF patients faced when using the app. The mean SUS score for the app was 70.8 out of 100, corresponding to good user-friendliness. Items with low scores included ‘I think that I would need the support of a technical person to be able to use this app’ and ‘I thought there was too much inconsistency in this system’.

5.8.4 Health-related quality of life (HRQoL)

As discussed earlier, self-perceived health status was measured to estimate how patients’ health status could affect their quality of life and their treatment burden. Prior to the intervention (see table 6 below) and upon completion of the intervention (see table 7 below), HF patients’ HRQoL was assessed using the 5-level version of the European Quality of Life-5 dimensions (EQ-5D-5L) tool. Pre-intervention, in self-care all respondents reported ‘no problem’, in mobility one indicated ‘moderate problems walking about’. However, in anxiety/depression and pain/discomfort dimensions, most of the respondents reported a ‘slight problem’.

Post intervention, self-care remained unchanged and one of the participants reported a better health state. In addition, one of the participants reported an improvement in pain/discomfort and anxiety/depression post-intervention. However, the remaining participants reported a change from having no problems at baseline to a ‘slight problem’ in the dimension mobility and usual activities. For all participants (pre- and post-intervention) the EQ-VAS rating remained unchanged.

Table 6: Quality of Life-5 (EQ-5D-5L) pre-intervention

Patient identifier	**Mobility**	**Self-care**	**Usual activities**	**Pain / discomfort**	**Anxiety / depression**	**EQ-VAS**
P1	3	1	2	1	1	90
P2	1	1	1	2	2	90
P3	2	1	1	2	2	100

Table 7: Quality of Life-5 (EQ-5D-5L) post-intervention

Patient identifier	**Mobility**	**Self-care**	**Usual activities**	**Pain / discomfort**	**Anxiety / depression**	**EQ-VAS**
P1	1	1	1	1	1	90
P2	2	1	2	2	2	90
P3	2	1	2	1	1	100

5.8.5. Normalisation Process Theory Framework and HCPs interview data pre-to-post intervention

Pre-to-post interview data from HCPs were mapped onto the themes within the NPT. As noted earlier, these include: cognitive participation, coherence, collective action and reflexive monitoring (see Table 8). The findings suggest that HCPs find the app useful and are willing to use it if supports patients' medication self-management. The findings also point to a number of potential barriers to adoption. These are presented in more detail below.

Table 8: Overarching themes and subthemes of thematic analysis (HCPs)

Overarching themes	Subthemes
Coherence	Medication app benefits Medication app use – A new practice for HCPs at the HF clinic Medication treatment changed by other HCPs HCPs attitudes towards technology in care of older adults Challenges to app adoption in the care of older adults Traditional medication review process Strategies employed by patients to keep an up-to-date medication list HCPs non-adoption of virtual clinics
Cognitive participation	Medication app promotion Medication app seen as part of the HCP work

	Medication app will be seen as a normal part of HCP work in future HCPs experiences on their new role using the app Factors affecting the HF clinic efficiency HCPs motivation to use the medication app
Collective action	The role of the app supporting medication management HCPs trust in the medication app Management supporting the adoption of the medication app Factors affecting the medication review process The impact of COVID-19 on HCPs working practice COVID-19 positive experiences COVID-19 negative experiences
Reflexive monitoring	Educating patients Medication management preferences Educating HCPs Technological support from informal carers Lack of technology support for patients Pre-intervention perceptions Clinical monitoring Gaps in service provision

5.8.5.1 Theme 1: Coherence

Evidence suggests that the use of technology in healthcare is increasing (Torous et al. 2020). Technology can also serve as a form of support for patients with HF, enhancing patient-provider collaboration for self-management (Athilingam and Jenkins 2018). The use of a medication app supporting HF patients with medication self-management was deemed to be a new practice by HCPs working in the clinic: *"So this was new for us as well. And that was great to have it. And the patient was able to show it to me as well. So that was good."*

Pre-intervention, all HCPs were shown how the app worked and were given opportunities to explore the app functions. Post-intervention they were asked if they had a good sense on how the app worked:

> *"ehm* [pause to think] *a little bit about it wouldn't say I know an awful lot about it. I had to get the patient really to show me how to work it, how to put the drugs in* [refers to inputting medication on the app] *at home."*

Another HCP responded:

> *"Well, I've seen it a few times. I suppose it probably was a little bit harder because I wasn't used to it. I think if I saw it a few more times it would be easier. I have to say I had to get the patient to show me and then press buttons to get the next lot of medications out."*

One of the challenges facing HCPs during consultations is patients failing to bring an up-to-date medication list to their appointment. HCPs have an awareness of the app contribution towards keeping an updated medication list:

> *"Because sometimes they forget to bring the tablets they just bring the written list and it's not up-to-date. And this one* [the app] *is very good. Like it's there* [referring to the updated medication list compiled in the app] *and they are able to upgrade it* [the information] *so that's very good."*

When patients attend their appointment without their medication or an updated medication list, clinic efficiency is disrupted. HCPs are forced to pause the consultation and telephone the pharmacist to verify the patient's medication list:

> *"And the other thing too, like we would spend so much time on the phone to pharmacists, because patients forget to bring their tablets. They forget to bring the list of medicines, but having the app if it's on their mobile, for example, if they can go on to their mobile, then they don't tend to forget their mobile, you know."*

Multi-morbidity is common in HF patients and attending various clinics (e.g. diabetic clinic) is a common practice. However, this clinical information is not shared amongst clinicians from different specialties. This lack of communication affects patients' treatment prescribed by the HF clinic when other clinicians stop and/or add a medication without notifying the HF clinic. HCPs are confident the app will capture a more comprehensive profile of a patient's journey navigating through different healthcare providers:

> *"Yeah if they use it is good, especially you know, sometimes they may go to the GP or something and if they change any of the tablets, they don't remember when they come back to us. But if they have an app, they can update it then and there, then when they come back to us they can show it to us. In that way is very good, because they are not only in this clinic, they could be attending diabetes clinic or GP or anywhere else. If they change any of the tablets we know exactly what has been changed."*

HCPs understand the role of the app in empowering patients as active participants on their medication management. Overall, all HCPs agree that patients are more aware of what medication they are taking, why they are taking it, the time of the day and how many they are taking:

> *"I think it* [the app] *empowers the patient more. The patients sometimes just take whatever box is there at home. And they don't, they don't really want to know much about their medicines. But I find with the app the person is more actively involved. Because they have to put into the app. And yeah, they learn more, I think that way."*

The medication app also supports patients and HCPs while conducting the medication titration process:

> *"Well for them as patients, knowing their drugs a little bit better, which I think is very important for a patient with chronic illness to know their medication. And also that they know when they're taking it, and that's a good benefit to me, because a lot of medications in heart failure we are manipulating, and often we're changing the time of day they take it. Many patients come in, and they don't know when they take each tablet. So using the app if they can be very specific the time of day, it helps us manipulate it better. So that part is very good."*

Despite the potential app benefits aforementioned, challenges to app adoption in the care of older adults emerged during the interviews. One of the challenges was the lack of patients' technological experience and the need to identify who will provide the app training:

> *"So if there is someone to educate them before they come to us that would be great, and then we can follow it on but to initiate itself from our side it could take time because we can't be teaching them how to use it…"*

Suggestions that relatives should be providing this training were suggested by HCPs:

> *"Family should take responsibility to teach them first, and then they come over to us, we can update and we can make sure that they're doing it right. To teach from the scratch. It takes time for us. I don't think our clinic is, you know, very busy clinic so we don't have time to teach them. The way you taught them you know, we don't have time to do everything."*

Another challenge to technology adoption is HCPs attitudes towards older people and the use of technology:

> *"I can't see a lot of our patients and the age group they are at. I just don't think that there would be enough of them willing to partake in it, I really don't."*

Cognitive decline experienced by some older adults was another barrier cited:

> *"Like, most of the patients, elderly patients, what we have seen is keep forgetting the name of the tablets and you know, kind of they are forgetful because of the age anyway."*

Another HCP suggested that older people are not interested or willing to use technology:

> *"Well is not going to work for everybody, you know, it won't work for everybody. So is really, because not everybody is into technology, so I know that from my own parents and they are only in their early 70s, they have no interest in technology. And so there is that, you know, we have to take that into account I suppose. It couldn't be a thing that has to be used for every patient because it won't work."*

HCPs ageist attitudes appear to be prevalent as another stated:

> *"For those that are interested in it, those younger people, but then a lot of younger people too they know what they're taking and they don't need an app and they don't need to write it down because it's in their heads, you know."*

5.8.5.2 Theme 2: Cognitive participation

Use of the medication app is currently not seen as a normal part of their work routine as a very limited number of patients (n=3) are using the medication app: *"I don't think we've seen it enough to be a normal part."*

Nonetheless, HCPs are motivated to use it and willing to try any tool (digital or not) that benefits their patients: *"Everything that is beneficial for our patients. We will be more than happy to help in any way."*

Another motivating factor for use is the positive role the app plays in patient self-management:

> *"So I suppose anything that helps patients understand their medication better, you know, if there's anything that could really be of benefit for them. That you know, motivates me, because chronic disease is about self-management. I think a lot of health care is maybe managing it for them. And the app is certainly all about self-management."*

Promoting the medication app amongst patients is fundamental for the sustainability of this initiative. However, HCPs cited lack of time as one of the reasons why promoting the app would impact negatively on their workload: *"... it would mean a longer clinic visit for that person, to talk about it especially if they have more questions. Is the time factor."*

The unsuitability and lack of space available in the HF clinic premises was alluded to: "*... where am I going to bring the patients to talk, to be spoken to about it* [promoting the app]? *You know, because our space is very limited."*

HCPs voiced their willingness to promote the app without compromising their consultation time: *"Oh, we can let them know, oh yeah absolutely, we could give them literature, you know, to read up about it if they want to."*

It appears that HCPs are willing to promote the app in the future but only if this initiative is scaled up and available to all patients:

> *"I suppose we could. But we can't at the minute unless this was something that was going to happen. I suppose it is something that could be looked at. In the future, yeah."*

The COVID-19 pandemic disruption on the clinic efficiency is detrimental to the sustainability of the medication app intervention. Conducting medical reviews several days of the week to deal with the long waiting list is unprecedented:

> *"Initially when we came down* [some HCPs were relocated to ICU during the pandemic], *waiting list was very long. Like usually, every Wednesday, we used to bring nearly 25 patients, but now it's got down to 12 because of social distancing. But we are trying to manage it, you know. Like we are doing pretty good now like lately because before, we used to do medical review only on Wednesday, but nowadays we are doing Tuesday. We are bringing in six patients on Tuesday afternoon just to try to get rid of the backlog."*

During the pandemic, the inability to conduct face-to-face consultations prompted HCPs to modify their working practices. Face-to-face consultations were quickly replaced with telephone consultations. While telephone consultations allowed HCPs to provide care to patients, it also presented new challenges. Challenges included longer consultation time as some patients were unable to read their medication name and/or understand instructions given or questions posed by the HCPs. Consequently, HCPs had to re-schedule a face-to-face consultation with those who were unable to provide their medication list:

> *"Now, over the phone, that's what I'm saying. Some patients, they'll tell, 'I have the tablets here, but I can't read it out'. That's what they say. Then we'll tell, 'Ok, if I tell, can you tell me that?' You know, it takes a lot of time sometimes over the telephone. At least physically when they're there, we'll tell, 'Ok, this one is this one'.*

Over the phone, with some patients, it's really hard, you know. We'll try to find and we'll ask, 'Do you have anybody else at home that is able to read for us, you know?' And they tell, 'Oh no, I don't have. I live on my own'. You know, so those things. In that case, we'll try to ring the chemist. It's all time-consuming sometimes, you know…"

Unscheduled telephone calls from patients with queries about their care also adversely affect the HCPs working practice:

"I have a list today, for example, I'd have a list with, how many have I got on it today? I've about 10. But so far, I'm only on the fourth one now since nine o'clock this morning simply because of the amount of unscheduled calls that are coming in from people at home. So you know, so that takes me away from my scheduled list because of all the unscheduled ones coming in. Like on Monday here, we made 30 phone calls. On Monday, yes, yes."

Furthermore, sometimes during telephone consultations HCPs are unable to pinpoint the symptoms described by patients. Consequently, HCPs have to schedule an ad-hoc, in-person visit to evaluate the patient:

"Over the phone, particularly in somebody you haven't met. That can be difficult. Like I had a phone call earlier today and I just couldn't get the person to give me the information I wanted, so they're coming in at two o'clock today because just my heart was breaking. I just couldn't get the information I wanted out of them with regards to symptoms, but anyway, so he's coming in so I can see for myself. So that is very difficult."

HCPs are dealing with the public health consequences of the pandemic and therefore promoting or sustaining the use of the app is challenging on an already overburdened workload. Overall, HCPs agree that the app could be integrated into their routine in the future: *"Well I can imagine Yeah, sure. You know, it's an ever changing world. So yeah, yeah, I don't see why not."*

5.8.5.3 Theme 3: Collective action

The extraordinary experience of the global pandemic has enormously changed working practices. Some of the HCPs working in the HF clinic were redeployed in response to the surge of COVID-19 cases. Redeployment caused a negative effect on the HF clinic operational work as two out of the four HCPs were redeployed:

> *"Well, first of all, when COVID started, I was redeployed upstairs to the coronary care unit and I was up there for I guess two months. So then one of the girls, her mother passed away, so I was redeployed back because she was going to be off for a couple of weeks*."

Returning to work in the HF clinic felt very unfamiliar:

> *"So when I came back, it was completely different here and I was kind of I suppose thrown into it because I work fulltime and then the other person that was here was part-time. So what was different was number one, we had no patients coming in. Zero. And everything was being done by phone..."*

For those redeployed, return to work in the clinic to a different work routine was concerning:

> *"When I came back* [from redeployment], *they told me that we are going to do titration over the phone. And I was worried like oh, how are we going to do titration over the phone? Because it was new for me as well, like you know."*

Those HCPs who remained working in the clinic felt overwhelmed as their workload increased significantly:

> *"So that* [redeployment] *completely depleted the staff, but we kept the show on the road, but we weren't bringing patients into the clinic… Anybody that was due to come to the clinic, we phoned them and we assessed them over the phone and we did monitor patients and get them on their disease modifying medication… You know, we were thinking on the run literally because it was so new. It was just overnight, everything changed."*

Collective effort and action from HCPs and patients is necessary for effective implementation of the app to support medication management. Patients with a good working knowledge of their medication play an important role in medication titration:

> *"And we, the clinic I suppose, there is an awful lot of changing and adjusting doses of medicine. And the patient needs to be aware of their medicines, and need to be aware of why we're doing it I suppose."*

HCPs described how the app contributes to the medication titration process:

> *"So I think by them in putting it* [medication information] *into the app themselves, then they can come along the next time and say, Oh, you increase such and such drug the last time. Where they might not know that, they might have forgotten about that the previous, you know in other visits. So I definitely think it would help them remember what tablets they are taking."*

A recent hospital-wide change made by management has negatively impacted HCPs' ability to perform timely medication reviews:

> *"And the other thing too now is there's a standard appointment letter that's going out to patients and this is hospital-wide for all appointments. Our previous specific letters to heart failure were, 'Please bring your medication and weight monitoring diary with you'. That's not on these new letters, so patients are now coming in with no medications with them, so that's going to be a bit of a bummer."*

Collective action from HCPs and management is warranted for the promotion and roll-out of this intervention:

> *"…that* [promotion and roll-out of the initiative] *would have to go through our consultant, we couldn't decide ourselves, you know, so there would have to be Yeah, it would have to go through the consultant and then management, if that was going to happen."*

A very positive collective action took place during the COVID-19 pandemic between the HF clinic and the community intervention team (CIT), albeit not technological. Older people were shielding at home and HCPs were unable to take blood samples and vital signs. The CIT, comprised of community nurses, visited older people in their homes to undertake these clinical assessments and relay the information to HCPs. This enabled the HF clinic staff to make decisions about medication titration:

> *"We also had girls* [HF nurses], *while I was gone* [redeployed to another service], *had organised the community intervention team to go out to people's houses. People were happy with that. To take their bloods, measure their pulses and blood pressures. So that was fantastic for us. And in one sense, that's a positive as a result of COVID because it just showed how many people were driving up to the clinic from the countryside, miles and miles away, that really didn't need really to come as often as they did. You know, these people who are 80-plus like and how difficult it is for the likes of those people to come all that way. It puts such a strain on them, to be honest, and then trying to get somebody to bring them was another issue. So the community intervention team are just fantastic throughout all of this."*

The CIT made a real difference to patients and clinicians during the height of the pandemic. However, despite all the benefits from this collaboration highlighted by HCPs, patients are currently travelling back to the hospital for blood tests and home visits from the team are no longer an option. In other parts of the country, the role of the community HF nurses is established. This role allows community HF nurses work alongside a HF clinic:

> *"In some parts of the country, there are integrated heart failure clinics and I see they're advertising them in Dublin and over on the west, I think."*

Unfortunately, this role is non-existent in the region where this research took place: *"No, not here in the northeast at the moment."*

5.8.5.4 Theme 4: Reflexive monitoring

Pre-intervention HCPs were asked for their understanding on how the app worked:

> *"My understanding, listening to you and reading and that, and I haven't actually played around with it myself, but I gather it's a little app, a little machine, a little iPad and it's basically there for the patient to record all the medicines and any changes and how they*

> *feel when the changes happen. Yes. So that's my understanding of it."*

Post-intervention feedback was positive as the app was found to be age friendly and easy to use:

> *"…what I like about it is the size and that you can read it, you know. The print is on the larger side, which is good, in comparison to a mobile phone, and that it's easy to input their medicines into it. And it's very easy, you know. You've got skip or take, so there's no… You know, it's just a matter of pressing one button or the other."*

The ability to make entries to record changes in medication and vital parameters was another benefit highlighted:

> *"Yes, it will be great. Like you know, we know what's happening with them. Like you know, they might not be accessing only our service. They might be accessing so many services. So if they have that app in their mobile, whatever service they attend, you know, they can update their medications and whatever changes then, and they know their blood pressure, they might have entered those things… They can enter it* [the information] *in the notes. So if they do those things, it will be really very good. You know, like when they come to next time, when they come to us, they will have met the diabetic nurse sometime and they might have uploaded their blood pressure and everything."*

Understanding how the app functions is necessary for the sustainability of this intervention. HCPs were asked to evaluate their app training needs pre- and post-intervention. Most HCPs agreed they did not require further training with one exception: *"Myself, yes. I would always say for me because I'm not tech-savvy and my memory does not last too long, yes."*

The lack of training and technological support for patients was a barrier to technology adoption cited by HCPs. HCPs were asked to provide their opinion on the creation of a new role for an independent health professional educating patients on how to use the app and working alongside the HF clinic. Ideally, this role will also involve providing ongoing technological support to patients experiencing technological issues. Opinions on the new role were sought:

> *"Probably, because is sort of similar to what you* [the researcher provided training on how to use the app and ongoing support to patients during the implementation] *were doing, supporting people. And as you were saying, you had someone who wasn't able to manage that actually could manage once they were taught. So it is just that, that teaching, and I think when they come into the clinic, we focus on a lot of things with teaching, and it's probably very hard for them to remember everything. Whereas if you just have one person who's teaching them a specific thing, they're more likely to learn it rather than if they've just heard that they have to do this this and this. By the way, here's this app, all at the same time. Yeah. So maybe a little separate session as you* [the researcher] *were doing will help them learn."*

Another HCP remarked:

> *"Yeah because if it is like a separate talk on that, yeah. Not in clinic because you're focusing on so many other things in the clinic whereas, an education session they come and they hear about certain topics. That could be ideal, actually."*

In principle, HCPs concur that this role might be of benefit to patients using the app. However, the process of establishing this new role will be long and burdensome:

> *"But from a management* [point of view], *like if it was something that was, that would be a benefit to the clinic, you know, you have to put a business case together, you know, and, like, you need a lot of statistics and all of that. So It's a big deal, is a big business case you have to put together and then you have to present it to management."*

One of the HF clinic goals is to ensure patients receive appropriate medication in effective doses. HCPs appraised the app and found it to be in line with the HF clinic goals:

> *"Oh yes. Well, the aims are to try and get them on the right medicines. Also for them to kind of just be empowered, you know, self-care, so it definitely would fit in with that ethos."*

Another HCP expanded on this topic by adding:

"Oh, just to try and make things easier when it comes to tablets, medications are a big part of the clinic, they play a vital role, actually, in the patient's care. And we, the clinic I suppose, there is an awful lot of changing and adjusting doses of medicine. And the patient needs to be aware of their medicines, and need to be aware of why we're doing it I suppose. And so I think by having the app, that helps them understand why they're taking medicines."

5.8.6 HF older patients Semi – structured interviews pre- and post – app use

HF patients (n=3): 2 females and 1 male, age ranging from 72 – 78 years of age, two living alone. For two participants, the highest level of education attained was primary school and one secondary school. All participants were diagnosed with HF and attend the HF clinic and have other chronic illnesses alongside HF. One of the interviewees had previous knowledge of using technology i.e. using apps, but none had previous knowledge of using a medication app.

Interviews were conducted with patients (n=3) pre-intervention and post-intervention. All subthemes were mapped onto the NPT framework: (1) Cognitive participation, (2) Coherence, (3) Collective action and (4) Reflexive monitoring. NPT analysis of themes suggest that the use of a medication app to support medication self-management was deemed to be a new practice by patients. It was also reported the app enhanced their awareness about their medication i.e. what are they taking, why are they taking it and when are they taking their medication. A very successful collaboration between patients and HCPs was the educational sessions provided by the HF clinic. During these sessions, patients received education on their medication. However, the sessions were disrupted during the COVID-19 pandemic and up to date, educational sessions have not resumed in the HF clinic. Therefore, HF patients do not have a comprehensive understanding of their medication and in some instances, were unable to recall their medication names. Table 9 presents the themes and subthemes and they are described further below.

Table 9: Overarching themes and subthemes of thematic analysis (HF older patients)

Overarching themes	Subthemes
Coherence	Taking medication prescribed by the HF clinic Medication refilling routine Medication app benefits Patients anxiety about using technology Patients medication self-management strategies A new system for medication management
Cognitive participation	Medication app use continuity Motivation to use medication app Recommending the medication app Sharing information from the medication app
Collective action	Challenges using medication app Using a medication app to support patients to keep an up-to-date medication list The role of the app supporting medication management Confidence in the use of medication app Feeling supported through joined-up care by HCPs Factors affecting medication management
Reflexive monitoring	Pre-intervention perception of the medication app Medication app feedback Patient training needs

5.8.6.1 Theme 1: Coherence

None of the patients in this study had previously used a medication app to support medication self-management. To make sense of the new practice, patients must differentiate between traditional medication management strategies and the new one using the medication app. Patients made reference to the “old” and “new” ways of medication management strategies. They also highlighted how the new practice enhanced their awareness and understanding about their medication i.e. what are they taking, why are they taking it and when are they taking their medication:

> *"Well the old way, between the old way and the new way, like the new way with the app. It has given me the idea that I should be taking them* [medication] *at the right times and it has got me into that routine. And if I don't have that with me, if I am out of the house, I have my medicine with me anyway. And then when I come home, I know how to get in [the app] to enter that it was taken* [medication] *on time."*

Prior to using the app, patients developed their own strategies and routines to remind then to take their medication on time:

> *"…I have the morning one down beside my bed locker and I take it as soon as I get up in the morning… Then I come down and have the breakfast in the mornings. After that I would normally take my other medication… I leave one on the table, the one for the evening the Entresto. I had to take two of them each day and one of them in the morning and one in the evenings and I leave it on the little table in front of me, when I come in I see it and it reminds me, which I found a great help because if I had it hidden away I forget"*

Another medication management strategy widely employed by patients prior to using the app was storing their tablets on a medication box. Most medication boxes are designed to store medication for a week and have different compartments labelled with times of the day:

> *"…is a seven-day box. There are four sections in each boxes morning, breakfast, No breakfast, morning, lunch and night. They are divided in those containers… I put my tablets out on the table and then we say we start with the morning, put the set of boxes out and start with the morning cabinet one, one, one, one until seven. So the next section.*"

Refilling the medication box using the medication list compiled by themselves was a source of confusion. Some patients were uncertain if the medication list they were using was up-to-date. After using the app, patients reported how using the app to refill their medication box assuage this concern:

> *"Well the old way, before we started using the app – It was a crazy system because that tablet, that's not the right one, this one, No I don't take that one in the morning, I take that one in the evening and*

then I have to go back over, you are very confused with your tablets because four tablets out of five look very similar. Whereas with the app, you have the tablet, you take it out of the box, you know exactly the box, it corresponded with the app, the whole thing corresponded. Before that, you were trying to take a chance, today I don't."

The standard procedure for patients to renew their medication is to make a request in their GP practice. The GP practice, in turn, sends the new prescription order to the pharmacy for patients to collect their medication. A feature of newly diagnosed HF patients' treatment is the frequent change of medication dose. Currently, there is no mechanism for the HF clinic to notify the GP practice about changes in medication. Therefore, the change is not noted on the renew prescription sent to the pharmacy. Rather the patient is tasked to remember and relay this information to the GP practice before renewing their medication. This lack of communication among HCPs negatively impacts patients' ability to renew their medication:

"... I send my prescription to the doctor [GP]. *The doctor renews it then he texts it to the chemist maybe a three-month supply or something and then go every month. Now the problem is if there is a change in medication it does create a problem. It's very confusing, is confusing at times.*

As patients adapted to the use of the app, new routines were created without disrupting their quotidian life:

"Oh, no, no, it didn't interfere, it just meant that I was more aware that it was going to go off [the app reminder] *at such a time and be around to turn it off, you know. Like if I was going out at half past nine, I knew the app was going off at half past nine, well I'd hold on till half nine, take the tablet and be able to record it. And not to go on and not be back till maybe half eleven and then not take the tablet, I will forget about the tablet altogether."*

Retirement, for example, was seen as an opportunity to change the medication routine. One of the patients voiced his desire to change his morning routine to stay in bed for an extra hour:

"I know I have to take them [the tablets] *at certain times ah 7.30, 8 o'clock, 1 o'clock and 10 o'clock. Now, at the moment I am doing*

> *some work at the church, hopefully I'm retired in January. So I might change my times [medication times]. Put it back an hour or an hour and a half in the morning, will see what I do in January."*

One of the challenges facing HCPs during consultations is patients failing to bring an up-to-date medication list to their appointment. Patients found the app to be useful to relay their medication information when prompted by HCPs, instead of relying on a medication list written on a piece of paper:

> *"Well I be going to the doctor, sure I would be looking to see what the paper was, sometimes I put it away and I forget where I put it and you are searching everywhere looking for it. Well, all you have to do now is lift the iPad and all is on it. You are not afraid that you forgot anything because is all in the app, do you know what I mean? You are not missing nothing; I think is actually great."*

Medication compliance is vital for improving HF symptoms and patients highlighted the support provided by the app medication reminders:

> *"Well, As I said, I forget half the time to take the medicine. I should be taking the tablets at half past nine I wasn't taking them until eleven, which meant that the second tablet I had to take at half two, I couldn't take until four o clock, so the app is really, I know every day the tablets been on time, it might be maybe two or three minutes later than the time but always around the time half past nine and half two. I think is absolutely wonderful."*

Patients with a greater rate of medication compliance are more likely to experience less HF symptoms, such as fatigue, one of the most common symptoms:

> *"I find a big difference and I feel an awful lot better. I really do. Not as tired… I feel good since I did go on them* [medication for HF]. *Whereas before that I think I might have told you, I mind the grandkids and when I get the dinner ready and sit down before they come home from school and watch a bit of TV I wouldn't even feel myself I would just fallen asleep. Ten minutes later I would think My god. I don't even remember feeling tired. It was like nearly going into deep sleep for 10 minutes and it would be like that on the chair."*

Trusting healthcare providers is necessary for the integration of this new intervention. Patients stated they were confident with the medication treatment prescribed by HF clinicians:

> *"Whatever it is they prescribe, right, I will take because either the doctor or other people in the heart clinic, what they are doing is for my good, I have to assume that the medication they given me, is for me, for my benefit."*

Trustworthiness in the app is also warranted for this intervention to be accepted amongst patients: *"… it* [the app] *helps with my medicines and it helps with my health problems, it helped me lift my head problems."*

Despite their trust in the app, some patients reported feeling anxious when they were encouraged to independently explore it at the beginning: *"I did* [explore the app] *but I didn't want to… In case* [laughs] *I did anything wrong and it went bang."*

The consequences of making a mistake was cited as one of the beginner anxiety sources: *"Is the fear of maybe I do something wrong and go somewhere else? This is what, you know, because you hear so much about what could happen."*

Another beginner anxiety source was the prospect of deleting the medication list compiled in the app:

> *"Well, first of all, I need to get rid of my fear of the iPad. In case I do anything that the whole list* [medication list available in the app] *would disappear and I wouldn't have it"*

One of the patients spoke about her fear of a recent telephone scam nationwide. The Irish authorities have warned, especially older people not to share bank details over the phone or click any links sent by text from unknown contacts. While telephone scams are not within the scope of this study, it was deemed important to report their concerns. It could be argued this could be a reason why some older people distrust digital technologies.

> *"Anyway I got one of those phone calls yesterday from Moldova* [referring to a recent telephone scam] *... I was just after going down to the back door and all of the sudden me phone rang and my grandkids were inside. And I said Oh I hope they don't answer my phone. I was afraid in case they pressed it by mistake. But it's scary"*

Overall, with time, patients grew confident using the app as they were reassured they were following the correct procedures: *"As I found the first day I was a bit anxious but I found as each day went on that I was getting more in to it"*

During the three months' app intervention, the researcher provided patients with ongoing technical support. Post intervention, one of them reflected on learning journey:

> *"Before that* [beginning of the intervention] *I would be afraid in case I knocked something off or couldn't get it back on. At my age, you wouldn't have made that until you* [the researcher] *came along really and truly."*

5.8.6.2 Theme 2: Cognitive participation

Patients mastered the tasks necessary to use the medication app independently shortly after training. They were motivated to use the app daily as it reminded them to take their medication on time:

> *"Well, first of all, you gave me the app. And when I got into it, it was a good motivation for, as I said to remember on time, taking tablets each day and at night-time as well."*

The app not only reminded patients to take their medication on time. It was also programmed to alert the patient 20 minutes after their scheduled medication time when/if a medication was not marked as taken. This feature was found to be useful:

> *"Well it's the reminder from the app, telling me what time to take it. I found like this morning when I didn't hear it at first for that medication I found that 20 minutes later it went off again and thought Oh my God, I didn't take it. So I went and took them."*

During the first home visit, the researcher outlined some of the potential benefits of using the app. One of the patients reflected about how the app could support those with cognitive decline associated with older age:

> *"Well, when I thought about what you* [the researcher] *talked about I said to myself – This is very important that I learn all this because I mean don't forget I am 78 years of age and my memory is not always going to be great. So when you have the app there, it will remind you. Is very important especially when you are my age, really and truly, magnificent for me."*

HCPs working in the HF clinic also played a pivotal role motivating patients to join this study and start using the medication app:

> *"Well* [name of the nurse] *at the hospital rang me and said that yourself had been asking different patients. She asked my permission to give you my number to ring me. And I decided I would give it a try. Just to see would it make any difference? I think it did make a difference like in reminding me as I said on time."*

Patients were motivated not only by the invitation to participate in the study but also by the benefits highlighted by the HCPs during recruitment:

> *"Through the nurses in the HF clinic, they phoned me would I be interested in taking part of this trial. The nurse said at the time that it would be very beneficial to me."*

Uncertainty was part of the journey for some patients at first, as one patient reflected on the whole process:

> *"I was told about it when I went to the HF clinic, the nurses asked if I would like to join [pause] and to be honest, I hesitated for a while, and then I said to myself, Sure, give it a try and see if I can handle it."*

Accepting a new challenge was described by another patient as the source of motivation to start using the app:

> *"Well I think everybody likes a challenge. Now at our age if you sit down and don't accept a challenge well then you are just giving up on yourself as well. It was more of a challenge to myself to learn. I was actually delighted that I took it on really, I really was."*

One of the patients was motivated by the researcher during the initial home visit:

> *"Well why not? You* [the researcher] - [participant laughs] *... No, just the first time you introduced yourself to me, and you talked about the app and you talked about this and you talked about that, it made no sense at that time, it does make sense now."*

Cognitive participation involves sharing the information contained in the medication app. Overall, patients agree to share this information with their HCPs:

> *"Well, it's to do with my health and my medication. So if I had to share with the health care or the doctor, it wouldn't do any harm to be sharing."*

However, patients hesitated when asked their willingness to share their medication information with their relatives: *"Well, I don't think they're interested* [laughs]."

One patient opposed to share medication information contained in the app with his adult children fearing it would burden them:

> *"I know my own family, they worry about me but they have their own lives and their own families, so I don't want them to be worrying about let's say, I took that tablet I deleted that tablet. I think I am wise enough to until such time when hopefully it never comes but maybe the day will come when they have to when they have to look after me but at the moment no."*

Recommending the app to others is another important component of cognitive participation. All patients stated their willingness to recommend the medication app: *"I would recommend it to anybody who's in my position taking plenty of medication"*

One of the patients commented on how he already recommended the app to a neighbour:

> *"Funny enough my neighbour next door, he is in a lot of medication and I talked to him about the services you are giving and the service I get from the HF clinic and using the app and the medication you know and he hadn't got it. Maybe I am being smart you know, I am getting all this attention, is a good thing to know."*

All patients agreed to continue using the app in their own devices after the three-months intervention period. However, one of the patients do not own a tablet or an iPad, impacting on his ability to continue using the medication app: *"I will consider it, maybe* [pause], *I have hinted to the boys* [his adult children to buy a tablet or iPad], *you know."*

5.8.6.3 Theme 3: Collective action

Collective effort and action from patients and HCPs is necessary for effective implementation of the app to support medication management. Greater medication knowledge enhances the medication titration process:

> *"I am more aware of my medication and the strengths of the medication. And I'm aware of that when I go to the heart clinic and they* [HCPs] *talk about we are going to increase tablet A, increase that by point point and decrease tablet C, it all makes sense to me now."*

Integrating this new initiative will also require collaboration from all HCPs involved in delivering care to patients:

> *"I say for instance we say last Friday I went to my own doctor* [GP] *for an MOT* [a health check] *and eh, and he tested everything like heart rate, blood pressure, my feet, the flow of blood to my feet and he was satisfied with everything… Yeah, well he* [GP] *knows that I am attending the heart failure clinic you know"*

The researcher was also seen as part of the healthcare team by one of the patients: *"I feel I am very well looked after in* [name of the hospital where the HF clinic is located] *and with yourself* [researcher]."

A very successful collaboration between patients and HCPs was the educational sessions provided by the HF clinic. During these sessions, patients received education on their medication (i.e. name, strength, type of medication and frequency of use). However, during the COVID-19 pandemic these sessions came to a stop very abruptly. Currently, two years after the COVID-19 disruption, the educational sessions have not resumed. Therefore, HF patients do not have a comprehensive understanding of the medication they are taking, impacting negatively on the ability of some to recall their medication names:

> *"Oh the names, no I don't know the names really. But I do take hmm* [pause to think] *one for the MS* [attempted to say the name of the medication] *or something like that. I think that's the name of them. I take 30 mg and I take the hmm* [pause to think] *the wee one for the heart, the name of it I couldn't tell you. I have all them down in there. I have been taking the ones for the MS for so long that I know the name of them you know."*

Ensuring patients recognise and name their medication is necessary for them to update the information in the app independently. One of the patient was able to recall some names:

> *"Yeah, the only ones I would have known are the Eltroxin and Simvastatin at night, they were really the ones and the other for the heartburn. Every day and that* [pause for thinking] *what do you call that yellow bottle over there? Eh* [pause to think} *Eltroxin first thing, hmm, the names hmm* [another pause, she is thinking about the names]."

Whereas another patient was unable to recollect any of the names when prompted: *"Yes, is all in the app. I, I know there is a.., no, not really, I don't know* [refers to the names of his medication]."

5.8.6.4 Theme 4: Reflexive monitoring

Pre-intervention, patients were asked for their understanding on how apps worked in general, some patients were not aware of what an app was: *"No, what's that?"*

Those with none or very limited technology knowledge rely on their relatives to solve their queries:

> *"I never used an app before, eh or sorry, I never used a tablet* [iPad] *before. I use a computer slightly. But if I have to find out something I make a phone call to the sons or me grandson."*

Those using apps cited varied reasons, for example, one of the patients uses an internet banking app with the support of her family: *"Yeah, I have it on the phone as well. Yeah. I don't understand the details."*

Another patient mentioned she uses Facebook to socialise: *"Facebook on a tablet for my friends in Facebook."*

One of them is using technology to fulfil her spiritual needs as she is unable to attend church in person:

> *"I use it every day to get the mass, every morning from the Friary* [name of her local church]. *I get the rosary every evening, from the Friary as well."*

Learning about using technology for some occurred by chance:

> *"Eh, just by chance fiddling around I just seen that from the Friary and I pressed, there is a bit there to remind you. I press remind every time I finished and they remind me for the next day about the mass."*

Post-intervention feedback provided by patient was positive as the app was found to be useful and the preferred feature was the app reminders:

> *"What I liked from it was, the fact that I will go around all day, I will get up in the morning, started to do things and maybe at eleven o'clock I forget, see I haven't taken my tablets. But I know now, by half past nine, I have to watch out because the app is going to tell me is time to take them. And that's why I find the app to be absolutely great. Taking the tablets on time all the time really."*

The app also supported patients to be consistent with the times of the day they were taking their medication:

> *"Well I liked it because in the mornings, it rings and it reminds me to take the first tablet at half seven. Get up then, it gets me up out of bed and way around, do the things I have to do. And I have then things again. Which, before this, I would have been taken tablets around half ten? Maybe a quarter to eleven. It would be erratic; it wouldn't be constantly the same time."*

Feedback was also sought on app features or any other element of using the app they disliked:

> *"At the start it would have been the usual, the first time getting in on this and then, you know, hoping I would be able to get in the next time and remember what way it was. And even if I forgot like I just fiddle around until I got in, you know?"*

A negative aspect of using technology reported was the beginner anxiety. This was resolved with time as patients practiced independently:

> *"Well there was nothing really that I wasn't happy with like, as I said to you at the start when we were going on to the different settings like I was just a wee bit anxious in case like, as I said, press the wrong button and bang out. But I got used to that very quick and if I did anything wrong I knew how to get back into it."*

One of the patients enjoyed using the app, however, his preference is not to use technology at all:

> *"Hmm* [pause to think] *I didn't dislike the app but I am not gone on electrical things. Ok I use them, I use my own phone, I use the house phone, I use the app but I am not gone on them."*

Understanding how the app functions is necessary for the sustainability of this intervention. Patients were therefore asked to evaluate their training needs to use the app. All patients agreed they did not require further training: *"When you* [the researcher] *taught me and showed me how to use it, I had no real problems using it."*

One of the patients highlighted how not a lack of skills or training but a medical condition may negatively impact on her ability to use the app:

> *"I don't think you need that many skills to use, you just need to use your fingers on that and be able to, you know, I have arthritis in this hand here, so the risk is that I can't use the fingers the same."*

The ongoing training provided by the researcher was found helpful, specifically at the beginning of the intervention when patients were a bit anxious about using technology independently:

> *"Well at the start I found it a wee bit afraid in case I pressed the wrong button, because I'm not used to technology as it is, at my age but towards the end I got very used towards the middle I misheard you know, and then sure, you explained everything to me. On your visits, if I asked you anything you could tell me."*

The use of the app was envisaged to support patients during the medication review process conducted during the consultations. Also, to remind them to take their medication on time. However, one of the patients reported using the medication list compiled in the app to refill his medication box on a weekly basis:

> *"I like the idea that all the medicines are on the tablet and that it was easy to follow it. When I will lay my tablets for the week, it was very easy to follow it with the app."*

A manual was developed by the researcher to support patients to use the app independently, one of the patients provided feedback on the manual:

> *"Yeah, well, when I got the app from you, for the very first time, I really hadn't a clue what to do and then you marked it all out, gave me the paper* [manual], *I could read straightaway. Now the first one or two times I made a mistake, but I got back and looked at the paper. I absolutely found it wonderful really and truly, wonderful for me… I seem to get the hang of it quick enough and I wouldn't be that easy of a person to pick things but because you had all written down for me and marked it, you made it so simple that only for that I couldn't have* [use the app]."

5.9 A case study of medication management using an app

This section presents one case study based on the HF clinic and three individuals case studies based on HF patients. As noted earlier, the case study approach was used as a strategy to present the findings, to compare the experiences and opinions of the HCPs and HF patients about the use of medication app and to highlight the diversity of older people and the everyday issues they faced while using the medication app.

5.9.1 Case study 1: the HF clinic

5.9.1.1 Background & setting

Managing the care of older adults with heart failure (HF) largely centres on symptom and medication management. Medication management in patients with HF is challenging due to frequent medication adjustments in response to changes in their symptomatology and polypharmacy, as some patients with HF typically take on average 10-25 tablets daily. Given the complexity of HF self-management, assisting older adults in managing their own care at home is critical to the success of HF management.

The use of mobile applications is becoming increasingly popular in the self-management of patients with chronic diseases including heart failure. Apps can potentially support older adults to find information on their medications (i.e. drug interactions), track their medication, communicate with health care providers, keep a daily record of their blood pressure and weight measurements, and facilitate an accurate medication history.

Setting

The HF clinic is an outpatient nurse-led service to optimise the management of patients with HF on discharge from hospital. The clinic is designed to:

- improve the post-discharge management of patients.
- educate patients and families on how best to manage HF.

- improve patients’ quality of life and reduce hospital readmissions

On discharge, patients receive weekly telephone calls for 3 months and attend the HF clinic on three occasions during this period (or more frequently if required). Patients are encouraged to ‘phone-in’ a weight gain of 2 Kgs over 2 days and/or any symptom deterioration.

5.9.1.2 The problem & the solution

Observations were conducted in the HF clinic by the researcher in June 2019. The primary objective was to understand how the clinic operated and identify day-to-day challenges for healthcare professionals (HCPs) delivering care. One such challenge involved medication review. Those patients who failed to bring their medication or an updated medication list negatively impacted the ability of the HCPs to complete this task in a timely manner. Patients at the clinic were actively encouraged to bring their medication (blister) pack or an updated medication list (this instruction was printed in their appointment letter and HCPs repeatedly emphasised the importance of bringing their medication during their appointments).

A correct medication list optimises the medication review process by avoiding medication errors, ad hoc clinic visits and rehospitalisation. The medication review therefore is central to guide patient pharmacological therapy. In the case of HF, frequent changes in medication and the dose taken by HF patients, makes the medication review process more complicated. Therefore, when patients attend the clinic and fail to produce the medication list, nurses have to pause the consultation and ring the pharmacist to obtain an accurate list of medications, delaying the consultation process and disrupting clinic efficiency.

The solution

The use of a medication app to support older adults to maintain and up-to-date medication list would improve efficiency.

5.9.1.3 The participants

As stated above, the HF clinic is a nurse-led service meaning that nurses conduct consultations on a daily basis. The clinic operates with four HF nurses, two full-time and two part-time and three nurses (2 full-time and one part-time) agreed to participate in this trial. All participants were female, age range 40-60 years of age. They worked between 18 hours to 39 hours per week. Their clinical experience in HF ranged from three years to more than ten years, and the number of years in clinical practice ranged from three to 42 years. They had little to no experience or confidence in using technology to support HF outpatients' care.

5.9.1.4 Technology acceptance of digital health interventions & implementation

Healthcare professionals' technology acceptance was assessed using the extended Technology Acceptance Model questionnaire (TAM; Asua et al. 2012). The results suggested that the HCPs perceived digital interventions as potentially useful but that they had little to no experience using digital technologies in a clinical setting. Nonetheless, the HCPs agreed that they could easily learn how to use digital tools, that it would be easy to monitor patients using digital technologies and that it would be easy for them to acquire the skills necessary to use digital tools. All HCPs reported their intention to use digital technologies.

Implementation

An evaluation of apps with a medication list functionality was conducted over four months in 2021. A medication management app (Medisafe) was selected for the implementation of a three-month trial. This is a free app publicly available to consumers, allowing them to keep an up-to-date medication list and to set medication reminders for their medication. In addition, it has the ability to record health measurements, i.e., weight, blood pressure, heart rate, temperature and mood.

Three HF older patients attending the HF clinic were recruited to participate in the trial. The patients were recruited by the HCPs working at the HF clinic. They had no previous experience of using a medication app. Training was provided on how to use the app. During the 3-month trial, the researcher communicated regularly with the participants, answering all queries and providing technical support when requested.

5.9.1.5 The role of the HCPs and the Normalisation Process Theory

Prior to the trial, the researcher met the HF nurses to provide an overview of the intervention (use of the medication app). This was an opportunity for the nurses to familiarise with the app and to ask any questions about the use of the app. During the trial, the nurses interacted with the patients coming into the consultation with the app to review their medications. The researcher was present during each visit observing the interactions between nurses and patients using the medication app.

Normalisation Process Theory (NPT)

The NPT framework was used to inform both the interview guide (pre and post-intervention) and the interpretation of results (thematic analysis). NPT was developed by May (2006) to help understand how new technologies can became routinely embedded in everyday work practices in healthcare organisations. NPT is concerned with the social organization of work, with making practices routine elements of everyday life, with embedding practices and sustaining this - in other words, integrating work practices. It has four core constructs representing the different kinds of work that people involved in an intervention undertake. These include coherence; cognitive participation; collective action; and reflexive monitoring.

Coherence refers to sense making work (what is the work?), how do people make sense of the intervention. Cognitive participation refers to the relational work that HCPs do to support a new intervention (who does the work?), how do HCPs engage with the app? Collective action refers to the operational work (how does the work gets done?), what do HCP do to make the intervention work and if the intervention presents significant additional work for HCPs. Reflexive monitoring refers to the appraisal work (how the work is understood?), how do HCPs perceive the intervention once it has been in place for a while (May et al. 2015).

5.9.1.6 Data collection, discussion and results

Observation of practice

Observations of nurses and patients using the medication app in clinical consultations were conducted. The clinical observations commenced with patients notifying the researcher of upcoming HF clinic appointments. On the scheduled appointment day, the researcher met with the patient in the waiting area outside the HF clinic and accompanied them inside the clinic when the nurses indicated it was time to come inside. The researcher communicated with the nurses *a priori* to ensure they knew the consultation would be observed by the researcher.

Interviews pre- and post-intervention

Semi-structured interviews were conducted pre-intervention with four HF nurses and a cardiologist and post-intervention with three HF nurses. Pre-intervention interviews were conducted on September 2020 and post-intervention on July 2022. The interviews allowed the researcher to explore views and perceptions about the use of a medication app during the medication review process during consultation.

Data analysis

The interviews were audio-recorded and transcribed verbatim, the transcripts were subject to theory-led qualitative analysis. Further discussion on the data analysis is presented in the data analysis section of this thesis.

Results, discussion and conclusion

Results, discussion and conclusion are presented in the respective sections of this thesis.

5.9.2 Case study 2: Mary

5.9.2.1 Demographic information, caring needs and attendance to the HF clinic

- Gender: Female
- Age: 72 years
- Marital status: Widower
- Housing status: Bungalow alone in a town
- Highest level of educational attainment: High school

Caring needs

Mary was independent, she drove her own car and did not need any support with day-to-day tasks. She regularly went shopping and visited the hairdresser. She put effort into her personal appearance (hair/ make-up) and dressed in a fashionable manner.

Family connections

From Monday to Friday, Mary collected her three grandchildren from school and cared for them until their mother finished work and collected the children from Mary's home. Every weekend, Mary stayed over in her daughter's home for one night. They also travelled abroad together for holidays.

Attendance at the HF clinic

Mary had been attending the HF clinic for six months prior to participation in the present study. Her signs and symptoms of HF have remained unchanged and her medication does not change as much as it used to when she was referred to the HF clinic. Alongside a diagnosis of HF she has hypertension but perceives her health to be good.

5.9.2.2 Previous strategies used for keeping an up-to-date list of medication prior to using the app

Prior to using the medication app, Mary kept a hand-written list of medications in her purse. She was able to recognise the various tablets and was aware of the number of tablets that should be taken in the morning and the evening. She knew the names of most of her medications - *"I know all my medication by heart"* - and the reasons why she was taking the medications (i.e. hypertension, hypercholesterolemia, heart failure).

5.9.2.3 Setting up the medication app & app training

An issue arose when the researcher entered the details of the handwritten medication list on the iPad during the initial visit. During the first week using the app, Mary noticed the name of a tablet she was not able to recognised. One of her medications was a brand name rather than the generic drug name. The researcher explained to the patient that this was not a medication discrepancy, but simply a change to the medication's name. To avoid confusion, another face-to-face home visit was scheduled with the researcher to replace the brand name with the generic name on the medication list in the iPad. Mary also updated her written medication list for use after the study ended.

App training

Mary and the researcher practised how to indicate in the app whether a medication was taken, skipped or snoozed (this function allowed Mary to postponed the reminder to a convenient time). Training took over one hour, longer than anticipated. Mary was reluctant to independently explore features in the app: *"I would like to try other features in the app but I need you to show me how it works. I think I will not be able to do it on my own."*

On the second visit, the researcher demonstrated how to use other features of the app (i.e. recording the weight, blood pressure, mood and social participation). Mary was visibly anxious about using the app independently and was fearful of breaking the iPad or making errors (e.g., accidentally deleting a medication from the list). To ease her anxiety, a telephone call with the researcher was arranged for the following morning to enquire about Mary's experience using the app on the first day. On the second day using the app, Mary was calmer and confident that she was following the correct procedures: *"I am very happy I was able to do it all by myself without your help".* After the first week, Mary's confidence with the app further increased: *"No difficulties, not really, it was only at the beginning I was afraid to touch it and mess with it. I am used to open the app and find my medication there."*

During the three months' app trial, Mary required ongoing support to update the medication list in the app if a dose was changed or a medication was added or discontinued temporarily or permanently.

5.9.2.4 Technology experience & family support

Mary owned an iPhone and she was comfortable making and receiving phone calls, texting and using apps. Examples of apps the patient used on a regular basis were: Facebook, YouTube, Apple store and internet banking. She had no prior experience using a medication app. On the initial visit to her home, Mary was asked to locate the name and password of her Wi-Fi on the modem to connect the iPad. However, she was not aware where the modem was located or where to find such information: *"I got this Wi-Fi last week and my daughter was dealing with them, I was not paying attention."*

Family support

Mary's daughter and grandchildren offer support when needed: "*If I need to know or I have a question about technology, my daughter or my grandchildren will do it for me. I only know how to answer a phone call, text or use Facebook."* However, she does not ask the family for support if the query was related to her health, such as updating the medication in the app. Mary was not comfortable discussing medical issues with her daughter: *“I don’t tell my daughter anything related to my illness as she gets very worried and anxious.*”

5.9.2.5 App usage and routines developed after using the app

Mary used the app every day for the duration of the trial and did not report any difficulties. She quickly learned how to indicate in the app if her medication was taken, skipped or missed. She particularly liked the app’s medication reminder feature and recorded her mood and social activities at least twice a week, but not daily. During the trial, Mary’s only living brother died, and his death had a significant impact on the patient. Her brother’s death resulted in a gap (4 weeks) using the app. She was also reluctant about recording her mood: *“I am still very sad and lack motivation, like, what is the point to record my mood if most days I am not feeling great.*” In another conversation she said *“Yes, I am using the mood and the social participation* [features] *twice a week, although I have to say, recording the mood makes me aware of how I am feeling.”*

Since weight gain is a sign of fluid retention, it is important for patients with HF to weigh themselves daily. However, Mary did not record her daily weight in the app: *“At the moment I am unable to weight myself everyday as my scales need new batteries, I bought them but I don’t know how to change the old batteries for the new. I have to ask my daughter to do it for me this week.*” In a follow-up conversation, when asked about her daily weight the patient remarked: *“I got the scales working last week and now they are not working, I can’t afford to buy new scales, these were very dear.”*

Routines developed after using the app

Mary developed a new routine through using the medication reminder app. The iPad was stored on the night table in her bedroom for safety reasons. In the morning, before leaving the bedroom, the medication reminder alarm rang and Mary took her morning medication: *“Well the iPad stays in my room all night in my* *night table. When the alarm goes off, I get up and take my medication. Then I walk out of my bedroom and go into the kitchen where I listen to the radio, prepare my breakfast and get ready for the day."*

For the evening medication, she was usually watching the television when the medication alarm rang. She could hear the alarm easily as the bedroom was a short distance from the sitting room. On those occasions when she stayed overnight in her daughter's house, she did not take the iPad with her as she was afraid the grandchildren would play with it and damage it. Instead, on those days she reverted to her previous habits of relying on her memory to take her medications. When she returned home from her daughter's house, she updated the app and indicated her medication that was taken.

5.9.2.6 Difficulties experienced with the app & perceptions and continuity of use

During the first week using the app, Mary found the volume of the alarm to be too low. She also raised the issue that the alarm only activated once and, as a result, Mary missed a dosage of one of her medications. *"I missed the reminder this morning because the app is in my room and I was in the kitchen with the radio on while having breakfast."* This issue was resolved with the help of the researcher in the second visit by changing the app's settings. The alarm was set to ring at the specified medication time and continue ringing for 10 minutes until the medication was marked in the app as taken or skipped. The volume of the alarm was raised to a higher level. Mary selected her preferred alarm tone during this second home visit. Another line of support was added: for the morning medication only, a second alarm was activated to ring after 30 minutes of the specified time in case Mary missed the previous reminder.

Another difficulty encountered by the patient was that the morning medication alarm was interfering with her ability to sleep longer during the winter: "*The only thing I would like to change is the time of the morning medication. You see, during January, mornings are very long and dark. So when the alarm goes off at 7.30 am* *to remind me to take my first round of medication, all I am thinking is of lying in my bed for another 20 minutes."* The researcher offered to resolve this issue by changing the time of her medication dosages. However, the patient declined: *"No, I rather you wouldn't do that* [change the medication reminder from 7.30 am to 8 am] *as this is only temporary. There is a stretch in the mornings now like today. Also, this would not fit with my mornings routine."*

After the death of her brother, Mary did not record her mood in the app for four weeks. During a follow-up telephone consultation, Mary remarked that this feature was not working in the app. The researcher explained how to access the section on mood and how to "save" inputted information. Mary forgot how to use the 'save' step but only needed a quick verbal reminder: *"It has been a while since I last used it . . .Now I know what I am doing."*

Perceptions of app and continuity of use

Mary was accomplished using the app, highlighting its utility in keeping an up-to-date medication list and issuing medication reminders: *"The app is helping me to remember to take my medication in case I forget" . . . the app I find great; it reminds me about my medication."* At the end of the trial, when asked if she would continue using the app, she replied: *"Yes, I will."*

5.9.3 Case study 3: John

5.9.3.1 Demographic information, caring needs and attendance to the HF clinic

- Gender: Male
- Age: 78 years
- Marital status: Widower
- Housing status: Terrace house alone in a town
- Highest level of educational attainment: Primary school

Caring needs

John was independent; he drove his own car and did not need support with day-to-day tasks. He regularly went shopping, collected his medication from the pharmacy, attended mass daily and walked his dog. He had worked in his local church for over 40 years, however, retired during the trial.

Family connections

His children and grandchildren visited him regularly, however he stated on several occasions that he would like to spend more time with them. His family organised family outings (e.g., a lunch in the local pub and a walk in the beach). John envisaged more family outings as the COVID-19 public health regulations eased.

Attendance at the HF clinic

John had been attending the HF clinic for four weeks prior to participation in the study. His signs and symptoms of HF have remained unchanged, his medication was titrated after each visit to the HF clinic. Alongside a diagnosis of HF, he has diabetes mellitus type 2 and chronic obstructive pulmonary disease and perceives his health to be fair.

5.9.3.2 Previous strategies used for keeping an up-to-date list of medication prior to using the app

Prior to using the medication app, John kept a hand-written medication list compiled by himself. Once a week, he used the list to refill his medication box. The box had four compartments labelled breakfast, morning, lunch and evening tablets and was refilled for seven days. He was not able to name his medications, however he recognised the various tablets by looking at them and was aware of the number of tablets that should be taken in the morning, afternoon, evening and night. When he was asked to comment on the strategies used to keep an up-to-date list of medication prior to using the app he replied "*I used a handwritten copy of my* *prescription, the one they gave me in the pharmacy. I was never sure which one was old and which was new so it was confusing. The app solves that problem."*

5.9.3.3 Setting up the medication app & app training

The medication app was set up for John by the researcher. However, while the researcher was comparing the medication list on the iPad and the medication contained on John's medication box, she identified a medication discrepancy. On the medication box, one of the afternoon tablets was doubled and the medication list indicated this tablet should be taken once a day. The investigator advised John to contact the HF clinic that day to discuss his medication. Another medication issue arose on a follow-up telephone call after the Christmas period. When John was asked if he was experiencing any difficulties using the app he stated *"I am confused with the medication. I take 11 tablets a day. In the app I see I have 10 tablets."* The researcher advised John to keep taking his medication in the same manner before to using the app. This was his second week using the app and he was using the app as a medication reminder and not as a medication list to refill his weekly medication. The researcher scheduled a face-to-face home visit the following day to explore this medication discrepancy in the app. After comparing the medication list on the app and the medication list compiled by John, it was clear that one of the medications was deleted from the app. The missing medication was consequently added to the list on the app by the researcher.

App training

The researcher and patient practised how to enter the medication and to indicate in the app whether a medication was taken, skipped or snoozed (this function allowed John to postpone a medication reminder to a convenient time). Training took less than thirty minutes and John practised independently for ten minutes. On the second visit, the researcher demonstrated how to use other features of the app (i.e., recording mood and social participation). The following week, John was asked if he was recording the mood and social participation and he responded: "*I know how to do the mood, I am doing it every day in the app. However, I haven't used the social participation yet as it does not mean much to me. You see, when I was working in* *the church I enjoyed greeting others and the stories they told about my late wife, that was very comforting. But I wouldn't call that social participation. What I really want to do is meeting my grandchildren, my sons and my daughters in law. They are important to me and those are the people I want to spend time with."*

During the three months' app trial, John required ongoing support to update the medication list in the app if a dose was changed or a medication was added or discontinued temporarily or permanently. When the researcher asked him if he was confident about updating a medication dose in the app independently he answered *"No, I would like you to do it for me, I don't want to muck it up."*

5.9.3.4 Technology experience & family support

John owned a mobile phone and he was comfortable making and receiving phone calls. He had no experience using internet facilities such as email, internet banking, video calls or Facebook. A week before attending a HF clinic appointment, John had a blood test. This test provided vital information before the HF nurses decided to titrate his medication. Post COVID-19, appointments can be booked online only. John was unable to book the appointment online independently and required the support of his son: *"I am waiting for my son to come one of the evenings to help me get an appointment for my bloods. They* [HF nurses] *look at the bloods and then they will consider changing my medication or not."*

Family support

John's children also supported him emotionally. John felt lonely as his wife died less than a year ago. On occasions he recalled how his mood improved while surrounded by his family: *"some days I feel like a three and other days I feel like a nine* [on a scale of 0 – 10]. *For example, my grandson visited over the weekend and that day I was very happy, let's say a nine. Other days I am alone and miss my wife and get a bit low. In those instances, I pray and it works for me, I forget the pain for a while.*" In another instance he said *"I am feeling very well today; I would say I am like an eight today. Depending on how the day ends, I could go up to a nine or a ten. This evening, I am going to my granddaughter's house to deliver her a present.*

She is turning 15 years of age tomorrow and I am looking forward to a hug or two and maybe plans for tomorrow after school to go somewhere for cake and coffee."

5.9.3.5 App usage and routines developed after using the app

John used the app every day for the duration of the trial and mastered very quickly how to mark his medication as 'taken', 'skipped' or 'missed'. His preferred features on the app were the ability to keep an up-to-date medication list and the medication reminders: *"I am using it* [the app] *every day as a reminder. I got used to use it* [the app] *now, looking at each tablet and knowing what time I should be taking them. The app helps me to keep my tablets under control, the way you set up my tablets on the app is great."* He also recorded his mood and social participation towards the end of the trial.

Routines developed after using the app

John developed a new routine through using the medication app. The iPad was left on the kitchen table all day to avoid damage by his dog: *"I have my routine now. The iPad is always on the kitchen table so when it beeps I can hear the alarm. My son every time it beeps now says – there is the nurse calling you again for you to take the tablets!! Is like a wee joke we have now."* Night-time was his preferred time to record his mood and social participation: "*Every day at 9 pm I sit and I record my mood and my social participation.*" Before the trial, John used his handwritten medication list to refill his weekly medication box. Towards the end of the trial, he started using the medication list on the app to refill his weekly medication box: "*As I explained to you, I developed a new routine. I am using the app to refill my medication box for the entire week. I used to do it with a written list I did myself, now I trust the app and use it as a guide to refill my medication.*"

When John joined the trial, he was still working as a sacristan in his local church. Four weeks into the trial, he announced that he was retiring and asked for the medication reminder times to be changed. He expressed his desire to change his morning routine so that he could stay in bed for an extra half an hour.

5.9.3.6 Difficulties experienced with the app & perceptions and continuity of use

During the trial, John experienced technical difficulties with the app: *"I had no problem using the app, except one day I wasn't here at lunch-time on Sunday and I didn't have the iPad with me. When I returned home, it was hard for me to come back into the medication section to mark my medication as taken. In the end, I found my way back into it.*" In another occasion he reported another difficulty with the app: "*It was only yesterday when I went to mark my night tablets as taken and it wouldn't work for me, I couldn't access the list of medication so I pressed take all and the issue was resolved*". In both instances, John resolved the technical glitches without the support of the researcher demonstrating increased confidence with the app.

Perceptions of app and continuity of use

John enjoyed using the app and highlighted its usefulness in keeping an up-to-date medication *list: "the app gives me more trustworthiness, the way I can do my tablets now, it gives me more confidence on my own."* At the end of the trial, when asked if he would continue using the app, he replied: *"Yes, I will, I don't own a tablet but I will ask my children to buy one for me.*"

5.9.4 Case study 4: Ann

5.9.4.1 Demographic information, caring needs and attendance to the HF clinic

- Gender: Female
- Age: 78 years
- Marital status: Married
- Housing status: Resides in a terraced house in a town
- Highest level of educational attainment: Primary school

Caring needs

Ann did not need any support with day-to-day tasks. However, she did not drive and often needed her daughter to drive her to medical appointments, shopping and visiting the hairdresser every Saturday morning. Ann enjoyed walking to a nearby supermarket on her own.

Family connections

Ann lived with her husband and a cousin. Her daughter was her formal carer and visited daily, in the morning and in the afternoon. Her three grandchildren visited her house regularly and alongside their mother, they provided technological support when needed.

Attendance at the HF clinic

Ann had been attending the HF clinic for three weeks prior to participation in the study. Her signs and symptoms of HF remained unchanged and her medication was titrated after each visit to the HF clinic. Alongside a diagnosis of HF she has multiple sclerosis (MS) and hypertension. Despite having a number of medical conditions, Ann described herself as being in good health.

5.9.4.2 Previous strategies used for keeping an up-to-date list of medication prior to using the app

Prior to using the medication app, Ann kept a hand-written list of medication that she had compiled herself. The medication list was not comprehensive, it only listed the names of the medication, and not the strength and frequency of use. However, as Ann had been living with MS for over 20 years she was able to recognise the tablets and was aware of the number of tablets that should be taken at different intervals of the day. She was less sure about her HF medication: *"what is this medication for? Is this one for the heart? I am new to the HF clinic; I have been there just once. I am trying to get the hang of things.*" Prior to her HF clinic referral, Ann fell very ill and was rushed to hospital where she spent three weeks as an inpatient. Advice on how to take her new medication for HF was provided by hospital staff before she was discharged: *"when I was discharged from the hospital in January they gave me a list with the names of all my new tablets and how to take them at such time and such time. They* [medication] *all corresponded with the tablets I was already taking for my MS. So they* [HCPs] *told me to put them in a weekly medication container with the days of the week, you know, Monday, Tuesday, Wednesday and to put the new tablets with the MS ones. Then I started taking them all together at 9.30 am, 2.30 pm and 8.30 in the evening."*

5.9.4.3 Setting up the medication app & app training

Using the medication boxes provided by the pharmacy, the researcher was able to accurately populate Ann's medication list on the app (name, dose and time of day). During this process, Ann observed closely how the investigator entered all the information into the app. Once the app was ready to use, Ann appeared to be anxious and asked questions about using the app independently: "*What is going to happen tomorrow? Is my daily routine going to be affected? Will the app remind me this afternoon and in the evening about my tablets?".* All her questions were addressed to ease her anxiety and a telephone call was scheduled for the following day to enquire about Ann's experience using the app on the first day.

App training

Ann and the researcher practised how to open the app to find the list of medication and how to indicate in the app whether a medication was 'taken', 'skipped' or 'snoozed'. This function allowed Ann to postpone the reminder to a convenient time. Training took thirty minutes and Ann's daughter was present as requested by Ann: *"can you come when my daughter is here in the house? She is my carer and I would like her to listen to all you are saying, so both of us can learn at the same time just in case I forget, then she can explain me later."* After practice, Ann was very excited about using the app independently and stated "*I am looking forward to this.*" On the second visit, the researcher demonstrated how to use other features of the app (i.e., recording weight, blood pressure, mood and social participation). A few weeks later, she independently started recording her level of pain and pulse daily. As Ann indicated she had no previous experience using apps, the researcher developed a guide (as seen in appendix S) to follow while recording her vital parameters data. A few weeks later, Ann commented on her experience using the guide: "*I found the manual very useful at first, Oh God, only for that I wouldn't be able to hack it. I still have it inside of the iPad box over there. Only for that now, really and truly, you did do it perfectively, you really did. It was very easy to follow. I use it if I am not sure what to do or how to do it.*"

During the three months' app trial, Ann required ongoing support to update the medication list in the app if a dose was changed or a medication was added or discontinued temporarily or permanently.

5.9.4.4 Technology experience & family support

Ann owned a smartphone and she was comfortable making and receiving phone calls. She had limited experience using technology and no previous experience using a medication app. Her daughter set up a Facebook profile for Ann to keep in touch with family and friends. She also used this app on a daily basis to watch Mass online: *"I really had not much experience at all, I don't even text on my phone. I only watch the Mass online because my daughter bought me a tablet for Christmas two years ago. My daughter set up the mass for me and showed me when the Mass is on what button to press to get a reminder for the following day. I will be sending birthday greetings to some friends in Facebook, my daughter set it up for me as well. It nearly spells it for you, when you write the word happy, you see the word birthday coming up.*"

A week before attending a HF clinic appointment, Ann needed an appointment for a blood test. This test provided vital information before the HF nurses decided to titrate her medication. Post COVID-19, appointments can be booked online only. Ann was unable to book the appointment online independently and required the support of her daughter: *"I am having difficulties with booking an online appointment to get my bloods done before visiting the clinic. I do think they* [the laboratory] *should have a certain time for older people* [a dedicated time of the day for older people to attend in person without booking online], *older people cannot* *go online, I can't do that* [get an online appointment], *my daughter does it for me. I haven't a clue on how to do it."* On the initial visit to her home, Ann was asked to locate her WIFI name and password on the modem to connect the iPad. However, she was not aware where the modem was located or where to find such information: *"No, I do not know what you are talking about. I have a black box in the hall, do you want to take a look at that? My daughter will be here in the house next time you come around so she will look after that".*

Family support

Ann's daughter and grandchildren offer technological support when needed*: "my daughter comes to me every morning at 9am. My husband is no use as he does not know even how to use a mobile phone. If I have any questions about technology I have to ask my daughter or my grandchildren, specifically my granddaughter, the boy wouldn't like to be bothered with those things, I wouldn't know how to update the software; you know, when you get the message to update? So I would say it to my daughter and she would come do it for me or my granddaughter."* On the initial visit, Ann requested for her daughter to be present when the medication list was to be entered in the app and for the practical session: *"Are you able to come when my daughter is here in the house*? *She is my carer and I would like her to listen to all you are saying, so both of us can learn at the same time just in case I forget, then she can explain me later".* In another occasion, she reiterated that when she needed support with the app, her daughter was her first port of call: *"If I am not sure what I am doing, I ask my daughter or I look at the guide you gave me".*

5.9.4.5 App usage and routines developed after using the app

Ann used the app every day for the duration of the trial, with little or no difficulties. She quickly learnt how to indicate in the app if her medication was 'taken', 'skipped' or 'missed'. She particularly liked the app's medication reminder feature and recorded her blood pressure and weight daily: *"I got the hang of it now. I am weighting myself every day and doing my blood pressure and putting it on the app".* A few weeks into the trial, she began recording her mood, pain level, pulse and temperature: *"The other day I sat looking at the app and I discovered the section* *for temperature, so I started to put my temperature there as well. I also saw the mood and I started to put my mood daily now"*. When she was asked to comment on her preferred app feature, she replied "*My favourite part of the app is actually seeing the blood pressure, the pulse and the weight staying the same, the way I can see it* [the daily data on the graph] *during the week and that there are no drastic changes, looking at the wee graph and knowing that the measurements are stable, not much of a difference day by day."*

Routines developed after using the app

Ann developed a new routine through using the medication app. The iPad was stored in a cabinet on the kitchen *"The iPad is always in the kitchen because I am always in the kitchen in the mornings, cleaning and tidying up around the kitchen. Around 9.30 am I sit for a while as I know the app will beep to remind me about my medication. I take my medication and tick in the app "taken". After that I take my blood pressure and my pulse and put it on the app, then at 10 am I watch mass online like every other day."* Her evening routine was modified from time to time: *"Sometimes in the evening if I am watching a television programme in the sitting room, that I know it will overlap with the time of the medication reminder, I bring the iPad with me to the sitting room so I don't miss the alarm."*

Ann visited the hairdresser every Saturday early in the morning, a routine she kept for over 15 years. The iPad was also incorporated in this routine: "*I get my hair done on a Saturday and I take the iPad with me to the hairdresser. I am there for 9 o'clock so by 9.30 am it goes off so I take my tablets out and the girl gives me a glass of water."*

Some of the benefits gained by this new routine were a higher medication adherence and the ability to take her medication on time: "*Before the app, I will take my tablets in the morning, but if I started doing things away up to town, then I will come home to cook something and forget my afternoon tablets. Then I will be sitting there at 4 pm or 4.30 pm saying Jesus, I never took my tablets when I should be taking them at 2.30 pm so that is 2 hours later. Then the other ones I have to take at half eight at night but now I am 2 hours late with them so I try to space them* *out, so yes, the app is a great reminder. Now with the app I am aware, I could be late if I have to use the toilet or something like that, but that's it, is minutes but does not go into hours, which means I am taking them all every day at a regular time."*

5.9.4.6 Difficulties experienced with the app & perceptions and continuity of use

At the beginning of the trial, Ann complained the volume was too low on the alarm: *"I am not going to say it was a disaster but I didn't hear the alarm going off, I missed the alarm."* The researcher spoke to Ann's daughter and the issue was resolved by increasing the volume to a higher level on the settings. It was agreed that both Ann and her daughter would pay attention to the next reminder to check if the volume on the alarm was adequate or not.

Ann continued talking about her experience on her first day using the app independently: *"I opened the app this morning after missing the alarm and it said 'time to take your medication' so I ticked the medication as taken or at least I think I did. I am going to ask my daughter to check it for me."* Her daughter corroborated that all the medication scheduled for that morning were ticked as "taken" and said *"My mum must have done it herself.*" During the trial, Ann did not encounter any other difficulty while using the app.

Perceptions of app and continuity of use

Ann found the app easy to use: *"the medication part is easy, the alarm goes off, I open the app and I mark the medication as taken. Then I close the iPad and take my tablets."* She further commented: *"I find the app very easy to use. I open the iPad, put my password and find the list of all my tablets there."* At the end of the trial, when asked if she would continue using the app, she replied: *"Yes, I would like to keep using the app in my own tablet once we finish because the app is very handy when I go into the clinic, you know, I can show them what medication I am on and I am able to show them the list with my tablets."* The researcher developed a manual to support Ann in updating her medication for future use (as seen in appendix T).

5.9.5 HF patients case studies comparison

As noted earlier, sociomaterialism is one of the theoretical frameworks guiding this study and it considers how materials (use of a medication app) influence human activity (HF patients self-managing medication at home using the app). Orlikowski (2007, p. 1435) held that all work practices are an "entanglement of the social and the material in everyday life", with limited consideration of human relationships. Fitzgerald et al. (2009) posit that by comparing case studies, researchers can have a wider understanding of the social phenomena under investigation. Therefore, the three case studies were analysed individually and later compared in a summary table presented below (see table 10) to look for similarities and differences.

Table 10: Comparison of the HF patients' case studies

	Case study 1	Case study 2	Case study 3
Gender	Female	Male	Female
Age	72 years	78 years	78 years
Marital status	Widow	Widower	Married
Housing status & living arrangements	Resides in a bungalow, lives alone	Resides in a terrace house, lives alone	Resides in a terraced house, with her spouse
Highest level of educational attainment	High school	Primary school	Primary school
Caring needs	Independent, drove her own car and did not need any support with day-to-day tasks	Independent; drove his own car and did not need support with day-to-day tasks	Did not drive and depended on daughter to attend medical appointments and shopping. No need for support with day-to-day tasks
Family connections	Looked after grandchildren and spent holidays abroad with family	Children and grandchildren visited him regularly, but not as regularly as he would like to see them	She lived with her husband and cousin. Daughter was her formal carer and visited daily, grandchildren visited often
Attendance at HF clinic	Had been attending the HF clinic for six months prior to	Had been attending the HF clinic for four weeks prior to participation in the study	Had been attending the HF clinic for three weeks prior to

	participation in the study		participation in the study
Previous strategies used for keeping an up-to-date list of medication prior to using the app	Kept hand-written list of medications in her purse	Kept hand-written medication list compiled by himself. Once a week, he used the list to refill his weekly medication box	Kept a hand-written list of medication compiled by herself. Medication list was not comprehensive, only listed names of the medication, not the strength/ frequency of use
Setting up the medication app	A medication issue arose during the first week and was easily resolved.	A medication discrepancy was detected during the first week while compiling the medication list in the app.	The medication list in the app was populated using her medication boxes. Her medication list was incomplete and did not reflect dose and time of the day of medication
App training	Initial training took over one hour. Reluctant to independently explore features in the app at the beginning	Initial training took 30 minutes and practised independently. Declined when asked to independently update medication list on the app	Initial training took 30 minutes; her daughter was present as requested it. Her daughter was her carer and was interested in learning about the app, to remind her mother if needed.
Technology experience	Previous experience using apps i.e. Facebook, YouTube, Apple store and internet banking. No prior experience using a medication app	No previous experience using internet facilities e.g. email, internet banking, video calls, Facebook or medication app	Limited experience of technology. No experience of a medication app. Daughter set up Facebook for her to greet family and friends.
Family support	Daughter & grandchildren offered support when needed. Not comfortable discussing medical issues with daughter	Adult children supported him emotionally, however, he felt lonely as his wife died less than a year ago. Children also provided technological support	Daughter & grandchildren offered technological support when needed. Husband lacks technological skills

App usage	Used app daily during the intervention and did not report any difficulties. Liked the app's medication reminder feature and recorded her mood and social activities at least twice a week, but not daily	Used app every daily during the intervention, quickly mastered its use. His preferred features were keeping an up-to-date medication list and reminders. Recorded his mood level but reluctant to record his social participation	Used app daily during the intervention, with little or no difficulties. She liked the app's medication reminder and recorded her blood pressure & weight daily. Towards the end, she also recorded pulse, pain level and temperature daily
Routines developed after using the app	In the morning, before leaving the bedroom, the medication reminder alarm rang and she took her morning medication	Towards the end of the intervention, he started using the medication list on the app to refill his weekly medication box, instead of the hand written medication list compiled by him	Visited the hairdresser every Saturday early in the morning, a routine she kept for over 15 years. The iPad was incorporated in this routine as she brought it along to take her morning tablets
Difficulties experienced with the app	During the first week, she found the volume of the alarm to be too low. She also raised the issue that the alarm only activated once	He experienced technical difficulties with the app i.e. technical glitches and on one occasion he reported being unable to come back into the app	At the beginning of the intervention, she complained the volume of the alarm was too low
Perceptions of app and continuity of use	She was accomplished using the app, highlighted its utility in keeping an up-to-date medication list and issuing medication reminders. She agreed to continue using the app	Enjoyed using the app and highlighted its usefulness in keeping an up-to-date medication list. Stated it gave him more confidence in his medication self-management. He agreed to continue using the app, however, mentioned he does not own a tablet and will ask his children to buy one for him	Enjoyed using the app and found it easy to use. She also found the manual developed by the researcher very useful. She agreed to continue using the app

Chapter 6: Discussion

This chapter discusses the results within and the theoretical framework which involves coherence, a key characteristic of which is that stakeholders (HCPs and patients) should have a common understanding of the medication app.

As discussed in the theoretical framework, the term coherence refers to understanding or making sense of a new practice (May and Finch 2009; May et al. 2015). In the present study, coherence describes HCPs and patients understanding the benefits of the medication app. For example, seeing the use of the app as a new way of working to support medication self-management.

Cognitive participation refers to how individuals "buy in" and engage in the new practice (May and Finch 2009; May et al. 2015). It describes the training needs of participants and the relational work of those engaged in the use of the app. For example, patients demonstrated "buying in" the app by mastering the tasks necessary to use the medication app independently shortly after training and if whether HCPs acknowledged the app as a legitimate part of their work practice.

Collective action is all about the work individuals and the wider organisation do to support the new practice (May and Finch 2009; May et al. 2015) such as acknowledging the app contribution to patients' self-management at home. It also refers to the support (or lack of) for the promotion and roll-out of the app in the HF clinic.

Reflexive monitoring refers to the appraisal of the new practice pre- and post-intervention (May and Finch 2009; May et al. 2015). For example, patients were asked to provide feedback on the app features and HCPs were given the opportunity to appraise the new practice and compared it with the traditional working practice. All participants were also given the opportunity to express their satisfaction or dissatisfaction with the app.

6.1 Interpreting HCPs' experiences the medication app

6.1.1 Theme 1: Coherence

Coherence refers to having an understanding or making sense of the technology, mastering the technology, and the value derived from using the technology (Piculell et al. 2021). In the present study, coherence was an important factor in the experiences of both patients and staff alike. This included both a sense of meaning of tasks by HCPs associated with patients' care, such as educating patients about the importance of taking their medication at specified times, and having a shared understanding of the tasks associated with using the medication management app (reviewing the medication list contained in the app during the consultation). In turn, evidence suggests that an increased sense of coherence and control is associated with greater empowerment (Musavinasab et al. 2016).

Patient empowerment has been an objective of the Irish government for a number of years, with the publication of the national framework for self-management support for chronic conditions intended to facilitate greater patient control of conditions such as COPD, asthma, diabetes and cardiovascular disease (Chronic Conditions Working Group 2017). Patient empowerment is associated with increased knowledge, skills and attitudes and the ability to make informed decisions about their care (Higgins et al. 2017). Previous research has shown that patients using technology to monitor health parameters and their medication feel more empowered and satisfied (Merchant et al. 2018; Payne et al. 2015). In addition, the conversations between patients and HCPs is more interactive as patients are empowered and feel confident to ask questions and to seek explanations.

The findings from the present study show that patients felt empowered to play a role in their consultations and demonstrate the app. Historically, this has been a one-way process, with HCPs being the source of knowledge and patients being passive recipients (Affinito et al 2020; Merchant et al. 2018). While showing HCPs how the app worked and where to locate their medication information, patients demonstrated a greater understanding of their medication and mastery of a medication app. In addition, the HCPs also understood the role the app played in empowering patients as active participants on their medication management. Patients were considered to be more aware of what medication they are taking, why they are taking it, the time of the day and how many tablets they are taking.

One of the challenges facing HCPs during consultations was patients failing to bring an up-to-date medication list to their appointment (Lewis et al. 2016). Medication management in patients with HF is challenging due to frequent medication or dosing changes (Marti et al. 2019; Clark et al. 2009) and polypharmacy, as some patients with HF typically take on average 10-25 tablets daily (Clark et al. 2010). In line with previous research, an app that supports HF patients in keeping an up-to-date list of medications is advantageous, not least because it reduces the potential for medication errors (Santo et al. 2019; Buning et al. 2016).

When patients attend their appointment without their medication or an updated medication list, clinical efficiency is disrupted. HCPs are forced to pause the consultation and telephone the pharmacist to verify the patient’s medication list. Crowley (2020) acknowledges that medication optimisation in HF patients is a time consuming process but necessary to minimise medication errors. Consequently, the consultation time increases as ringing a pharmacy is not a prompt process. This was the case in the present study if the line was engaged or if the pharmacist was busy at the time the phone call comes through, HCPs are asked to phone at a later time. In the meantime, the patient remains seated in the consultation room until the nurse obtains the medication information from the pharmacist, with resource implications.

Efficiency in outpatient departments can significantly reduce costs and extended appointment time, increase patient satisfaction and ensure human resources are employed more effectively. HF outpatient visits cost the taxpayer an estimated €172 per visit (Heartbeat Trust, Irish Heart Foundation and NUI Galway 2015). Patients attending their consultation with an updated medication list on their app contribute to a reduction of their consultation time and health care costs (Buning et al. 2016). This raises the issue of sharing information between clinicians.

Multi-morbidity is common in HF patients attending various clinics (e.g. diabetic clinic). The benefits of information sharing have been widely described in the literature. Makeham and Ryan (2019) argues that sharing information on a timely manner is the foundation of a modern healthcare system and can potentially avoid harm and death of patients. Mickelson et al. (2015) highlights the need for a centralised communication channel for all HCPs to share any change in the care plan and medication regimen of patients to guarantee their safety, treatment compliance and better healthcare outcomes. However, clinical information is not shared amongst clinicians from different specialties. As the findings from the present study show, lack of communication affects patients' treatment prescribed by the HF clinic when other clinicians stop and/or add a medication without notifying the HF clinic. This is compounded by the fact that many older patients may assume that the multiple HCPs involved in treating their health conditions are aware of the medications they are taking, when this is often not the case. In practice, this lack of communication can lead to acute HF (McMurray et al. 2012) negatively impacting patient outcomes (Frankenstein et al. 2015). Rehospitalisation, an exacerbation of symptoms and a deterioration of the overall patient condition are amongst the negative outcomes experienced by some patients (ibid).

HCPs do not rely solely on patients' ability to recollect factual information as they acknowledge some patients are unable to inform them who changed the medication, when and/or what medication was changed. Effective care coordination and clear communication channels between the cardiologist and the GP is vital to decrease the risk of hospitalisation and mortality for HF patients (Frankenstein et al. 2015; Ezekowitz et al. 2005). In the present study, HCPs working in the HF clinic felt confident that the app would capture a more comprehensive profile of a patient's journey navigating through different healthcare providers. For example, when the patient visits the GP and a medication dose is changed or suspended, it will be reflected in the app. This information will be readily available for the HCPs when the patient attends their next HF clinic appointment.

Despite the potential app benefits aforementioned, challenges to app adoption in the care of older adults emerged during the interviews. One of the challenges was the lack of patients' technological experience and the need to identify who will provide the app training. Older adults are not as comfortable adopting technology in comparison to their younger counterparts (Berkowsky et al. 2018; Van Deursen and Van Dijk 2014). Some of the barriers to technology adoption by older adults cited in the literature include the lack of appropriate instructions as well as lack of digital skills (Vaportzis et al. 2017). Patients participating in the present study had no experience using a medication app pre-intervention. However, ongoing training was provided by the researcher on how to use the app, setting up medication reminders and how to edit a medication entry. Saborowski and Kollak (2015) investigated HCPs experiences with assistive technology use with older people. Their findings showed that staff expected to provide training to older people had limited knowledge and felt this (educator) role was adding to their existent workload. This is in line with the findings of the present study, as HCPs reported dealing with medical reviews several days a week and long waiting lists post-COVID. Therefore, they are unable to allocate time at present to support patients on learning how to use the app regardless of how beneficial the app might be. Nonetheless, HCPs welcomed the app and agreed they are willing to use it with appropriate support for the patients. Looking towards the future, HCPs were adamant that training will be required for older patients and the need to identify who will provide this training (more discussion on the role of an educator provided below in theme 4). Literature evidence from previous research showed that effective training is associated with higher uptake amongst older people (Holden et al. 2020; Berkowsky et al. 2018).

Another challenge to technology adoption is HCPs' attitudes towards older people and their ability to use technology. According to Mannheim et al. (2021) HCPs' ageist attitudes and/or age-based stereotypes towards older people using digital technologies are prevalent. HCPs' attitudes towards the adoption and uptake of digital technologies are influential. HCPs have been described in the literature as healthcare technology "gatekeepers" (Addala et al. 2021; Cowan et al. 2019). Gatekeepers influence potential clients (patients) by recommending the technology or by prescribing it. By profiling older adults as disinterested or unable to use digital technologies, HCPs are curtailing their ability to "buy in" and impacting negatively on technology adoption for this cohort. Therefore, healthcare institutions addressing their HCPs' learning gaps and providing training on healthcare technologies, specifically on the use of apps and older people, is warranted (Morton et al. 2021). Previous research has shown that a short training offered to HCPs on integrating apps in clinical care can increase knowledge of HCAs and willingness to recommend apps post-training (Armstrong et al. 2018).

6.1.2 Theme 2: Cognitive participation

Apps can potentially support older people to find information on medications (i.e. drug-drug interactions alerts, track their medication, facilitate up-to-date lists of medications, communicate with healthcare providers and record daily blood pressure and weight measurements). The use of apps with HF patients have been found to improve self-management, confidence in self-care and knowledge about HF (Wali et al. 2019; Athilingam et al. 2017), medication-taking behaviour and medication adherence (Santo et al. 2019), and supporting patients to maintain an accurate list of medication (Buning et al. 2016). In the present study, HCPs were motivated to use the medication app and indeed willing to try any tool (digital or not) that benefits their patients.

Part of the challenge providing care, particularly for older adults, is the difficultly in making consistent change (Lam et al. 2013), something which patients in the present study achieved. There are several self-management tasks required for HF patients to minimise the impact of their illness. Some of these tasks involve daily recording their weight, blood pressure and pulse. In addition, taking their medication at a specified time of day, exercising, reducing salt and fluid intake and recognising when their symptoms exacerbate. The findings from the present study concur with Payne et al’s (2015) a systematic review which found that apps are well accepted by users to modify health behaviours and health outcomes. Thus in the present study, patients were found to be more aware of the importance of medication management, to successfully monitor their symptoms daily, identify triggers and learn how to respond.

“Buy-in” to the medication app amongst patients is fundamental for the integration of this initiative. As discussed in the literature review, despite mHealth promises of delivering better quality of care and alleviating pressure points in healthcare systems, HCPs remain cautious about mHealth adoption. Previous research on

HCPs' mHealth adoption highlights personal concerns such as increased workload and workflow (Jacob et al. 2020; Keyworth et al. 2018), specifically, how it might affect their already overstretched working hours. Similarly, in the present study, HCPs indicated that they are unable to allocate extra time during their consultation to discuss and answer questions about the medication app with their patients. From the observations of practice between the HCP and patients in the HF clinic (n=76 interactions), the average visiting time was 24 minutes (SD 8.3, range = 9-45 minutes), suggesting that allocating time to discuss the medication app will add extra work to HCPs and potentially extend the consultation time.

The COVID-19 pandemic disrupted the clinic's efficiency, placing added burden on already overworked staff. Conducting medical reviews several days of the week to deal with the long waiting list is unprecedented. In the present study, HCPs described how their working practice has changed post COVID. Pre-COVID, medical review consultations were carried out with patients (n=25) on Wednesdays. Today, social distancing measures means that the HF clinic continues to operate at a reduced capacity, with the number of consultations on Wednesday now halve (n=12) what it was pre-COVID, resulting in a long waiting list. This is compounded by the number of new patient referrals to the service and those who were shielding during the pandemic and/or avoided attending clinical settings fearing to contract the COVID-19. Evidence points to a similar picture elsewhere. Nicholls (2021) reported how last year several European countries were dealing with the effects of COVID-19 and long waiting lists for cardiology services and documented the changes to working practices. Thus in the present study, to deal with the exceptional backlog of patients, HCPs modified their working practice and are seeing patients at the HF clinic on different days of the week, albeit at reduce numbers.

During the pandemic, the inability to conduct face-to-face consultations also prompted changes to working practices, with face-to-face consultations quickly replaced with telephone consultations (Hasan et al. 2021). While this provided a continuity of care, it was not without its challenges as the findings from this study show. In particular, longer consultation time was required as some patients were unable to read their medication name and/or understand instructions given or questions posed by the HCPs. Participant described how, on several occasions, they asked patients to spell the name of their medication from the medication boxes to no avail. This is in line with the findings of (Dharmar et al. 2013) study, where patients availing of telephone consultation experienced a higher rate of clinician related medication errors compared to those receiving video virtual consultations. In the present study, this was observed primarily among older people living alone, without the support of relatives. Consequently, HCPs had to re-schedule a face-to-face consultation with those patients who were unable to provide the medication list. The lack of visual cues was cited in van Galen and Car (2018) as a disadvantage of telephone consultations, compromising patient safety.

The workload of HCPs increased due to long telephone conversations with patients unable to provide a medication list. Unscheduled telephone calls from patients with queries about their care also adversely affected the HCPs' working practice (Macartney et al. 2012). During the present study, one of the HCPs complained that she had ten scheduled telephone calls arranged for one day, but only made four calls by lunch-time due to a large number of unscheduled phone calls coming to the HF clinic from patients at home. In addition, sometimes during telephone consultations, HCPs were unable to pinpoint the symptoms described by patients. This supports the findings from another study of Irish HCPs (Olwill et al. 2021) where it was reported that HCPs' ability to diagnose patients was greatly curtailed by telephone assessments due to the lack of opportunity to physically examined them. In response to this issue, HCPs working in the HF scheduled ad-hoc, in-person visits to evaluate patients.

In line with previous research, working conditions also emerged as an issue. Inadequacy of the physical environment and the lack of privacy are factors affecting the work provided by HCPs (Samur and Seren 2019, Halcomb and Ashley 2017). Samur and Seren (2019) highlighted how HCPs working on premises with restricted space can potentially affect their well-being, job satisfaction and productivity. This is echoed in Kim and Yang (2020) study, linking the physical work space to sociomateriality. As discussed in the theoretical framework section, sociomateriality is concerned with human agency (HCPs) and materiality (physical environment). Therefore, inadequate physical environments can impede HCPs to carry out effectively their caring tasks. In the present study, the HF clinic consultation room was very small and included two cubicles where patients were seen by the HCPs, separated by curtains. Both consultation rooms were used simultaneously and while the curtains were fully closed during consultations to ensure (physical) patient privacy, all sounds and conversations could be overheard. An adjacent room was equally unsuitable as there was a constant flow of personnel (registrar, consultant, administrative personnel) coming and going, unannounced. Therefore, there was no physical space that HCPs could bring patients to talk about the app as their space was very limited.

HCPs agreed to discuss the app with HF patients attending the clinic without compromising their consultation time. They were willing to signpost patients towards the medication app and to provide information using leaflets or redirecting patients to online resources. This cautious approach to the use of technology in care has been identified as a barrier to uptake of technology among older adults in particular (Mace et al. 2022; Nakrem et al. 2018). Other factors that can impede technology uptake among older adults include family support (or lack of) and e-health literacy (Barbosa et al. 2019), perceived ease of use (Cajita et al. 2017) and perceived value of a digital health intervention (Berkowsky et al. 2018). Cajita et al. (2017) investigated intention to use mobile health in older adults with HF. The authors report that most participants concurred that the health advice provided by their HCPs was important. In addition, most indicated a willingness to engage with technology in care if/when their clinicians endorsed it, particularly older adults. Thus HCPs' inability to allocate time to discuss the app face-to-face with HF patients could therefore jeopardised patients' "buy in" to the medication app intervention.

Cognitive participation refers to whether HCPs acknowledge the app as a legitimate part of their work practice, for example, comparing medication information between the list contained in the app and the medical record of the patient. Evidence suggests that cognitive participation is associated with the task of engaging individuals with the new practice (Finch et al. 2012), for example, HCPs discussing the medication app with patients. In the present study, while HCPs reported a willingness to discuss the app in future practice, they tied their support to scale-up involving all patients. In practice, achieving spread and scale-up involves building infrastructure to support widespread implementation and this is difficult. Greenhalgh and Papoutsi (2019) argues achieving any change takes work and usually also involves spending money, diverting staff from their daily work, shifting deeply held cultural or professional norms, and taking risks. In the present study, the implementation of the medication app in the HF clinic was not a hospital-led project, but a doctoral project designed to explore the feasibility of a medication app for use by older people attending a HF clinic. This could explain why HCPs did not see the use of the app as a legitimate part of their work practice and appear to be reluctant to currently promote the app with patients. Saldaña et al. (2021) evaluated a mobile health intervention with HF patients and HCPs working on a HF clinic. They found HCPs became demotivated to continue its use as it was a new practice, some staff stopped using it and it was not made compulsory by management (ibid).

6.1.3 Theme 3: Collective action

Collective action is all about the work individuals and the wider organisation do to support the new practice, such as acknowledging the app contribution to patients' self-management at home. Collective action is associated with the work that individuals and organisations do to enact the new practice (Finch et al. 2012). Collective action can also be prompted by crises and the need for improvised innovation as part of the responses to a critical situation (Wiedner et al. 2020). Thus in March 2020, remote health services were introduced in Ireland and elsewhere to manage the spread of COVID-19 and reduce the burden on health systems. In the present study, changes to working practices saw half the team redeployed to support front-line services dealing with people who were the most critically ill. For those HCPs who remained in the HF clinic, workloads doubled and they had to quickly implement arrangements for remote consultations, with little or no preparation. When restrictions ended, redeployed staff returned to work in the HF clinic, which was now characterised by new working practices, with patients no longer physically attending appointments and telephone consultation were the new way to assess patients.

The literature on ‘reverse innovation’ demonstrates how improvisation may emerge in resource-poor environments, with the potential for innovations to be latterly adopted in contexts where resources are less restricted (ibid). In the present study, a very positive innovation during the COVID-19 restrictions, resulting from the collective action between the HF clinic and the community intervention team (CIT), meant that older people shielding at home had their blood samples and vital signs taken at home by community nurses working in the CIT, who then relay the information back to HCPs in the HF clinic. This enabled the HF clinic staff to make decisions about remote medication titration. One of the benefits from this collaboration was the realisation that most patients travelled to the hospital unnecessarily. According to the HF clinic HCPs, the CIT made a real difference to patients and clinicians during the height of the pandemic. At the time of writing (November 2022), when COVID-19 restrictions no longer apply and older people can move freely, this collaboration is no longer an option. Home visits from the CIT are no longer an option for HF older patients travelling to the hospital for blood tests. In other parts of the country, the role of the community HF nurses is established. This role allows community HF nurses work alongside a HF clinic visiting patients at home.

A new Sláintecare Heart Optimisation project is underway in the Midland Regional Hospital, Portlaoise (Health Service Executive 2022). The CIT works closely with the heart optimisation team visiting patients at home, to assess them and take their blood samples. The heart optimisation team also, in conjunction with an initiative which enable remote monitoring of patients’ blood pressure, heart rate and weight remotely with a digital platform, enables patient to upload their health data and HCPs to review it remotely (Edwards et al. 2020). Unfortunately, the role of the community HF nurse and the heart optimisation team are not available at present in the region where this research took place. This change in practice and mind-set could present an opportunity to introduce the medication app in the HF clinic.

As Wiedner et al. (2022) argued, a crisis such as the COVID-19 paved the path for some ad-hoc innovations in healthcare to stay in place post-pandemic, that is incrementally. The NPT framework also points to the importance of context and how it should be negotiated and transformed for cultural change and collective action to take place (May et al. 2016).

Increased knowledge of patients about their medications is important for collective action between HCPs and patients and the optimal use of the medication app during the medication titration process. The progressive use of multiple drugs is common and recommended by international guidelines for HF patients (Ponikowski et al. 2016; McMurray et al. 2012). In line with the European Society of Cardiology HF guidelines, one of the strategies employed by the HF clinic is medication up-titration until they reach the maximal tolerated dose (Ponikowski et al. 2016; Yancy et al. 2013). Consequently, the medication dose can be increase often, in some cases it may be changed twice in the space of one week. Therefore, higher rates of patient medication knowledge and the ability to take medication at specified times are integral factors to optimise the medication titration process (Zeng et al. 2017; Wu et al. 2008). Patient involvement will support HCPs making health decisions, in turn, decreasing hospital re-admissions and mortality in HF patients (Fitzgerald et al. 2011).

Patients manage their medication at home, therefore, they are responsible for medication errors. Some of the common medication errors are taking a different medication from the one that was prescribed, not taking the correct dose, taking a medication at the wrong time of the day and missed doses. According to Elliott et al. (2016) medication errors are common among the older population but not unavoidable. HCPs interviewed during the present study described how the app contributes to the medication titration process. The app allows patients to keep an updated medication list and to edit according to any change made to their medication (Diaz-Skeete et al. 2021; Morawski et al. 2018). This in turn support patients to avoid medication errors, provides a comprehensive picture of different HCPs adjusting medication and optimises the medication titration process.

Löfgren et al. (2012) cited lack of management support as a main barrier to collective action. In the present study, a recent hospital-wide change made by management negatively impacted the collective action of HCPs and patients. The issue was raised during the interviews and relates to HCPs' ability to perform timely medication reviews. Previously, an appointment letter with detailed information was sent home to all HF patients. It clearly instructed patients to arrive 15 minutes before the appointment time and requested to bring their medication and weight monitoring diary to their appointment. In the last year, a hospital management decision reverted to a very generic letter without specific instructions about bringing medication. For long standing HF patients attending the clinic for over a year, this new letter may not affect their ability to present their medication and weight diary as they are well accustomed to the routine and procedure. However, the decision will affect newly diagnosed patients attending the clinic for the first time. Such patients are new in the service and are unaware of the importance of bringing their medication to appointments. In a study by Hardy et al. (2001), information to new patients was sent two weeks prior to an out-patient department appointment. Information ranged from the name of the HCP they were attending to, what to bring to the appointment, exact time and location, what was expected on the day and even where to park. The authors reported an increase on patients' attendance to appointments, highlighting the importance of sharing detailed information with patients (ibid).

Collective action from HCPs and management is also warranted for the promotion and roll-out of the app intervention. As Wiedner et al. (2022) highlighted, innovations are more likely to be effective in organisations with experience on innovation projects, champions leading the new initiative and support and encouragement from hospital management. In the present study, while the cardiologist and the HCPs were supportive of the intervention, their line managers were not aware of this intervention. As discussed earlier in the theoretical framework section, sociomaterialism recognises the importance of 'team-based care' to reshape working practices. It highlights that the team is not only comprised by HCPs but others such as administration staff, management, patients and families (Orlikowski and Scott 2008). This draws attention to the importance of moving away from working and communicating in silos, a common feature of large organisations (Sheard et al. 2017). Innovative healthcare programmes are characterised by stakeholders collaborating, specifically hospital administrators who are committed to support new practices (Lutz et al. 2020).

6.1.4 Theme 4: Reflexive monitoring

Reflexive monitoring refers to the appraisal of new practices in comparison to previous working methods. Reflection supports HCPs to continually improve their practice by drawing on previous experiences, allowing them to render a more effective judgement in clinical situations (Mantzourani 2019). Pre-intervention, HCPs were asked for their understanding of how the app worked and their training needs. Most HCPs indicated having sufficient knowledge on how the app worked and did not require further training with one exception. Patients thus received ongoing training whereas HCPs received one training session only. Mayer et al. (2019) investigated HCPs (nurses in particular), use of health apps and training needs. They found that most participants identified the need for specific training related to the use of health apps as crucial. This is very relevant to the present study as the HF clinic is a nurse-led service and nurses represent the largest number of employees in the healthcare sector in Ireland (Wells and White 2014) and elsewhere (Crisp and Chen 2014). Similarly, Orhan (2019) explored nurses' level of use and overall thoughts about technology in care. They found that nurses are unable to use technological devices properly and that there was a need for nurses to specialise in the use of such devices.

While the use of apps is increasing exponentially, the use of apps in healthcare is not ubiquitous. Therefore, before a new technological innovation is introduced, HCPs should be offered training to increase knowledge, acceptance and confidence in the new system (Kontilla et al. 2019). Naheza et al. (2020) recommended healthcare organisations should provide this training to staff to ensure they are equipped with the necessary digital competencies. For example, this training could be provided as continuous professional development regardless of whether they are involved in a mHealth project or not. Benefits of digital technologies training highlighted in the literature are increase perceived usefulness and intention to use (Holden 2016; Strudwick 2015).

Post-intervention feedback for the present study was positive, with the app found to be age friendly and easy to use. These functionalities were found by HCPs to be of the utmost importance for uptake by older patients (Bhattarai et al. 2020). HCPs favoured the app's capability of enlarging or decreasing the font size and use on a tablet which has a larger screen in comparison to a mobile phone. They also welcomed that the app is easy to navigate, has large buttons and when reminded, the patient can choose to skip/take/snooze the medication dose. From an implementation point of view, it is more likely HCPs will endorse an intervention they perceive easy to use. Evidence suggests the uptake among older people can also be increased when devices offer the option to customise features and functionalities (Ghorayeb et al. 2020; Park et al. 2017).

The present study explored HCPs' thoughts on the need for a new role for suitably qualified professional to educate patients on how to use the app in collaboration with staff in the HF clinic. In principle, HCPs concurred that this role might be of benefit to patients using the app. However, they recognised the process of establishing this new role would be long and burdensome. One of the respondents explained that from the management point of view, if it is an initiative that would benefit the HF clinic, HCPs are required to put a business case together and present it to management. The decision-making process of implementing a new practice, specifically a healthcare technology, requires the involvement of an interdisciplinary team (Gagnon et al. 2006).

The work which takes place in a HF clinic is designed to: improve the post-discharge management of patients, educate patients and families on how best to manage HF and improve patients' quality of life and reduce hospital readmissions. Evidence points to the important role technology can play in supporting health monitoring. Hamine et al. (2015) found the use of mobile health actively engaged a group of patients that otherwise would have not been motivated to avail of face-to-face health services. mHealth has also been shown to have a positive impact on patient's outcomes including HF patients. A review of systematic reviews reported a reduction of HF symptomatology, a reduction in hospitalisation, death rates and an overall improvement in quality of life (Marcolino et al. 2018). This is a very positive result as patients with symptomatic HF find it hard to cope with activities of daily living and participating in hobbies and interests. The findings from the present study also point to a role for technology to support effective medication management.

6.2 Interpreting HF Patients' experiences of the medication app

6.2.1 Theme 1: Coherence

For patients, coherence is associated with understanding how using the app differs from the traditional medication self-management strategy and how it works (Finch et al. 2012). The findings from the present study suggest the patients had no prior experience of using a medication app. According to May and Finch (2009), to make sense of a new routine (new practice), patients must differentiate between traditional medication management strategies and the new strategies using the medication app. Patients interviewed referred to "old" and "new" ways of managing their medication strategies. They acknowledged that the new practice (using the app) enhanced their awareness and understanding about their medication i.e. what are they taking, why are they taking it and when to take it.

Older adults taking a complex medication regimen integrate their medication with their daily routine (Rodríguez et al. 2021; Sanders and Van Oss 2013). Prior to using the app, patients developed their own strategies and routines to remind then to take their medication on time. For example, one patient keeps her medication beside the bed locker to remind her to take it first thing in the morning. In the evenings, she watches television in the sitting room, where her medication is displayed on a coffee table as a reminder. She admitted that if/when the medication is not visible to her, it is more likely she forgets to take it. Another medication management strategy employed by patients prior to using the app was storing their tablets on a medication box. Medication boxes, also called pillboxes, are widely used amongst older adults (Look and Stone 2018; Sanders and Van Oss 2013). Most medication boxes are designed to store medication for a week and have different compartments labelled with times of the day. However, refilling the medication box using the self-compiled medication list can be a source of confusion for some, as the findings from the present study show. One patient admitted that sometimes he was uncertain if the medication list he was using was up-to-date. Tellingly, all patients reported that using the medication list compiled in the app to refill medication boxes allayed this concern.

Evidence suggests that poor communication between HCPs negatively impacts patients' ability to renew their medication (Plácido et al. 2021; Nicosia et al. 2020). The standard procedure for patients to renew medication is to make a request in their GP practice. The GP, in turn, sends the new medication prescription order to the pharmacy for patients to collect. In the present study, a feature of the treatment for newly diagnosed HF patients' is the frequent change in medication dosages. The HCPs in the HF clinic did not notify GPs about medication changes. Instead, the patient was tasked with attending the GP in person to hand in their new prescription. Only then, was the medication change noted on the renewed prescription sent to the pharmacy. During interviews, one patient recollected how confusing it was when a medication dose was changed by the HF clinic. Notifying the change to the GP practice and collecting the new medication in the pharmacy could take up to one week, and was indeed longer during COVID-19 when access to GP practices was limited.

Since 2014, HCPs in Ireland have had the ability to prescribe medication via email using 'Healthmail', a HSE platform for the secure transfer of patient data between the GPs and community pharmacies. In 2020, the COVID Emergency Legislative Provisions designated Healthmail as the national electronic prescription transfer service (The Pharmacy Regulator, Medical Council and HSE 2020), abolishing the need for paper scripts. This allowed pharmacists to continue dispensing medication during the exceptional and unprecedented times of the COVID-19 disruption in Ireland (Hayden and Parkin 2020). However, the uptake of this intervention amongst HCPs remained low after comparing the number of HCPs with a registered Healthmail account and how many, in fact, use the service (Larking et al. 2018).

As patients adapted to the use of the app, new routines were created without disrupting their quotidian life. One of the patients recalled how she would delay a morning outing until the reminder alarm went off, she would then take her medication and marked it in the app as taken. She admitted this was an effective medication management routine, as she will often go out in to town without taking her morning medication. According to Blok et al. (2020), older people adopt digital technologies when/if they perceive it offers a new solution to a problem (i.e. forgetting to take the morning medication) and or when it facilitates completion of their daily activities (i.e. taking daily medication on time). With time, as they become used to the technology, they develop daily routines. Routines are created by older people to assist them in organising their daily lives and to keep track of time as the day goes by (Björklund et al. 2015). Creating new medication routines also maximises patient's independence and sense of control over their lives (Blok et al. 2020).

One of the challenges facing HCPs during consultations is patients failing to bring an up-to-date medication list to their appointment (Lewis et al. 2016) including HF patients (Mickelson et al. 2015). All patients participating in this study brought their iPad with an updated medication list to their consultations. Patients found the app to be useful to relay their medication information when prompted by HCPs, instead of relying on a medication list written on a piece of paper. This is supported by previous research which found that computer tablets can make it easier for ageing individuals to read on screen menus and use apps to improve their quality of life (Chen et al. 2021). In addition, computer tablets are lightweight, easy to hold and carry and are associated with increased accessibility and connectivity (Vaportzis et al. 2018). In the present study, one patient described keeping a medication list written on paper as a continuous source of anxiety. He explained how before attending an appointment, a thorough search took place at home to locate the piece of paper containing his medication information. In contrast, he found the app much easier, as before the appointment, all he needed to do is lift the computer tablet from the kitchen table where is kept at all times.

In the present study, all patients reported a high level of medication compliance. Before using the app, some admitted to occasionally forgetting to take their medication on time. In addition, when they were late taking morning medication, they would change their medication schedule for the day to compensate for the delay. Evidence from the literature confirms this is not uncommon for patients (Albassam et al. 2021; Gilbert et al. 2002). The findings from the present study point to the benefits of using a medication management app, with participants reporting high levels of adherence to medication regimen. This finding is also supported by results from a meta-analysis of estimated efficacy of app-based interventions for medication adherence, with users found to be more likely to self-report adherence to medications (Armitage et al. 2020).

Heart failure is a chronic illness accompanied by a cluster of symptoms such as dyspnoea (difficulty breathing) and fatigue (extreme tiredness/loss of energy) (HSE 2018). This results in significant personal, social and occupational impairment. Patients with a greater rate of medication compliance are more likely to experience less HF symptoms, such as fatigue, one of the most common symptoms. In the present study, one patient commented on how her fatigue was impacting on her ability to look after her grandchildren causing her to take regular breaks and often fall asleep during the day. After taking her HF medication regularly, she reported a decrease of HF symptoms. The findings from a systematic review and meta-analysis of controlled trials on HF medication adherence confirm that higher medication adherence rates are associated with a reduction of symptoms exacerbation, hospital visits and an improvement of overall physical functionality (Ruppar et al. 2016).

Trust and confidence are key components of the clinician-patient relationship**,** with identified benefits accruing from a trusting relationship linked to better communication, improved adherence to medical advice, and better health outcomes (Baker et al. 2020; Gordon et al. 2014). Patients interviewed showed a high level of trust in their HF clinicians, expressed as having confidence in the medications prescribed by clinicians. Trustworthiness in the app was expressed in terms of app reminders to patients to take their medication, and how this alleviate them of the daily burden of remembering to take their medications on time (Santo et al. 2016).

Despite their trust in the app, some patients reported feeling anxious when they started using the app independently. Concerns of making mistakes and not knowing how to reverse them has been reported in several studies (Kim et al. 2022; Gatti et al. 2017). In the present study, patients initially hesitated when they were asked to explore the app. Fear of making a mistake and dealing with the consequences was cited as their primary source of anxiety. An example provided by one of the patients was the prospect of deleting the medication list compiled in the app. According to Askari et al. (2020) feelings of anxiety is negatively associated to intention to use health apps. In the present study such anxiety was resolved by the researcher reassuring participants and demonstrating how deleting the medication list from the app was a mistake that could easily be resolved.

Overall, with time, patients grew confident using the app as they were reassured they were following the correct procedures. After a month, they were asked how confident they felt using the app. All patients agreed they found it daunting to begin with but as each day went by, their confidence in the app increased. Evidence from a study conducted by Aure et al. (2020) into the opinions and experiences of older adults using a health app also points to patients' confidence increasing over time and to the importance of support from HCPs. In the present study, the researcher provided patients with ongoing technical support throughout the 3-month intervention. Post intervention, one patient reflected on the learning journey, and how anxious she had felt at the beginning and how as in Aure et al's study, the support of the researcher facilitated the use of the app.

As the findings suggests, fear of technology was a constant concern for some older people. Such fears often stem from reports of older people losing money on technological support scams. The Irish authorities have warned citizens, especially older people, not to share bank details over the phone or click any links sent by text from unknown contacts (Moore 2021). Telephone scamming became so prevalent that the Banking and Payments Federation Ireland conducted a survey in 2019, anecdotally increasing even more during the pandemic. The survey revealed that over 30% of Irish citizens admitted losing money to fraudsters (Banking and Payments Federation Ireland 2022). The most affected group was older people as the average sum of money scammed from them was almost six times over than those aged 18-24 years of age. The scammers call a landline or a mobile phone and/or send a Short Message Service (SMS) text or email impersonating government officials. This issue had a wide coverage in the news and media and banking institutions are constantly reminding customers not to provide sensitive information. Consequently, most people, including older people, are wary about receiving telephone calls from unknown sources and/or responding to emails and SMS texts. Arguably such concerns are why some older people are in a high state of alert and distrust the use of digital technologies (Hattery and Smith 2019).

6.2.2 Theme 2: Cognitive participation

Patients demonstrated "buy in" of the app, mastering the tasks necessary to use the medication app shortly after receiving training. This result is similar to that found in other studies indicating higher level of technology acceptance amongst older adults after training was provided (Yang et al. 2022; Park et al. 2017). In the present study, patients were motivated to use the app daily as it reminded them to take their medication on time. The app not only reminded patients to take their medication on time, it was also programmed to alert the patient 20 minutes after their scheduled medication time when/if a medication was not marked as taken. This feature was found to be useful, specifically when patients were attending to their daily chores and missed the first medication reminder. As noted earlier, one patient admitted missing the morning medication from time to time, only to take her medication later in the day.

HCPs working in the HF clinic played a pivotal role motivating patients to join this study. According to Kost et al. (2011) individuals are more likely to participate in research when they value the relationship with those involved in the research team and when they perceive they will gain personal benefits by participating (McCann et al. 2010). One participant shared her experience, stating she was curious about the use of the app and the difference it would make to her self-management. Patients were motivated not only by the invitation to participate in the study but also by the benefits highlighted by the HCPs during recruitment. However, uncertainty was part of the journey at first. One patient recounted how when the HF nurses invited him to participate, he hesitated for a while, only deciding to participate to "*give it a try and see if he could handle it.*" As Etkind et al. (2022) point out, uncertainty in patients is not necessary a negative experience as it allows them to proactively participate in decision-making about their care.

Oh and Kang (2021) posit that the use of digital technologies may support older adults to maintain cognitive abilities. Accepting a new challenge was described by one patient as the source of motivation to start using the app - *"… now at our age if you sit down and don't accept a challenge well then you are just giving up on yourself as well."* This participant noted how at her advanced age, it was beneficial to accept the challenge instead of remaining in a passive mode to her medication self-management. This finding was echoed in Holender et al. (2018) where cardiovascular patients labelled technology as a memory aid that supports them to take their medication on time. Another patient in the present study was motivated by the researcher to use the app during the initial home visit. He recalled how during the initial home visit the researcher explained all the potential benefits the medication app offered, prompting him to use the app.

While it can develop at any age, as discussed in the literature review, HF becomes more common with increasing age. It is estimated that around 1% of Irish people under 65 years of age have HF, rising to 10% of 75-84-year olds and to 15% in people 85+ (Heartbeat Trust, Irish Heart Foundation and NUI Galway 2015). In the present study, one patient reflected on how the app could support those with cognitive decline associated with older age. This participant in particular is 78 years of age and according to her, it was important to learn how to use the app to remind her to take her medication as "[her] *memory is not always going to be great".* HF patients have an increased prevalence of developing cognitive impairment (Athilingham et al. 2017) impacting negatively on medication adherence (Advinha et al. 2017). The challenges for older patients with HF in managing their use of multiple medications is well recognised, especially polypharmacy, cognitive impairment, and frailty (Butrous and Hummel 2016). Previous research has found that medication reminders can and do improve adherence (Shu and Woo 2021), specifically in HF patients with cognitive decline (Park et al. 2020; Athilingam et al. 2017). The challenge for policymakers is therefore one of understanding what infrastructure and services are needed to enable greater uptake.

Overall, patients agree that sharing their medication information with their HCPs was beneficial. However, patients hesitated when asked if they would share their medication information with relatives. Lack of interest by relatives and fear of burdening them were some of the reasons cited by patients. This is well established in the literature. Crotty et al. (2015) investigated the information sharing preferences of both, older adults and their relatives. They argue that the concept of burden should be considered from two perspectives. On one hand, patients prefer not to share their medical information to shield their relatives from the daily difficulties they face associated with their illness. On the other hand, relatives perceive that by setting some time aside to discuss medical issues it would decrease disease burden and improve loved ones' mental well-being. Another point raised by Crotty et al. (2015) was that older people prefer to practice autonomy for as long as possible, only to transfer that responsibility to relatives when/if they are no longer capable to do so. These findings are echoed in the present study, with patients found to be willing to remain autonomous and make their own decisions without involving relatives. Lastly, Crotty et al. (2015) study encouraged healthcare providers to embrace patients' differences and recognise there is no "one-size-fits-all" approach. By providing individualised care, HCPs should accept that older adults are not a homogenous group. Some will prefer to disclose medical information to relatives and others will not be comfortable with that. Therefore, the level of healthcare information to be shared with relatives should be an option best left to patients.

As May et al. (2015) argue, recommending the new way of working, in this case using the medication app to others is an important component of cognitive participation. Offering an app recommendation is associated to the experience and level of satisfaction of users, more recommendations will indicate a higher level of satisfaction and positive experience (Palomba et al. 2015). In addition, patients in the present study rated the app using the System Usability Scale (SUS) and reported a positive user experience and high level of satisfaction and acceptance. Thus they reaffirmed their willingness to recommend the medication app, specifically to others taking multiple medication. One patient commented on how he recommended the app to a neighbour. According to the participant, the neighbour has multi-morbidities and a complex medication regimen.

App use continuity post intervention has been previously reported in the literature (Brickwood et al. 2020; King et al. 2016) with older adults found to be sustaining use of technology for a prolonged time. In an Irish mHealth study, more than half the participants were found to be continuing to use the app independently for ≥180 days and 28% for ≥360 days after the initial six-week observation period (Edwards et al. 2020). Similarly, in the present study with all patients agreed to continue using the app in their own devices after the three-months intervention period.

However, one patient admitted to not owning a computer tablet, potentially impacting on his ability to continue using the medication app. Vaportzis et al. (2017) investigated barriers to the use of computer tablets amongst older adults. The financial implications of owning a computer tablet was one of the barriers for adoption cited in the study. Cost was also a predicting factor associated to technology adoption in older adults reported by (Czaja et al. 2006). In contrast, healthy young people with high income are more likely to afford and use technology (Carroll et al. 2017). This highlights a financial gap, as older adults with HF have higher costs associated to their illness, compared to young healthy people. Examples of higher costs associated to HF are multiple medication regimen and attending to clinic appointments on a regular basis. In addition, most HF patients' ability to work is greatly impacted by the severity of their symptoms. In Ireland, decisions on reimbursement for health interventions are informed by the Health Technology Assessments (HTAs). However, those decisions are heavily influenced by cost effectiveness rather than the need for financial support for older adults to purchase health technologies.

Diaz-Skeete et al. (2020) highlighted the need for a change in reimbursement models in Ireland. The authors pointed out how reimbursement in healthcare refers primarily to drug payment and long-term illness schemes with little attention to mHealth. The Health Information and Quality Authority (HIQA) is an independent authority with the ability to grant or revoke an application for a HTA. HTAs are evidence based decisions on the grounds of positive health outcomes and low-cost impact/value for money (Health Information and Quality Authority 2015). To date, HTAs assessment covers medication, diagnostic techniques, equipment (mainly replacing computers in clinical settings) and health promotion and protection activities. However, HTAs do not offer reimbursement for technological equipment for individuals. Furthermore, HIQA specific advice on HTAs for HF is that the use of telehealth (telemedicine and structured telephone support) was found to reduce hospitalisation and mortality. Despite the positive outcomes of telemedicine for HF patients and cost-neutral effect, HIQA report indicated telemedicine should not be funded. The reason cited was the lack of evidence towards which specific component of telemedicine improved patient care. Of interest to note that in the HIQA report there is no mention to mHealth and/or apps used in HF care. It can be argued this could be due to the lack of Irish studies documenting the experiences of HCPs and older adults with HF using apps.

6.2.3 Theme 3: Collective action

Collective effort and action from patients and HCPs is necessary for effective implementation of the app to support medication management (May and Finch 2009; May et al. 2015). An example of collective action between patients and HCPs is the medication titration process. As mentioned earlier, patients with a higher knowledge on their medication enhances the medication titration process (Zeng et al. 2017; Wu et al. 2008). Patients highlighted how their medication knowledge increased while using the app and how they understood HCPs when they made decisions about medication changes during their consultation. This is in contrast to (Custodis et al. 2016) study, where HF patients' medication knowledge decreased three months after discharge. Custodis et al.' study suggest the need for interventions to increase patient's health literacy and medication knowledge. In the present study, one patient compared his experience before and after using the app and stated the medication titration process *"made sense to him now."* He felt before using the app he was compliant with the instructions provided by HCPs whereas now he *understood* those instructions.

One of the benefits associated with app use is the enhanced communication patient-healthcare provider (Qudah and Luetsch 2019; Moore et al. 2014). The implementation, embedding and integration of the medication app will also require collaboration from all HCPs involved in delivering care to patients. One patient recalled a recent visit to the GP for a check-up and stated how satisfied the GP was with the results. He also noted that the GP was aware of his regular attendance to the HF clinic and the treatment provided by the HF clinicians. One of the main aspects of HF continuity of care is collaboration and sharing of detailed information amongst all HCPs and the patient (Östman et al. 2021). As discussed elsewhere, HF patients are more likely to visit different HCPs in primary and secondary care and may assume that HCPs are communicating. In some instances, this is not the case as some HCPs are not aware of changes in patients' treatment and medication regimen (Alazri et al. 2006). The medication app has the capability for patients to record information when visiting different clinicians and to relay it with the HF team (Diaz-Skeete et al. 2021). Patients participating in this study were advised by the researcher to bring along their iPad to all their consultations to record any changes. The aim of this was twofold: to empower patients to take an active approach in their HF self-management and to capture information from different points of entry in healthcare provision.

A very successful collaboration between patients and HCPs is the educational sessions provided by the HF clinic. Educational sessions provided by HF nurses have been shown to encourage patients to take their medication as prescribed and to improve disease control and quality of life (Dessie et al. 2021; Sezgin et al. 2017). According to the National HF Programme Guidelines, nurses should provide at least three hours of education to recently diagnosed patients (Irish Heart Foundation 2010). During these sessions, patients received education about their symptomatology, lifestyle modification and their medication (i.e. name, strength, type of medication and frequency of use). However, during the COVID-19 pandemic these sessions came to a stop very abruptly. To date, despite the easing of COVID-19 regulations, the educational sessions have not resumed in the HF clinic.

On a medication app adherence usability study (Chew et al. 2020), participants found the process of adding a new medication in the app to be confusing. Therefore, ensuring patients possess good understanding of their medication is necessary to independently update the information in the app. However, patients participating in the present study showed limited knowledge on the medication they are taking. One was able to recall some medication names, whereas another was unable to recollect any medication names, even when prompted. Evidence shows that patients with limited medication knowledge are less likely to be aware of the side effects and drug-drug interaction of the medication they are taking (Field et al. 2006). Consequently, they are at risk of medication errors, drug-drug interactions and rehospitalisation given that HF is the leading cause of hospitalisation for older adults (Farmakis et al. 2015; Bocchi 2013). The medication app can support HF patients to avoid drug-drug interaction and to learn about medication side effects (Diaz-Skeete et al. 2021). One of the app features educates patients about the best times of the day to take certain medication and alerts if any of their medication interacts with another. It also provides side effects information when the medication information is entered in the app. All this information is provided in videos using a clear and concise language and in text format (ibid).

6.2.4 Theme 4: Reflexive monitoring

Seeking feedback is a widely used strategy for soliciting users' experiences while using apps (Jácome et al. 2021), including the app used in the present study (Huang et al. 2019; Salgado et al. 2018). Pre-intervention, patients were asked for their understanding on how apps worked in general, some patients were not aware of what an app was. There was an increase of app usage in general amongst older adults, specifically during the COVID-19, apps were used to stay in contact with family, friends and HCPs (Torous et al. 2020). However, it should not be assumed that every older adult has an interest in using apps. For example, one patients in the present study enjoyed using the medication app but stated his preference is not to use technology at all. He added that he uses his mobile phone and the app *"but he is not gone on electrical things."* Motivation, a significant factor in technology adoption, was found to vary among participants, with, for example, one patient using an app for internet banking and for socialising, and another to fulfil spiritual needs (using it to get the Mass and the rosary every evening).

There is evidence to suggest that older adults prefer learning technological skills from those around them i.e. family and this support heavily influence technology uptake (Portz et al. 2019; Xiong and Zuo 2019). Support takes many forms, for example, teaching how the new technology work, buying and installing equipment and technical support (van Houwelingen et al. 2018). Patients who were previously using apps (before they were recruited to this study), admitted that they do so with family support. Relatives are the first point of contact if they have technical queries, need to update software or need to find information online. Some patients were taught how to use an app by relatives and one in particular, mastered how to use an app independently, by chance. This participant explained how her daughter set up her computer tablet with an app for her to watch the Mass online. One day, when

Mass was finished, she decided to press a button only to discover that it was a reminder to join Mass the following day. When she was asked by the researcher how she learnt she stated by *"fiddling around with the tablet."*

Feedback was also sought on app features or any other element of using the app the patients disliked. In general, feedback was positive and all patients reporting that they liked the app. However, as stated earlier, technology anxiety was evident. Technology anxiety is not a new term and it was first coined computer anxiety by (Heinssen et al. 1987). The term can be described as technology fear and is associated in the literature with older adults use and uptake of mobile technologies (Askari et al. 2020; Tsai et al. 2020; Guo et al. 2013). One participant recalled how, at the beginning, remembering the procedure for getting back into the app was worrisome. Pressing the wrong buttons was the main concerned reported. However, this was a very short lived experience, with participants having easily resolved this by practicing (using) the app independently every day.

Understanding how the app functions is necessary for the sustainability of this intervention (Yang et al. 2022; Park et al. 2017). Patients were asked to evaluate their training needs to use the app. All patients agreed they did not require further training. A possible explanation may be the ongoing support provided by the researcher to participants during the app intervention period. Ongoing technological training and support to older adults participating in digital health projects have been recommended by (Bhattarai and Phillips 2017). During the 12-weeks, weekly scheduled home visits or telephone calls took place, creating the opportunity to raise any concern patients had about the app and its use and the researcher acting upon it. The training provided by the researcher was found to be helpful by participants, specifically at the beginning of the intervention when they were anxious about using technology independently. Patients remarked how all their queries and concerns related to the app were addressed on a timely manner. On this point, one patient highlighted how, not necessarily lack of skills or training but a medical condition may negatively impact the ability to use the app. She explained she has arthritis in one hand, therefore, her ability to use her fingers with ease on the iPad screen may be compromised, especially when in pain.

Sustained involvement with the app is associated with perceived usefulness and improved health status (Svendsen et al. 2022). The use of the app was envisaged to support patients during the medication review process conducted during the consultations. Also, to remind them to take their medication on time. However, one patient reported using the medication list compiled in the app to refill his medication box on a weekly basis. This is evidence of how the use of the app is embedded on his medication management routine.

Providing a manual with detailed instructions guiding older adults on the use of technology is associated with greater technology adoption (Vaportzis et al. 2017; Barnard et al. 2013). At the beginning of the intervention, one patient expressed some concerns about her ability to use the app independently. She indicated she had no previous experience using apps. For that reason, a manual was developed by the researcher to support patients to use the app independently. Post-intervention, this patient was asked to provide feedback on the use of the manual and her experience. She started by describing herself as *"I wouldn't be that easy of a person to pick things"*, but indicated the manual was a very useful tool and was regarded as a vital assistance.

Manuals as a self-training material has been recognised as one of the preferred methods for older people to learn how to use technology (Mitzner et al. 2008). The manual was handwritten with instructions on how to navigate the app, how to mark the medication as taken and how to find the sections to record her daily weight and vital parameters data. In line with Vaportzis et al. (2017), the manual was developed with detailed instructions and easy to understand language. This patient, in particular, started recording her daily weight and blood pressure only in the app. However, towards the end of the 12-weeks period, she reported she was also recording heart rate, levels of pain, level of social participation and mood on a daily basis. Once again, this is another example of how the use of the app is embedded in this patient HF daily self-management. Of interest to note that the positive feedback on the manual provided by this patient motivated the researcher to compiled a second manual. It was developed to support patients to continue to use the app independently post-intervention.

6.3 Understanding the lived experience of older patients **(case studies)**

The case studies highlighted similarities of patients (e.g. over 70 years of age, attending the HF clinic, agreeing to continue to use the medication app after the intervention) and differences (e.g, living arrangements, educational level, caring needs and type of dwelling), which in turn shape the needs and actions of patients, as discussed below.

All participants in the present study were supported by family members, albeit to varying levels. Family connection and support plays an integral role in older adults' technology adoption and technology continuity of use. According to Vroman et al. (2015) when older adults feel disconnected and lack family support, they are less likely to engage in the use of technology or continue its use. This is echoed in Portz et al. (2019) findings, suggesting that older adults prefer learning about technology from family members. In terms of who provides the support, their first port of call is grandchildren, followed by children, and wider social circle such as neighbours (ibid). The type of family support offered described in Portz et al' study varies from technical support (technical glitches and troubleshoot issues), to setting up equipment and/or providing detailed information on how the system works. Of note, the Portz et al. study was not designed to capture the extent of family support for older adults. However, it developed as a theme during the analysis as participants kept discussing the family support subject, highlighting how important family support is to older people using technology. The authors in Portz et al. study recommended the level of family support (or lack of) should be taken into consideration by HCPs implementing new technology in care, specifically with older adults.

During the intervention in the present study, only one participant reported experiencing technical issues twice. According to Li et al. (2020) older people experiencing technical issues during a mobile health intervention is not uncommon, regardless of their level of technological experience (with previous experience or without). In Li et al.'s study, participants had experience using technology (unlike the participants in the present study) and five out of eight participants reported technical issues, especially during the first week of the intervention.

During the initial home visit, the medication list was populated in the app by the researcher. Two of the participants were newly diagnosed with HF and were not very familiar with the new HF medication they were taking. Two medication errors were detected in separate occasions while populating their medication list. Furthermore, a total of seven medication discrepancies were detected during the intervention (see table 7 in section 5.3.3). As mentioned earlier, according to Elliott et al. (2016), medication errors are a common feature among the older population and is more prevalent in HF patients (Butrous and Hummel 2016; Fialová and Onder 2009) due to their complex medication regimen. In addition, a study reported that 88% of patients attending an outpatient service had at least one or more medication discrepancies (Ashjian et al. 2015). Thus the findings of the present study highlighted the need and importance of medication reconciliation and review in the community setting for this cohort of patients (Cardwell et al. 2020; Tamblyn et al. 2018; Lehnbom et al. 2014), specifically for newly diagnosed HF patients (Gunadi et al. 2015).

Medication reconciliation is the process whereby all the medication is checked to resolve inaccuracies and all changes are documented (Redmond et al. 2018). On the other hand, medication review refers to the process of checking the medication history of a patient and cross referencing with other data such as co-occurring chronic illnesses and patient preferences (Beuscart et al. 2021). Both interventions can be facilitated by a GP (McCarthy et al. 2022), a community pharmacist and/or a pharmacist technician (Pevnick et al. 2018), a geriatrician (Choukroun et al. 2021) and more recently, electronically (Beuscart et al. 2021). Several benefits of medication reconciliation and review have been described in the literature such as reduction in hospital admission (Dautzenberg et al. 2021), medication optimisation (Doucette et al. 2022) and patient safety (Redmond et al. 2018). However, despite all the benefits aforementioned, medication reconciliation and review is not implemented regularly in the community setting (Doucette et al. 2022; Beuscart et al. 2021). More specifically, in Ireland, as unlike other countries such as the USA and the UK, community pharmacists are not an integral part of routine patient care (McCarthy et al. 2022; Cardwell et al. 2020), impacting negatively patients' health outcomes and quality of life.

Despite all participants in the present study reported having several chronic conditions, HF included, they all perceived their health as very good. Only one of the participants reported an improvement in pain/discomfort and anxiety/depression post intervention. In general, the test-retest (pre- and post-intervention) showed similar findings, and remarkably, their perceived health status reported using the EQ-VAS scale remained unchanged between both testing periods. The findings of the present study are unlike other studies using the EQ-5D-5L tool (Lawson et.al 2020; Purba et al. 2018) where disagreement between test-retest (17 days in Purba et al. 2018 and 15 days in Lawson et al. 2020) was reported.

There is a positive correlation between technology uptake and perceived quality of life amongst older adults (Chou et al. 2013). Chou et al. (2013) study found that older people availing of a telecare programme reported the system as adequate to meet their health needs and a higher quality of life. Another study used ICT supporting cognitive impaired older adults with memory recollection of events also reported benefits in quality of life (Browne et al. 2011). Murciano-Hueso et al. (2022) also described how the use of technology such as smartphones during the COVID-19 pandemic improved older adults' quality of life by enabling social communication. Lastly, another study focused on older people living alone and investigated the relationship between technology acceptance and quality of life using the older people's quality of life (OPQOL) tool (Bong et al 2019). The findings revealed that participants with a more positive attitude towards technology use reported a better quality of life. Of note that in all the above mentioned studies, quality of life was self-reported by participants with the exception of (Bong et al. 2019) study.

6.4 Strengths and limitations of study

The present study employed a small sample, therefore the findings may not be generalised to the wider population, other settings or geographical areas. However, working with a small sample allowed the researcher to collect richer data to gain a deeper understanding of the lived experiences of HF patients using the medication app.

The results of the JSS survey are limited by the use of a relative small convenience sample (n=5). Nonetheless, the findings may be beneficial to other HCPs working in small out-patient departments, in particular those implementing (or considering to implement) a new technological intervention

Participants were sampled using a purposive approach – all were diagnosed with HF, currently attending the HF clinic and all are over 65 years of age. Therefore, participants included shared similar experiences and that also limits the study in terms of generalising the findings. However, this study provided a key insight into HF patients' lives, capturing their similarities but also their diversity and showing how accomplished they were while using the medication app.

Another strength of this study was the inclusion of HCPs and HF patients rather than only one perspective. Findings revealed the motivation of HCPs to "buy in" any tool (digital or not) to support HF patients and their willingness to use the medication app. This is in line with the Irish eHealth strategy (Government of Ireland 2013) which strives to promote the use of digital technology in care to foster better health outcomes for all Irish citizens. However, HCPs working in the HF clinic are trying to cope with the demand and innovation is stifled.

Lastly, most studies using the NPT framework tend to focus on exploring the implementation of interventions at the organisational level and to a lesser extent, the individual (patient) level. The use of the NPT framework in the present study captured individual and organisational barriers and facilitators to the normalisation of the use of the medication app with HF older patients. Some of the barriers to technology uptake identified in this study were: HCPs attitudes towards older people using technology, lack of managerial support and the need for training and ongoing technical support for older adults. These barriers need to be overcome to enable the implementation and scaling up of this intervention.

6.5 Conclusions

One of the most rapidly growing cardiovascular diseases globally is HF, and it is the only major cardiovascular disease on the increase in Europe. Furthermore, HF is one of the main contributors to rehospitalisation and mortality on older adults. The progressive use of multiple drugs is common for HF patients. Concerns have been growing around polypharmacy, particularly management of HF by older people at home. In addition, medication non-adherence and medication errors are common for older HF patients. Therefore, this study was set up to explore the feasibility of a medication management app supporting medication self-management at home for older patients attending a HF clinic.

On a personal reflection, this thesis was a journey that in many respects was extraordinary because in the middle of it we had a global pandemic. One of the challenges along the way in particular was the long periods of lockdown without access to HF patients. This led to changes not only on the study design but on the field process itself as well. The methodology of the study had to be re-planned during the lockdown when access to HF patients was curtailed. Even the daily operation of the HF clinic has changed and perhaps forever, as face-to-face consultations now only take place for newly diagnosed patients and those with symptoms exacerbation. Face-to-face consultations have been replaced for telephone consultations which in many respects, presents as a greater opportunity for medication self-management at home using an app, as reflected in the case studies.

Indeed, perhaps now like never before there is an opportunity for technology to play a role in healthcare delivery. In the three case studies presented in this thesis, patients found the app particularly useful, easy to use and were able to express how they felt using the app. The case studies also demonstrated how patients benefited from greater levels of empowerment, medication knowledge and medication adherence while using the app. Most importantly, the case studies drew attention to the diversity of older people and highlighted the everyday issues that they face while using technology.

Equally, the case study of the HF clinic showed how the app contributed to patients' medication self-management and the medication review process. In addition, the NPT theoretical framework was, as noted above, very effective in demonstrating how HCPs were motivated to use the app and acknowledged the app contribution towards supporting HF patients self-managing at home. Similarly, HF patients normalised the use of the app and it was evident in the new medication routines they created. This is in line with the Irish eHealth strategy (Government of Ireland 2013) which promotes a health system that embraces technology in care to increase the quality of life of all citizens.

The government has committed to a greater use of technology in care and now with more services being provided remotely there is an opportunity like never before. However, it will require collective action of all stakeholders, as this thesis has shown, to ensure that overstretched staff are supported. HCPs are ready and willing to use technology in care but they need the support of the HSE. The HSE is a hierarchy organisation and widespread changes tend to occur when they are dictated from the top. Concerted efforts will be required to achieve scale and spread of the use of a medication management app among an older cohort of patients.

This study has shown that a medication management app is feasible for use with HF older patients, even those who are living alone, with the right support in place. A greater number of people with HF may be facilitated to make technology, such as medication apps, a greater part of their life to increase their quality of life and health outcomes. All that is needed is the same political will that went into changing services during the COVID-19 pandemic.

The findings of the present study showed the importance of exploring different perspectives. Exploring the views and experiences of HF patients captured how they mastered the technological skills required to use the app while documenting their journey. The findings from this study are encouraging and warrant further investigation to test the effectiveness of a medication app with HF older adults at a larger scale.

While this study has shown that a medication management app is feasible for use with HF older patients, it also draws attention to some social and practical implications in terms of implementation and scale up potential. Older patients need training and often ongoing support to use technology as part of their care. As it currently stands, there is no technology support. At the same time, it is not feasible nor indeed desirable that HCPs should provide such support. HCPs working in the HF clinic deal with medical reviews several days a week and have an already heavy workload. Therefore, they are unable to allocate time to support patients' learning around the app regardless of how beneficial the app might be. This draws attention to the need for a new role, a suitably qualified professional to educate patients on how to use the app in collaboration with staff in the HF clinic. However, while the cardiologist and the clinical staff in Our Lady of Lourdes hospital were supportive of the use of the medication management app for their older patients, their line managers had limited knowledge of the intervention. To support local policy decisions, the findings of this study will therefore be shared with Our Lady of Lourdes Hospital management for consideration regarding possible scale up. This will include a face-to-face presentation by the researcher to management in the hospital.

A second important issue that the present study has drawn attention to is the role of the community intervention team (CIT). Implemented during COVID-19 as a practical solution to collect bloods and check older patients' blood pressure, the CIT became a popular service with both patients and staff alike. As the findings from this study have shown, the CIT service was effective for medication titration as well as avoidance of lengthy journeys for older patients. Post-COVID, however, this service has been withdrawn. Moreover, the clinic, as previously noted, now operates more remote consultation via telephone calls to older patients rather than face-to-face consultations. Consequently, opportunities for patient contact are now much reduced. Taken together, changes in patient consultations in the clinic and the withdrawal of the CIT service, appear to run counter to the "Making Every Contact Count" policy. Making Every Contact Count aims to capitalise on the opportunities that occur every day for health professionals to support patients to maintain a healthy lifestyle to reduce the burden of chronic disease (Haighton et al. 2021). As the findings from this study imply, the delivery of "Making Every Contact Count" requires leadership throughout the organisation, but particularly clinical leadership. In presentations of the findings to hospital management the research will draw attention to the potential benefits of the CIT, beyond its use during the COVID pandemic, which were illuminated in this study. One benefit of the CIT service for example is the potential for engagement to contribute to positive behaviour change by older HF patients in line with the ethos of Making Every Contact Count.

Lastly, there are also research implications at a local level. The local Institute of Technology in Dundalk (DkIT) currently train nursing students. The researcher has arranged to deliver presentations to students to highlight the social and practical implications of this study. These presentations will provide an opportunity for nursing students to spark a debate and raise awareness of challenges and benefits associated with incorporating technology into the care of older patients. In addition, two academic papers have been published on this study and a number of others are planned. Ultimately this will make this research part of a bigger conversation, reaching an even wider audience.

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List of Appendices

Appendix A: Letter of support from Dr Murphy consultant cardiology

Feidhmeannacht na Seirbhíse Sláinte
Health Service Executive

RCSI Hospital Group (Dublin NE)
Our Lady of Lourdes Hospital
Drogheda
Co. Louth

Telephone: 041 9837601
Fax: 041 9833868

2nd July 18

Re Eastern Corridor Medical Engineering – Advancing Cardiovascular Healthcare Technology

To whom it may concern;

I am writing to confirm the support of the Heart Failure Clinic in Our Lady of Lourdes Hospital, Drogheda for the above referenced study, which will be conducted by a research team from NetwellCASALA Centre for Ageing in Dundalk Institute of Technology.

I confirm that the research team have been granted access to the clinic to recruit participants for this research as outlined in the research protocol. This research will commence once the protocol has been reviewed and ethical approval is in place.

Yours Faithfully,

Dr Niamh Murphy,
Consultant Cardiologist

Appendix B: NPT Constructs and components (May et al. 2015)

1. Coherence	**2. Cognitive Participation**	**3. Collective Action**	**4. Reflexive Monitoring**
1.1 **Differentiation:** Understanding how a set of practices are different from each other. For example, when a mobile application is used with patients, what does the cardiac team do to understand and organize the differences between face-to-face consultations and mobile health application use.	**2.1 Initiation:** Whether or not key individuals are working to drive forward the new way of working e.g. a new group of managers and professionals charged with the work of making things happen.	**3.1 Interactional Workability:** Interactional work people do with each other when organising a mobile health application.	**4.1 Systematization:** Information collected by individuals to determine how effective and useful the new way of working is for them e.g. anecdotal examples of problems in practise.
1.2 Communal specification: Building a shared understanding of the aims, objectives, and expected benefits of a set of practices. An example is how the cardiac team integrate the mobile health application trial into their clinic and as they try to identify and anticipate the relationship between element of the trail and everyday clinical practice.	**2.2 Enrolment:** The team may need to organise / reorganise themselves and others in order to collectively contribute to the work involve in successfully introducing a new work of working e.g. nurses “buying in” to mobile health application system is vital to its success, but it is about building broader engagement.	**3.2 Relational Integration**: Knowledge work that people do to build accountability and maintain confidence in the new system and in all parts of it e.g. doctors do not lose confidence in data generated from the mobile health application and start to request patients to use a paper medication list in conjunction with app.	**4.2 Communal appraisal:** People work together to evaluate the worth of a set of practises. This happens continuously in almost every setting where people interact around or new way of organising work and ask each other - Is it working? How they answer these questions and negotiate difficulties that stem form conflicts, and how it counts for different groups, are central to the future of any set of practises.

1.3 Individual specification: How individuals understand their specific tasks and responsibilities around a set of practices. For example, nurses recruiting patients into the trial need to have a strong understanding of mobile health application and how it works.	**2.3 Legitimation:** Ensuring individuals believe it is right to be involved, and that they can make a valid contribution. New service interventions often fail because of a lack of investment in ensuring that they fit with the ways that professionals - and sometimes patients - define their possible contribution to them.	**3.3 Skill set Workability**: The allocation work that underpins the division of labour that is build up around a mobile health application as it is operationalised. Who gets to do the work is an important element of any sets of practices e.g. who decides on any changes to the system or procedures?	**4.3 Individual appraisal**: Individual appraisal of the new way of working on them and the contexts e.g. a nurse working in a new service will work to appraise not only the worth of a mobile health system, but also the impact on her other tasks e.g. a demanding workload may not be valued in practice.
1.4 Internalization: Understanding the value, benefits and importance of a set of practices. For example, the work individuals do to attribute worth to a new way of working based on a mobile health application.	**2.4 Activation:** Collectively defining actions and procedures needed to sustain the new way of working. This is the work of keeping new practises in view / connecting it with the people who need to be doing it.	**3.4 Contextual Integration:** Managing a set of practices through the allocation of different kinds of resources and the execution of protocols, policies and procedures. For example, resourcing the ways the cardiac team members enact the service.	**4.4 Reconfiguration:** Appraisal work by individuals or groups may lead to attempts to redefine procedures or modify practices – and even to change the new services itself e.g. a nurse leading on the mobile health intervention might look again at some aspects of work or tasks, which she calculates is disproportionate to the work involved to make it workable in practice.

Appendix C: Participant information leaflet

HCP Information Leaflet

What is ECME?

This study forms part of a four-year, INTERREG VA -funded initiative entitled, Eastern Corridor Medical Engineering Centre (ECME). ECME is a collaborative research project focused on improving cardiovascular health. The goal of the ECME project is to create better models of heart disease care through research and developing generic solutions for the remote patient monitoring market. I am a student from Dundalk Institute of Technology (DkIT) and I am inviting you to participate in my study.

Before you decide whether or not you wish to participate, you should read the information provided below carefully. Take time to ask questions – don't feel rushed and don't feel under pressure to make a quick decision. You should clearly understand the risks and benefits of taking part in this study so that you can make a decision that is right for you. This process is known as 'Informed Consent'. The researcher will fully explain the study and the content of the information sheet. Then you will be asked to sign a consent form to demonstrate that you have agreed.

Why is this study being done?

This study is part of a larger programme designed to investigate a telemedicine trial for older people with cardiovascular disease. It is designed to understand how telemonitoring practices emerge within and between health care professionals. We are exploring healthcare staff / managerial and support staff experiences with telemedicine pre- and post-trial. We are also interested on barriers / facilitators for the uptake of telemedicine. This study will yield valuable information from health professionals at hospital and community level and how telemonitoring tasks are handled [or not]. It will also inform policy makers charged with planning for the needs of a growing older population living with chronic illnesses.

Why am I being asked to take part

You are being asked to participate in this study because:

- You are a member of the Heart Failure clinic team in Our Lady of Lourdes Hospital, Drogheda.
- We would like to hear your experience on your role and responsibilities at the clinic, experiences dealing with telemedicine projects etc.

What will happen to me if I agree to take part?

If you agree to take part, you will become a participant in the study. Phase 1 of the study involves a few observational visits to the clinic where you work followed by an interview and a questionnaire, giving you the opportunity to reflect on your current work practices and experiences while caring for older adults with Heart Failure. The interview and questionnaire will last approximately 45 minutes. You will be invited to repeat this process at the end of the telemedicine trial. This will allow the researcher to compare your responses in time 1 and time 2. You can change your mind about taking part in the study any time you like. Even if the study has started, you can still drop out without giving us a reason. If that is the case, rest assured it won't affect your current employment.

Is this study confidential?

This study will be confidential, your name will not be used while collecting data and / or at any point of the research process. You will be assigned a participant identification number instead of your name. Only the DkIT primary researcher will have access to the file that matches each person to their participant identification number. This will be kept at a secure location at DkIT, and it will only be used for administrative purposes. Your contact details will be stored separately from any data we collect from you. Anything we write about the research study will not include your name or contact information. In line with the General Data Protection Regulation (GDPR) 2018, all records not required will be destroyed 7 years after completion of data analysis.

Where will the research take place?

Research will take place at the location of the Heart Failure clinic, Our Lady of Lourdes Hospital.

What are the benefits of participating in this study?

There will likely be no direct benefits, health-wise, to you taking part in the study. However, it will inform our research and help us to improve the way technology can be used to manage older people with heart failure living at home, receiving care at a distance. Therefore, your participation may be of invaluable assistance to understand how healthcare professionals can support the use of technologies and how the change takes place: from the traditional face to face care pathway to one utilising telemedicine. Also, by taking part on this study, you will be contributing to national and international research study.

What are the risks?

We do not envisage any risks attached to your participation in this research. You can choose not to answer any questions you do not wish to answer. If you become upset at any point during the research, the researcher will provide you with details of support and counselling services. If you feel there is a demand on your time, there is no obligation for you to continue.

What if I have a complaint?

If you have any complaints or concerns about the ethical conduct of this research, you may contact Dr Edel Healy of DkIT Ethics Committee at 0429370262 ext 2716.

Where can I get further information?

If you need any further information now or at any time in the future, please contact me.

Name: Yohanca Diaz Skeete

Address: Dundalk Institute of Technology, Dublin Road, Dundalk, Co. Louth.

Phone No: 0429378495 ext. 2592.

Appendix D: HCP interview guide Phase 1

Interviews were conducted with staff to elicit understanding on the following themes:

Description of usual working practices and routines
Individual description of roles and responsibilities
Associated time spent on tasks
Staff experience on using remote mHealth with their clients: If yes, they were asked to expand and explain about the system used
Staff perspectives on utilising a mHealth with their clients
Barriers and/or facilitators in relation to using mHealth and how they might affect or not the uptake of a mHealth intervention
Impact of mHealth on their job performance e.g. productivity, workload and time
Staff views on organizational change, for example, how mHealth might change their daily practice
Staff allocated time to discuss patient preferences and their views on patient preferences influencing the care they receive
Concerns regarding the use and implementation of mHealth in their daily practice, for example, costs, training, reliability and maintenance of equipment.

Appendix E: Observation protocol

Place of observation

Start time

Finish time

Observations	Example	Field notes
Observable Behaviour	Any observable overt behaviour (what) shown by whom / where?	
Conversation	Any interesting conversation today (what/by whom/ where)	
General mood of HCP & patients alike	What is the general mood (both HCP & patients/ how is their mental well-being / are the HCP preoccupied – tense – worried for some reason	
Context	Is it a sunny – rainy -cold day/is the outpatient clinic very busy this morning? /	
Time difference between patient arrival & consultation	Is there much time difference between patient arrival at clinic check in & patients' entrance to consultation room?	
What does the clinic waiting room looks like?	Is it busy / quiet / orderly manner /patients look tired or hungry? / Is there reading material for patients? Is there enough seating arrangements?	
CLINIC CHECK IN	What happens at clinic check in? Who do they check in first? Is this procedure different for new patients versus established patients?	
Appointment as scheduled / early / late	Was the patient seen at the allocated time for appointment / earlier or later & reasons	
Greetings / HCP using the patient's name	HCP calling patient by name / making the patient feel comfortable during the visit to the clinic / HCP being friendly / asking about family / using relatives names	
How much time the visit lasts for? On average each patient	Time they enter room / Time they leave room. ***NOTE - After the initial observation, average time for each patient was recorded.***	
Is the patient alone?	Is the relative with them in consultation room? Is the relative asking questions in relation to	

	care? Is the relative waiting outside the consultation room? Is the relative calm / anxious?	
DURING CONSULTATION	Is weight, blood pressure, pulse, blood tests done today? Medication reviewed?	
Explaining results of tests to the patient	HCP allocating enough time to explain the blood results / heart rate / weight / BP to the patient & how to proceed regarding treatment	
Health promotion & patient education	HCP explaining / educating patient on how to prevent further deterioration of signs and symptoms / health promotion activities on offer / Time spent on this on consultation / education session done some other day	
Facilitating follow-up	Arranging a follow up appointment for the patient before they leave the clinic, saying that they will receive a follow up appointment by post	
Allowing patient to ask questions	HCP giving enough time for patients to voice their concerns	
Answering patient's questions	HCP allowing sufficient time to answer patient questions	
Listening attentively to patients	HCP listen carefully to patient's questions / concerns / complaints	
Interruption during consultation	Any interruptions? By whom? Reason	
Use of medical jargon	HCP avoiding jargon / explaining concepts in lay terms	
BEFORE LEAVING THE CLINIC		
Follow up appointments & Referrals	Is someone in the clinic responsible for scheduling follow up appointments & patient referrals? Who is responsible? Has the patient been informed on his / her new appointment? Is it the patient responsibility to make a new appointment? Who is responsible to check if referrals were completed? Does anyone in the clinic make reminder calls if a referral was not completed?	

NEW PATIENTS (1ST VISITS)		
Explaining the diagnosis / prognosis of disease to the patient	HCP providing explanation on the diagnosis / prognosis of the condition / time spent on this	
Explaining the cause of disease to the patient	HCP dedicating time to explain the cause of the condition	
Explaining treatment to patient	HCP dedicating time to explain treatment to patients and providing advice	
Explaining the side effects of the treatment to the patient	HCP dedicating time to explain the side effects of tablets or treatment to patient	
Asking patient if s/he understood the explanation	HCP asking the patient if they understood what was told / spoken about in the consultation	

Appendix F: Staff demographic information questionnaire

Demographic information

Following our interview, please provide this information. This will help the researcher to describe in general the sample of participants.

Gender: Female ☐ Male ☐

Age: <30 years ☐ 30-39 years ☐ 40-49 years ☐ 50-59 years ☐ > 60 years ☐

Level of experience - Indicate the number of years in clinical practice

Indicate number of years working in the Heart Failure clinic

Indicate number of days/ hours worked per week

Level of education - Highest grade obtained (you may choose more than one option)

☐ Diploma

☐ Bachelor

☐ Master's degree

☐ PhD

☐ Consultant

☐ Doctor

Other (please specify): ________________

Thank you, your participation is greatly appreciated!!!

Appendix G: Job satisfaction Survey amended (no supervision items)

	JOB SATISFACTION SURVEY AMENDED Paul E. Spector Department of Psychology University of South Florida Copyright Paul E. Spector 1994, All rights reserved.						
	PLEASE CIRCLE THE ONE NUMBER FOR EACH QUESTION THAT COMES CLOSEST TO REFLECTING YOUR OPINION ABOUT IT.	Disagree very much	Disagree moderately	Disagree slightly	Agree slightly	Agree moderately	Agree very much
1	I feel I am being paid a fair amount for the work I do.	1	2	3	4	5	6
2	There is really too little chance for promotion on my job.	1	2	3	4	5	6
3	I am not satisfied with the benefits I receive.	1	2	3	4	5	6
4	When I do a good job, I receive the recognition for it that I should receive.	1	2	3	4	5	6
5	Many of our rules and procedures make doing a good job difficult.	1	2	3	4	5	6
6	I like the people I work with.	1	2	3	4	5	6
7	I sometimes feel my job is meaningless.	1	2	3	4	5	6
8	Communications seem good within this organization.	1	2	3	4	5	6
9	Raises are too few and far between.	1	2	3	4	5	6
10	Those who do well on the job stand a fair chance of being promoted.	1	2	3	4	5	6
11	The benefits we receive are as good as most other organizations offer.	1	2	3	4	5	6
12	I do not feel that the work I do is appreciated.	1	2	3	4	5	6
13	My efforts to do a good job are seldom blocked by red tape.	1	2	3	4	5	6
14	I find I have to work harder at my job because of the incompetence of people I work with.	1	2	3	4	5	6
15	I like doing the things I do at work.	1	2	3	4	5	6
16	The goals of this organization are not clear to me.	1	2	3	4	5	6

	PLEASE CIRCLE THE ONE NUMBER FOR EACH QUESTION THAT COMES CLOSEST TO REFLECTING YOUR OPINION ABOUT IT.	Disagree very mcuh	Disagree moderately	Disagree slightly	Agree slightly	Agree moderately	Agree very much
17	I feel unappreciated by the organization when I think about what they pay me.	1	2	3	4	5	6
18	People get ahead as fast here as they do in other places.	1	2	3	4	5	6
19	The benefit package we have is equitable.	1	2	3	4	5	6
20	There are few rewards for those who work here.	1	2	3	4	5	6
21	I have too much to do at work.	1	2	3	4	5	6
22	I enjoy my coworkers.	1	2	3	4	5	6
23	I often feel that I do not know what is going on with the organization.	1	2	3	4	5	6
24	I feel a sense of pride in doing my job.	1	2	3	4	5	6
25	I feel satisfied with my chances for salary increases.	1	2	3	4	5	6
26	There are benefits we do not have which we should have.	1	2	3	4	5	6
27	I have too much paperwork.	1	2	3	4	5	6
28	I don't feel my efforts are rewarded the way they should be.	1	2	3	4	5	6
29	I am satisfied with my chances for promotion.	1	2	3	4	5	6
30	There is too much bickering and fighting at work.	1	2	3	4	5	6
31	My job is enjoyable.	1	2	3	4	5	6
32	Work assignments are not fully explained.	1	2	3	4	5	6

Appendix H: Extended Technology Acceptance Model (TAM) Questionnaire

PURPOSE OF THE QUESTIONNAIRE

To find out the opinion of health care professionals from the heart failure clinic at Our Lady of Lourdes Hospital, Drogheda on a Digital Health Intervention (DHI)

The objective of this study is to find out your opinion on Digital Health Interventions.

1. I often use computing tools in my work:

☐ Yes
☐ No

2. I feel comfortable with information and communication technologies (e.g. e-mail, Internet, videoconference, on-line etc.):

☐ Yes
☐ No

3. I have already used a DHI to monitor my patients:

☐ Yes
☐ No

4. I am going to participate in the ECME PhD study.

☐ Yes
☐ No

Here are 26 statements related to various factors that may be involved in the acceptance of a DHI as a working tool. Please, indicate your level of agreement with each of the following statements using the scale provided below:

** Remember to **select a single option** for each statement.

-3 **Totally disagree**	**-2** Disagree	**-1** Slightly disagree	**0** Neither agree nor disagree	**1** Slightly agree	**2** Agree	**3** **Totally agree**

Statement	-3	-2	-1	0	1	2	3
1. The use of a Digital Health Intervention (DHI) could help me to monitor my patients more rapidly	☐	☐	☐	☐	☐	☐	☐
2. I think that I could easily learn how to use DHI's	☐	☐	☐	☐	☐	☐	☐
3. I have the intention to use DHI's when it becomes available in the Heart Failure Clinic	☐	☐	☐	☐	☐	☐	☐
4. The use of a DHI may imply major changes in my work practice	☐	☐	☐	☐	☐	☐	☐
5. The use of a DHI could improve the monitoring of my patients	☐	☐	☐	☐	☐	☐	☐
6. I think that it would be easy to perform the tasks necessary for the monitoring of my patients using the system	☐	☐	☐	☐	☐	☐	☐
7. Most of my older patients will welcome the fact that I use a DHI	☐	☐	☐	☐	☐	☐	☐
8. I think that the heart failure clinic has the necessary infrastructure to support my use of a DHI	☐	☐	☐	☐	☐	☐	☐
9. Using a DHI could help me get the most out of my time to monitor my patients	☐	☐	☐	☐	☐	☐	☐
10. I believe that the monitoring carried out by the system would be clear and easy to understand	☐	☐	☐	☐	☐	☐	☐
11. The use of a DHI is compatible with my work habits	☐	☐	☐	☐	☐	☐	☐
12. Most of my colleagues will welcome the fact that I use DI	☐	☐	☐	☐	☐	☐	☐
13. Using DHI's could improve my performance in patients care	☐	☐	☐	☐	☐	☐	☐

-3 **Totally disagree**	**-2** Disagree	**-1** Slightly disagree	**0** Neither agree nor disagree	**1** Slightly agree	**2** Agree	**3** **Totally agree**

	-3	-2	-1	0	1	2	3
14. I think that DI is a flexible technology to interact with	☐	☐	☐	☐	☐	☐	☐
15. I have the intention to use DHI's when necessary to provide health care to my patients	☐	☐	☐	☐	☐	☐	☐
16. Health managers would welcome the fact that I use DI	☐	☐	☐	☐	☐	☐	☐
17. Using the system could facilitate the care of my patients	☐	☐	☐	☐	☐	☐	☐
18. I think I would find it easy to acquire the necessary skills to use the system	☐	☐	☐	☐	☐	☐	☐
19. The use of the DHI could promote good clinical practice	☐	☐	☐	☐	☐	☐	☐
20. I would use the system if I receive appropriate training	☐	☐	☐	☐	☐	☐	☐
21. Other health professionals (specialist, nurses, GPs etc.) would welcome the fact that I use a DHI	☐	☐	☐	☐	☐	☐	☐
22. In general, a DHI could be useful to improve the care of my patients	☐	☐	☐	☐	☐	☐	☐
23. I have the intention to use a DHI routinely for the care of my patients	☐	☐	☐	☐	☐	☐	☐
24. The use of a DHI could interfere with the usual follow-up of my patients	☐	☐	☐	☐	☐	☐	☐
25. I think that a DHI will be easy to use	☐	☐	☐	☐	☐	☐	☐
26. I would use a DHI if I receive the necessary technical assistance	☐	☐	☐	☐	☐	☐	☐

Please use this space to provide any additional comments you may wish to add.

Appendix I: Dundalk Institute of Technology & HSE NE REC committee ethical approval letter (2019)

DUNDALK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA
DHÚN DEALGAN

Tel: 353 42 9370200
Fax: 353 42 9370201
Web: www.dkit.ie
E-Mail: reception@dkit.ie
E-Mail: first.surname@dkit.ie

11th January 2019

Ms. Yohanca Diaz-Skeete,
Netwell CASALA Research Centre,
School of Health and Science,
Dundalk Institute of Technology,
Dundalk,
Co. Louth

Re: Workforce transformation in Technology Enabled Community Care to Older People with Cardiac Conditions

Dear Yohanca,

The School Ethics Committee considered your application for the above study at its meeting dated 8th October 2018 and your amendments submitted on the 17th December 2018. I note that you received ethical approval from the HSE North East Area Research Ethics Committee on the 17/12/18. The project is now granted ethical approval by DkIT. Wishing you the best of luck with your research.

Yours Sincerely,

Edel Healy

Dr.Edel Healy
Chair of School of Health & Science Ethics Committee

HEA HIGHER EDUCATION AUTHORITY

EUROPEAN UNION
European Social Fund

Appendix J: HSE Northeast Committee ethical approval letter (2020)

Feidhmeannacht na Seirbhíse Sláinte
Health Service Executive

Regional Manager Consumer Affairs
HSE Dublin North East

Bective Street, Kells
Co. Meath
A82 NX32

Tel: +353 (0) 46 9251262/263
Fax: +353 (0) 46 9251774

Loughtee Business Park
Drumalee, Cavan
H12 Y329

Tel: +353 (0) 49 4377343
Fax: +353 (0) 49 4377379
Email: consumeraffairs.hsedne@hse.ie

Ms Yohanca Diaz-Skeete
Netwell/CASALA Research Centre
Dundalk Institute of Technology
PJ Carroll Building
Dublin Road
Dundalk, Co Louth. A91 K584

9/1/2020

Re/ Research Study Proposal:
"Cardiac outpatients care; an exploration of mobile health (mHealth) applications from the perspective of staff and patients – phase 2"
REC Ref: REC/19/044

Dear Ms Diaz-Skeete

I refer to your email correspondence of the 9/1/2020 in response to issues raised by the HSE North East Research Ethics Committee (REC) in connection with the above study. I wish to advise that I have had an opportunity to review same.

I can confirm that you have met all the conditions of the Committee.

Approval is now given to commence the above Study.

You should note that ethical approval will lapse if you do not adhere to the following conditions:

1. Submission of an Annual Progress Report (due annually from the date of this approval letter)
2. Report unexpected events or any event that may affect ethical acceptability of the study.
3. Submit any changes to study documentation (minor or major) to the North East REC for review and approval.
4. Notify North East REC of discontinuation of the study.
5. Submit a final Study Report/Study Synopsis when the study has been completed.

This approval will be formally noted at the next REC meeting.

Yours sincerely,

R. Smith - Lynch.

Ms Rosalie Smith Lynch
Chair, HSE North East Area
Research Ethics Committee

Copied to/ Fiona Brady, General Manager, Our Lady of Lourdes Hospital, Drogheda, Co. Louth
Niamh Murphy, Director, Department of Cardiology, Our Lady of Lourdes Hospital, Drogheda, Co. Louth

Complaints Management • Freedom of Information • Data Protection • Consumer Participation • Regional Ethics Administration

Appendix K: HSE Northeast Committee amended ethical approval post-COVID-19 (2021)

Feidhmeannacht na Seirbhíse Sláinte
Health Service Executive

Bective Street, Kells
Co. Meath, A82 NX32

Tel: +353 (0) 469251264/
Fax: +353 (0) 469251774

HSE Dublin North East

Hampton Court, Cootehill Road
Cavan Town, H12 YY84

Tel: +353 (0) 49 4377343
Fax: +353 (0) 49 4377379
Email: consumeraffairs.hsedne@hse.ie

Yohanca Diaz-Skeete
NetwellCASLA Research Centre
Dundalk Institute of Technology
PJ Carroll Building
Dublin Road
Dundalk
Co Louth
A91 K584

15/10/21

Re/ Research Study Proposal:
"Cardiac outpatients care; an exploration of mobile health (mHealth) applications from the perspective of staff and patients"
REC Ref: REC/19/044

Amendments to above study due to COVID-19
- **Sample Size will decrease**
- **The researcher will visit participants at home**
- **Pre and post-intervention questionnaires will be administered at home. Interviews will take place at participant's home or by phone9**

Minor Changes to Participants Consent Form

Dear Ms Diaz-Skeete

I acknowledge receipt of your correspondence of the 2/6/21 and 13/7/21 regarding amendments to the above study.

On behalf of the Committee I am approving the amendments as indicated in your correspondence.

This will be formally noted at the next REC meeting.

Yours sincerely,

Ms Rosalie Smith Lynch
Chairperson
HSE North East Area –
Research Ethics Committee

Copied to/ **Fiona Brady, General Manager, Our Lady of Lourdes Hospital, Drogheda, Co. Louth**
Niamh Murphy, Director, Director, Department of Cardiology, Our Lady of Lourdes Hospital, Drogheda, Co. Louth

Complaints Management Freedom of Information

Appendix L: Mobile Application Rating System (MARS)

Mobile Application Rating Scale (MARS) App Classification

The Classification section is used to collect descriptive and technical information about the app. Please review the app description in iTunes / Google Play to access this information.

App Name: ____

Rating this version: ____________________ **Rating all versions:** ____________________

Developer: ____

N ratings this version: ____________________ **N ratings all versions:** ____________________

Version: ____________________ **Last update:** ____________________

Cost - basic version: ____________________ **Cost - upgrade version:** ____________________

Platform: ☐ iPhone ☐ iPad ☐ Android

Brief description: ____

____

Focus: what the app targets (select all that apply)

- ☐ Increase Happiness/Well-being
- ☐ Mindfulness/Meditation/Relaxation
- ☐ Reduce negative emotions
- ☐ Depression
- ☐ Anxiety/Stress
- ☐ Anger
- ☐ Behaviour Change
- ☐ Alcohol /Substance Use
- ☐ Goal Setting
- ☐ Entertainment
- ☐ Relationships
- ☐ Physical health
- ☐ Other ____________________

Theoretical background/Strategies (all that apply)

- ☐ Assessment
- ☐ Feedback
- ☐ Information/Education
- ☐ Monitoring/Tracking
- ☐ Goal setting
- ☐ Advice /Tips /Strategies /Skills training
- ☐ CBT - Behavioural (positive events)
- ☐ CBT – Cognitive (thought challenging)
- ☐ ACT - Acceptance commitment therapy
- ☐ Mindfulness/Meditation
- ☐ Relaxation
- ☐ Gratitude
- ☐ Strengths based
- ☐ Other ____________________

Affiliations:

☐ Unknown ☐ Commercial ☐ Government ☐ NGO ☐ University

Age group (all that apply)

- ☐ Children (under 12)
- ☐ Adolescents (13-17)
- ☐ Young Adults (18-25)
- ☐ Adults
- ☐ General

Technical aspects of app (all that apply)

- ☐ Allows sharing (Facebook, Twitter, etc.)
- ☐ Has an app community
- ☐ Allows password-protection
- ☐ Requires login
- ☐ Sends reminders
- ☐ Needs web access to function

Queensland University of Technology

App Quality Ratings

The Rating scale assesses app quality on four dimensions. All items are rated on a 5-point scale from “1. Inadequate” to “5.Excellent”. Circle the number that most accurately represents the quality of the app component you are rating. Please use the descriptors provided for each response category.

SECTION A

Engagement – fun, interesting, customisable, interactive (e.g. sends alerts, messages, reminders, feedback, enables sharing), well-targeted to audience

1. **Entertainment: Is the app fun/entertaining to use? Does it use any strategies to increase engagement through entertainment (e.g. through gamification)?**

   1 Dull, not fun or entertaining at all
   2 Mostly boring
   3 OK, fun enough to entertain user for a brief time (< 5 minutes)
   4 Moderately fun and entertaining, would entertain user for some time (5-10 minutes total) 5 Highly entertaining and fun, would stimulate repeat use

2. **Interest: Is the app interesting to use? Does it use any strategies to increase engagement by presenting its content in an interesting way?**

   1 Not interesting at all
   2 Mostly uninteresting
   3 OK, neither interesting nor uninteresting; would engage user for a brief time (< 5 minutes)
   4 Moderately interesting; would engage user for some time (5-10 minutes total) 5 Very interesting, would engage user in repeat use

3. **Customisation: Does it provide/retain all necessary settings/preferences for apps features (e.g. sound, content, notifications, etc.)?**

   1 Does not allow any customisation or requires setting to be input every time
   2 Allows insufficient customisation limiting functions 3 Allows basic customisation to function adequately
   4 Allows numerous options for customisation
   5 Allows complete tailoring to the individual’s characteristics/preferences, retains all settings

4. **Interactivity: Does it allow user input, provide feedback, contain prompts (reminders, sharing options, notifications, etc.)? Note: these functions need to be customisable and not overwhelming in order to be perfect.**

   1 No interactive features and/or no response to user interaction
   2 Insufficient interactivity, or feedback, or user input options, limiting functions
   3 Basic interactive features to function adequately
   4 Offers a variety of interactive features/feedback/user input options
   5 Very high level of responsiveness through interactive features/feedback/user input options

5. **Target group: Is the app content (visual information, language, design) appropriate for your target audience?**

   1 Completely inappropriate/unclear/confusing
   2 Mostly inappropriate/unclear/confusing
   3 Acceptable but not targeted. May be inappropriate/unclear/confusing
   4 Well-targeted, with negligible issues
   5 Perfectly targeted, no issues found

A

SECTION B

Functionality – app functioning, easy to learn, navigation, flow logic and gestural design of app

6. Performance: How accurately/fast do the app features (functions) and components (buttons/menus) work?

1 App is broken; no/insufficient/inaccurate response (e.g. crashes/bugs/broken features, etc.)
2 Some functions work, but lagging or contains major technical problems
3 App works overall. Some technical problems need fixing/Slow at times
4 Mostly functional with minor/negligible problems
5 Perfect/timely response; no technical bugs found/contains a 'loading time left' indicator

7. Ease of use: How easy is it to learn how to use the app; how clear are the menu labels/icons and instructions?

1 No/limited instructions; menu labels/icons are confusing; complicated
2 Useable after a lot of time/effort
3 Useable after some time/effort
4 Easy to learn how to use the app (or has clear instructions)
5 Able to use app immediately; intuitive; simple

8. Navigation: Is moving between screens logical/accurate/appropriate/ uninterrupted; are all necessary screen links present?

1 Different sections within the app seem logically disconnected and random/confusing/navigation is difficult
2 Usable after a lot of time/effort
3 Usable after some time/effort
4 Easy to use or missing a negligible link
5 Perfectly logical, easy, clear and intuitive screen flow throughout, or offers shortcuts

9. Gestural design: Are interactions (taps/swipes/pinches/scrolls) consistent and intuitive across all components/screens?

1 Completely inconsistent/confusing
2 Often inconsistent/confusing
3 OK with some inconsistencies/confusing elements
4 Mostly consistent/intuitive with negligible problems
5 Perfectly consistent and intuitive

B. Functionality mean score = ___________

SECTION C

Aesthetics – graphic design, overall visual appeal, colour scheme, and stylistic consistency

10. Layout: Is arrangement and size of buttons/icons/menus/content on the screen appropriate or zoomable if needed?

1 Very bad design, cluttered, some options impossible to select/locate/see/read device display not optimised
2 Bad design, random, unclear, some options difficult to select/locate/see/read
3 Satisfactory, few problems with selecting/locating/seeing/reading items or with minor screen size problems
4 Mostly clear, able to select/locate/see/read items
5 Professional, simple, clear, orderly, logically organised, device display optimised. Every design component has a purpose

11. Graphics: How high is the quality/resolution of graphics used for buttons/icons/menus/content?

1 Graphics appear amateur, very poor visual design - disproportionate, completely stylistically inconsistent
2 Low quality/low resolution graphics; low quality visual design – disproportionate, stylistically inconsistent
3 Moderate quality graphics and visual design (generally consistent in style)
4 High quality/resolution graphics and visual design – mostly proportionate, stylistically consistent
5 Very high quality/resolution graphics and visual design - proportionate, stylistically consistent throughout

12. Visual appeal: How good does the app look?

1 No visual appeal, unpleasant to look at, poorly designed, clashing/mismatched colours
2 Little visual appeal – poorly designed, bad use of colour, visually boring
3 Some visual appeal – average, neither pleasant, nor unpleasant
4 High level of visual appeal – seamless graphics – consistent and professionally designed
5 As above + very attractive, memorable, stands out; use of colour enhances app features/menus

C. Aesthetics mean score = ____________

SECTION D

Information – Contains high quality information (e.g. text, feedback, measures, references) from a credible source. Select N/A if the app component is irrelevant.

13. Accuracy of app description (in app store): Does app contain what is described?

1 Misleading. App does not contain the described components/functions. Or has no description
2 Inaccurate. App contains very few of the described components/functions
3 OK. App contains some of the described components/functions
4 Accurate. App contains most of the described components/functions
5 Highly accurate description of the app components/functions

14. Goals: Does app have specific, measurable and achievable goals (specified in app store description or within the app itself)?

N/A Description does not list goals, or app goals are irrelevant to research goal (e.g. using a game for educational purposes)
1 App has no chance of achieving its stated goals
2 Description lists some goals, but app has very little chance of achieving them 3 OK. App has clear goals, which may be achievable.
4 App has clearly specified goals, which are measurable and achievable
5 App has specific and measurable goals, which are highly likely to be achieved

15. Quality of information: Is app content correct, well written, and relevant to the goal/topic of the app?

N/A There is no information within the app
1 Irrelevant/inappropriate/incoherent/incorrect
2 Poor. Barely relevant/appropriate/coherent/may be incorrect
3 Moderately relevant/appropriate/coherent/and appears correct
4 Relevant/appropriate/coherent/correct
5 Highly relevant, appropriate, coherent, and correct

16. Quantity of information: Is the extent coverage within the scope of the app; and comprehensive but concise?

N/A There is no information within the app
1 Minimal or overwhelming
2 Insufficient or possibly overwhelming
3 OK but not comprehensive or concise
4 Offers a broad range of information, has some gaps or unnecessary detail; or has no links to more information and resources
5 Comprehensive and concise; contains links to more information and resources

17. Visual information: Is visual explanation of concepts – through charts/graphs/images/videos, etc. – clear, logical, correct?

N/A There is no visual information within the app (e.g. it only contains audio, or text)
1 Completely unclear/confusing/wrong or necessary but missing
2 Mostly unclear/confusing/wrong
3 OK but often unclear/confusing/wrong
4 Mostly clear/logical/correct with negligible issues
5 Perfectly clear/logical/correct

18. Credibility: Does the app come from a legitimate source (specified in app store description or within the app itself)?

1 Source identified but legitimacy/trustworthiness of source is questionable (e.g. commercial business with vested interest)
2 Appears to come from a legitimate source, but it cannot be verified (e.g. has no webpage)
3 Developed by small NGO/institution (hospital/centre, etc.) /specialised commercial business, funding body
4 Developed by government, university or as above but larger in scale
5 Developed using nationally competitive government or research funding (e.g. Australian Research Council, NHMRC)

19. Evidence base: Has the app been trialled/tested; must be verified by evidence (in published scientific literature)?

N/A The app has not been trialled/tested
6 The evidence suggests the app does not work
7 App has been trialled (e.g., acceptability, usability, satisfaction ratings) and has partially positive outcomes in studies that are not randomised controlled trials (RCTs), or there is little or no contradictory evidence.
8 App has been trialled (e.g., acceptability, usability, satisfaction ratings) and has positive outcomes in studies that are not RCTs, and there is no contradictory evidence.
9 App has been trialled and outcome tested in 1-2 RCTs indicating positive results
10 App has been trialled and outcome tested in $\geq$ 3 high quality RCTs indicating positive results

D. Information mean score = ____________ *

* Exclude questions rated as "N/A" from the mean score calculation.

App subjective quality

SECTION E

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20. Would you recommend this app to people who might benefit from it?

1 **Not at all** I would not recommend this app to anyone
2 There are very few people I would recommend this app to
3 **Maybe** There are several people whom I would recommend it to
4 There are many people I would recommend this app to
5 **Definitely** I would recommend this app to everyone

21. How many times do you think you would use this app in the next 12 months if it was relevant to you?

1 **None**
2 1-2
3 3-10
4 10-50
5 >50

22. Would you pay for this app?

1 No
3 Maybe
5 Yes

23. What is your overall star rating of the app?

1	★★	One of the worst apps I've used
2	★★★★	
3	★★★★★★	Average
4	★★★★★★★★	
5	★★★★★★★★★★	One of the best apps I've used

Scoring

App quality scores for

SECTION

A: Engagement Mean Score = ___________________________

B: Functionality Mean Score = ___________________________

C: Aesthetics Mean Score = ___________________________

D: Information Mean Score = ___________________________

App quality mean Score = ___________________________

App subjective quality Score = _________________________

App-specific

These added items can be adjusted and used to assess the perceived impact of the app on the user's knowledge, attitudes, intentions to change as well as the likelihood of actual change in the target health behaviour.

SECTION F

---

1. **Awareness: This app is likely to increase awareness of the importance of addressing [insert target health behaviour]**

   Strongly disagree Strongly Agree

   1 2 3 4 5

2. **Knowledge: This app is likely to increase knowledge/understanding of [insert target health behaviour]**

   Strongly disagree Strongly Agree

   1 2 3 4 5

3. **Attitudes: This app is likely to change attitudes toward improving [insert target health behaviour]**

   Strongly disagree Strongly Agree

   1 2 3 4 5

1. Intention to change: This app is likely to increase intentions/motivation to address [insert target health behaviour]

Strongly disagree Strongly Agree

1 2 3 4 5

2. Help seeking: Use of this app is likely to encourage further help seeking for [insert target health behaviour] (if it's required)

Strongly disagree Strongly Agree

1 2 3 4 5

3. Behaviour change: Use of this app is likely increase/decrease [insert target health behaviour]

Strongly disagree Strongly Agree

1 2 3 4 5

Appendix M: System Usability Scale (SUS)

Participant ID: _____ Site: _______________________ Date: ___/___/___

System Usability Scale

Instructions: For each of the following statements, mark one box that best describes your reactions to the use of the medication list app.

	Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree
I think that I would like to use this app frequently.	☐	☐	☐	☐	☐
I found this app unnecessarily complex.	☐	☐	☐	☐	☐
I thought this app was easy to use.	☐	☐	☐	☐	☐
I think that I would need the support of a technical person to be able to use this app.	☐	☐	☐	☐	☐
I found the various functions in this app were well integrated.	☐	☐	☐	☐	☐
I thought there was too much inconsistency in this app.	☐	☐	☐	☐	☐
I would imagine that most people would learn to use this app very quickly.	☐	☐	☐	☐	☐
I found this app very cumbersome /awkward to use	☐	☐	☐	☐	☐
I felt very confident using this app	☐	☐	☐	☐	☐
I needed to learn a lot of things before I could get going with this app.	☐	☐	☐	☐	☐

This questionnaire is based on the System Usability Scale (SUS), which was developed by John Brooke while working at Digital Equipment Corporation.

Appendix N: EQ-5D tool

Under each heading, please tick the ONE box that best describes your health TODAY

MOBILITY

- I have no problems in walking about ☐
- I have slight problems in walking about ☐
- I have moderate problems in walking about ☐
- I have severe problems in walking about ☐
- I am unable to walk about ☐

SELF-CARE

- I have no problems washing or dressing myself ☐
- I have slight problems washing or dressing myself ☐
- I have moderate problems washing or dressing myself ☐
- I have severe problems washing or dressing myself ☐
- I am unable to wash or dress myself ☐

USUAL ACTIVITIES *(e.g. work, study, housework, family or leisure activities)*

- I have no problems doing my usual activities ☐
- I have slight problems doing my usual activities ☐
- I have moderate problems doing my usual activities ☐
- I have severe problems doing my usual activities ☐
- I am unable to do my usual activities ☐

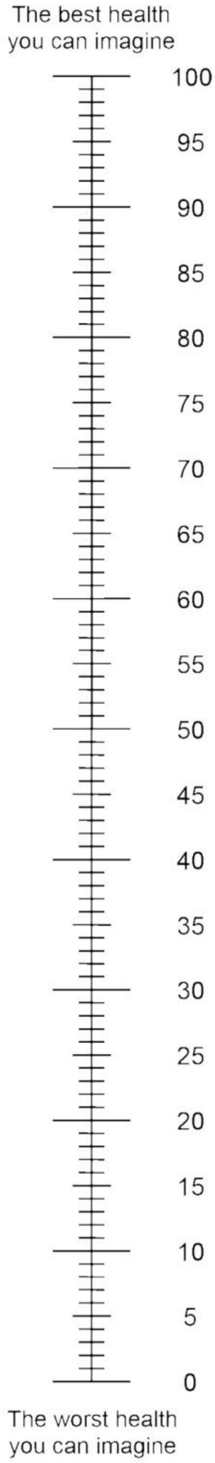
PAIN / DISCOMFORT

- I have no pain or discomfort ☐
- I have slight pain or discomfort ☐
- I have moderate pain or discomfort ☐
- I have severe pain or discomfort ☐
- I have extreme pain or discomfort ☐

ANXIETY / DEPRESSION

- I am not anxious or depressed ☐
- I am slightly anxious or depressed ☐
- I am moderately anxious or depressed ☐
- I am severely anxious or depressed ☐
- I am extremely anxious or depressed ☐

- We would like to know how good or bad your health is TODAY.
- This scale is numbered from 0 to 100.
- 100 means the best health you can imagine.
  0 means the worst health you can imagine.
- Mark an X on the scale to indicate how your health is TODAY.
- Now, please write the number you marked on the scale in the box below.



YOUR HEALTH TODAY = ☐

Appendix O: Interview guide Phase 3

NPT constructs	Sub-components and example of questions HCPs
Coherence	**Differentiation:** Have you used an app for the medication review process before? Do you have a clear understanding on how the medication app works? How using the app differs from the traditional medication review process? **Communal specification**: What do you think the benefits are of using the app? **Individual specification:** Moving forward, what would you say your role is in using the app during consultations? **Internalization**: How valuable do you think the app will be in the future during the medication review process?
Cognitive participation	**Enrolment**: What motivated you to get involved in this study? Would you continue to support patients using the app after the end of this trial? Can you explain why? **Activation**: Would you commit the time and effort to promote or discuss the use of the app among your patients? **Initiation:** If a patient asked for your advice, about whether to use the app or not, what would you say? **Legitimation**: Do you think that one of your professional roles is the discussion and promotion of the use of the app with your patients? Or do you think someone else should do it? – Who & why?
Collective action	**Skill set workability**: Do you think promoting and/or using the app would affect your daily work practices? Would it increase your workload? **Contextual integration**: Do you feel you need training on how to use the app? Is there organisational support from within the clinic/hospital to support your needs? Or to support this initiative? **Interactional workability:** Was using the app easier or harder than you expected? Does it make the medication review process easier?

	Relational integration: Do you feel you can trust the app? If this initiative was to be rolled out to other HF clinics in the country, what advice would you offer to other clinicians?
Reflexive monitoring	**Reconfiguration**: You have seen how the app works – Is there anything you feel it needs to be changed? Do you have any suggestions on how the use of the app can be improved? **Communal appraisal:** Do you think the HF clinic offering/recommending a medication app to patients is worthwhile? Did you asked patients using the app for feedback? If yes - What did they say? **Individual appraisal**: How well do you think you did when some patients arrived to the consultation with the app? Can you explain your answer? **Systematization:** In future, how would you measure the benefits of using the app in terms of: • Patient engagement? • Patient understanding of their medication? • Level of medication adherence? • Medication errors? • Clinic efficiency?

NPT constructs	Sub-components and example of questions (patients)
Coherence	**Differentiation:** Can I take you back to the way you used to manage your medication before using the app – How was it? Have you ever used a medication app? Is using the app too much of a difference? **Communal specification**: Having using the app – Do you know what to do when you attend the HF clinic appointment with the app? **Individual specification:** Do you have a clear understanding on how the medication app works? What was hard and what was easy about using the app? **Internalization**: Do you think the app adds any value to your medication self-management? How valuable the app is to you? Why?

Cognitive participation	**Enrolment**: Can you tell me why you thought it was right for you to get involved in the trial? What motivated you to use the app? **Activation**: Are you committed to start using the app? Will you continue to use the app after this trial? **Initiation:** Do you feel you are ready to use the app on your own? **Legitimation**: Do you think that taking part on this trial of the app is right for you? Do you think is right for you to tell others about the app?
Collective action	**Skill set workability**: Does using the app adds to much to your usual routine? Can you tell me what skills you felt you needed before using the app? **Contextual integration**: Can I ask you what type of support you needed before using the app? And while using the app? Who provided this support? Prompt - Family, friends, the researcher, online support? **Interactional workability:** Tell me how you find the app for managing your medication at home? And for keeping an up-to-date medication list? Was it easier than before? Why? **Relational integration:** Do you feel the same level of confidence managing your medications after using the app? Do you feel you can trust the app?
Reflexive monitoring	**Reconfiguration**: You have been using the app now for three months – Is there anything you feel it needs to be changed? Do you have any suggestions on how can we improve the use of the app? **Communal appraisal:** Can you provide some feedback about the app? Did you asked the nurses in the clinic what they thought about the app? If yes - What did they say? **Individual appraisal**: How well do you think you did when you were asked to use the app? Can you explain your answer? **Systematization:** Now that you are using the app independently, how do you think the app supported you?

	Prompt: - A greater understanding of your medication? - Empowered to ask more questions about your care?

Appendix P: Interview initial coding example

Participant ID: P003
Researcher: Yohanca Diaz
Third Party: Informal Carer/Partner
Date:

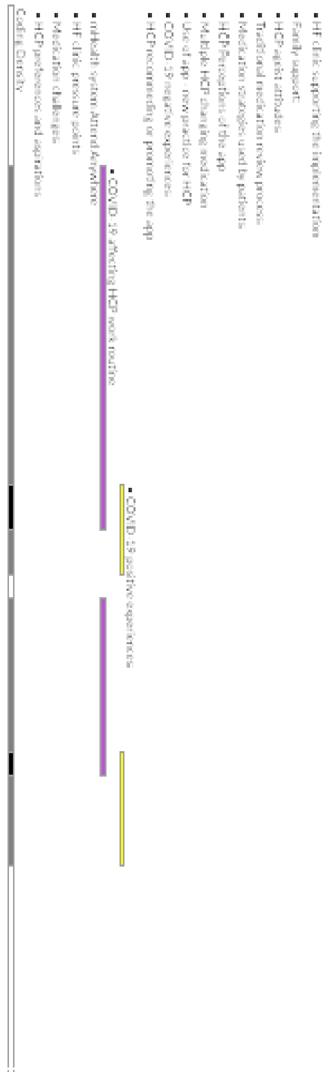
R
Ok, so three sets of questions and the first one will be can you talk to me about the COVID, how it has affected your practice so far?

P003
Ok. Well, COVID, yes, there's a huge effect because initially, COVID happened. We were told changes happened in March of this year and two of my colleagues, Cathy and Vena, were redeployed, so that left myself, Margaret and Margaret. So that completely depleted the staff, but we kept the show on the road, but we weren't bringing patients into the clinic. So that kind of patients were very fearful and worried, but we still were very concerned that they needed to be monitored and, you know, try and get them on their disease modifying medication. So we did all the… Anybody that was due to come to the clinic, we phoned them and we assessed them over the phone and we did monitor patients and get them on their disease modifying medication. We kept patients out of hospital with metolazone and, you know, that was a great help and bloods. You know, we were thinking on the run literally because it was so new. It was just overnight, everything changed. And we even got our community intervention team involved. Those are nurses out in the community and we got them involved to do bloods and this enabled us to titrate things like ACE inhibitors, make sure that their kidney function.

So we were very, very busy, but we kept, you know, it was all virtual. We had the odd patient in. That was in the very early days of COVID. And now things have evolved and we've got our staff back on board and we're starting to see patients. We have clinics, you know, on a Wednesday. A Tuesday afternoon, we have new diagnostic consultant review patients and then we have Wednesday, all day Wednesday, but it's completely different to in the past because in the past, we might have seen 24 patients on a Wednesday. Now we're down to 12 to facilitate social distancing. So we're being really, really careful about who we're picking to see, you know. It really is. I mean it was always a specialist clinic, but sometimes that was probably exploited because people just came willy nilly and we'd bring them in, but now we've to be very particular because the clinic, we can't have a line of patients out here because of COVID and the nature of our patients. They're very elderly, very frail, very vulnerable, very, very fearful.

R
Very sick.

P003
Yes, yes, so.



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R
And this community team, do you foresee that that's going to be a long-term solution, even though when we go back to the normal?

P003
I know, whenever that is, yes, yes, yes.

R
Do you foresee that?

P003
Definitely there will be a role for them, definitely. Now, whether it's the community intervention, but things have to evolve outside that. Things have to evolve to the community, yes, because these patients are frail, vulnerable, fearful and you know, why can't they be seen in the community when they're over the acute phase for continuous monitoring? Yes. But that is happening. In some parts of the country, there are integrated heart failure clinics and I see they're advertising them in Dublin and over on the west, I think.

R
Some parts have heart failure community nurses.

P003
Yes, the community, yes.

R
We don't have them here.

P003
No, not here in the northeast at the moment.

R
So can you then tell me which ones would be the main pressure points in the clinic right now?

P003
When you say pressure points, what do you mean like?

R
Pressure points, well, an example could be now you might have a backlog of patients because if you're seeing, for example, 12 now.

P003
Yes.

- HF clinic supporting the implementation
- Family support
- HCP ageist attitudes
- Traditional medication review process
- Medication strategies used by patients
- HCP Perceptions of the app
- Multiple HCP changing medication
- Use of app - new practice for HCP
- COVID-19 negative experiences
- HCP recommending or promoting the app
- COVID-19 positive experiences
- COVID-19 affecting HCP work routine
- mHealth system Attend Anywhere
- HF clinic pressure points
- Medication challenges
- HCP preferences and aspirations

Coding Density

R

Yes? So that could be a pressure point in the clinic.

P003

Yes, I suppose, but the programme patients, in the past, we would always have seen the programme patients. Anybody with acute decompensated heart failure, they would have been seen at two weeks, medically reviewed. They're in touch with us on the phone always, every week, but they would have to have a medical review. This is as per the guidelines of two weeks and six weeks and 12 weeks, and during the height of COVID, we were lucky if we got them seen once in that 12 weeks. Yes. And obviously that's a pressure point. We're dealing with those patients and we're dealing with the new ones. Yes.

And also in the beginning, in the height of COVID, when there was only the two of us here, it was only one and a bit between the two of us with the hours. It was just one whole-time equivalent and a few hours. So we weren't getting up to see the patients, which was also a concern, to educate them and to make sure, you know, do all that. Yes. And that was a huge pressure point because they were home. We hadn't seen them. We're now on the phone with them. So you know, it was hard to kind of get it and that's still nearly a problem, although we're getting to see them now. We're getting on top of things now that we have back our medical reviews. Yes.

R

Very good. So which areas of your practice have been affected from COVID?

P003

Well, definitely the education. Yes, the education. Definitely the medication because when they come in here to the clinic, we would see everything. You know, they hand us the blister pack. So it means we talk to them over the phone. A lot of them can't read what's on the blister pack, so it means another phone call to the pharmacy. So those are just, it's adding. Just because they're not sitting here or sitting on the corridor waiting to come in, it doesn't mean the workload has reduced. It's actually probably got busier, you know, because we're, you know, going through the medicines and also we've to make the call. We don't see them. When they're telling us they're short of breath and then in the atmosphere or the climate of COVID, you've got to say to yourself, 'Is this heart failure or is it COVID or what are we dealing with here?' So it just adds an extra pressure. It's definitely an extra pressure. Yes.

R

Definitely. And from all those challenges you just mentioned or pressure points, which one would you like to prioritise?

P003

Which one would I like to prioritise? Get rid of COVID.

R

All of them?

- HF clinic supporting the implementation
- Family support
- HCP against attitudes
- Traditional medication review process
- Medication strategies used by patients
- HCP Perceptions of the app
- Multiple HCP changing medication
- Use of app - new practice for HCP
- HCP recommending or promoting the app
- COVID-19 positive experiences
- COVID-19 affecting HCP work routine
- mHealth system Attend Anywhere
- HF clinic pressure points
- Medication challenges
- HCP preferences and aspirations

Coding Density

- COVID-19 negative experiences

P003
Yes, all of them or none of them. You know, they're all...

R
Important?

P003
You know, they're all important, part of, you know, you assess the patient. They're all interlinked, you know. Based on their assessment then, we titrate up with their medicine. So the medicines are very important. We know exactly what they're on, you know, that they're not on 40 of Lasix and they're telling me they're on 40 of Lasix and they could be on 80 of Lasix. So you know, and I'm here going over now thinking that he's only on 40. So they're all kind of interlinked. So everything is important. Yes.

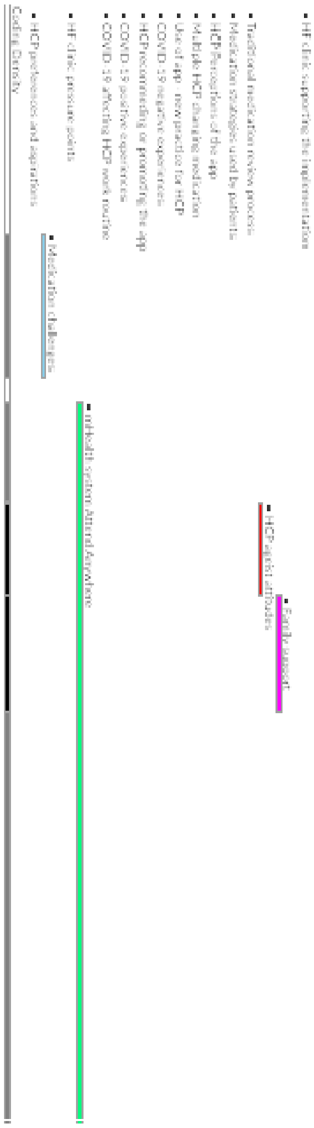
R
And my last question here on mobile health technologies and COVID, I've heard you've been using a web portal called Attend Anywhere. So how is that going?

P003
So that's not going at all because we've got trained up. We've got our passwords. We've got our equipment, but again, it's like we had a few patients. I even have a list of them there. That we were identifying that would buy into it because you do have to be kind of a bit savvy with the technology and a lot of the patients aren't, but that's fine. We were prepared. A lot of them have a family member that would bring them to the clinic, so we said maybe when we send out the application, the family member would be with them in the house or whatever and give them the link. But again, that's just a bit... That's work, do you know what I mean, that's something we have to coordinate. So we haven't, unfortunately. And then, you know, we had annual leave. We had sick leave. All these things impact. You know, we're busy as it is, besides bringing in a new... I mean it would help. I think it would help because we could see the patient. We could look at the blister pack. It would be a brilliant help, but it's just a matter of getting the patient to buy into it and that's the challenge. A big challenge.

R
So maybe it might work for other areas, like I don't know, dermatology or something, where you have patients from 16, 18 to whatever it might be.

P003
Yes, yes.

R
In a particular client.



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P003
Yes.

R
You still haven't, not seeing the value, but it's hard because of the barriers.

P003
Yes, the barriers, yes, yes.

R
Of your population or the people you see.

P003
Yes, yes. We were full of it. We'd it all set and then something might, do you know, we've had a few different things, you know, bereavement, family bereavements. We've had, you know, family issues and you know, there's been an awful lot that has happened here in the heart failure clinic actually between us all in the last few months, so just getting our heads around it. Something new.

R
Fair enough, fair enough. So now, the following questions will explore the medication management process. So briefly because I know, I interviewed you last year.

P003
Yes. Yes.

R
So I kind of know, but can you briefly describe how medication management is done face to face? So when the patient comes in.

P003
Yes.

R
And you assess him, so.

P003
This is pre-COVID?

R
Pre, yes.

P003
Pre-COVID, oh yes.

- HF clinic supporting the implementation
- Family support
- HCP against attitudes
- Traditional medication review process
- Medication strategies used by patients
- HCP Perceptions of the app
- Multiple HCP changing medication
- Use of app - new practice for HCP
- COVID 19 negative experiences
- HCP recommending or promoting the app
- COVID 19 positive experiences
- COVID 19 affecting HCP work routine
- mHealth system Attend Anywhere
- HF clinic pressure points
- Medication challenges
- HCP preferences and aspirations

Coding Density

R
Face to face, pre-COVID, yes.

P003
Oh yes. How many visits each patient would have like or?

R
How it works. How do you review the medication?

P003
Oh yes, oh yes, when they come in.

R
When they used to come in.

P003
The patient comes in. We check their blood pressure, get a renal profile and assess them, dizzy, lightheaded, do the usual kind of assessments. And if we're happy enough, we'll go titrate up their medicines and that happens. Yes, that's the way it works. Yes.

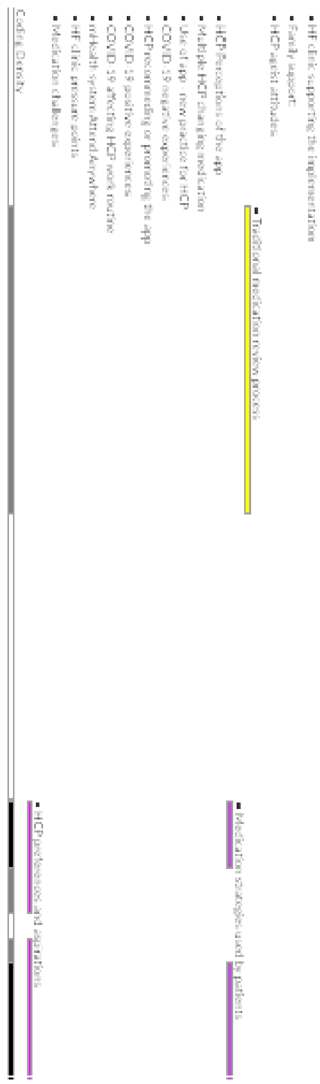
R
So from those patients that you see, or you used to see before COVID, 24, 25 on a Wednesday.

P003
Yes.

R
What are the strategies they prefer to keep the medication list? What do they prefer? Do they prefer to bring it to you?

P003
Some of them will just bring a list. Some of them bring a list. Some of them don't bring anything and others bring the tablets. So with the patients, it varies, but we the nurses actually, we like to see the medicines, regardless of lists or anything. We actually like to see and even for them to bring in the box and say, 'I take one tablet out of that'. Yes, you know what I mean, actually, that's the way we like to know. Yes, yes.

R
And for those ones that bring you the blister pack, does the pack have all the names listed or you just look at them?



P003
Yes, all of them. No, no, the blister pack has everything in the pack and the names of the medicines, so we look at that. Yes.

R
And you like that one because it's more reliable?

P003
I like that one, yes.

R
Or more up to date.

P003
And I know that they push out that little thing and I know that that's the tablets that are in that. And that's done on a weekly. Sometime the pharmacy will do it on a monthly and then if patients are finding it very difficult or they're not that compliant or they might forget to take them and they might have all these blister packs at home, we link in with the pharmacist and we say, 'Listen, I think this patient is suitable for just a weekly blister pack'. So we know. Then they go back to the pharmacy in a week's time to say yes, they've taken all those tablets. Can we give them a new one? And if we make any adjustments, we link in with the pharmacist as well. Yes.

R
From those ones that you used to see before COVID, let's say 20 a day, how many of those patients will have medication error or medication that was missing or medication that the dose was not up to date?

P003
Even before COVID? Yes.

R
Before COVID.

P003
Yes.

R
From 20 that you'll see one day, approximately?

P003
Well, I mean the 20 on a Wednesday now, they mightn't always be titrated. Yes.

R
Yes, but approximately, let's say that you used to see 10 on a morning.

- HF clinic supporting the implementation
- Family support
- HCP agent attitudes
- Traditional medication review process
- Medication strategies used by patients
- HCP Perceptions of the app
- Use of app - new practice for HCP
- COVID 19 negative experiences
- HCP recommending or promoting the app
- COVID 19 positive experiences
- COVID 19 affecting HCP work routine
- mHealth system Attend Anywhere
- HF clinic pressure points
- HCP preferences and aspirations

Coding Density

- Multiple HCP changing medication
- Medication challenges

P003
Yes.

R
How many approximately -

P003
Of that 10, yes.

R
- will have a change in their medication?

P003
That wasn't right? Is that what you mean?

R
Yes, yes, yes.

P003
Yes.

R
One? None? 10?

P003
It could be one. Yes, no, no, not 10. Yes, it'd be, again, there would be some, but there'd be one or two, yes, one, yes.

R
Ok, one or two from 10?

P003
Yes, out of 10. Yes, yes.

R
Because I'm just trying to ascertain is it something that it happens?

P003
I suppose say on a weekly, we could have two or three, you know what I mean.

R
Out of 40?

- HF clinic supporting the implementation
- Family support
- HCP patient attitudes
- Traditional medication review process
- Medication strategies used by patients
- HCP Perceptions of the app
- Multiple HCP changing medication
- Use of app - new practice for HCP
- COVID-19 negative experiences
- HCP recommending or promoting the app
- COVID-19 positive experiences
- COVID-19 affecting HCP work routine
- NHS system Attend Anywhere
- HF clinic pressure points
- Medication challenges
- HCP preferences and aspirations

Coding Density

P003
Two or three, and this is even pre-COVID now. We're still seeing or talking to the same patients, still making adjustments. Oh god, how many patients do we see a week? 50, 60. Yes, 50.

R
From 50, two, three will happen a medication issue?

P003
Three or four, yes, yes, issue, yes, yes.

R
And would you say that this was more pronounced before COVID or what's the situation now with COVID?

P003
Yes. That's a good question because you know, we find even that, yes, I suppose, god, I'm trying to think now. I wouldn't say there's a huge difference, would you believe it, and that's credit to the fact that we talk to the pharmacists and it's nearly a matter of course now, where sometimes if you're busy in the clinic, you mightn't just get to talk to the pharmacist if the patient didn't bring their medicines or you might leave it until... Or you might go on an old list that they have or... I think, yes, I think there's probably not a huge difference. I wouldn't say there's a huge difference.

R
Ok, pre and post, there's no...?

P003
Pre and post, I don't think there's a huge difference, yes.

R
But having the ability or the time because you don't see many patients face to face now, give you the ability of?

P003
I think that that gives you kind of time to get your head around it. Yes, yes. I do think that. Yes, I think so. But it adds more pressure, I suppose. Yes. It's hard to...

R
And now this is my last set of questions and it's just around the app, the intervention.

P003
Oh yes.

- HF clinic supporting the implementation
- Family support
- HCP apriori attitudes
- Traditional medication review process
- Medication strategies used by patients
- HCP Perceptions of the app
- Multiple HCP changing medication
- Use of app - new practice for HCP
- COVID-19 negative experiences
- HCP recommending or promoting the app
- COVID-19 positive experiences
- COVID-19 affecting HCP work routine
- mHealth system Attend Anywhere
- HF clinic pressure points
- Medication challenges
- HCP preferences and aspirations

Coding Density

R
The app, right. So are you aware that any of your patients have used any medical app before? Medical app for a scale that might be connected to an app?

P003
Oh yes. There's only a handful of patients. There was another research study, ProACT. Yes.

R
So you've seen that?

P003
Yes, yes. And just a handful of patients. Not a lot.

R
But that was linked to a project?

P003
Linked to a project. But other than that, it's not, no.

R
Are you aware if any of your patients have ever a medication app before?

P003
Not that I'm aware of, yes.

R
And looking back at the Medisafe app, the one I showed you last week, right? Do you understand how it works?

P003
Not really. I didn't probably have a good look at it. Yes, yes.

R
So if you were to describe briefly this app to an older person coming into the clinic, what would you say about the app? What is it for?

P003
Well, yes, this is what I would. My understanding, listening to you and reading and that, and I haven't actually played around with it myself, but I gather it's a little app, a little machine, a little iPad and it's basically there for the patient to record all the medicines and any changes and how they feel when the changes happen. Yes. So that's my understanding of it.

- HF clinic supporting the implementation
- Family support
- HCP ageist attitudes
- Traditional medication review process
- Medication strategies used by patients
- Multiple HCP changing medication
  - Use of app - new practice for HCP
- COVID 19 negative experiences
- HCP recommending or promoting the app
- COVID 19 positive experiences
- COVID 19 affecting HCP work routine
- mHealth system Attend Anywhere
- HF clinic pressure points
- Medication challenges
- HCP professions and aspirations

Coding Density

- HCP Perceptions of the app

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R
Would you think that this medication app will fit with the goals of the clinic? The goals in general, the aims of the clinic?

P003
Oh yes. Well, the aims are to try and get them on the right medicines. Also for them to kind of just be empowered, you know, self-care, so it definitely would fit in with that ethos. Yes.

R
And would you promote the use of this medication app with your patients after let's say we'll try it with six patients? Would you promote that app after the intervention? Would you tell any patients?

P003
Well, hopefully it helps them. I don't want to confuse them completely and utterly, but I mean if it helps them and they buy into it, yes, that's fine by me. Yes. I wouldn't stand in their way.

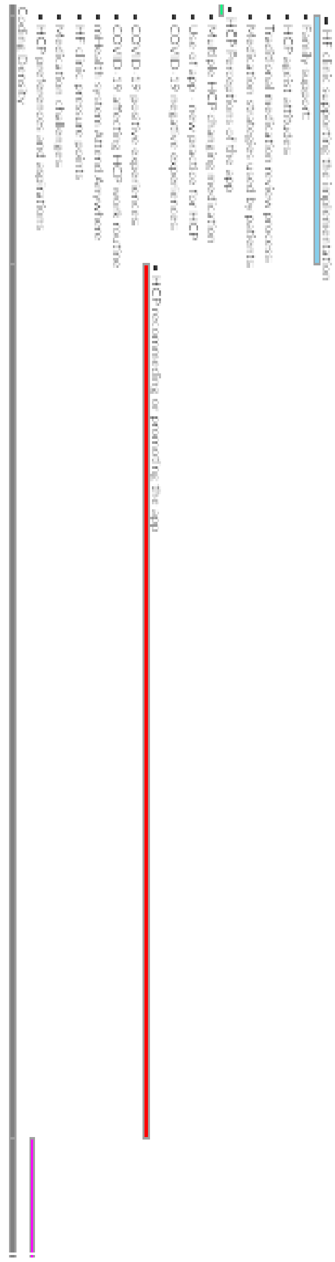
R
And if you were to promote this app down the line -

P003
Yes.

R
- after the intervention, how would you do that? Would you tell them in person when they're coming in here or would you talk to all the colleagues when you're having a coffee or?

P003
Well, we'd discuss it amongst ourselves definitely. We'd discuss and see, you know, will this suit the patients, you know, who are we going to... How are we going to implement this change? And so we'd kind of have a discussion ourselves and then I suppose each of us, you know, we're all kind of empowered ourselves to identify patients then that would. So I'd leave it like that. You know, we'd identify and have a chat with the family and as I said, this is another way of keeping a close eye or just like we give them a little booklet at the moment. We write down their medicines. We like them to weigh themselves and we like them to check their blood pressure and heart rate now. So this'd be just another part of the education. So I suppose that's the way we'd introduce it.

R
Do you feel that you need training in order to use this app? Training as how it works, the app?



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P003

Yes. Yes. We would.

R

And how would you like to get this demonstration or training? Would you like me to come here physically and demonstrate how it works or would you like me to just give you some instructions on a piece of paper and then you sort it out or would it be more beneficial if I come in here and talk to two of you and then the following day just show you how it works?

P003

I suppose well, you've shown us a certain amount how it works, but I suppose would it be another idea of having a kind of a trial run of it with patients? Would that be a way of going?

R

No, but for you, for the nurses, for the healthcare staff?

P003

The nurses.

R

Yes, for you.

P003

To know exactly how it works?

R

Yes, yes.

P003

Yes, yes. Well, I think it would be nice if you had a group of us together. Yes, if we can, yes.

R

So it would be a matter of organising that. Ok, ok. And lastly, what sort of impact or benefit do you think this app will have on patient care?

P003

Well, hopefully it would be positive, you'd hope, yes, yes, yes.

R

And the last question, tell me about any aspiration you might have about the app supporting patients?

- HF clinic supporting the implementation
- Family support
- HCP special attributes
- Traditional medication review process
- Medication strategies used by patients
- HCP Perceptions of the app
- Multiple HCP changing medication
- Use of app - new practice for HCP
- COVID-19 negative experiences
- HCP reconsidering or promoting the app
- COVID-19 positive experiences
- COVID-19 affecting HCP work routine
- mHealth system Altered Anywhere
- HF clinic pressure points
- Medication challenges
- HCP preferences and aspirations

Coding Density

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P003

Well, I mean, you know, as far as I can see at the moment, it's you write down. You write it in and then hopefully the patient makes the changes, and that's what you're hoping will happen. Yes. And then say if they go to the GP, are we hoping to link them in to make the changes and the patient to make the changes? You know, is that going to happen? And maybe the pharmacists, are they aware of what's on the app? So that's where I'd have the difficulty, that we're kind of out on our own still. It hasn't changed things. I mean at the moment, we write it down on a piece of paper, but this is just changing it into an app and it hasn't really changed. A major change, yes. My aspirations would be definitely to link it in with the... And especially now that we're going into integrated care as per Sláintecare.

[0:20:00]

You know, these things, we have to be linked with the community pharmacists and the community GP definitely when it comes to medicines. That's the only way it's really going to make a big difference. Yes, yes.

R

Everybody working from the same page.

P003

Yes, from the same page and understanding why patients are coming to the heart failure clinic. Yes. And that they're not being titrated on their medicines just for their blood pressure. It's for their actual heart to prevent the disease progressing. Yes. That's the reason why these are.

R

That's grand. Well, that's the end of the interview. Do you have any questions for me?

P003

I don't think so.

R

No? Ok. Thank you very much.

End

- HF clinic supporting the implementation
- Family support
- HCP-patient attitudes
- Traditional medication review process
- Medication strategies used by patients
- HCP Perceptions of the app
- Multiple HCP changing medication
- Use of app - new practice for HCP
- COVID-19 negative experiences
- HCP recommending or promoting the app
- COVID-19 positive experiences
- COVID-19 affecting HCP work routine
- mHealth system Attend Anywhere
- HF clinic pressure points
- Medication challenges
- HCP preferences and aspirations

Coding Density

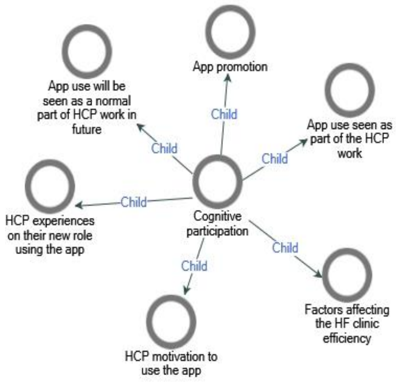
Appendix Q: Code book containing the list of codes emerging from the data (HCPs)

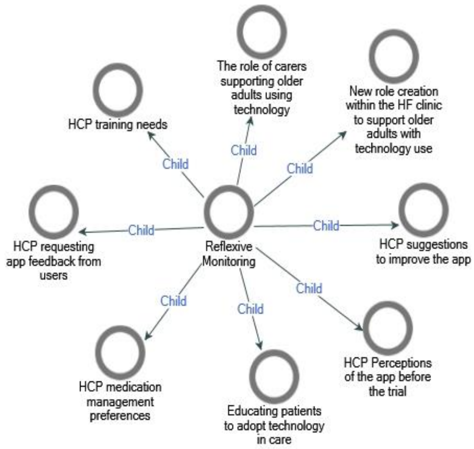
Name	Description	Files	References
App currently part of HCP work	Refers to HCPs seeing the app as imbedded in their current clinical practice	3	4
App feedback	Refers to HCPs seeking app feedback from patients using it	3	3
App helps with medication or medication review	Refers to the app supporting the medication review process while the patient visits the clinic and how? Also if the app supports medication self-management for the older person at home and how?	3	15
App will be a normal part of HCP work	Refers to HCP seeing the app as part of their clinical practice in future	3	3
Challenges to app use (HCP)	Refers to HCP highlighting barriers/challenges they foresee to the implementation of the medication app in the clinic (HCP and patient point of view). Also, if the HCP perceives as their role to discuss/promote the app with the patients during the clinic visit	3	12
COVID-19 affecting HCP work routine	Makes reference to how the COVID-19 pandemic affected HCPs' work routine/clinical practice	5	13
COVID-19 negative experiences	Makes reference to negative experiences during and after the COVID-19 pandemic in the HF clinic	4	8
COVID-19 positive experiences	Makes reference to positives experiences learnt/informed by COVID-19 pandemic in the HF clinic	4	8
Creation of a new role in the clinic	Makes reference to HCPs insights on the need for a new role within the clinic teaching and supporting patients to use the medication app	3	5
Educating patients	Refers to HCP highlighting the need to educate HF patients. Also to technical support and education on how to use the app for patients	4	8
Family support	Refers to HCPs highlighting the need and value of family support for older people using the app or technology in general	5	5
HCP ageist attitudes	Refers to HCPs ageist attitudes towards their older patients in the clinic	7	17

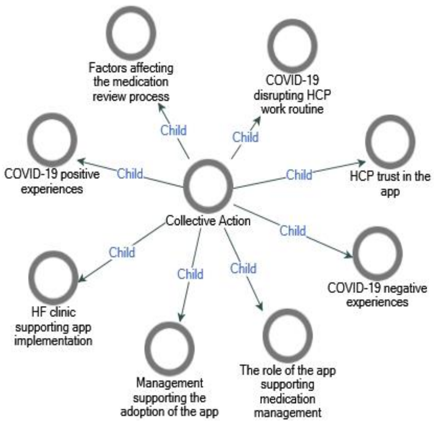
HCP aware of their role with the app	Refers to HCPs awareness of the difference between the traditional care pathway and using the app during the consultation. Also, does HCPs is aware of how to use the app or interact with the patient using the app?	4	7
HCP finds the app to be of benefit to patients	Refers to the HCPs acknowledging the value and benefits added (or lack of) using the app (benefits for patients, adding value to their clinical practice). Also HCPs providing examples of the benefits (if any)	6	16
HCP lack of experience using technology with patients	Refers to the HCPs lack of experience using technology with their patients during their clinical practice. Also refers to the HCPs technological training needs/gaps	3	9
HCP meeting management	Makes inference to HCPs meeting with management (frequency and type of discussions held at such meetings). Also HCPs exploring the possibility or opportunity to discuss implementing/scaling the use of the app in the HF clinic with management	3	5
HCP motivation to use the app	Refers to HCPs motivation to use the app with their patients. Also exploring why they decided to participate in the study?	3	5
HCP perceptions of the app	Makes reference to HCPs understanding and perceptions of the medication app before the start of the intervention	4	8
HCP preferences and aspirations	Refers to HCPs preferences and aspirations regarding the capabilities of the app. What HCPs would like the app to do for their patients? It also refers to ascertaining what app capabilities HCPs would like to see in the app?	8	24
HCP recommending or promoting the app	Refers to HCPs recommending and or promoting the medication app with patients during the consultation. Also refers to HCPs highlighting the challenges they may face if they were to promote the app during the clinic visits with patients	8	28
HCP trusting the app	Refers to HCPs trusting the app	3	3
HF clinic pressure points	Refers to HCPs highlighting the HF clinic pressure points	4	10
HF clinic supporting the implementation	Makes reference to HCPs views on management support for the implementation of the app? Also, if the app is a good fit with the clinic aims?	6	9

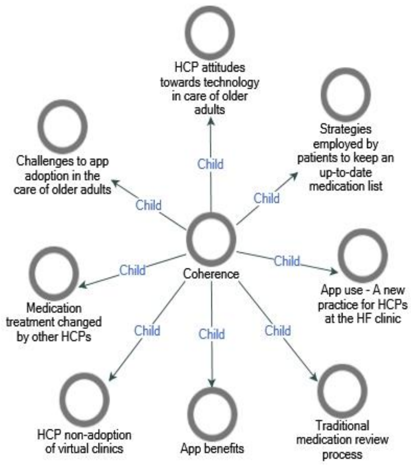
Medication challenges	Refers to medication challenges experienced by the HCP and the older person self-managing at home	8	33
Medication strategies used by patients	Refers to the different medication list strategies (keeping an up-to-date list of medication) used by patients during the medication review process in the consultation with HCPs	5	8
mHealth system Attend Anywhere	Refers to HCPs experiences, perceptions and challenges using a virtual clinic platform called "Attend Anywhere" during the COVID-19 pandemic	5	7
Multiple HCP changing medication	Refers to HCPs providing examples of how other HCPs changed patients medications and how it affect their work in the clinic and patient care	5	12
Queries	Refers to HCPs overall queries about the app or the study	1	1
Traditional medication review process	Makes reference to the traditional medication review process performed by the HCPs during patients appointment	4	4
Use of app - new practice for HCP	Refers to HCP understanding of the new role using the app, how this practice is different to the traditional care pathway. Also if the new practice using the app was easier or difficult than they anticipated. Refers also to HCPs awareness of any current or past projects in the clinic using technology?	8	20

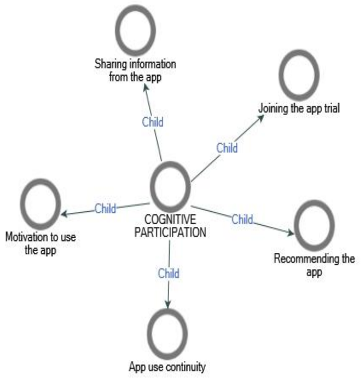
Appendix R: Themes mapped onto NPT coding framework (HCPs followed by patients)

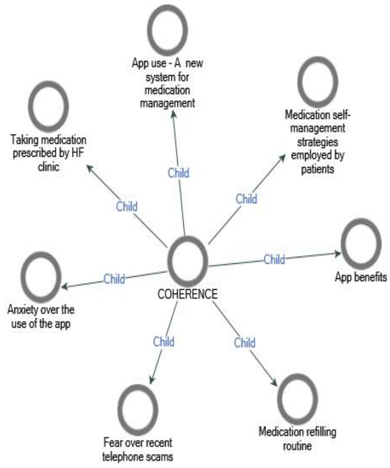


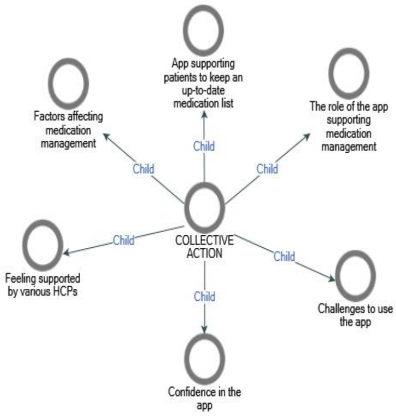


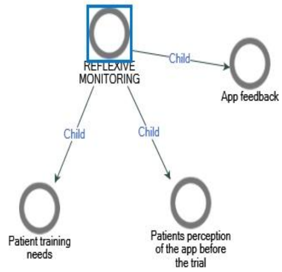





COGNITIVE PARTICIPATION
Sharing information from the app
Joining the app trial
Motivation to use the app
Recommending the app
App use continuity
Child
Child
Child
Child
Child


COHERENCE
App use - A new system for medication management
Taking medication prescribed by HF clinic
Medication self-management strategies employed by patients
App benefits
Anxiety over the use of the app
Fear over recent telephone scams
Medication refilling routine
Child
Child
Child
Child
Child
Child
Child


COLLECTIVE ACTION
App supporting patients to keep an up-to-date medication list
Factors affecting medication management
The role of the app supporting medication management
Feeling supported by various HCPs
Challenges to use the app
Confidence in the app
Child
Child
Child
Child
Child
Child


REFLEXIVE MONITORING
App feedback
Patient training needs
Patients perception of the app before the trial
Child
Child
Child

Appendix S: Guide developed to support the participant recording vital parameters data (blood pressure and weight).

Open The app

To select Weight or Blood Pressure go to More

BOTTOM of The screen

Home Updates Medication More

Press More Then Press Measurements

Measurements

Diary

Appointments

Doctors

Reports

Select and Press Blood Pressure from The list

Press The symbol + on The top right corner

Press Systolic (high) and enter The first number on your machine

Press Diastolic (low) to enter The 2nd number on your machine

Press Save on The top right corner

Press The arrow ← on The left corner (Top)

Press The X to exit Measurements (Top left corner)

For WEIGHT

Select and Press Weight from The list

Press The symbol + on The top right corner

Enter The number (your weight on The day)

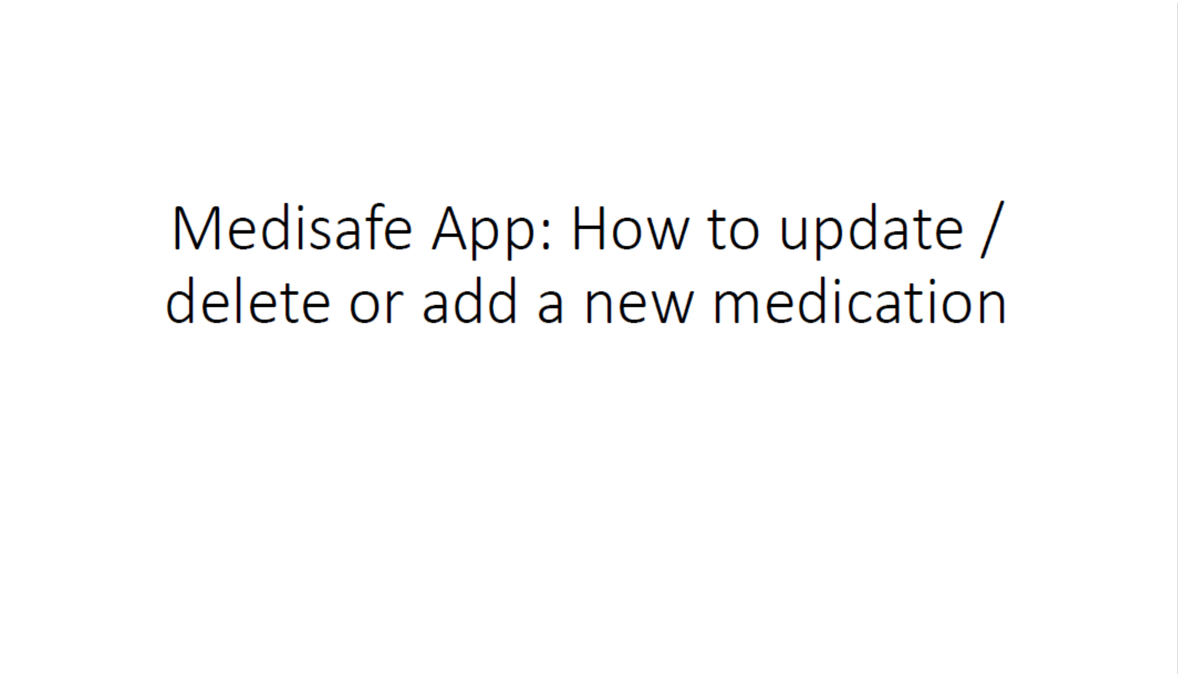
Press Save on The top right corner

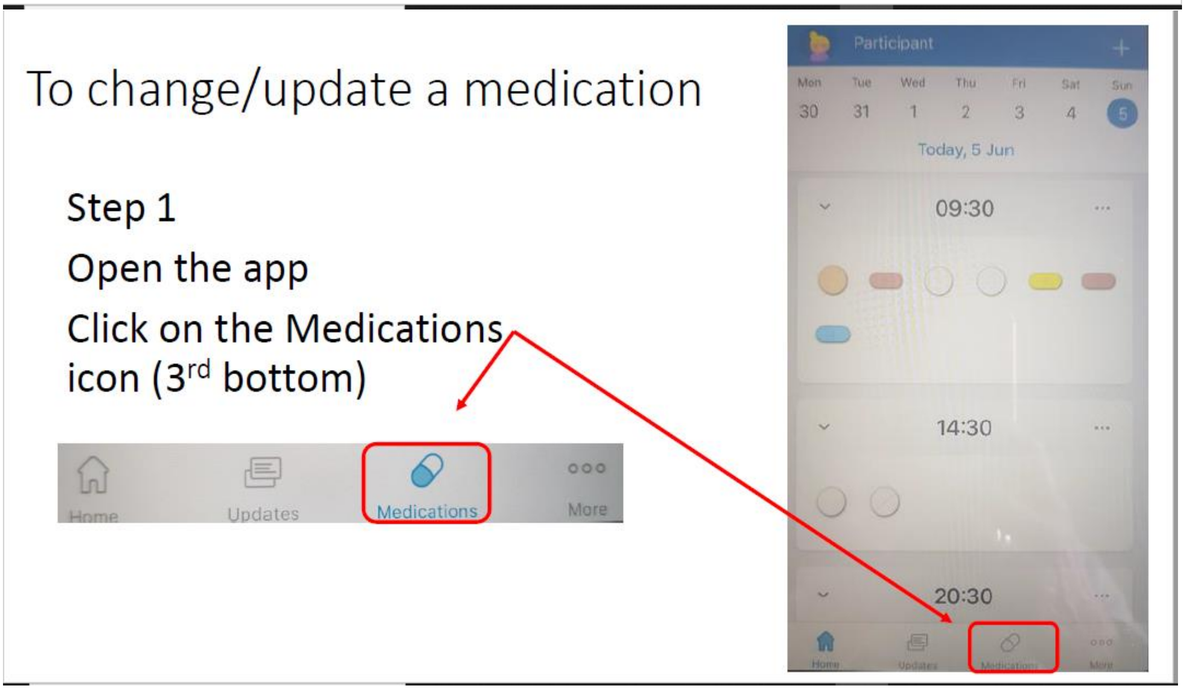
Press The arrow ← on The top left corner

Press X on The left corner (TOP) to exit Measurements

Press Home Bottom left corner to see your medication.

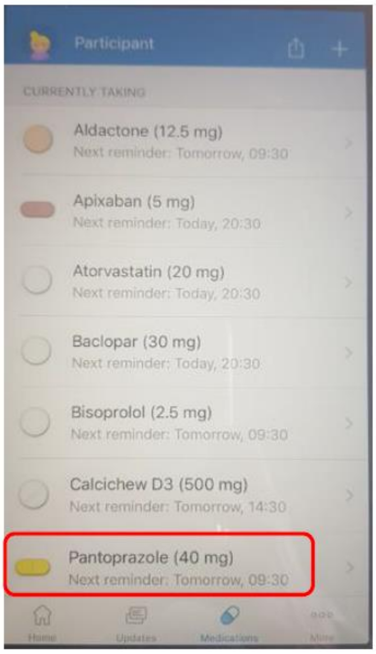
Appendix T: Manual developed to support the participant to independently update/add/delete a medication from the app after the trial



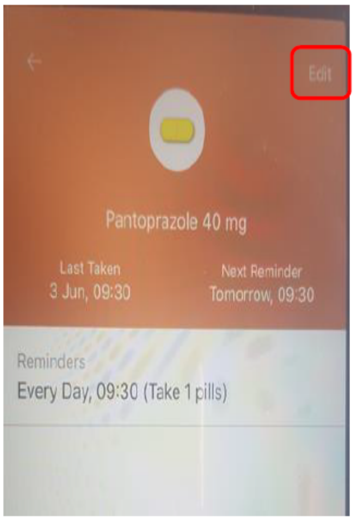


Step 2

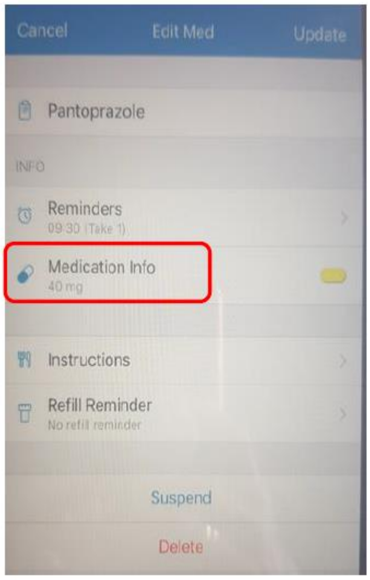
Tap on the medication you want to change, for example, Pantoprazole.



Tap “Edit” on the top right corner



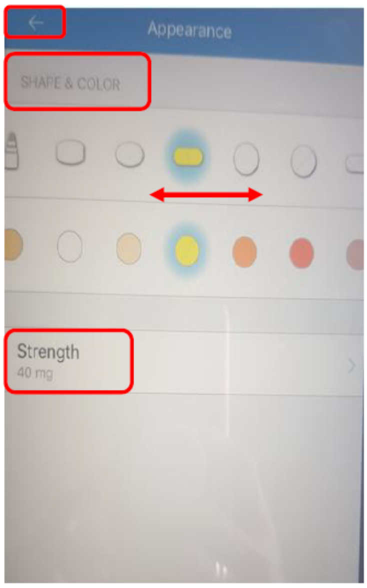
Tap “Medication info”



*For changing the tablet shape & colour, tap on “Shape and colour”. Swipe right or left until you find the desired one.

Tap “Strength” to set up a new value.

Tap on the arrow on the top left corner to exit this page when you finish.

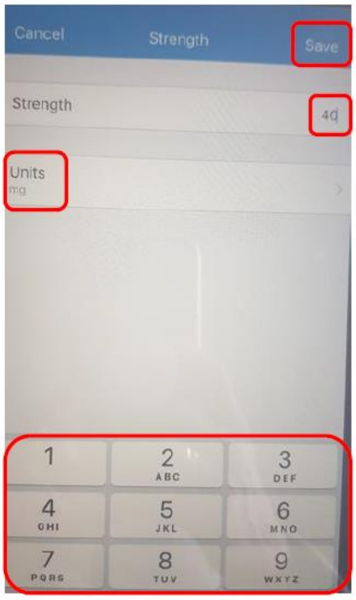


Input the value by choosing the correct dose on the numbers pad.

For example if the dose is increased from 40mg to 60 mg, press the number 6 followed by 0.

Then tap on “Units” and select “mg” for milligrams.

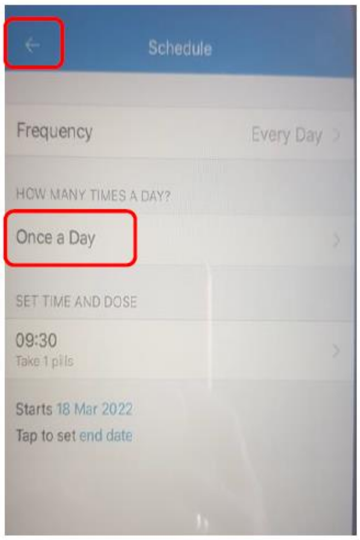
Press “Next” on the top right corner to exit the page.



Tap “Once a day” under “How many times a day” to schedule how many times a day you take the tablet.

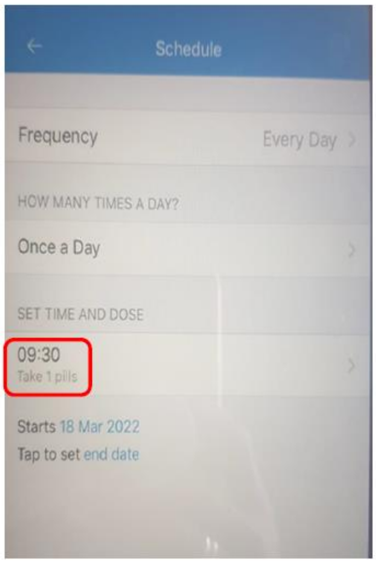
For example, once, twice or three times a day.

Then tap Next on the top left corner to exit the page.



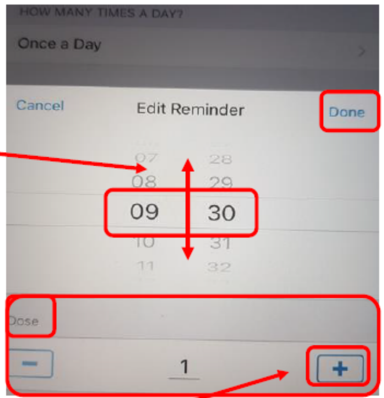
Tap the time under "Set time and dose" to change the time for a tablet.

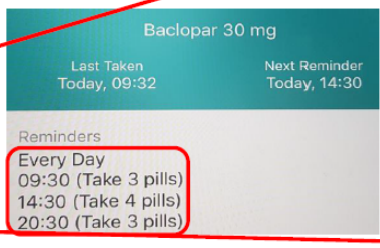
* "Frequency" should not be changed if you take the tablet every day.



Change/schedule the time for each time of the day (by scrolling up or down). If you take the tablet twice a day, pick 2 times a day (9.30 am & 2.30 pm).

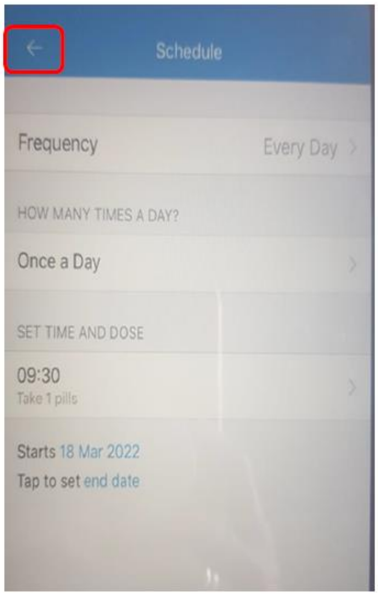
Tap "Dose" to indicate how many tablets of the same medication you take at each time of day. If you take 3 tablets, press the + symbol 3 times. Tap "Done" to exit.





Tap the arrow on the top left corner to exit the page once you finish setting up:

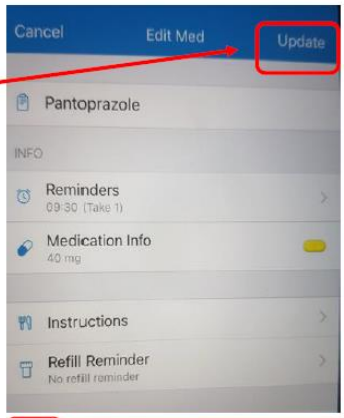
- How many times a day you take the tablet
- The time & dose
- The reminders

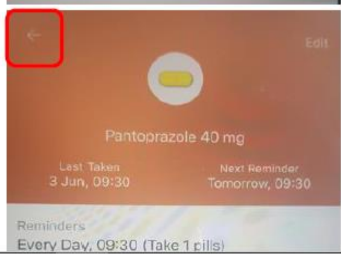


Press update on the top right corner.

Then tap the arrow on top left hand corner.

That's it, you successfully updated your medication!!





To delete a medication

Step 1 (as above)

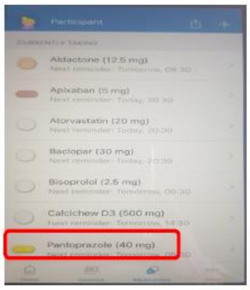
Step 2 (as above)

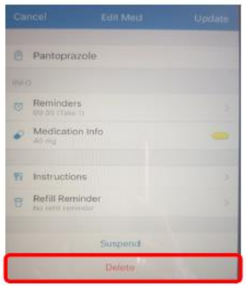
Click on the medication you want to delete

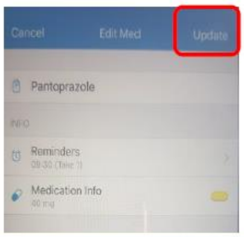
Tap "Delete"

Tap "Delete history"

Tap Update on the top right corner







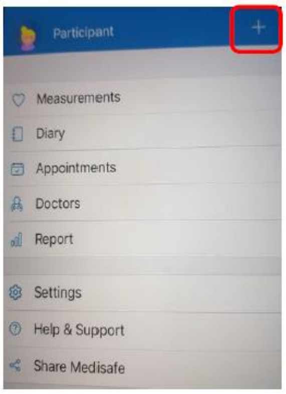
To add a medication

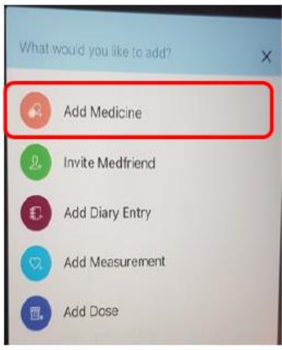
Open the app (Step 1 above)

Go to "More" as below

Tap the + symbol on the top right corner

Tap "Add medicine"

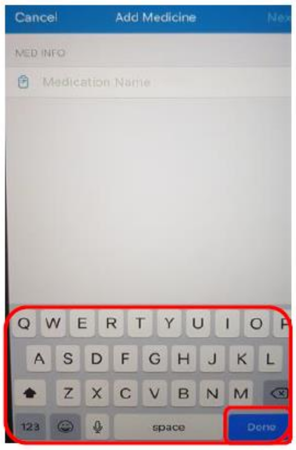


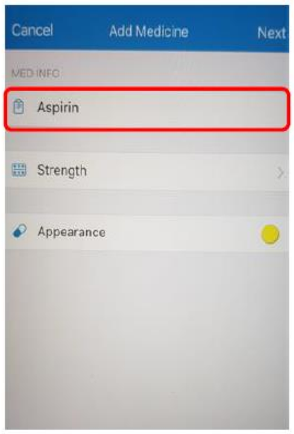


Type the name of the medication on the keyboard.

In this example, Aspirin was selected.

Tap “Done”.

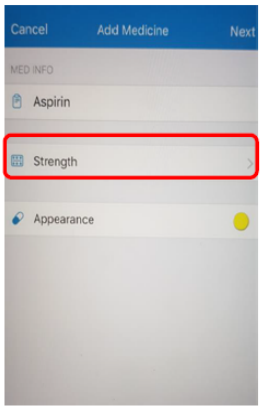


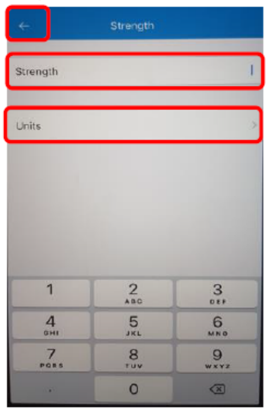


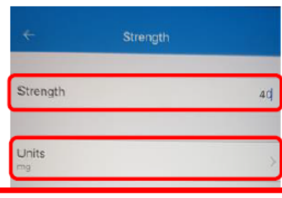
Tap “Strength” and select on the keyboard the strength of the medication and the unit (mg).

In this case, 40 mg was selected.

Tap the arrow on the top left corner to exit the page.



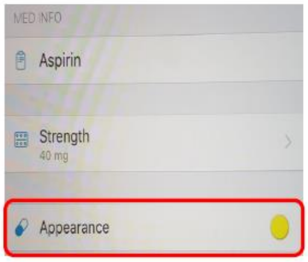


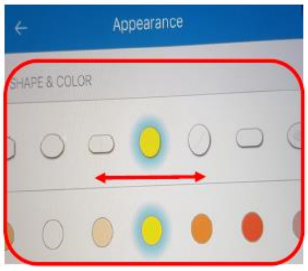


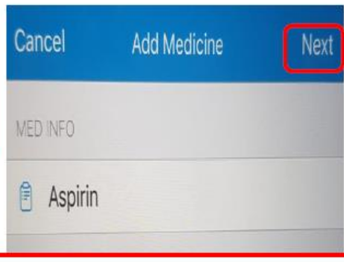
Tap “Appearance” to chose desired shape and colour of tablet. Swipe right or left to find different options.

Tap the arrow on the top left corner to exit the page.

Then tap next on the top right corner.



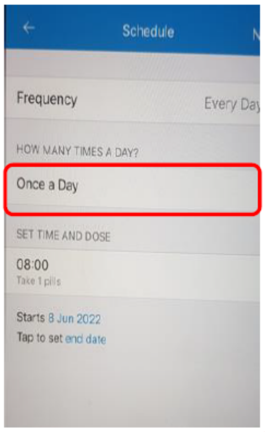


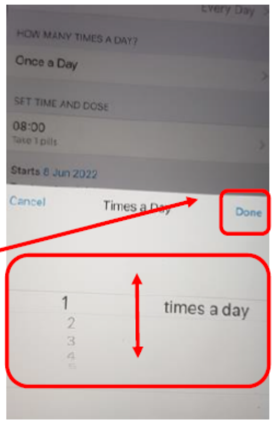


* “Frequency” should not be changed if you take the tablet every day.

Tap under “How many times a day” to indicate if the tablet is to be taken once, twice or three times a day.

Then tap “Done”



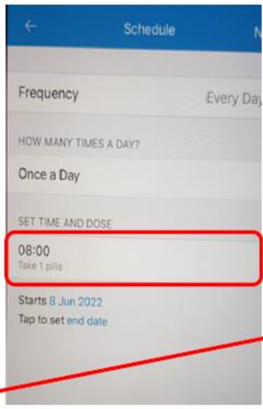


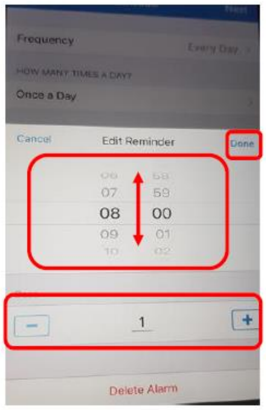
Tap under “Set Time and dose” to schedule the times for the tablet. Scroll up or down to select the time.

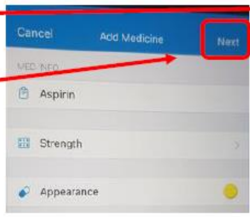
Tap “Dose” to indicate how many tablets of the same medication you take at each time of day. If you take 3 tablets, press + symbol 3 times.

Tap “Done” when you finish.

Tap “Next”.







Tap “Done”

Medication added successfully!!

Tap Continue to home screen.