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Value Cocreation in Health

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Abstract

A shift in the focus of healthcare from diseases and treatment to wellness and prevention has contributed to the widespread acceptance and commitment to adopt preventive healthcare practices – including preventive health applications (apps) and devices. The aim of these apps and devices is to equip the user with information about their health to enable them to make better lifestyle choices that will positively impact their health in the long run. However, the use of these preventive health apps and devices is pervaded by a high user dropout rate. This draws attention to the way these technologies are designed.

Recently, design frameworks for technology taking account of the values of users have arisen. These surface value explicitly and enable the use of value to incentivise action on the part of users towards prevention. Improvements in the effectiveness and efficiency of such frameworks offer new opportunities to use value to achieve behavioural change. As healthcare delivery and management becomes increasingly digital and used by highly diverse populations, understanding the role of value as an incentive gains importance. Many attempts at digitalisation of healthcare systems (particularly when we try to do things at scale) have failed and one potential reason for this is the different (and often competing) value systems of the stakeholders and different notions of value they use to judge and motivate use of the system.

This thesis addresses value and value systems as a key factor in the development of healthcare systems and investigates how such an approach could be taken. Taking Value Sensitive Design (VSD) as a starting point, we analyse the role of stakeholder value. Motivated by our empirical experience we extend VSD to take account of the emergence of value through interaction.

The main contributions of this thesis are: (a) The empirical analysis of a large-scale pilot on the adoption of wearable health technology and (b) motivated by this empirical analysis, the development of the Value Cocreation Design (VCD) framework (an extension of the VSD framework). VCD is a novel model that shifts the design focus from creating value to cocreating value. VCD focuses on the services that actors exchange in order to identify value in contrast with VSD that uses a predefined framework of values that the designer expects users to hold. The VCD framework is validated using empirical evidence obtained from the Berkshire Wearable Technology Pilot study. We also evaluate VCD by applying it to the Berkshire Wearable Technology Pilot. This exemplifies its application in a real-life design scenario.

Lay Summary

A shift in focus of healthcare from treatment to prevention has contributed to the development and use of preventive health practices and technology. But despite the potential long-term benefits of preventive health technology (apps and devices), they are plagued by a high user dropout rate. Hence, it becomes important to investigate how these technologies are designed. Many attempts at digitalising healthcare systems have failed, potentially due to the different (and often competing) value systems and perceptions of the direct and indirect users of the system. Thus, a closer look into technology design frameworks that enable the incorporation of users' value into the technology is necessary. This thesis investigates how value and value systems can be used in the development of healthcare systems. We introduce a novel value-centric design framework (named Value Cocreation Design) which extends an existing framework (known as Value-Sensitive Design) to shift the design focus from simply creating value to cocreating value. The development of the Value Cocreation Design (VCD) is motivated by and validated using findings from a large-scale pilot study on the adoption of wearable health technology. The VCD framework is also evaluated by its application in a real-life design scenario.

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Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

(Uchenna Chioma Nnabuko)

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Chapter 1

Introduction

1.1 Research Problem Statement

In recent times, healthcare policy has undergone and is undergoing transitions from a focus on diseases and treatment to prevention and wellness. National Health Service (NHS) England described “getting serious about prevention” as a crucial step towards building a healthier nation (NHS England, 2014). Often, preventive healthcare (also called preventative healthcare) usually includes tests and examinations, screenings, and immunisations; commonly known as medical preventive healthcare. However, true preventive health requires the efforts of the healthcare organisations and the individuals to be successful and efficient. In 2000, about half of the deaths in the United States were due to behaviours and exposures which could have been prevented (Galea et al., 2011). The researchers also identified some of these preventable behaviours as physical inactivity, poor diet, and smoking. It is important for individuals to value lifestyle preventive measures as much as medical preventive measures.

A popular proverb says, “Prevention is better than cure”. Preventive healthcare has been reported to be beneficial to individuals as it can help improve health outcomes and consequently, reduce the mortality rate. Regular screenings can aid early diagnosis of a chronic illness which leads to early treatment which can reduce, or even eradicate, the symptoms of the illness. Healthy lifestyle choices and behaviours can prevent the onset of some chronic illness such as cardiovascular disease and diabetes. Generally, preventive healthcare can lead to better healthcare which involves improved quality of life for more people, more patient empowerment, lower health costs, improvement in the time taken to “fix” people and/or ways of ensuring that people stay “fixed” longer, more effective management of chronic conditions, decrease in unhealthy life years and

increase in healthy life expectancy (Haveman-Nies et al., 2002; Neumann and Cohen, 2009; Klein et al., 2014).

Linström *et al.* conducted a randomised controlled trial which was aimed at preventing the incidence of type-2 diabetes by introducing a lifestyle intervention (Linström et al., 2006). The intervention group received personalised counselling with the study nutritionist to enable them to achieve their lifestyle goals of weight reduction, less daily fat intake, increased fibre intake, and increased physical activity while the control group received no personalised counselling. Doctors were not involved in the trial; however, during the follow-up period of seven years, all participants had an annual visit with the study nurse. The participants included in the study had impaired glucose tolerance but no mention was made of their comorbidity (e.g. depression, heart disease) and the effect of the intervention on these health conditions. This frames the study in the silo of a particular health condition (type 2 diabetes); however, most wellness interventions have effect across multiple conditions but most study evaluations are not set up to take this into account.

However, after an intervention and follow-up period of seven years, there was 43% reduction in participants' relative risk of type-2 diabetes with the intervention group reporting better results than the control group. In this case, relative risk is the ratio of type 2 diabetes incidence rate for participants in the intervention group to the incidence rate for participants in the control group. Preventing diabetes through a change in lifestyle increased the life expectancy of about half of the participants of the prevention study.

The benefit of preventive healthcare on health costs has been hugely debated by researchers. Contrary to popular opinion that preventive healthcare measures are more cost-saving than treatment, Neumann *et al.* discovered that the cost-effectiveness ratios for both interventions were similar (Neumann and Cohen, 2009). Of all the preventive measures they studied, only two (child immunisations and counselling on the use of low dose aspirin) were reported as cost-saving by all three literature reviews investigated (which mostly focused on clinically recommended preventive measures). A measure is *cost-saving* when it decreases the associated cost while it is *cost-effective* when its benefits outweigh its associated costs, even if money is not saved. The cost saving ratio was in dollar per Quality-Adjusted Life-Years (QALYs) which takes the length and quality of life into account (e.g. to be free from pain for one year). Since the interventions reported in these reviews focused on clinically recommended preventive measures, measures practised outside the health system, including individual-based

lifestyle preventive measures, were not captured.

Similarly, a National Institute for Health and Care Excellence (NICE) review of the cost-effectiveness of 200 preventive health interventions reported 15% as cost-saving and 70.5% as cost-effective (British Medical Association, 2017). These interventions included mass media campaigns to promote healthy eating and policy to reduce the access of young people to cigarettes. Hence, preventive healthcare measures evidently provide good value for money paid; however, there is no substantial evidence that they reduce costs while improving health outcomes. More emphasis should be placed on the QALYs gained from these measures than on their cost-saving potentials for lifetime healthcare costs.

To support individuals in practising preventive health by adopting and maintaining healthy lifestyles, there has been an increase in the design and development of preventive health and fitness applications (apps). However, it has been observed that utility of eHealth applications and devices for preventive healthcare is “plagued” by high attrition rate (Nijland et al., 2011) as most users tend to lose interest after some weeks or months (user dropout is discussed in more detail in Chapter 2). There is a distinction between user uptake of the apps and those who become regular users of the apps. Usually, people who find utility in an app adhere to its use or adapt its use to their needs. But the problem lies in getting users to become regular users as preventive health needs to become a lifestyle that is adopted and practised over an extended period for any significant health outcomes to be observed. Hence, it requires a continuous and sustained change in health behaviours. Even a small number of specific changes (such as improving diet, reducing alcohol consumption, and increasing physical activity) would have widespread effects on individuals’ health.

There might exist many factors that influence individuals’ dropout rate in the use of preventive health apps, but I will focus on two factors which I consider most relevant to my research.

1. **Behavioural Factors:** Despite knowing the benefits of healthy behaviours, many people struggle with adhering to a healthy lifestyle (Klein et al., 2014), probably because humans are not inherently inclined to practice prevention. However, the disposition to practice prevention varies across age, health condition and social group. For instance, some individuals are described as the *worried well* because they would visit the doctor even though they do not need medical treatment while some are the *unworried well* whose behaviour is on track for illness but do not see such behaviour (e.g. overeating, not doing exercise) as risk taking but as

“normal”, probably because they had not noticed any apparent symptoms. It is likely that the worried well would be more receptive of preventive measures than the unworried well. Kelly et al. acknowledge the effect of this behavioural disposition by designing an effective study recruitment strategy to reach male study participants beyond the ‘worried well’ group (who are usually more willing to engage in health promotion programmes) (Kelly et al., 2018). Also, according to Hart’s Inverse Care Law, “the availability of good medical care tends to vary inversely with the need of the population served” (James, 2014). So, the groups with the worst education, limited social capital and the fewest resources have the least access to health services. Such individuals are more susceptible to poor health as they cannot afford some medical treatment and as a result, continue to fall behind the wealthier demographics. Generally, individuals who are more susceptible to poor health might have increased levels of motivation to practice preventive health. However, poor people with low education and social position might lack agency and feel like things happen to them rather than them making things happen. Perhaps, the key challenge for public health today is how to reach this group of individuals (those with poor health and unable to afford healthcare services) who probably need preventive health practices the most.

These behavioural factors are mostly influenced by individuals’ intrinsic motivation to practice prevention long enough to see the health benefits. In any case, change is a difficult concept for us to adopt and embrace.

2. **Technology Design Factors:** Although there are existing behavioural constructs that make it difficult for individuals to maintain an intrinsic motivation to adopt and continue healthier behaviours, technology can provide affordances to support individuals with the extrinsic motivation they might need when they are “low” on intrinsic motivation. Intrinsic motivation entails performing a task because the individual finds it inherently interesting while extrinsic motivation involves performing a task to achieve a specific outcome. This seems a bit like the notion of return on investment where the app gives the user some features (investment) and the user provides the effort to obtain the benefits (return). The user has some control over what the return can be (e.g. increased physical activity), how much return they can obtain for some investment (e.g. the ability to set step count goal) and how the return varies with investment.

The technology design factor investigates the design frameworks employed in

the development of these preventive health apps to discover effective design principles that can transform such apps into motivational and persuasive technologies (discussed in Chapter 2) that encourage individuals to use them to achieve better quality of health. For example, the use of social networks in health applications has been discovered to have a positive impact on individuals' social support measures which, in turn, can improve clinical outcomes and assist in the adoption of healthy behaviours (Nnabuko and Anderson, 2018, p. 16).

The two factors discussed are closely related to each other; however, this research will focus on the way the technology is designed and investigate affordances technology can provide to address the high user attrition rate in the use of preventive health apps. For technology to be properly adopted and used by individuals, they need to find it valuable. Hence, it is important to focus on and investigate the value-integrating design frameworks in order to provide a viable answer to the problem and support individuals in their journey to healthier lifestyles.

1.2 Study Aims and Objectives

This research was initially intended as an extension of the researcher's M.Sc. dissertation to design and evaluate a prototype for eRedbook, an electronic version of the Personal Child Health Record informally known as "Red book". This initial goal later evolved to investigating the use of wearable trackers and how they can influence individuals' health behaviours and wellbeing, specifically its role in the adoption and practice of preventive health. Findings from this investigation would support the development of a design framework for the design of value-integrating preventive health applications.

Health professionals put high value on the effects of the use of wearable technology (e.g. pace makers, ECG sensors) and preventive health apps where people adhere to the use of the technologies (Ventola, 2014a). Users with aligned values to the health professionals are prepared to make the level of effort required by the technology to gain those benefits. On the other hand, users who are either not aligned to the values of health professionals or who are not prepared to put in the level of effort required often drop out from using the technologies. So, if we want wearable technologies to be more effective we need to:

- Get the apps to return different types of value in addition to the health benefits.

- Reduce the amount of effort required to adopt the use of the apps.
- Work out what a sustainable long-term pattern of use of the apps might be.

Returning different types of value to the users affords them the opportunity to find use of the technologies valuable. But value production is social because an individual's value is influenced by the social group they belong to; thus, it is important to consider co-production as apps that are co-productive or social in nature generate a mix of different kinds of value that is significant to a wider range of people. For instance, social support channelled via apps is effective in achieving better adoption and effectiveness of the apps as reported in (Nnabuko and Anderson, 2018).

Therefore, the main aim of this research is to develop a value-integrating framework to highlight the challenges and opportunities for the design of preventive health applications as motivational technologies that can support individuals to adopt and maintain healthier behaviours. In this context, a motivational technology is a type of interactive technology that appeals to individuals' intrinsic motivations to achieve a desired behaviour or habit. This is discussed in more detail in Chapter 2. Addressing this goal gives rise to these research questions:

- How do individuals use preventive health devices to achieve long-term health benefits and behaviour change?
- How do we enable co-production of preventive health?
- What mechanisms or frameworks can be leveraged to provide incentives for preventative behaviour?
- Particularly, are value-integrating design frameworks effective and important for this?

Based on the described research problem and questions, the necessary steps required to design the proposed value-integrating design framework are broken down into objectives or tasks which also capture the chronological presentation of the thesis, where each issue is addressed in different chapters or sets of chapters.

1. Identify existing design mechanisms or frameworks used in the design of preventive health applications and evaluate their effectiveness.
2. Design and/or conduct a trial study on the natural use of wearable fitness trackers to provide qualitative and quantitative evidence for improved prevention.

3. Design a novel value-integrating design framework for the development of preventive health applications as motivational technologies.
4. Investigate the impact of the use of wearable fitness trackers on individuals' health outcomes and health behaviour.
5. Test the value-integrating design framework against empirical evidence to improve the validity of the framework.

1.3 Overview of Research Design

This is design-based research involving the conceptualisation of a design intervention which is implemented iteratively in natural settings to test the validity of established theory and generate new frameworks for designing preventive health apps. This research was motivated by the high participant dropout rate in the use of preventive health applications, which have been shown to offer long-term health benefits. As established earlier, effective preventive health will require the collective efforts of the individuals and healthcare providers to co-produce healthcare and cocreate health values. As shown in Chapter 3, existing design frameworks have not been successful in providing affordances to support effective co-production of healthcare and cocreation of health values in preventive health applications.

In order to develop this design framework, a research of existing value-centric design frameworks was performed (outlined in Chapter 3). This highlighted two frameworks which were investigated in more depth – Value-Sensitive Design (VSD) and Service-Dominant Logic (SDL). These two frameworks were merged to generate the Value Cocreation Design (VCD) framework, which is described in Chapter 4. The VCD is an incremental and iterative design framework that supports the cocreation of health by the users of a preventive health application. It was designed to target and address the identified shortcomings of existing value-centric design frameworks. This resulting framework was evaluated functionally (through testing its application to a real-life design scenario) and was validated using data obtained from an empirical study.

We thought it useful to investigate the long-term impact of preventive health applications on users' health and wellbeing using a wearable fitness tracker as a case study. The empirical study was conducted via the Berkshire Wearable Technology Pilot which was designed to test how a wearable fitness tracker can support users to

make better lifestyle choices that may improve their health and wellbeing. Detailed description on how and why the researcher became a part of the Berkshire Wearable Technology Pilot is presented in Chapter 4. The pilot lasted for twelve months and was for a cohort of 400 volunteers from the Berkshire NHS workforce. In addition to the Garmin Vivosmart HR+ device and Garmin Connect app that were used for the study, a Berkshire Wearable Patient Portal was designed and tested during the pilot study. Hence, we were given the unique opportunity of observing how these two preventive health apps were used simultaneously. Details of the pilot study are outlined in Chapter 4. Quantitative and qualitative data were obtained and analysed to provide a rich and holistic picture of participants' health and wellbeing. This data also provided evidence to support the development of the VCD framework earlier described. Evidence from the empirical study is presented in Chapter 5.

Having identified shortcomings in the design and implementation of the pilot study, the VCD framework was evaluated by applying it to the Berkshire Wearable Technology Pilot to test its application in a real-life design scenario. This entailed a hypothetical, step-by-step description of the implementation of the pilot study from the design conceptual stage to the technology design and implementation stage using the VCD framework. This is outlined in Chapter 6.

After the proposed design methodology was evaluated, it was revised, and the revised version is presented in Chapter 7. Figure 1.1 presents an overview of the four stages of the VCD framework development – discovery, definition, evaluation, and refinement.

1.4 Contributions of Research

The outputs or contributions of this research are in three forms – scientific, practical and societal outputs.

Scientific output - Design model/framework and empirical evidence

The design framework that was formulated portrays comprehensive procedures in software development to produce motivational technologies in the context of large-scale organisational use. Generalisation of the model in the given context could be limited as it was designed with a focus on the healthcare organisation; hence, other scientists would have to analytically determine which insights might be relevant to their research setting. Evidence obtained from the empirical study adds to existing knowledge on

individuals' usage patterns of wearable fitness trackers and the device's impact on individuals' health outcomes and motivation to maintain healthier behaviours.

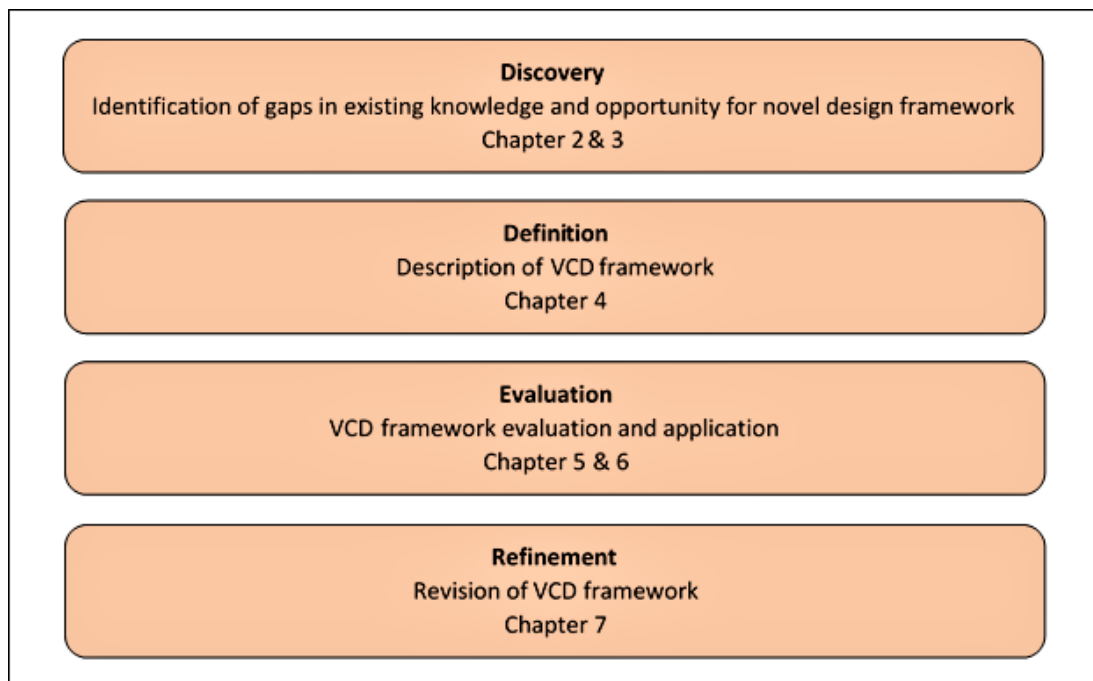


Figure 1.1: Stages of the VCD Framework Development

Practical output - Designed artefact

The Berkshire Wearable Patient Portal app is a major practical output of this research as it was designed during the research period. Most health apps end up as data silos and are unable to share data across different platforms and apps because they are heterogeneously built (Peng and Goswami, 2019). Hence, the integration of data from the wearable tracker into the patient portal is an important practical output because integrating patients' personal data with medical/clinical data will provide health and social care staff with a richer picture of an individual's health.

Societal output - Better quality health

This research contributes to improving the quality of individual and societal health as it provides tools to support the motivation and engagement of users to practice preventive healthcare. The VCD framework highlights the role of societies and their institutions in defining the standards by which individuals live. Having a better understanding of how society influences the values of individuals, at the design stage of preventive health applications, gives us opportunities to better leverage this influence to achieve better quality of health for the individuals and, subsequently, the society.

1.5 Overview of the Thesis Document

This thesis is organised as follows:

Chapter 2 Background

This thesis begins with a review of literature that are most relevant to the research. This chapter starts with a description of preventive health applications and their benefits. We then look closer at Personal Health Records and Wearable Technologies as examples of preventive health technologies. We also review the phenomenon of the *Quantified Self* and its impact on health outcomes and habits. The dropout rate of users of health monitoring technologies is also discussed in this chapter. Finally, a review on preventive health technologies as motivational technologies and some existing design models (and their shortcomings) is presented.

Chapter 3 Value in Technology

This chapter reviews the role of value as a viable framework for technology design. The influence of social groups on individual value and some existing value-centric design frameworks are discussed, highlighting the critical role of institutions in the shaping of value cocreation.

Chapter 4 Methodology

The first section of this chapter outlines the empirical methodology for the Berkshire Wearable Technology pilot. Then, the characteristics of the study sample are outlined, describing their demographic, clinical and lifestyle characteristics. Finally, an initial description of the proposed design framework is presented.

Chapter 5 Results: Empirical Evidence

In this chapter, results/findings from the empirical study for the development of the proposed VCD framework are presented. This chapter also presents other study measures from the pilot study.

Chapter 6 Application of VCD: Berkshire Wearable Technology Pilot as a Case Study

In this chapter, we exemplify the application of the proposed VCD design model by applying it to a real-life design scenario, using the Berkshire Wearable Technology

Pilot as a case study.

Chapter 7 Revision of the VCD Framework

Here, we present the revised version of the VCD framework which has been validated through its application to a real-life scenario and with empirical evidence from the pilot study.

Chapter 8 Conclusion

This chapter summarises the main findings of the research, the limitations of the research and recommendations for further research.

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Chapter 2

Background

2.1 Preventive Health Applications

During the 20th century, the practice of screening to identify a disease or pre-disease condition in people presumed to be healthy started to gain recognition and has now become widely accepted in society (Holland and Stewart, 2005). This contributed to the concept known as *preventive medicine* or *preventive healthcare* which involved screening to determine individuals' susceptibility to disease. The first demonstration of the benefits of screening was for the identification of individuals with tuberculosis using mass miniature radiography (MMR) (ibidem). Since then, different tools and concepts for preventive healthcare practices have been developed.

Behavioural medicine is one of such concepts and it emphasises the application of behavioural science findings to various settings of clinical interventions (Arigo et al., 2019). This has been leveraged in the prevention of health conditions such as cardiovascular disease, cancer and diabetes. Examples of its application in medicine include the use of "Quit smoking" campaigns and self monitoring. With a shift in the health narrative from diseases to wellness, individuals have become increasingly concerned about maintaining their wellbeing and staying fit. This makes patient behaviour important in creating or mitigating health risks (and benefits). There are three main types of prevention mechanisms (Karunathilake and Ganegoda, 2018):

- **Primary prevention:** This involves the steps taken to prevent or reduce the risk of the onset of a disease. This can be administered on the population and individual level (Sieber et al., 2018). It can be practised by the individual by, for instance, adopting and maintaining healthy lifestyle choices (diet, exercise, sleep, etc.) or the healthcare organisation through health promotion and actions

like screening and vaccination.

- **Secondary prevention:** This type of prevention focuses on reducing the impact of a disease by the detection of early signs or early diagnosis before any critical damage is done (Karunathilake and Ganegoda, 2018).
- **Tertiary prevention:** This aims to reduce the impact of a long-term chronic condition by helping the individuals to manage the symptoms and increase their life expectancy and quality of life (Karunathilake and Ganegoda, 2018). For instance, improved diet and exercise can increase the quality of life of diabetic patients.

Practising preventive health involves getting individuals to change their unhealthy behaviours, for a sustained amount of time, to healthier ones in order to achieve long-term health benefits. Behavioural change usually focuses on cessation of behaviour with negative consequences and adoption of behaviour with perceived positive consequences; there is often only a fairly loose link to any one health condition but it has impact across many health conditions. For instance, weight loss can help alleviate the symptoms of diabetes, heart conditions such as atrial fibrillation, and musculoskeletal conditions such as low back pain. Achieving behavioural change is often done by using social mechanisms e.g. smoking cessation has used the social strategy of making smoking more uncomfortable such as prohibiting smoking indoors in a public place, reducing advertising for smoking and using advertisement that says that smoking smells bad, making the consequences of smoking clearer, increasing tax on cigarettes, and in some way these channels combine to put pressure on smokers to move to alternatives like vaping or nicotine patches.

Traditional behavioural interventions such as health education programmes (e.g. using tooth brushing campaigns to improve dental health), support groups, and screenings and vaccinations (interventions with behavioural elements geared towards increasing compliance with clinical treatment regimes) were designed to be delivered in face-to-face meetings; however, challenges such as scheduling, availability, and cost of resources and travel can limit the delivery of these interventions (Arigo et al., 2019). Hence, the use of technology such as wearable trackers, fitness apps, and personal health records to enable the remote delivery of preventive health interventions.

These preventive health apps can enable individuals to monitor their physical and mental health and manage an illness (usually, chronic illness) and wellness alike. These apps can either be linked to a wearable device/app or function as a stand-alone app.

There are preventive health apps to help individuals manage anxiety and practise mindfulness such as Headspace¹ and iMindfulness². There are apps to assist individuals in managing chronic illnesses like diabetes (e.g. Diabetes PA³) and apps to help individuals store and monitor their health or fitness data such as Personal Health Records and fitness apps (e.g. Samsung Health⁴, MyFitnessPal⁵).

In this section, we will describe two examples of preventive health apps (Personal Health Record) and devices (Wearable Fitness Tracker) that are relevant to this research as they encapsulate the technologies designed and used for this research. We will also discuss briefly the limiting effect of the high user dropout/attrition rate in the use of such apps and devices.

2.1.1 Personal Health Record (PHR)

After the 1960s, health facilities began to store and manage health records electronically. This concept is popularly known as *Electronic Health Record (EHR)* and this record is created and solely managed by health facilities. The use of the EHR offers some advantages over the use of traditional records (paper) such as faster retrieval and access of health records, easier and less-costly data editing and sharing, elimination of wear and tear effects on health data and the prevention of duplication of health data. There were also subtle implications of using paper records such as conferring ownership of the patient. However, given the affordances of the physical form of paper and its deep embedding in work practices, it is key in coordinating data in the hospital ward. Unfortunately, the transfer of health data between paper and digital media over time and space can introduce disparities in the data and lead to a deterioration of the data integrity. In some cases, data gets lost on the EHR when these paper-based records are not transferred to the EHR. Hartswood et al. describe how the different purposes for documents associated with a screening episode at different times and places by different personnel introduced many irreconcilable contrasts between the original documents and their digital versions (Hartswood et al., 2012).

Despite its advantages, the EHR had inherent features which made it ineffective in advancing the shift of healthcare focus from diseases to wellness. It was primarily designed to support care delivery and management and was solely managed by health

¹<https://www.headspace.com/>

²<https://apps.apple.com/us/app/imindfulness/id473747142>

³https://play.google.com/store/apps/details?id=com.diabetes.android&hl=en_GB

⁴<https://www.samsung.com/uk/apps/samsung-health/>

⁵<https://www.myfitnesspal.com/>

professionals and personnel. It was typically not universal; hence, it was difficult to access outside a specific facility. Individuals/patients had limited or no access to the data stored on the EHR and were not in control of who viewed and used their health data. It was event-driven and had support for tracking episodes of illness but none for storing consumer wellness data; hence it was not a suitable facility for recording and tracking wellness.

The shortcomings of the EHR to support preventive health practices contributed to the invention of the electronic Personal Health Record (PHR). The PHR is a digital tool that empowers individuals to access their clinical records, maintain their health and social care services, and share their health information safely and privately (Symons et al., 2019). Google Health and Microsoft HealthVault were two major players in the PHR market, developed by Google and Microsoft respectively. Google Health was withdrawn in 2012 because it was not widely adopted and only achieved limited use (Spil and Klein, 2014). For similar reasons, Microsoft HealthVault was withdrawn from the market in November, 2019. This draws attention to the model used to design and maintain these PHR applications.

The topic of data ownership remains a debated issue. The International Organization for Standardization (ISO) says that data held in the PHR can be owned by the patient, healthcare provider or healthcare organisation (Señor et al., 2012). In Europe, even though the patient can view data stored by the healthcare provider on the hospital EHR via their PHR, they only own the data they have stored on the PHR (ibidem). It is important to note that these terms of data ownership might differ in the case of patients with severe mental health conditions which predispose them to cause *serious harm* to themselves or others. In such situations, health professionals might decide to block the patient's access to certain records to protect them (Ennis et al., 2011). However, the patient/individual is usually considered the ultimate owner of the health record (Blumenthal and Squires, 2015) and (s)he authorises access to the records. Ideally, giving individuals ownership of their health data should improve data quality and integrity as only authorised people can have access to the health data but for this to happen, it is important that users are properly educated on their responsibility to maintain data quality (Khatri and Brown, 2010). This makes it necessary that the PHR owner is someone capable of taking responsibility; hence, in the case where the individual is a minor or incapable of managing their PHR, a legal guardian can manage the health record on their behalf (JASON, 2014). For instance, the Personal Child Health Record (PCHR) is a PHR managed by the parent(s) or legal guardian(s) on behalf of their ward until

the child is old enough to manage the health record him or herself (Nnabuko, 2015). The ownership of data on preventive health apps is discussed further in Section 2.1.2.

Because individuals can move from one health organisation to the other, the National Coordinator for Health Information Technology (NCHIT) defines the ideal PHR as one that can be “managed, shared and controlled by the individual” (Kahn et al., 2009), making PHR integration with the individual’s current health organisation easier. This integration usually starts with the need to give the health professionals an integrated view of the patient’s data, but it also supports patient self-management of their health. The ideal PHR provides and supports the capture of a complete summary of the health and medical history of individuals (Puustjärvi and Puustjärvi, 2010), this includes health and care-related events from the individual and authorised health professionals, which has the potential to enhance the individual’s awareness of his or her health condition. This awareness places more responsibility on the patient to get more enlightened and engaged in their medical care by staying up to date about their health condition, actively contributing health data to the dataset via preventative care tools like sensors, and complying with prescribed medication (JASON, 2014), thereby maintaining their health and adopting healthier lifestyles. Some of the routes to healthier lifestyles include but are not limited to healthy diet, exercise, improved adherence to medication and less use of tobacco. PHR use aims to facilitate the P4 medicine agenda; which makes healthcare preventive, predictive, participatory and personalised (Hood and Friend, 2011).

- **Preventive:** Entails a shift in the focus of healthcare from disease to wellness.
- **Predictive:** Seeks to identify individuals’ transition to a specific disease by comparing their health data with a baseline measurement of wellness or a healthy state.
- **Participatory:** Highlights the cultural and technical barriers involved in healthcare and seeks to address these barriers to get patients, health professionals and the community involved in the management of care.
- **Personalised:** Entails an individualised approach to managing patients’ health instead of a general approach which often does not produce the same outcomes for different individuals. For instance, in research programmes funded by the European Union (EU), this means healthcare driven by the genetic information of the individual.

Ideally, a PHR should be a repository for the integration of an individual's health data from various sources. However, this scenario is yet to be obtained. The difficulty of transferring wellness data out of proprietary apps and the incompatibility of gathered data due to varying data formats (Caligtan and Dykes, 2011; Heart et al., 2017) make unifying health data from various sources hard to implement. Poor data quality due to wearable device inaccuracy, digital health illiteracy, lack of technical competence, and difficulty with interpreting the data inhibits the confident use of PHRs (Abdolkhani et al., 2019). Also, the training obtained by health professionals makes them sceptical of patient-gathered data; hence, narrowing the prospects of PHR use. Nonetheless, the PHR serves as a tool for practising preventive healthcare. As a wide array of consumer health monitoring devices and service have emerged, facilitated by the growth of platform infrastructures such as Fitbits and Internet of Things which continuously measure consumer wellness data, the PHR could act as an integration point for lots of health data which could aid the health professionals to detect any impending health anomalies by observing trends in the individual's health data collected over time or use machine learning to identify "events" in that data stream which are relevant to wellness. An ideal PHR could also support a long-standing relationship between the individuals and their healthcare providers. It was observed from a randomised controlled trial of patients who monitored their hypertension at home that improvement in health outcomes was significantly higher for patients who used PHRs that supported communication and feedback from their care provider (Caligtan and Dykes, 2011).

Given the sensitivity of health data, data security and privacy are major concerns for physicians and patients in the use of preventive health apps like PHRs and wearable fitness trackers, as any problems with data security and privacy can cause distrust among intended users who could consequently choose not to participate in the systems (JASON, 2014). The threats to the security and privacy of health records can be categorised under three main factors (Wang, 2015):

- Natural hazards such as floods, fire, and hurricane.
- Technological faults like a system crash.
- Human threats which consist of intentional and unintentional data breaches from employees (present and previous) and hackers. As a result of insufficient control over access to databases, the NHS experienced a privacy breach when a staff member used their insider access to compromise the medical records of Prime Minister Gordon Brown in 2009 (JASON, 2014).

Some of the data security and privacy solutions include the use of encryption mechanisms. For instance, the use of a cryptographic key to transform plain data into encrypted text to secure the data. The use of distributed networks reduces a system's vulnerability to cyber-attacks by using a decentralised data management system instead of a single-copy centralised system. A centralised system is less secure because there is a higher risk of losing all the data when the system is attacked by hackers than when the data is stored on a decentralised data management system. User authentication techniques also ensure data security and privacy by verifying that the users who gain access to the data are authorised to do so. This includes the use of smart contracts to maintain a log of patient and provider accesses to health records (Ekblaw et al., 2016). However, the security and privacy of health data can be difficult to manage due to contradictory goals to share data to identify health risks but not breach personal privacy or autonomy.

The Berkshire Wearable Patient Portal app designed for the pilot study is an example of an electronic PHR which aims to integrate fitness and wellness data entered by the patients/users and clinical data provided by the healthcare organisation. This is described in more detail in Chapter Four.

2.1.2 Wearable Technology for Health Tracking

The miniaturisation of electronic devices has contributed to the invention of wearable sensors and devices with a focus on health and fitness. As of 2016, one in six consumers in the United States used a wearable technology for monitoring their health (Piwek et al., 2016). These devices enable individuals to continuously monitor their health behaviours and obtain insights from the collected data into their health and well-being (Hänsel et al., 2015). Some of such devices provide intervention techniques that can influence the individual's behaviour (ibidem). They track individuals' activities in real-time and are portable to support continuous tracking. There are various types of wearable devices ranging from general health trackers (such as heart rate sensors) to fitness and wellness devices (such as pedometers that monitor physical activity). There is a population of self-trackers, referred to as the Quantified Self (QS) movement, who use wearable devices (among other methods) to monitor their daily life. In this section, we will discuss the concept of the Quantified Self and the wearable fitness tracker - a type of wearable technology relevant to this research.

2.1.2.1 Quantified Self (QS)

As the use of self-tracking apps and technologies became more pervasive, so did the phenomenon of improving quality of life using personal data. This movement of tracking daily life has been known as Lifelogging, Personal Informatics, Personal Analytics and (now, more formally) Quantified Self (Lupton, 2016). The Quantified Self (QS) also refers to a community of individuals who share an interest in obtaining a more complete knowledge of themselves through self-tracking.

The Quantified Self community was founded by two former editors of Wired Magazine, Gary Wood and Kevin Kelly, in 2007 and currently claims over 45,000 members in about 40 countries (Schüll, 2016). They operate via online forums and in-person meetings where members share their self-tracking experiences. Members are usually called *quantified selfers* or *self-quantifiers*. Most members of the QS movement are mostly healthy participants seeking to optimise their healthiness or stay healthy using data self-tracking. They are interested in tracking multiple aspects of their lives which are not necessarily limited to fitness and sleep; it can range from steps to music to time spent in front of the computer. They seek a more comprehensive understanding of their bodies and how to keep them healthy. This is similar to the concept of *Tuning for Health* which proposes the use of tools that support essential volitional processes (like cogitate, eat, engage, move, and sleep) to get the body in tune with inbodied, non-volitional processes which are constantly responding and adapting to our context (mc Schraefel, 2020).

However, individuals have various motivations for practising self-quantification. This could be as a result of the individual's desire or choice, by necessity due to an existing medical condition, for company-provided incentives, for a sense of belonging, or due to work-related requirements or commitments. Gimpel *et al.* developed a framework to conceptualise individuals' motivation for self-tracking based on an exploratory survey with 150 self-trackers (Gimpel *et al.*, 2013). The framework consisted of five motivational aspects - self-entertainment, self-association, self-design, self-discipline and self-healing.

- **Self-entertainment:** Individuals can be motivated to self-track because they find the process of collecting data and *playing around* with it pleasurable and fun.
- **Self-association:** This is concerned with the motivation to self-track due to the prospect of belonging to a community and exercising individuality within the social group. This motivation is rooted in the idea that a self-tracker can understand

himself/herself better by comparison with (an)other self-tracker(s).

- **Self-design:** Individuals can be motivated by the possibilities of self-improvement and self-optimisation - they take responsibility for their actions and actively seek to improve their health and wellbeing.
- **Self-discipline:** This involves motivation due to possibilities of self-gratification and incentives. This can be in the form of supporting individuals' self-discipline, motivation to achieve a goal, or the potential for reward.
- **Self-healing:** Individuals can self-track because of the possibilities of self-healing through increased health-awareness. This includes the motivation fuelled by the desire to manage a chronic illness or rebellion to traditional medical practices and systems.

Similarly, Lupton identifies different modes of self-tracking that an individual can undertake (Lupton, 2016):

- **Private:** This is restricted to the individual's personal objectives.
- **Pushed and Imposed:** Self-tracking is pushed onto and imposed on individuals by an external agent (e.g. health insurance premium policies).
- **Communal:** This involves sharing tracked personal data with other people.
- **Exploited:** This entails the re-purposing of individuals' personal data for the commercial or research benefit of other people.

The QS community appears to support all modes of self-tracking, except the pushed and imposed modes as they [the community] promote the initiation of self-tracking by each individual. It is unclear whether the QS community is driven by any one of the self-tracking motivations or some combination of the motivations. It also appears practising prevention is not the main focus for self-quantifiers. Self-quantifiers appear to be motivated to self-track by the possibility of uncovering new knowledge from the data they collect (Wolf, 2010). Arguably, the motivations that drive the QS community group will influence the structure and norms of the processes within the community.

Different from mainstream "self-trackers", the QS community is usually characterised by diligent recordings of their daily activities and intense self-scrutiny to critically analyse one's life (Alkhatib and Boellstorff, 2014). Quantified selfers participate

in active self-tracking which is an analog process and requires effort from the individual to log what they are tracking. They usually track data manually or with a device and this can be logged on an app, word processor/spreadsheet, or paper. They interact with self-tracking apps and devices as active participants who aim to see beyond the frame these apps and devices set for them (Nafus and Sherman, 2014). On the other hand, most mainstream self-trackers practice passive self-tracking which is a digital process and employs the use of technology like sensors that mostly collect and process personal data in the background (Watson, 2013). They are more comfortable with outsourcing data creation to sensors and the data frame these devices provide. Members of the QS community are considered active forerunners of mainstream self-quantification as opposed to other users of self-tracking technologies who passively track their movements and activities.

Concerning self-quantifiers' perception of self-tracking, they express a preference for data collection and storage services that offer the ownership of user-generated data to the user (who consequently has the right to delete their data at will) (Alkhatib and Boellstorff, 2014). They highlight the importance of manually tracking data as opposed to focusing on the use of technologies to automatically collect such data because automatic tracking limits the tracker's self-awareness which the self-tracking exercise requires (Nafus and Sherman, 2014). They do not rely on the mainstream definition of healthy behaviours (e.g. adhering to a recommended daily step goal) but more on listening to the body and critically analysing and interpreting the tracked data. Due to self-quantifiers' approach to self-tracking, most of the empirical studies carried out in this community are ethnographic studies; hence, it is difficult to measure their dropout rate in the use of tracking devices. But it appears that they do not necessarily perceive the discontinuation of a tracking exercise as a problem when it comes to self-tracking. Nafus & Sherman conducted an ethnographic study with quantified selfers and discovered a participant who did not consider it a failure when he stopped tracking a certain aspect of his life (Nafus and Sherman, 2014). He rather felt that he did not need data on certain behaviour if that behaviour has been successfully integrated into his lifestyle.

Most self-quantifiers do not seem concerned about sharing their data using self-tracking devices as they consider the co-ownership of data tracked with these companies a fair exchange and an opportunity to access population data that gives cross-sectional context to their data (Alkhatib and Boellstorff, 2014). They also value the potential impact that access to their personal data could have on healthcare and well-being research by contributing to pattern and trend identification in the population

data. One of the commonly shared values amongst Quantified Selfers is “a trust that the usefulness of data outweighs the risk of harm or exposure from that data” (Watson, 2013).

The Quantified Self approach to self-tracking receives more criticism than praise from mainstream media (Watson, 2013) and even though their approach is not well understood, there are things that could be learned from this approach. For example, the need for conscious self-tracking using wearable devices that has the potential to positively influence individuals’ attitude in the use of such devices. Also, the personalised method of self-tracking seems like a more efficient approach than the generalised method as “a universal standard for human experience does not exist” (Wolf, 2010) - body type, goals, strengths and weaknesses vary for individuals and tracking for health should take these differences into account. On the other hand, the lack of standardisation in the tracking approach can limit its large-scale adoption because the cognitive load required to manually collect and analyse the data limits the approach to a niche user group which is not representative of the wider population.

2.1.2.2 Wearable Fitness Tracker

Wearable Fitness Trackers (also known as Wearables) are [mostly] commercial technologies that can assist individuals in the self-regulation of their health behaviours by automatically tracking their physical activities which provides data such as number of steps taken, number of stairs climbed, distance travelled, heart rate, number of hours slept, calories burned, minutes of moderate-to-vigorous intensity physical activity (MVPA), etc. These devices are usually worn around the wrist or attached to the individual’s clothing. The data tracked are usually accessed via a smartphone or online app; some devices have a screen which gives users a preliminary view of the data and enables them to choose some device settings.

As the use of wearable fitness trackers become more widespread, various models have been developed and marketed by different manufacturers. Fitbit and Garmin devices are some of the most commonly used fitness trackers (Maher et al., 2017). Although these trackers show promising potential for preventive health practices, their long-term impact on users’ health behaviours is still heavily debated. But some of the important questions to address are:

- Considering the various fitness and wellness practices (e.g. diet, exercise), how effective is the use of fitness trackers in changing individuals’ health behaviours?

- What motivations do individuals have for using them?
- Is there a high user retention rate in the use of fitness trackers?
- Can we find a convincing account for users' retention behaviour?

The effect of fitness trackers on users' health behaviours has been researched in recent times but most of these have been short-term studies and/or are conducted on a small sample size. Gualtieri *et al.* provided a free wearable activity tracker (Withings Pulse) to 10 patients who had at least one chronic medical condition, including obesity, joint pain, hypertension, type 2 diabetes, and hyperlipidemia (Gualtieri *et al.*, 2016). The study focused on adults with a chronic medical condition because this population is considered a part of the group that is least likely to procure a tracker and most likely to have difficulties with using it (*ibidem*). Participants were signed up to a physician-led Wellness Group for 12 weeks. By the end of the study, participants had lost an average of 0.5 lbs per week and a mean total weight loss of 5.97 lbs ($p=0.004$). Additionally, there was a 9.2% decrease in low-density lipoprotein (LDL) cholesterol reported at the end of the trial ($p=0.038$). However, it was difficult to separate the impact of using the tracker from that of attending the wellness group educational meet-ups.

In a Randomised Controlled Trial (RCT) conducted by Hartman *et al.*, 54 women with elevated breast cancer risk were randomised into a weight loss intervention group ($n=36$) and a usual care control group ($n=18$) for 6 months (Hartman *et al.*, 2016). In addition to receiving standardised coaching calls from trained counsellors, participants in the intervention group used the MyFitnessPal app and website to monitor their diet and the Fitbit One activity tracker to monitor their physical activity while those in the control group only received the U.S. Dietary Guidelines for Americans booklet and two brief coaching calls. At the end of 6 months, participants in the intervention group had lost significantly more mean weight than participants in the control group (4.4 kg vs. 0.8 kg, $p=0.005$). Interestingly, a different outcome was obtained from a similar RCT conducted by Laing *et al.* where 212 primary care patients were randomised to a control group that received usual care ($n=107$) and an intervention group that downloaded the MyFitnessPal app in addition to receiving usual care ($n=105$) for 6 months (Laing *et al.*, 2014). At the end of 6 months, no significant difference in weight was found between participants in both groups although participants in the control group gained a mean weight of 0.27 kg and those in the intervention group lost an average of 0.03 kg ($p=0.63$).

This variation in reported outcomes could be due to various factors. The latter study experienced contamination of the control group which could have affected the result of this study because 13% of the control group participants used the MyFitness-Pal during the trial; the participant who logged into the app the most and lost the most weight (13.1 kg) by the end of the trial was in the control group. This study did not measure or track physical activity data for the trial period; it is possible that the participants who lost weight the most supported their calorie tracking exercise with physical exercise. Also, despite participants receiving a \$20 gift card incentive for attending each follow-up meeting, the participant dropout rate was high (51%) compared to that of the study by Hartman *et al.* (13%). The Hartman *et al.* study stratified the general patient population to target participants with elevated breast cancer risk while the latter study included primary care patients that were not stratified by their medical conditions. Hence, participants in the first study might have received training and support most relevant for their collective medical condition while training and support for participants in the second study might not have been sufficient for the different medical conditions presented by the participants. Also, since the participants in Hartman *et al.*'s study had an increased risk of breast cancer, they probably had a stronger motivation to lose weight compared to the patients in the latter study.

Despite the reasons for the insignificant effect of the wearable device intervention in (Laing *et al.*, 2014), wearable fitness trackers have the potential to improve physical activity in the short term [six months or less] (Shin *et al.*, 2019) but its long-term effects are still uncertain because there are few longitudinal studies in this research area. Reviewing some of such long-term studies, it seems the impact of wearable fitness trackers wanes with time. Jackicic *et al.* randomised 470 adult participants (aged 18-35 years) into a standard intervention group that self-monitored their diet and physical activity using a website (n=233) and an enhanced intervention group that was provided with a commercial wearable device and the accompanying web interface to monitor their diet and physical activity (n=237) for 24 months (Jakicic *et al.*, 2016). By the end of the trial, participants in the standard intervention group had consistently lost more mean weight than those in the enhanced intervention group (difference = 2.4kg, p=0.002). There were also no significant between-groups differences in dietary intake, body composition and physical activity. This suggests the use of the wearable device was less effective for weight loss during the 24-month study period. The reason for this result is uncertain as there were no significant differences observed for change in diet and physical activity between the groups.

Similar to the pilot study conducted for this research, Crowley *et al.* conducted a Personal Health Management Study (PHMS) which recruited 565 employees of Boehringer Ingelheim Pharmaceuticals, Inc. who used the Jawbone wristband to track their steps and sleep for 12 months (Crowley *et al.*, 2016). Participants were kept engaged during the study by weekly emails providing aggregated step and sleep data for all participants and health tips, gamified virtual challenges and awards, and voluntary on-site social events. They were also encouraged to use the tracker and engage in positive health behaviours using a *variety of incentives* (which the authors did not describe in the paper). However, there was no significant difference in steps between the first and last months of the intervention ($p=0.55$). The authors attribute this finding to the program's failure to maintain motivation for behaviour change.

Conducting a content analysis study, Chia *et al.* examined six fitness trackers to determine whether they incorporated Behaviour Change Techniques (BCTs) that support self-management strategies to increase physical activity such as goal-setting and self-monitoring (Chia *et al.*, 2019). The inclusion criteria for the fitness trackers examined are: (i) able to track physical activity (ii) is swim proof (iii) is compatible with Apple and Android operating systems, and (iv) costs below 105 USD. The 6 fitness trackers that met the inclusion criteria were Fitbit Flex 2, Polar A300, Misfit Sine 2, Huawei Band 2 Pro, Nokia Go, and Moov Now. Findings from the study highlighted that the low cost fitness trackers exhibited evidence-based BCTs to promote physical activity; however, only one of the fitness trackers (Nokia Go) had techniques (like social support and behaviour practice) effective for special population groups such as adults with obesity and chronic illnesses.

Individuals have various motivations for using wearable devices and these motivations, to an extent, determine how they use these devices. Some people use wearable trackers passively to help them to lose weight, monitor their sleep and physical activity while some people (mostly members of the Quantified Self community) use them to actively track and collect data on their daily activities to be able to better understand their bodies and improve their overall health and wellbeing. In the next section, we will discuss the dropout rate in the use of personal health monitoring technologies.

2.1.3 User Dropout/Attrition Rate in the Use of Health Monitoring Technologies

As technology advances to provide better data security, affordability of smartphones and mobile devices and faster data network, preventive health applications and technology stand a better chance of encouraging individuals to incorporate healthier behaviours and lifestyles into their lives. These health monitoring technologies (including preventive health apps and wearable devices) have the capacity to provide information that could enable individuals to monitor their health, but a prior challenge is the high user dropout or attrition rate that pervades the use of such technologies. In this section, we will discuss user attrition and usage of health monitoring technologies. The focus will be on both user dropout from studies and the discontinuation of normal use of these technologies by users because although these dropout types are similar, they differ significantly in context. We will also consider one of the concerns around the use of these technologies - “At what point can individuals stop using them?”

Ledger & McCaffrey reported that about a third of US consumers stop using their wearable activity tracker within the first six months of receiving it (Ledger and McCaffrey, 2014). Hermesen *et al.* conducted a study to identify the determinants for individuals’ sustained use of their wearable trackers in the first year after purchase and they discovered that the mean number of days that participants used their Fitbit devices was 129.3 days (about 4.2 months) (Hermesen *et al.*, 2017). Of the 711 participants that were recruited for the study, 50% of them ($n = 356$) still used their trackers after 6 months and 12% ($n = 85$) continued to use them after 300 days (about 10 months). Apparently, the dropout rate is even higher in the use of preventive smartphone apps where about 80% of the users drop out within the first few days of installing and using the app (Hermesen *et al.*, 2017).

Kononova *et al.* conducted a focus group study to investigate the use of wearable activity trackers among 48 older adults aged 65 years and older (Kononova *et al.*, 2019). The participants were grouped into 4 types of activity tracker users - long-term (usage of 6 months and longer), short-term (usage of less than 6 months), former users and nonusers. Findings suggest that the long-term users of the activity tracker continued to use it because of the incentives they obtained from it such as social support and long-term benefits of regular physical activity (e.g. reduced pain, mobility). However, these users concluded that external factors did not fully determine their motivation - internal motivation played the most important role while the technology (tracker) came

in second as a facilitator.

There are two processes of attrition observed in longitudinal studies: **drop-out attrition** where participants are lost to follow-up and **non-usage attrition** where participants don't use the intervention (Postel et al., 2011). Usually, a high loss-to-follow-up suggests that a considerable number of participants either lost interest in the intervention or left for personal reasons before the follow-up stage. However, a low loss-to-follow-up does not necessarily mean that participants used the intervention as expected; it is possible for participants to stay until the follow-up stage but not use the intervention as instructed or expected. Non-usage measures need to take the nature of the intervention into account; Renal PatientView (RPV), for instance, is a web-based system that allows patients to access their laboratory test results and other health data but individuals tend to access their test results only just before and after their clinic appointment (Phelps et al., 2014; Woywodt et al., 2014). In this case, people use RPV occasionally not necessarily because they lose interest in it but because of its nature as a data repository. Because attrition in longitudinal studies focuses more on the change in the number of users at baseline and follow-up stages, it is not a very good measure of usage.

The measure of usage differs for different types of apps just like individuals perform different activities at varied capacities in life. The way people use health monitoring technologies could depend on the value users place on them, the context of use and the nature of activities supported by the technologies. Wang *et al.* proposed a classification scheme which classified mobile health apps according to three dimensions (Wang et al., 2014). These dimensions are:

- in terms of predisposing, enabling, and reinforcing factors for behaviour change;
- prevention versus management of disease; and
- physical health versus mental health.

Arguably, there will exist different modes of use for these various classifications of apps. Some health apps, such as RPV mentioned above, require an occasional mode of usage while some others, such as the Fitbit fitness tracker, tend to require a more consistent and long-term mode of usage in order to keep the user up-to-date on how their daily actions affect their health over a space of time. However, former users of activity trackers from the study conducted by Kononova *et al.* did not find the long-term use of activity trackers necessary nor a priority because over time, they had

learned the amount of steps and calories associated with their daily activities (which more or less remained the same). Also, the frequency of use could depend on the nature of health data collected and what can be done to/with the data.

Hermesen *et al.* presented some potential determinants for the sustained use of activity trackers which can be projected on to other health monitoring technologies (Hermesen *et al.*, 2017). Some of these factors are:

- **Technical Failures:** This consists of failures in user experience, usability, functionality, aesthetics, fit, durability of the device and accuracy. Individuals' sustained use of health monitoring technologies is limited by such failures. Also, the presentation of data and feedback to the individuals can influence individuals' use of these technologies. Some tech companies aim to move feedback provided by wearables from quantitative metrics to qualitative, personalised directions and meanings in the analysis and presentation of tracked wearable data (Schüll, 2016). This should help users make meaningful sense of their data in order to effectively act on it.
- **Perceived Self-efficacy:** This entails the individual's perception of their efficacy or confidence in using these technologies. This is also influenced by the individual's computer literacy level. The higher their perceived self-efficacy, the longer individuals are likely to use the apps and devices.
- **Socioeconomic Status Markers:** This consists of education, employment, age, and gender. Individuals with higher levels of education and employment are expected to use the apps and devices for longer. Older individuals show more sustained use of the apps and devices, although younger individuals are more likely to adopt the use of these technologies (Krebs and Duncan, 2015). Female individuals have also been found to use these preventive health technologies longer than male individuals.
- **Psychological Traits:** Individuals with a higher capacity for self-regulation and inhibitory strength exhibit a more sustained use of these technologies. Ruckenstein conducted an empirical self-monitoring study focused on heart-rate variability measurement using Firstbeat device (Ruckenstein, 2014). He discovered that most participants who were keen on joining the study were actively involved in a sporting activity while unhealthier subjects were more likely to decline an invitation to participate in the study. It seemed the study appealed more to peo-

ple who already had a disciplined relationship with sports and exercise or who had an existing interest in self-tracking technologies.

- **Health-related Factors:** Poor health (physical and mental health) reduces self-efficacy and this can lead to less sustained use of preventive health technologies. However, the management of a chronic illness can increase motivation for the adoption and sustained use of these technologies (Krebs and Duncan, 2015). Fox and Duggan reported that people in the United States living with chronic conditions were significantly more likely to track their health and take the tracking exercise more seriously than those with better health conditions (Fox and Duggan, 2013).
- **Goal Setting:** Achieving set goals can boost initial motivation and perceived self-efficacy which can increase the chance for sustained use of preventive health technologies. However, achieving these goals can also lead to device abandonment when users feel they no longer need the technologies to support behaviour change.
- **Social Support:** Social factors such as social support and competition have been found to encourage individuals to adhere to physical activity interventions. The study by Chang *et al.* discovered that social support obtained via social network sites was instrumental in increasing individuals' adherence and engagement with wearable activity trackers (Chang *et al.*, 2016). Also, the presence of other activity tracker users was found to be the top motivator for long-term users of activity trackers in the study by Kononova *et al.*, this consists of both competitive and cooperative interactions (Kononova *et al.*, 2019).

Given the pervasive narrative that we are all potentially sick and must leverage measures to ensure we keep well, the use of wearable devices and preventive health apps seems like a continuous and lifelong task to collect, analyse and manage personal data daily (Schüll, 2016).

Schüll argues that the use of wearables, although beneficial, can also inhibit cultural ideals for individual responsibility as it outsources the task of lifestyle management to the devices which contradicts the culture of active or conscious self-regulation (Schüll, 2016). She raises the concern that these tracking devices transfer the burden of behaviour tracking from individuals to sensors; thereby, relieving themselves of some responsibility for their health.

A key limiting factor for the sustained use of preventive health technologies is the design models for such technologies. The norms and institutions that underpin the design and affordances of these preventive health technologies are mainly shaped by the preferences and values of the individuals or establishments that design them. As a result, most of these apps and devices target a narrow demographic of users or a certain aspect of life which may not be generalisable to include the needs and values of other individuals. This is in line with Lupton's view on mainstream self-tracking practices.

“Self-tracking technologies, discourses and practices predominantly assume a certain type of user, located within a supportive economic and social milieu. They tend not to acknowledge or recognise the effects of low income or poverty, racism, sexism, living with a mental health condition or disability, residing in a remote community, identifying as queer or transgender or belonging to an ethnic or racial minority group.” (Lupton, 2016, p.140)

On the functionality of preventive health technologies, Househ *et al.* suggested that PHRs (and by extension, other health monitoring technologies) should not just function as a data repository for patient data but should be dynamic and “meaningfully used” by patients for an improvement in health outcomes to be observed (Househ et al., 2014). Involving the patients or users extensively in the technology development process will be essential in ensuring that they find the use of the technology meaningful for their personal health and wellbeing management.

2.2 Preventive Health Technologies as Motivational Technologies

Two important classes of motivation are commonly identified; intrinsic motivation which “refers to doing something because it is inherently interesting or enjoyable” and extrinsic motivation which “refers to doing something because it leads to a separable outcome” (Deci and Ryan, 2012). Motivational technology is technology which not only informs the user but encourages and empowers them to perform a certain behaviour (Sundar et al., 2012). It can also support individuals to change their health behaviours by disciplining and punishing users for performing unhealthy behaviours. Like motivational technology, persuasive technology is designed to support the behaviour change of individuals and motivation is an important factor for building persuasive technology (as we will see later in this section). Hence, I will use motivational

technology and persuasive technology interchangeably in this thesis. In this section, we will review some of the existing design models and considerations for building motivational technology.

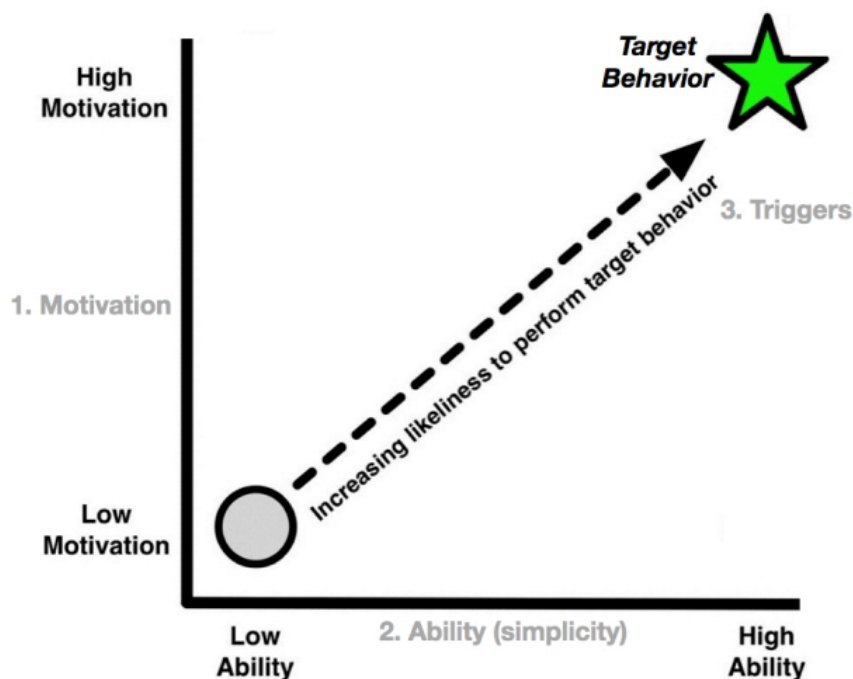


Figure 2.1: Three Factors of the Fogg Behaviour Model (Fogg, 2009)

Since the aim of preventive health applications is to provide a platform to encourage individuals to adopt healthy behaviours in order to prevent or curtail the occurrence of chronic and non-chronic illnesses, they assume the role of motivational technologies. Hence, it is important to understand the factors and design considerations which could lead to a change in human behaviour. Different studies have proposed models of how to design applications to encourage behaviour change. According to the Fogg Behaviour Model (FBM), motivation, ability, and trigger are the three factors which have to be present in order to get an individual to perform a target behaviour (Fogg, 2009). These three factors ought to be present for a target behaviour to happen; although there can be a trade-off on motivation and ability, an appropriate trigger is necessary for the target behaviour to occur. A high motivation and ability increase the likelihood of the individual to perform the desired behaviour. See Figure 2.1 for the relationship between the three factors of FBM.

According to FBM, the elements of motivation include three core motivators. These are sensation (pleasure/pain), anticipation (hope/fear) and belonging (social acceptance/rejection). Each element has two complementary poles on a spectrum and either

pole can be useful in motivating individuals. Individuals' fear of the consequences of their current unhealthy behaviours could be utilised to enhance behaviour change. For instance, the fear of having heart disease could motivate a person to undertake physical activity (which they might initially find unpleasant). Also, smoking cessation is usually motivated by the fear of the health-related consequences of smoking (Gallus et al., 2013), although sometimes it might be based on immediate benefits or incentives of quitting. On the other hand, individuals' hope for behaviour change can be utilised by providing a better alternative for performing a task in order to make the existing unhealthy behaviour irrelevant. For instance, food delivery services like Diet Chef deliver healthy food and recipes to individuals to help them lose weight and eat healthy food. This is a healthier (and probably cheaper) alternative to snacking and fast food. As a design consideration, risk projection mechanism can serve as an example of the anticipation motivator, where individuals are presented with a visual projection of the consequences they are at risk of facing (say, bad dentition) if they do not change a certain behaviour (say, smoking). Social networks are an implementation of the belonging motivator as they afford the opportunity for either social acceptance or rejection due to its supportive and competitive nature. The Fitbit community is an example of a social network that can provide support for behaviour change by challenging and encouraging members to perform physical activities.

The elements of simplicity or ability are time, money, physical effort, thinking time, social deviance, and non-routine. In this case, the ability of an individual to perform a task is related to the simplicity of the task. Usually, a task is considered simple if it requires less time, less money, less physical effort, little mental stimulation, least defiance of social norms and/or involves routine activities. However, these elements are relative depending on the individual – some people might appreciate some mental challenge while others might not. Gamification can be utilised to simplify the task of behaviour change. It involves the use of elements for game design in real life, nongame contexts (Lister et al., 2014) and has become common in the design of health and fitness apps. In preventive health applications, it uses game-like incentives (like leaderboards, levels, digital rewards, competitions, real-world rewards and social/peer pressure) and (more recently) engaging narratives to sustain individuals' habits and increase motivation over time. Hence, these apps can be immersive or non-immersive in nature. Immersive apps are designed to generate images or narratives that appear to surround the user. *Zombies, Run!*⁶ is an example of an immersive fitness app while some

⁶<https://zombiesrungame.com/>

non-immersive apps are Garmin⁷, Fitbit⁸, and MyFitnessPal⁵. An example of a successful implementation of gamification in preventive health technology is the running app *Zombies, Run!* This app motivates users to enjoy their running/walking experience by providing a narrative that presents the user as one of the survivors of a zombie epidemic. This helps add some fun and entertainment to the (sometimes, tedious) task of running.

The model also outlines the three types of triggers as spark, facilitator, and signal. A spark trigger uses a medium (text, multimedia, etc.) to communicate material designed to highlight any of the motivational elements; for instance, a text message that encourages social acceptance. A facilitator trigger uses a mechanism designed to make a target behaviour easier for the individual to perform; for instance, Amazon's 1-click purchase method. Signal triggers serve as a reminder to the user to perform a target behaviour and it is most effective when people have positive levels of motivation and ability. Nudging is an example of the implementation of signal triggers. This is a concept that aims to influence individuals' behaviours through (in)direct suggestions. Most wearables utilise the nudge technology (mostly through notifications and tactile responses) to encourage users to be more active. As earlier stated, signal triggers work best when individuals are already able and motivated to perform a task but there are plans to invent nudges that are still effective even when there are low levels of motivation. Future design considerations for nudges include a smart watch that can inform users to walk to work instead of catching the bus or train and a smart sofa that can kick people off it when they have been on it for too long (Lupton, 2016). I am not convinced that these highly persuasive nudges will be effective for achieving sustained behaviour change as this limits the individuals' agency to determine appropriate ways specific to them for practising healthy behaviours.

According to the Motivational Technology Model framework for designing preventive health applications as motivational technology outlined in (Sundar et al., 2012), there are three affordances of media interfaces that can enhance the intrinsic motivation of individuals for preventive healthcare by meeting the three psychological needs of individuals known as autonomy, competence, and relatedness (Ryan and Deci, 2015). These affordances are

- **Navigability:** This refers to the extent of individuals' ability to find their way around the system, and it builds the individuals' need for competence as people

⁷<https://www.garmin.com/>

⁸<https://www.fitbit.com/>

feel more competent using a system when they can comfortably navigate through the system's online content.

- **Interactivity:** This is the existence of a reciprocal exchange between a user and the system (system interactivity) or other users (user interactivity), and it builds the need for relatedness because users feel related or connected to the system or online community where reciprocal interaction is present.
- **Customisation:** Here, users are empowered to tailor content to suit their needs or preferences. It builds the need for autonomy as individuals feel they are in control of tasks related to their health when they have the power to “tweak” application content to suit them.

These affordances can support the elements of motivation previously discussed to facilitate the design of preventive health technologies which go beyond providing users with health information about their health status to encouraging them to assume the responsibility of practising healthier behaviours to improve their health outcomes. Molina and Sundar conducted an empirical test for the relationship between the technological affordances of BodySpace (which is a body building and weightlifting app) and individuals' fitness behaviour and they discovered that features of the app that support autonomy, relatedness and competence were positive predictors of individuals' app usage and fitness behavioural outcomes (Molina and Sundar, 2018).

The FBM provides a framework with which to assess persuasive technologies such as preventive health applications. The model can be useful at an individual level, but some complexities are introduced when attempting to reproduce it at a population level. For instance, individual and social differences mean that one person's motivator is another's demotivator, and this becomes a limitation. So, we need some higher-level framework or concept to achieve behaviour change at a population level.

2.3 Summary

Motivation is closely enmeshed with the individuals' values. Mismatched values, between what the technology provides (or rather, what the system developers offer via the technology) and what the individuals are interested in, do not motivate user participation of the system (Waycott et al., 2016). System developers sometimes build applications based on general assumptions which do not always successfully translate

into real-life scenarios and this leads to users disengaging from the technology. One way to address this issue is to focus on the individual(s) who will use the technology during the system development stage.

Despite the importance of trial studies of preventive health technologies, there are potential institutional problems involved with administering trial studies in the fitness tracker ecosystem because of the difficulty of applying a clinical methodology to fitness tracker studies when you look at fitness trackers as part of a marketplace ecosystem. Usually, such studies are administered with a "representative" population consisting of people who may not all like the technology used for the study and this can contribute to high dropout of the study participants. However, research shows that social support, among other factors, can support sustained use of activity trackers and positive behaviour change.

The design models and considerations reviewed in this section mostly work with individuals who are already interested in their health, but the big public health issue is with individuals that are not bothered about their health (the *unworried well*). The *worried* and *unworried well* categorisation is a useful way of stratifying the population; however, there might exist interesting sub-categories within these groups. In any case, both groups use health resources in different ways – the worried well may use the resources by seeing their General Practitioner (GP) more often than necessary while the unworried well (due to their nonchalance to their health) develop conditions that take up time and resources.

Also, the reviewed design models are more focused on the usability of preventive health technologies than on the values and needs of the users of the technologies. This necessitates the consideration of design models that implicate individuals' value and underlying value systems in preventive health technologies to achieve behaviour change at a population level. Hence, a discussion on the role and integration of value in technology is presented in the next chapter.

Chapter 3

Value in Technology

It is common knowledge that individuals' [health] behaviours are influenced by the values they develop. Young & West conducted a survey on young people who provided data about their values and substance-use when they were 15 years and by 18 or 19 years, data on their substance-use was collected again (Young and West, 2010). They found that the participants' values were associated with substance-use as young people with anti-authoritarian values were more probable to use different substances (smoking, drinking and drugs). Apps that only target behaviour change can be limited because they target specific behaviours and will succeed or fail but health is influenced by a myriad of tiny (almost unconscious) decisions which will not all be addressed by a single app. Hence, achieving a change in values will better support behaviour change since individuals' behaviour is influenced by their values.

There are various design mechanisms that have been utilised in the design of preventive health applications to achieve positive behaviour change, some of which have been briefly discussed in the previous chapter (nudges, gamification/incentives, and social networks/community). However, I chose to focus on value-based design mechanisms for this research because of its potential to influence individuals' health behaviours in a more sustained manner. In this chapter, we discuss some value-centric frameworks and their applications and ways to handle the differences in the values of individuals.

3.1 Description and Background

Value can refer to the economic worth of goods/services but in this thesis, value refers to the individual's and society's desires which serve as standards or criteria to guide

their actions, judgement and choices (Pereira and Baranauskas, 2015). This is different from *values* which are beliefs, attitudes and principles that people hold about a thing and these are established in a social group (e.g. Christian values which could be held by Christians and non-Christians alike because values can transcend an individual's beliefs). Individuals subscribe to or hold values (which can be changed or reinterpreted by the individuals within the social group). Values provide a framework for identifying the value of some activity (e.g. a service); so, an individual's values are the framework for attributing value to performed actions. For example, an old person's values might emphasise the importance of family, so high value would be placed on receiving a visit from a son or daughter.

Value moves within social groups in a continuous flow - being transformed and repurposed, and we can create more value through interaction. Technologies that are built with an understanding of the values of different groups that interact with the technology can use data to keep track of the flow of different types of value. They can also accelerate the creation of new value by facilitating actions that would not have happened without the technology. Hence, the technology has pointers to value and the possibility to control the flow of value and interactions that create new value. Depending on the analysis of value we have, we should aim to keep track of the different kinds of value. This involves data collection and the use of that data allows us to exercise control over data flow and value creation. For instance, linking wearable fitness trackers with the MyFitnessPal diet app produces data that can be leveraged to create new value.

Incorporating value in technology entails discovering users' values to construct systems that can use the flow of values as an incentive to achieve the desired outcomes. Value is implicated through engagement and not embedded in the technology (Brock et al., 2013). After the inception of industrialisation, software developers and companies were solely responsible for choosing and incorporating/creating value into technology and this usually led to conflicting situations. Friedman gives an example of a 3D rendering system designed to support artists with animation production (Friedman, 1996). The system designers assumed users would work from static hand-drawn or computer-generated images, but the users had a different idea of how the system should work. They tried to work from video images and discovered the system had no support for video input. This might seem like a requirements gathering problem, but from a value perspective, there was a mismatch between what the system designers considered important for animation production and what the artists valued.

This mismatch of value for the technology between the providers and users contributed to the introduction of value-centric design models and frameworks that take the users' values into account throughout the design process. As technology and access to it improves, the narrative has and continues to move from value creation to value cocreation in technology. In the next section, we will discuss some of these frameworks.

3.2 Value-Centric Frameworks

This section provides a discussion on some existing design frameworks which have as a focal point the involvement of end users in the design of technology and the value obtained by the users from the technology. These design frameworks obtained their roots mainly from the *socio-technical design* which is a design approach that equally takes into account the social and technical issues involved in designing any new technology (particularly, new work systems within organisations) (Mumford, 2000a). This design approach was developed by the *Tavistock Institute*. The approach was motivated by what was seen as the spread of *Taylorism* - a philosophy focused on the optimisation of the way work is done to increase productivity (Littler, 1978), into many areas of work supported by information systems that forced the pace of work. This famously led to an industrial dispute at the Lucas company in the UK and spawned Mike Cooley's book "Architect or Bee" (Cooley, 1981) that analysed the effects of paced work and proposed a socio-technical alternative growing out of organised labour in the company. This response to the advance of Taylorism is captured in (Brödner, 1990). Socio-technical design developed further in the last two decades of the 20th century with approaches such as computer supported cooperative work (CSCW) originating in the mid 1980s. Baskerville et al. (2013) provides a useful summary of the state of socio-technical design at the end of the 20th century. Socio-technical design aimed to improve the quality of working life by involving the future users of the new technology in the design phase (Mumford, 2006). This approach to IT systems design and development is particularly relevant to this research because of its focus on the rights and needs (value) of the users in addition to the non-human factors of the new technology (*ibidem*). In many ways the principles of socio-technical design provide the starting point for the the development of the range of design frameworks we summarise in this section.

Here, we provide a brief summary of the principles of socio-technical design (Mum-

ford, 2000b; Cherns, 1976) and how they provide the basis for the frameworks we consider.

1. **Compatibility:** This points to the idea that the design process must be compatible with the processes, organisations, and work structures you intend to create. For instance, if the objective is to create work processes that support the co-production of health, then the design process should support co-creation and participatory activities. This principle describes the origins of participatory design.
2. **Minimal Critical Specification:** This says there should not be over-specification of details and the exercise of control where none is necessary in order to provide freedom for the individual to improvise where necessary. This can be difficult to implement because individuals might perform some tasks inefficiently without detailed specification.
3. **The Socio-technical Criterion:** This is like a principle of subsidiarity where deviations from the expected norms are resolved by members of the group where such deviations originate and does not go beyond that group. This principle is also a part of participatory design where the relevant users who have knowledge of the socio-technical context of the design problem are active participators in the design process.
4. **The Multifunctionality Principle:** This is about designing work with redundancy built in so people can adapt and learn to cope with exceptional systems. This principle builds the roots of dependability and resilience.
5. **Boundary Location:** This says boundaries between groups and work processes should follow the logic of the work and not some other organisational imperative so that people working can understand how the work is split up and encourage smooth transitions. This is utilised in Service-Dominant Logic that highlights the existence of institutions and institutional arrangements, at various levels of the organisation, which define boundaries that either enable or constrain service exchange. It is also used in the Service Codesign approaches.
6. **Information:** This is about how information flows and ensuring it informs people doing the work so they can make effective local decisions (see 2 and 3 above).

7. **Support Congruence:** This focuses on incorporating social support into design to reinforce social behaviour. Providing social support in technology through social networks to support behaviour change is discussed in section 2.2. Social support is a different type of value which needs to be designed into work systems and can be addressed by either of the value-centric frameworks later discussed in this section.
8. **Design and Human Values:** This identifies six sub-principles that identify human values in work processes such as opportunities to meet challenges, learning opportunities, feeling valued as a decision taker, obtaining social support, opportunities to relate work to social life, and feeling you have a future. Such human values are at the center of frameworks like value-sensitive design, value constellation model, and service-dominant logic.
9. **Incompletion:** Design is iterative and never stops because things keep changing. This principle characterises some of the frameworks discussed in this section such as value-sensitive design and service-dominant logic.

There are several design frameworks and approaches such as Computer-Supported Cooperative Work and information systems which have evolved, in part or whole, from the concepts of the socio-technical design. Some aspects of Human Computer Interaction (HCI) have also been influenced by socio-technical design ideas such as usability and user-centered system design (Baxter and Sommerville, 2011). Some of these resultant design frameworks and approaches are discussed in this section. The aim of this discussion is to give the reader some understanding of the broader literature where this research is situated.

3.2.1 Service Codesign Approaches

The involvement of end users in the design and evaluation of services and technology determines, to a large extent, the successful adoption of the technology (Kushniruk and Nøhr, 2016) and can support the codesign of services by the designers and users. The creation of these approaches was driven by changes in the technology and society - particularly, the use of computers by the general public and not just by computer experts and its use in all aspects of life beyond the workplace (Forlizzi, 2018). It has been understood that new services and products are more likely to be accepted and sustained when the people who understand the existing processes and context for the

innovation are involved as active participants in the design process (Robertson and Simonsen, 2012). Essentially, these individuals will better know what the new design will need to do and will be key to how well the new practice will work. The service codesign approaches differ depending on the degree of user involvement and there are three main classification of user-involvement design approaches (see Figure 3.1 for a graphical representation).

- (a) **User-Centered Design:** This is the *design for* approach where users provide the primary input in the design process which designers use to design products and services for the users (Perrott, 2013). In this design approach, the designers bring the users into the design process, taking their needs and interests into account with an emphasis on the usability and usefulness of the design project (Dwivedi et al., 2012). This usually involves the designer observing the users and making notes of their needs, interactions, and preferences using observational and usability testing methods such as guided walkthrough, interviews, etc. The main challenge with this approach is understanding the users' needs and designing to meet those needs (Kushniruk and Nøhr, 2016). Duarte and Guerra applied this approach within a health center to understand users and employees behaviours, their needs and interaction with technology to provide better health services to patients (Duarte and Guerra, 2012). The researchers used the Grounded Theory Method to produce a theoretical account grounded in observations of the users and employees.
- (b) **Co-operative Design:** This is the *design with* approach where the users work together with the designers in providing solutions to design issues by coming up with the designs and any modifications to the design (Perrott, 2013). The main challenge with this approach is how the designers cooperate with the users in the design process (Kushniruk and Nøhr, 2016). Computer-Supported Cooperative Work (CSCW) is a research field that helps to address the coordination of such cooperative activities using computer systems (Olson and Olson, 2007). This involves the use of prototyping and simulations to allow users to explore future use cases and support discussion between users and designers (Kushniruk and Nøhr, 2016). A study conducted by Procter *et al.* explored the experience of older people who were living with assisted living technologies and care services (Procter et al., 2014). They found that successful ageing was made possible by the collaborative, daily efforts of the older people and their formal and informal

networks of carers.

- (c) **User-Driven Innovation or Participatory Design:** This is the *design by* approach where the users are active participators in the design process (Perrott, 2013). The goal of this approach is to engage the users to design and develop services themselves. As shown in Figure 3.1, the user is a key part of the design team and responsible for the key aspects of the design decision making while the designer supports and facilitates the users' creative design process. The emphasis in Participatory Design is more on the design practice than the resultant service or product (Bannon and Ehn, 2012); this consists of mutual learning where the potential users learn about what is being designed, the design process and its outcomes and the designers learn about the users and their existing practices (Robertson and Simonsen, 2012). Some tools and techniques used in this approach are design workshops, mock-ups, prototyping and personas (ibidem). A major challenge for this approach is the appropriate way to allow room for user innovation, collect and analyse these innovations, and transform them into new services or products (Kushniruk and Nøhr, 2016). Davidson and Jensen applied the participatory design approach in their examination of the capability of older adults (who usually have little experience with technology) in designing novel smartphone design ideas (Davidson and Jensen, 2013). The researchers also observed the effect of critiquing existing applications prior to ideation on the participants' creativity and discovered that this limited their ability to produce more creative design ideas. They found that out of five focus groups, the group that produced the most creative design idea consisted of older adults who had no smartphone experience or exposed to existing applications before producing their design idea.

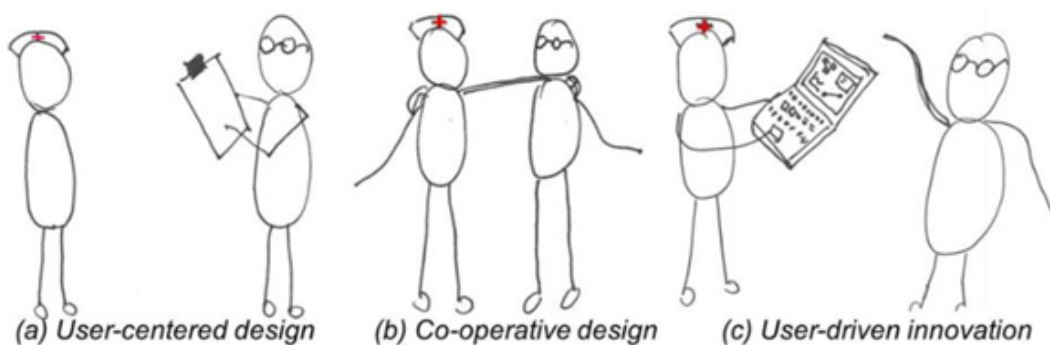


Figure 3.1: User-Involvement Design Approaches (Kushniruk and Nøhr, 2016)

Although the three classes of user-involvement design approaches share some design methods and tools in common, the major difference between them is that it is essential in participatory design for the research and design work to be done with the users while the work can be done on behalf of the users in the other approaches. However, what these design approaches have in common include the iterative nature of their design process and their goal to understand the context of use and design services that meet the users' preferences, values and needs. User-involvement approaches underpin value-centric design approaches because to incorporate users' value in a research design, these users will need to be included in the design process. In the following sections, we discuss some value-centric frameworks in detail.

3.2.2 Value Constellation

The Normann and Ramirez's Value Constellation Model, which is a business dominant model that dates back to 1993 (Patrício et al., 2011), seeks to present a commercial idea beyond the flow of value within a simple customer-to-firm structure to a more complex constellation of players who may each participate in creating and consuming value (Musumeci, 2017) (see Figure 3.2). It aims to move from value creation to value cocreation and it is used to highlight or uncover where the value lies within a constellation of players or users. This model is relevant in the context of digital technologies where an individual's data can gain additional value (for the user, firms, researchers etc.) by being combined with data from other users of the technology.

This model utilises a *Value Constellation Map* to highlight the different kinds of value (what they are and where they reside) that are created and consumed by relevant players as they exchange services and integrate resources. This map outlines an extensive description of the actors and processes involved in the value cocreation activity represented by the green area in Figure 3.2. The example in Figure 3.3 outlines the value constellation map for a fictitious cleaning service (Crucera, 2014). This constellation map example illustrates how the users of the cleaning application can cocreate value and in which services those values lie. Aspire, a company that produces high quality and pricey vacuum cleaners, created a digital technology Cleanbook in order to reach new markets. Cleanbook is a social platform where students, the unemployed or occasional cleaners can offer their cleaning services in their spare time to make some money. Using this digital platform, customers can choose the cleaner(s) they require for a cleaning task based on reviews and rating provided by other customers. When a

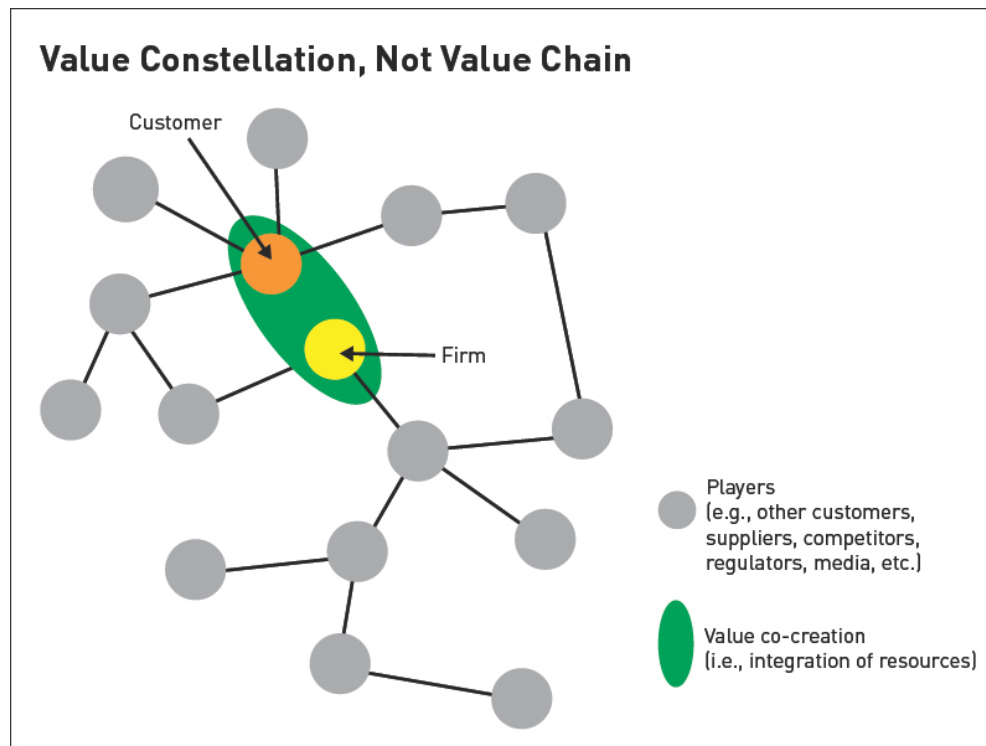


Figure 3.2: Value Constellation (Musumeci, 2017)

cleaner is chosen by a customer, (s)he receives the necessary cleaning materials from Aspire. Suppose there are different possibilities for the cleaning products used; for instance, a premium service that uses harsh chemicals and a green service that uses environmentally friendly cleaning products.

As a result, value gets cocreated and consumed by all actors involved. The customers receive affordable cleaning services that support the expression of their social and environmental values, the cleaners earn money, reputation and trust via customer ratings and the Aspire company gets launched into new markets. A more complete analysis of the value created and consumed by the users is represented in Figure 3.3. It is important to note that the online booking service is a part of the Cleanbook digital platform but has been presented as a separate service in Figure 3.3 because it is only directly used by the customer.

From Figure 3.3, we see that users can exchange value directly and through the three service organisations provided. For instance, customers value the cleaning provided by the cleaner while the cleaners value the reviews and rating provided by the customer. The company adds quality and brand to the Cleanbook platform which in turn, provides access to a new market and more customers to the company.

Despite its relevance in digital technologies, the Value Constellation Model serves

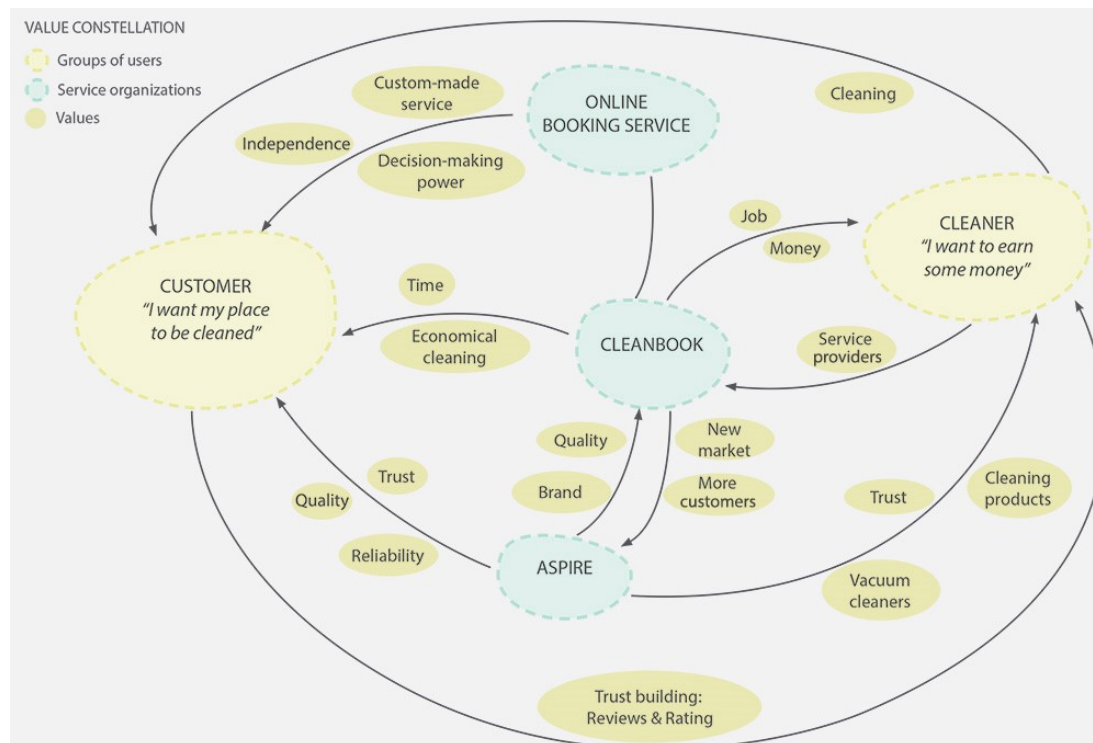


Figure 3.3: Example of a Value Constellation Map (Crucera, 2014)

best as a tool for the identification of the users of a technology, their values and value flows between the users. It does not provide a methodological approach for how the identified values are incorporated into the technology. However, it is useful in its approach of taking the focus off the company or firm and on the value-creating system instead (Musumeci, 2017). This makes it applicable to various contexts and fields, although applications of the model in existing literature have been mostly business-based.

Thus, in the next section, we will discuss a value-centric framework which accounts for the design, development and implementation of a technology.

3.2.3 Value Sensitive Design (VSD)

Value Sensitive Design is a technology design process which proactively incorporates the consideration of human values into the technology; it prioritises the ethical import of human value in technologies over the technology's use and performance (Friedman et al., 2013). In the field of Human-Computer Interaction (HCI), it is recognised as the most extensive framework for the consideration of human values in technology design (Davis and Nathan, 2015). VSD encapsulates a tripartite methodology

composed of conceptual, empirical and technical investigations to account for human values throughout the technology design process. It is important to note that these investigations are iterative and integrative, so they are not to be used in isolation. This three-part methodology is outlined below and presented in Figure 3.4.

- **Conceptual Investigation:** This component strives to identify the direct (individuals who will use the technology) and indirect (individuals who will be influenced by other peoples' use of the technology) stakeholders affected by the technology, their varying (sometimes conflicting) values and how those values are implicated in technology. Stakeholders, in this context, refers to roles and not individual people (Davis and Nathan, 2015). This component focuses on investigating the concepts on which the technology is grounded. For instance, the health professional's value of using data from the PHR to identify trends in the user's health data could conflict with the user's value of data security and privacy.
- **Empirical Investigation:** Here, the focus is on the humans' response to the technology which is mostly obtained via quantitative and qualitative research methods such as interviews, surveys, questionnaires, prototyping and measurements of human behaviour.
- **Technical Investigation:** This can be conducted in two forms:
 - a investigating how existing and underlying technological properties and mechanisms support or constrain human values and
 - b incorporating design principles that support the values identified in the conceptual investigation into the technology (Friedman et al., 2013).

The question of whether these investigations must be followed sequentially has been hugely debated with some scholars insisting that the conceptual investigation must be done first while some suggest that the researcher can start with either an empirical or technical investigation (Davis and Nathan, 2015). In my opinion, the conceptual investigation should be the first step because you need to first identify the stakeholders of the technology to know the target population that would need to participate in a trial study or survey. Ignoring a technology's context and stakeholders limits its influence on individuals' behavioural change; hence, it will also be inappropriate to begin with the technical investigation.

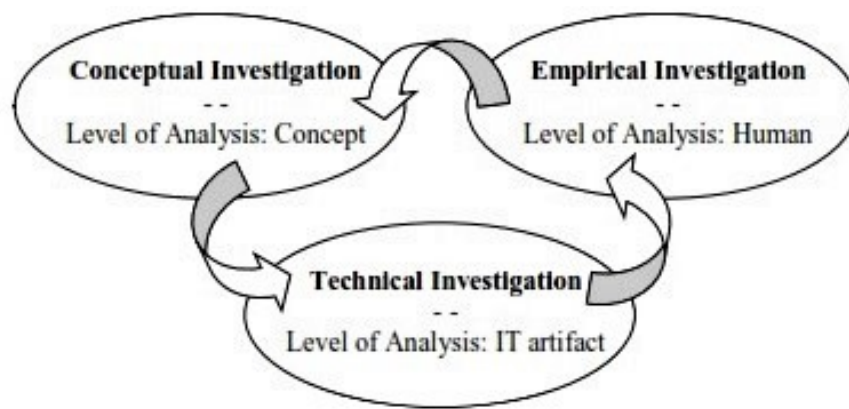


Figure 3.4: VSD Methodology (Dadgar and Joshi, 2015)

Since its formal inception and introduction in 2006, VSD has been directly applied in various domains of healthcare systems. Walton and DeRenzi applied the methodology to the design, development and implementation of health information systems (a vaccine delivery project and a mobile support tool for healthcare workers) in two developing countries in Africa (Walton and DeRenzi, 2009). Nouwen *et al.* used the VSD approach to conduct an explorative inquiry into and understand stakeholders' needs and values for a parental software that balances online opportunities and risks for young children (Nouwen *et al.*, 2015). Some researchers have adapted the framework in the design of new design frameworks. Van Wynsberghe applied VSD as a blueprint for the retrospective and prospective ethical evaluation of prospective robots in healthcare (which she calls *care robots*) to ensure their design and use does not hinder the values of the patients (Van Wynsberghe, 2013). The author adapted the VSD methodology to create a framework tailored to the care contexts and ethics which she referred to as *Care Centered Value-Sensitive Design* (ibidem).

However, VSD has been critiqued by different scholars highlighting flaws in the way the methodology has been formulated and is applied (Davis and Nathan, 2015). VSD's conceptual investigation is based on the premise that certain values are universal, although they can be expressed differently across various cultures (Friedman *et al.*, 2013). In response to this position, Borning and Muller proposed a shift from a philosophical to empirical analysis for stakeholders' values (Borning and Muller, 2012). Although an empirical analysis for the stakeholders' values helps to ensure that the elicited values are within the relevant context of use, I think there could be the risk of selection bias (that is, selecting an unrepresentative sample of the population for the analysis) especially when the technology is intended for large-scale use. This

can also introduce conflicts in the identification and definition of implicated values as individuals of different nationalities can have opposing values (such as individualism versus collectivism) (Hofstede, 2011). Hence, an empirical analysis for values can still be flawed depending on the selected sample and a flawed conceptual investigation is more likely to produce faulty empirical and technical investigations. Also, values defined by an individual may conflict with the values shared by a group to which this individual belongs (Davis and Nathan, 2015); hence, the importance of identifying values through the lens of the institutions and social norms that guide the different stakeholder groups.

3.2.4 Service-Dominant Logic (SDL)

As presented in Figure 3.5, value co-creation is defined as “Establishing nested and interlocking service ecosystems of actors involved in resource integration and service exchange enabled and constrained by endogenously generated institutions and institutional arrangements” (Vargo and Lusch, 2016). In Service-Dominant Logic (SDL), a constellation of actors integrates resources in service-for-service exchange for the purpose of cocreating value. From this definition, there are four major components involved in value cocreation - Service Ecosystems of actors, Resource Integration, Service Exchange, and Institutions & Institutional Arrangements.

Service-Dominant Logic is very similar to the Value Constellation Model because they both have value cocreation at the core of their processes. However, SDL differs from the Value Constellation Model in the way it takes the institutions and institutional arrangements that enable or constrain service exchange in the value cocreation process into account. For instance, looking at the institutional arrangements that enable or constrain the services exchanged by cleaners in the example outlined in Figure 3.3 draws attention to the role of cleaning agencies who act as an intermediary between cleaners and the customers that require cleaning services. Understanding the existence of this institutional arrangement might necessitate a verification process when users sign up on the digital platform as a cleaner to ensure they are individual cleaners and not cleaning agencies who can constrain the monetary value that individual cleaners can receive in exchange for their cleaning services.

Interestingly, the implementation of *disruptive innovation* is often characterised by the absence of institutional arrangements relative to their predecessor arrangement. For example, Airbnb did not have to satisfy the same institutional arrangements as hotels,



Figure 3.5: The narrative and process of value cocreation (Vargo and Lusch, 2016)

but slowly new institutional arrangements (e.g. the introduction of city lodging taxes by local regulations) are being put in place that make Airbnb establishments behave more like a conventional hotel and as a result, their competitive advantage is being eroded.

Recent SDL literature recognise institutions and institutional arrangements as the “foundational facilitators” of value cocreation (Vargo and Lusch, 2016) and rightly so, as they consider the social contexts involved in the value cocreation narrative. SDL presents a more complete picture of how a technology is developed and embedded in existing institutions and processes to enable value cocreation and is thus the more suitable framework to explore for the development of the theoretical methodology outlined in Chapter Four. Furthermore, given that the empirical methodology for this research was conducted at an institutional level, it is appropriate to have an institutional understanding and outlook on the value cocreation process when designing a technology at this level.

Following a shift of mainstream marketing focus from an emphasis on production to an emphasis on value (co)creation, service-providing enterprises including the Health Industry have identified the need to deviate from a company-centric stance to engaging customers/clients in the process of production and value creation. This ap-

proach is encapsulated in the SDL framework to support value cocreation processes within organisational processes and practices. As information and advances in technology increase, so does the practice and application of SDL which in turn increases the prevalence of the concept of value cocreation.

A Goods-Dominant Logic (GDL) firm is characterised by the understanding that value is internally produced and embedded in goods and services by the firm and without any direct interference by customers whose role was to consume the goods and services; thus, fostering a customer-to-firm relationship (Skålén and Edvardsson, 2016). But in the value cocreation process, actors can be on either end of the service exchange process – receiving or providing. Here, the customer-to-firm relationship from the GDL is replaced by the actor-to-actor relationship where all actors (from individuals to large companies) can integrate resources and participate in the exchange of services. In SDL firms, customers take on an active role in value creation as opposed to GDL firms where customers are treated as a passive audience (*ibidem*). As in VSD, for each service exchange there are direct and indirect actors involved in resource integration. However, unlike VSD, SDL points to a concrete notion of value and its creation through interaction that orients designers to capturing flows of value and providing the means to cocreate. The role of institutions in the transmission and maintenance of human values is well acknowledged by most theorists (Devos et al., 2002). Institutions, in this case, do not refer to organisations but to routinised rules, norms and beliefs devised by humans, and institutional arrangements refer to sets of interrelated institutions. Institutions and institutional arrangements are instrumental in understanding the underlying functioning and structure of the service ecosystems and consequently, the value cocreation process because the context of use for the innovation is considered from the onset.

An example of institutions are the clinical standards set up in NHS which guide the administration of care to individuals and the NHS Foundation Trust is an example of an institutional arrangement because it consists of different participating organisations and actors with their (often competing) institutions. For instance, Berkshire NHS consists of participating organisations, General Practitioners (GPs), hospital managers, patients and their family and friends. A more detailed description of how these actors interact and what and where values are created is presented in Chapter Six.

Institutions and institutional arrangements, as outlined in figure 3.5, can enable or constrain service exchange and value cocreation as they can lead to the prevalence of (in)effective ideologies or norms. For instance, clinical standards within the NHS that

restrain general practitioners (GPs) from establishing a connection with their patients can constrain value cocreation because it maintains the status of an expert-to-amateur type of relationship which does not give much room for service exchange to occur. However, depending on the approach, these constraints can provide an avenue for innovation to occur (Vargo and Lusch, 2016).

Since value can be cocreated by relevant actors, it is important to note that it can also be co-destroyed by these actors. According to (Palumbo, 2017), value co-destruction is mainly due to a misuse of the available resource by either the users of healthcare, its providers, or both of them; and is sometimes, the unintended consequence during service exchange between actors. Keeling *et al.* conducted an ethnographic study within the NHS where healthcare practitioner consultations with their patients were observed to capture the delivery of health services in a natural context (Keeling et al., 2020). The study was conducted with 13 specialist practitioners and 24 patients and it was discovered that the mechanisms that contribute to value co-destruction include

- lack of resolution of power tensions and reluctance of the patients which limit opportunities for knowledge sharing,
- the eagerness of practitioners to provide solutions to the patients without providing room for doubt which inhibits patients from providing their perspectives and concerns on their health conditions and treatment,
- and denial of affirmation (by either practitioner or patient) which limits opportunities to allay negative emotions and reduce tension during dialogue.

3.2.4.1 Services, Resources, Values and Prices: How do these relate?

Value is inherently heterogeneous and multi-faceted; however, we can agree that money is a type of value. A price can refer to the amount of payment (usually monetary) given in exchange for a unit of goods or services. Price is related to markets and is determined, to some extent, by supply and demand. On the other hand, value is, to some extent, independent of markets but it is not individual – it depends on the social group to which an individual belongs; hence the importance of understanding the underlying institutions and institutional arrangements. In GDL firms, value is perceived to be embedded into goods and services at the point of production without any direct contribution from the customers whereas in SDL firms, goods and services are viewed as

having potential value which is realised when resources are integrated and used (Skålén and Edvardsson, 2016).

Services are usually non-material in nature; however, they utilise the integration of often material resources for service delivery. In other words, services are the integration or application of resources (Vargo and Lusch, 2016) which can sometimes be embedded in a tangible good and other times can be directly delivered to another actor (Joiner and Lusch, 2016). There are two types of resources: operand and operant resources. Operand resources are mostly tangible and are the main resource for the GDL as the focus was embedding value into the attributes of these operand resources which could be products or services such as funds, equipment, computers, raw materials, smart phones, buildings & facilities, etc. Conversely, operant resources are generally intangible, human-driven and shaped out of experience/knowledge. For instance, to deliver diagnostic or treatment services, you will require the expertise of a human resource (a health professional) who will integrate her medical skills to provide the appropriate diagnosis or treatment. In SDL firms, the employees are mainly treated as operant resources because their skills and knowledge are valuable in supporting value cocreation and resource integration for their clients.

Services and resources can have inherent explicit or implicit value in themselves and a price depends on the market; however, value can also be created when a service is exchanged. There are cases where the price of a resource/service predisposes people to use the service. For instance, cardio-vascular fitness services are valued highly by “fitness freaks” but not so highly by other people. However, many people who do not value these services might choose to purchase them because they can afford them, and they might think using the services circumvents some adverse consequences. Interestingly, the manner of use of the services by such users might differ significantly from that of those who have an inherent/intrinsic value for the services. Thus, it appears that the inherent value that actors receive from services and resources plays a more vital role in the integration and exchange of these resources and services than the extrinsic value (price or monetary incentive) they possess.

Adherence to treatment and behavioural modification services can also be influenced by access to formal intervention or treatment programmes. For example, participants who received formal cardiac rehabilitation after a cardiovascular accident were found to have spent significantly more time on physical activity and experienced significant increases in self-efficacy and behavioural processes of change by the end of the treatment period (Bock et al., 1997). However, by the 3-month follow-up stage

after treatment had ended, some regression toward earlier behaviours were observed as 42% of the participants had started to exercise less each week when compared to the post-treatment stage. So, it seems these participants valued adherence to exercise a bit less after they had completed the rehabilitation exercise. The removal of a health expert and termination of the rehabilitation exercise caused a change in the coproductive arrangement and perhaps, a change in value(s). Perhaps this arrangement could have been sustained by introducing individuals who had previously begun the rehabilitation exercise to the participants early in the programme because they could have created links that would have been sustained to support their existing coproductive arrangement. This emphasises the importance of value(s) integration into activities where individuals' motivation can be affected by other external factors.

However, for successful value cocreation to occur, actors need to integrate available resources to deliver cost-effective services in such a way that other actors can determine what value(s) they consume from such services and are able to exchange a service that other actors may find valuable.

3.3 Value Cocreation and SDL Application in Healthcare

As SDL encapsulates the value cocreation process well, it is an appropriate framework for the design of technology that provides affordances that can support actors in the cocreation of value through service exchange and resource integration. Since healthcare is the context of interest for this research, it is relevant to review how value cocreation and the SDL have been previously applied in this context.

Existing literature have addressed the use of value cocreation in healthcare in various ways. Zhang *et al.* developed a model for an application of value cocreation in healthcare services by collecting feedback, via a scale-based feedback system, on participants' satisfaction as an input for producing insight on the improvement of healthcare services (Zhang *et al.*, 2015). Nambisan *et al.* developed a theoretical framework that describes four models of consumer value cocreation (the partnership, open-source, support-group and diffusion models) that healthcare organisations can adopt to involve consumers as partners in the development and delivery of innovative healthcare products and services (Nambisan and Nambisan, 2009). Spanò *et al.* conducted a controlled trial to determine whether home-based therapeutic solutions can drive value cocreation

for patients and healthcare systems and they claim that self-administration is a good example of value cocreation where all actors can benefit despite conflicting logics and objectives within healthcare systems (Spanò et al., 2018). This trial was funded by a commercial organisation in the biotechnology sector which makes it potentially difficult to extend the intervention approach to other health services that might be driven by different (or even conflicting) values for the economic utility of such products or services, and to individuals/voluntary users who may have different relevancies (cultures and identities) from the individuals used in the study.

Hence, it is important to explore the production of value cocreation models that can be successfully replicated in various health systems and user contexts. And to the best of my knowledge, few scholars have explored the development of a value cocreation model for the design of health applications and technology.

In healthcare, value cocreation means the shift from Goods-Dominant Logic which involves the production of goods (such as medications) and services (such as hospitalisation) solely by the healthcare organisations or expert health professional who build value into the goods and services for the supposed medically inexperienced patient to consume, to Service-Dominant Logic which involves both the health professional and clients (patients and carers alike) in deciding which values are important and created. It means a shift in the value proposition for individuals from healthcare (rooted in GDL) to health (rooted in SDL); a shift from nouns such as nurses, doctors, and hospital rooms to verbs such as healing, monitoring, and feeling (Joiner and Lusch, 2016). It is important to note that services can be provided in the GDL framework; however, the difference is that these services are solely produced and supplied by the healthcare systems. Whereas, the services exchanged in the SDL framework are co-produced by the healthcare system and the clients.

When we talk about getting individuals to change their health behaviours, the focus is more on the individual's health than on the healthcare they receive. Sadly, concepts like patient-centred care, and patient activation and engagement are often implemented as the customisation of health treatments and services for individual patients instead of really involving the patients/individuals in the decision of what needs to be implemented and how (Joiner and Lusch, 2016).

A few papers have attempted to explore the application of SDL in the context of healthcare. Joiner and Lusch proposed a new lexicon for describing value in healthcare based on SDL (Joiner and Lusch, 2016). The authors had presented some care approaches which they envision as SDL applications in the healthcare system. Except

for the Internet, e-health apps and mobile technology, the applications described (Motivational interviewing, Home-based primary care, Holistic cancer care, and Medical devices and pharmaceuticals) appeared to be team-based care approaches obtainable in the health system and not SDL applications. In SDL, value is cocreated by the actors through service exchange; the authors failed to present a clear description of the services that the health professionals receive in exchange for their services. The narrative sounds more like value being created for the consumer by team effort and that is still in the realm of GDL where goods and services are pre-planned and provided for the consumer to use and find valuable.

Perhaps this strengthens the idea that the most direct application of SDL to healthcare is through the Internet, eHealth applications and mobile technologies - and consequently, can be directly applied in the field of preventive health. This is most likely due to these platforms' focus on support and community rather than on diagnosis and treatment and they offer consumers some level of autonomy over the type, amount and quality of information they consume and transmit. Hence, it is important for the technology and apps to present this information in a way that the consumers can determine its value for them and integrate that value in their daily activities.

It is probably the case that there are limits to the extent to which healthcare can be personalised given the standardised nature of health and care procedures and dissemination. GDL strongly pervades the way health is managed and still manifests in ways such as the health professionals' distrust of patient-collected health data. Although health professionals could have good reasons for this attitude, it is partly founded in the fact that the patient is seen as incapable of producing value. Co-creators often have local knowledge of circumstances and resources that are not accessible to health professionals; hence, many actors involved in the health system currently operate in a fragmented fashion which makes the journey to realising service exchange and value cocreation a more tedious and less travelled one.

3.4 Summary

In this chapter, we discussed the meaning of value in technology, the influence of social groups on individual value, the heterogeneity of value and values, various value-centric frameworks and the critical role of institutions in the shaping of value cocreation. We also discussed the relationship between services, resources, values and prices and looked into some applications of value cocreation and SDL in the field of health-

care presented in existing literature. The cocreation process can be facilitated in the case of prevention and treatment by health professionals, carers/family, and friends. ICT interventions have a positive impact on social support measures which in turn, positively influence health outcomes (Nnabuko and Anderson, 2018). As eHealth applications were described as one of the most direct applications of SDL to healthcare, it is important to provide social support features on such apps to facilitate the coproduction of health by all relevant actors in the cocreation process. The focus of SDL on institutions is a useful way of understanding how the institutional frameworks limit coproductive capacity. This could highlight what needs to change in the institutions and ways it may be possible to work around these frameworks. Maybe it also helps to explain how locally successful coproduction is hard to scale up to larger regions because workarounds might not successfully scale since they depend on personal relationships between actors in order to circumvent institutional arrangements.

In the next chapter, we discuss the empirical methodology for this research and a brief description of the proposed design framework will also be presented.

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Chapter 4

Methodology

This chapter outlines the empirical methodology for this research, describing its aims, participants, study design and procedures, study measures and data analysis procedures. The second section of the chapter presents the characteristics (demographic, clinical and lifestyle) of the study sample. This chapter ends with a presentation of the proposed value-centric framework designed to address some of the shortcomings in the design of the empirical study.

4.1 Empirical Methodology

4.1.1 Description

Within the first 12 months of my Ph.D. programme, the biggest challenge was with defining the scope of the research and securing a suitable project for the empirical study. Given the various types of preventive health applications, it was a hurdle choosing one type and securing funds and consent to undertake the project. Following on from my M.Sc. dissertation (Nnabuko, 2015), I began the programme with an interest in extending research on the Personal Child Health Record (PCHR), eRedbook, with a focus on social interaction and team-oriented design models. However, the process of gaining approval from SiteKit (the eRedbook developers) and securing enough funds to conduct the study was a long and tedious one. There was also the choice of the context of use - the decision between a preventive health application for managing a chronic illness or one for maintaining general health and wellbeing.

Since the focus of the research was to investigate the adoption and use of a preventive health application within a large-scale context, the health sector was a suitable

choice. Also, given that the health sector [NHS] is considered as a highly institution-alised organisation (Bunduchi et al., 2015), it offered a useful platform to investigate the role of institutions in the embedding of IT innovation technology into existing work practices. The NHS across Berkshire recognises their staff have a direct impact on patient experience and the quality of care they receive. A healthier workforce is beneficial to patients and staff, reinforces public health promotion messages and can help in reducing costs associated with sickness absence due to both poor physical and mental health. As part of the NHS healthy workforce programme, East/West Berkshire NHS proposed a 12-month pilot study to observe the impact of a wearable device on the workforce registered with a Berkshire General Practitioner (GP).

This pilot study, the Berkshire Wearable Technology Pilot, provided a solution to the challenges I was faced with and helped determine the scope of the research to the use of wearable fitness trackers in the context of general health and wellbeing. The pilot was funded, designed, and implemented by Berkshire NHS; hence, this research project inherited the scope of the pilot study. However, there was enough flexibility in the design that allowed me to use data from the pilot for my Ph.D. research purposes.

The study offered a unique opportunity to test how data from wearable technology can be included within the Berkshire shared care record system (Connected Care) to support/encourage patients to take actions to improve their own health. Connected Care is an existing portal which shares information about a patient's medical condition across subscribing health and social care organisations in Berkshire. Successful integration of data in Connected Care would allow users and health professionals to access patient-uploaded data in addition to prescription, reminder, and mental health data. The NHS healthy workforce initiative incorporates three action plans - move more, sleep better, and eat well. This stems from findings in existing literature that improved physical activity, healthier diet and sufficient sleep can improve general wellbeing and health. For instance, Lopresti *et al.* conducted a review of the effect of diet, sleep and exercise on depression and reported that poor diet, impaired sleep and reduced physical activity can negatively influence several physiological pathways associated with major depression (Lopresti et al., 2013). Consequently, the project aimed to:

1. Enable and encourage participants to be more proactive in managing their overall health and wellbeing.
2. Test the extraction and integration of wearable data into the existing Connected Care system.

3. Develop and test a patient portal so participants can view their wearable data, enter additional lifestyle data, and engage with their goals and plans for a healthier lifestyle.
4. Investigate the effect of using the wearable device on participants' wellbeing, in terms of improvement in step count, sleep, and other relevant measures, over time through benchmarking and evaluation.
5. Study participant attitudes to using the wearable device and viewing their data, changes in their behaviour/activity levels, awareness of healthier behaviours and engagement.
6. Raise awareness of health and wellbeing within the NHS workplace.
7. Prove a working concept for potential roll out to patient cohorts in the future as part of the New Models of Care Initiative.

Additionally, my goal as a researcher was to obtain evidence to inform the design and implementation of preventive health apps within the healthcare organisation.

Over the longer term, if the integration of clinical and fitness data with Connected Care is widely implemented, Berkshire NHS will capture a rich and holistic picture of an individual's health and wellbeing. This will support the provision of new models of care in Berkshire NHS using wearable technology, personalised care plans and a patient portal to promote self-management of conditions and access to current health and social care information.

The 12-month pilot consisted of providing employees of Berkshire NHS with the Garmin Vivosmart HR wearable device, a wristband that collects data about steps, calories, heart rate, sleep and additional cardio activity such as swimming and cycling; and studying the behaviour of the cohort (without intervention or interference from the project team) in relation to engaging with the information collected with the wearable device.

4.1.2 Participants

Participants for this study were East/West Berkshire NHS staff volunteers who were employed by participating NHS Berkshire organisations including

- Frimley Health Foundation Trust (FHFT)

- Royal Berkshire Foundation Trust (RBFT)
- Berkshire Healthcare Foundation Trust (BHFT)
- Berkshire West Clinical Commissioning Groups (CCGs) consisting of Wokingham CCG, Newbury and District CCG, South Reading CCG, North and West Reading CCG
- Berkshire East CCGs consisting of Bracknell and Ascot CCG, Slough CCG, and Windsor, Ascot and Maidenhead CCG

The goal was to recruit 400 participants to match the number of activity trackers available for the study. To be eligible for inclusion in the trial, the participant is expected to own a smartphone, be registered with a Berkshire GP and complete the recruitment survey. A Privacy Impact Assessment (PIA) was conducted and internal Information Governance procedures were followed to ensure upfront informed consent and minimal use of participants' personal data. The study was approved by the Integrated Research Application System (IRAS) which is responsible for granting permissions for health and social care/community care research in the United Kingdom¹.

4.1.3 Study Design and Procedures

My involvement in the pilot as the Chief Investigator/Researcher was on the recommendation of my supervisors. I was involved from April 2017 until July 2019. My tasks as the Chief Investigator included the design of the survey materials (questionnaires and interview script), selection of interview respondents, administration of the semi-structured interview, analysis of the quantitative and qualitative data, and reporting of findings. This enabled me to shape the study to meet my needs while delivering the study required by NHS South, Central and West Commissioning Support Unit (SCW CSU).

The project utilised a 12-month single-cohort, mixed methods study design. It entailed piloting the Garmin Vivosmart HR band, which tracked physical activity (consisting of steps, activities done, moderate-to-vigorous physical activity (MVPA) minutes, calories burned), heart rate, and sleep (hours). Berkshire NHS employees started to receive invitations to volunteer for the pilot in June 2017 and recruitment continued across the participating organisations for six to seven months to allow enough time

¹<https://www.myresearchproject.org.uk/>

for staff from all participating organisations to respond to the invitation. There were 942 volunteers who completed the recruitment or expression of interest (EOI) survey (outlined in Appendix B.1). Initially, the survey disqualified participants who did not have a smartphone or were not registered with a Berkshire GP. Preference was given to permanent employees over contract staff and volunteers who had not provided a valid *nhs.net* email address were not contacted. A welcome email was sent to eligible volunteers which required them to complete and return the consent form and provide their preference for one of the handover meetings that were to take place across the various participating sites. Participants were shortlisted to participate in the study on a first-come first-served basis. A large proportion of the participants were lost to follow-up during the recruitment time frame which lasted for seven months (1st June 2017 till 3rd January 2018).

The onboarding process started in January 2018 and this happened in two phases. From January to March 2018, participants first attended a handover meeting which held at local sites representing each participating organisation on different days. At the handover meetings, the participants completed and signed the study consent form (outlined in Appendix A), completed the onboarding survey (outlined in Appendix B.2), received their free Garmin activity tracker and obtained help from the project team with setting up the *Garmin Connect app* and syncing their tracker to their smartphone. The project team set up each participants' goals for their steps and floors climbed based on their activity level response in the recruitment survey. For instance, participants who said they exercise for 30 minutes or more for 5 or more days per week were assigned goals of 10,000 steps and 10 floors per day. In line with the physical activity recommendation for adults aged 18 years and older, all participants were assigned a weekly MVPA minutes goal of 150 minutes². There were 359 employees who attended one of the handover meetings. Additionally, 22 employees attended alternative handover meetings in March to receive their Garmin devices. Hence, by the beginning of the data collection phase in March, 381 participants had been successfully enrolled on the study and completed the onboarding survey.

Due to delays in the development of the technology for the pilot, a second onboarding phase began in April 2018 to remotely setup participants who had received their wearable device on the *Berkshire Wearable Patient Portal app* (also called Patient Portal app). Onboarded participants received an email guiding them on how to remotely set up the Patient Portal app on their smartphones and to sync the Garmin

²<https://www.nhs.uk/live-well/exercise/>

Connect app with the Patient Portal app. The patient portal app was useful to test the linking of participants' Connected Care record with the patient portal and it also made it possible for the project team to anonymously view participants' wearable data extracted from the Garmin Connect app. The pilot did not pull any clinical data from the Connected Care record into the patient portal app. Participants could only view their patient-contributed data (wearable data) and public data on their Pilot Patient Portal app. In line with Information Governance procedures for this pilot, the Human Resources (HR) department was not granted access to the data collected during the pilot. The remote setup process involved:

1. registering for a Pilot Patient Portal using a social media account by following a link within an email sent directly to participants;
2. downloading the Berkshire Wearables app (same as Patient Portal app) to a smartphone;
3. logging into the Berkshire Wearables app with the social media account used when registering for the Pilot Patient Portal and setting a pin code for future use;
4. following a link within an email confirming the participant's Pilot Patient Portal is ready for use;
5. opening the Berkshire Wearables app and selecting 'Settings', then 'Health Services' and then 'Garmin Connect';
6. entering the email address and password used when registering for a Garmin Connect account; and
7. selecting 'I consent' to share data from the Garmin Connect account with the Berkshire Wearables app.

However, not all 381 participants were able to complete this remote onboarding process. By June 2018, only 240 participants had completed remote onboarding which accounted for a 63% completion rate. There was an update for the Berkshire Wearables app in June 2018 which meant all participants that had previously linked their Garmin to the Berkshire Wearables app were automatically unlinked and had to do this last step again. But despite emails and mailbox support from the project team, the initial 240 participants were not recaptured. By the end of August 2018, only 208 participants were completely set up on the Berkshire Wearables app. An invitation to complete the

two follow-up surveys at months 9 and 12 was sent to the 208 participants who had been successfully set up on the Berkshire Wearables app (see Appendix B.3 and B.4 for the 9-month and 12-month follow-up surveys respectively). Please refer to Figure 4.1 for a presentation of the flowchart showing participant selection and drop-out.

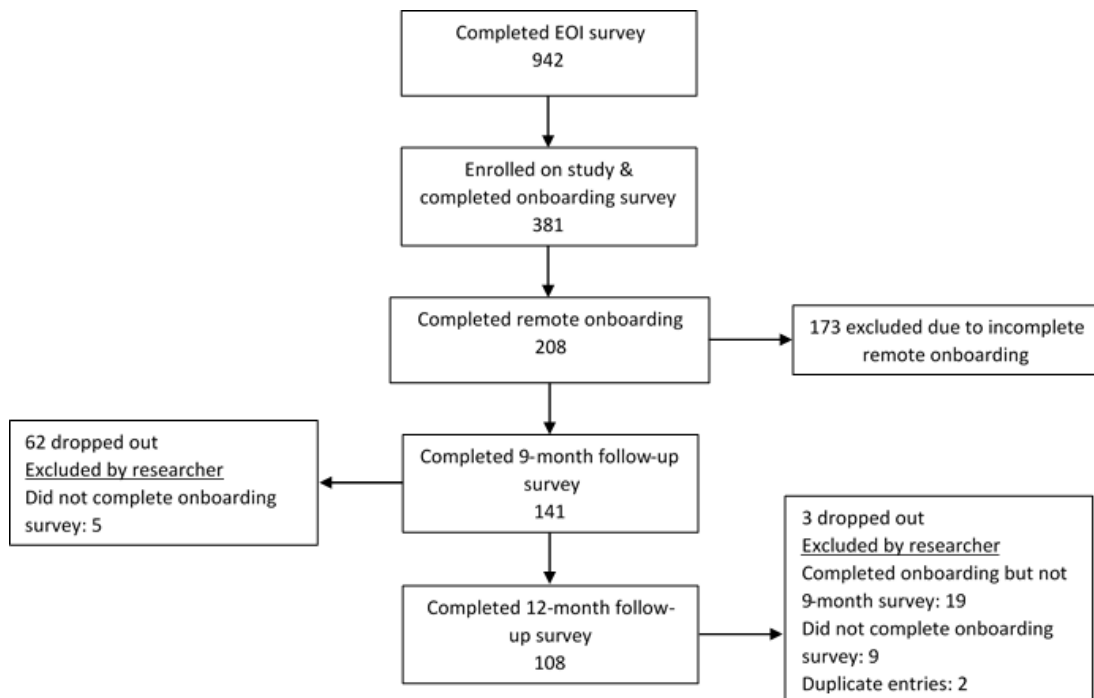


Figure 4.1: Flowchart of Participant Selection and Drop-out

The pilot experienced a substantial drop-out of study participants at various stages of the study. By the end of the study, the participant attrition/drop-out rate was 48.08% (using the number of participants who completed both onboarding exercises as the baseline). The demographic characteristics of the study sample at baseline is outlined in Table 4.3. Participants with A-level education had the lowest dropout rate (57.6%) while those with College education dropped out of the pilot the most (73.5%). Also, there was a 100% dropout of CCG directors and doctors by the end of the pilot; the dropout rate for consultants (77.8%), midwives (80%), and nurses (74.1%) were also high. The high dropout of health professionals could be due to their distrust of decision support systems (Hofmann, 2013); also, the failure of the pilot team to engage them in the project design and implementation phases, failure of the pilot to properly model their roles or their high workload which may have left them little time to actively participate in the study.

On the 12-month follow-up questionnaire, participants were asked whether and why they had stopped wearing their Garmin device. These responses were collated,

in addition to findings following a review of the pilot mailbox, to discover the reasons why participants stopped using the wearable device during the pilot study. These reasons have been outlined in Table 4.1. Participants occasionally did not wear the device because it did not match their outfit when going out, they were away on holiday or they forgot to wear it after charging it/in the morning. Even though participants had the option to wear the device on their clothing while at work (as some employees had to follow a “bare below the elbow” policy), some of them chose to leave the pilot instead.

Table 4.1: Reasons why Participants Stopped Using the Wearable Device

Reasons	Number of participants
Inaccuracies in data tracked	23
Faulty – battery issues/broken charger	14
Unable to wear Garmin due to clinical environment	12
Faulty – screen frozen	9
Faulty – broken strap	7
Unable to wear Garmin due to irritation/allergy from wristband	7
Unable to wear Garmin due to discomfort (especially at night)	5
Lost Garmin/Garmin charger	4
Unable to wear Garmin due to poor health	3
Faulty – screen cracked	1
Difficult to use and follow	1
Caused the user stress when they do not meet goals	1

Additionally, over the course of the pilot, 63 participants explicitly requested to leave the pilot. The most common difficulties participants faced during the study were with completing the remote setup of the Berkshire Wearables app. Some of these difficulties were as a result of technical malfunctions, whereas others resulted from user error. For instance, difficulties with downloading and logging into the Garmin Connect app were usually due to incorrect login details entered or the specification of a participant’s phone. Participants were also often confused by the different app names and which app they were being asked to use or update. It appears that participants would have benefited from face-to-face support to successfully complete the tech setup procedures.

As part of the Berkshire Wearable Technology pilot, semi-structured interviews were conducted to obtain participants' perception concerning the conduct and effectiveness of the pilot. Hence, the objectives of the interview were

1. To explore participants' understanding of the purpose for the pilot and their expectations for the pilot
2. To explore participants' experience with the pilot onboarding process
3. To explore participants' experience with using the Garmin fitness tracker
4. To explore participants' experience with using the Garmin Connect and Patient Portal apps
5. To obtain participants' suggestions for improvements on the tracker and apps

On the onboarding survey, participants were asked whether they would be willing to be *project champions* which meant participating in the interview. Participants who responded positively to this question were asked for their contact phone number via email. After nine months of the pilot, fifteen participants were selected to participate in the interview. Additionally, five participants were interviewed at month twelve of the pilot. So, a total of 20 respondents were interviewed during the pilot. A non-probability sampling method was used to select the 20 respondents for a 20-minute interview based on their availability to participate; organisation and gender were accounted for in the selection process. The interview was administered via a phone call. The interview script used for the study is outlined in Appendix C.

The average age of the interview respondents was 46.65 years (min = 25 years, max = 58 years). There were 13 female (65%) and 7 male (35%) respondents. All five participating organisations were represented in the interview. There were 5 respondents each from BHFT and RBFT, 4 respondents from FHFT, and 3 respondents each from Berkshire East and Berkshire West. Most of the respondents (45%) were administrative staff and CCG managers. See Appendix D for the characteristics of the interview respondents.

The decision to use the Garmin wearable device was made after careful consideration of the budget available for the pilot and the features the device offered. The maximum budget for procuring the wearable devices was £100 per device. Three wearable devices that fit in the budget were analysed, see Table 4.2 for an overview of this analysis. The table entries represent the features that the devices can provide. Garmin

Vivosmart HR was chosen because it sufficiently met the data and functionality requirements for this project compared to Withings Go and Sony Smartband 2 (which were more affordable options). Although the Garmin's battery only lasts up to 5 days, it can track steps, calories, heart rate, sleep, running, and exercise. It also uses nudges to encourage users to be more active and has an interactive display.

Table 4.2: Overview of wearable devices considered for Berkshire Wearable Pilot

Device Name	Steps	Calories	Heart Rate	Sleep	Run	Exercise	Nudges	Battery Life	Water Resistant	Screen	Wearable Function	Price
Withings Go	✓	✓	NS	✓	✓	Swim	NS	8 Months	50 Meters	Basic Step Only	Clip On	£39
Sony Smartband 2	✓	✓	✓	✓	NS	NS	NS	5 Days	3 Meters	No Screen	Pocket	£70
Garmin Vivosmart HR	✓	✓	✓ Continuous when worn	✓	✓	✓	✓	Up to 5 Days	50 Meters	Interactive	Strap Only	£99-£149
NS – Not Satisfactory												

To upload/share data for the pilot, participants were required to open and sync the Garmin Connect app at least once a week. Garmin Connect has gaming and social community features, such as the formation of groups and sub-groups and competitive challenges and rewards which were expected to foster the development of various social processes within the app. Participants did not receive monetary incentives to participate in the trial; they rather received a Garmin wearable free of charge, which would be theirs to keep after the end of the pilot. However, if a participant lost the device during the study, they were responsible for replacing it. The price of wearable devices has been identified as the biggest barrier to its adoption (PwC, 2017); hence, most wearable technology studies provide free devices to the study participants. However, it is likely that individuals who purchase an activity tracker will have more commitment to use and know about it than the people who have received it as a gift, because they had committed funds and research time to ensure they buy a device most valuable for them. Detailed research in this area is encouraged as it can implicate individuals' underlying value flows and shape the implementation of wearable technology studies to support behaviour change.

Since the goal was to observe how participants would use the wearable device in their natural setting, there was little interference from the project team in terms of frequent updates sent to participants on the progress of the pilot, provision of health tips or facilitation of competition and social interaction between participants.

4.1.4 Measures

Data obtained from the wearable device will be accessible in:

- **Garmin Connect:** a mobile application that is provided with all Garmin devices
- **Berkshire Wearable Patient Portal:** Patient-contributed wearable data were cloud hosted on Microsoft Azure for participants to view their data on their pilot patient portal app.

Quantitative and qualitative data were collected for the Berkshire Wearable Technology Pilot study to provide versatile data on the use and effect of the Garmin fitness tracker on participants. The quantitative data consisted of data obtained from the Garmin tracker and through onboarding and follow-up surveys while the qualitative data consisted of data obtained via interviews with selected participants. The pilot was an exploratory study; hence, there were no formal hypotheses as the purpose was to determine how participants would use the fitness tracker for a year and obtain evidence to inform the design and implementation of preventive health apps within the healthcare organisation. Some of the measures for this project are:

- Increased awareness of healthier behaviours amongst the cohort. This was measured by responses to the research surveys and interviews at 9- and 12-month follow-up stages of the project.
- Sustained wearable usage was measured by the percentage of participants who continue to wear the device after nine and twelve months.
- Changes in lifestyle was measured by the evaluation of wearable data captured by the Garmin wearable device following benchmarking as part of the initial cohort engagement. This included indicators such as sleep patterns (captured as total number of hours slept and amount of deep and light sleep hours), heart rate (beats per minute), number of steps taken, activity data (such as swimming, cardio, cycling), and calories burned (kcal). The Garmin device allows users to sync the Garmin Connect app with third party apps; users can sync to a diet app like MyFitnessPal to monitor the calories they consume and burn but this was not a requirement for this study. Participants also provided their weight and height measures at 9- and 12-month follow-up to measure change in weight and Body Mass Index (BMI) over time.

- Participant engagement with the preventive health apps was measured by responses to the research surveys and interviews at 9- and 12-month follow-up. The mode of use for the apps was evaluated to determine how users interacted with them and whether they found one more engaging than the other.

The onboarding survey had 36 questions and collected information on participants' demographic data, health status and habits, Internet and social media usage, existing experience of using wearable devices and their expectations for joining the pilot. The follow-up survey was administered at months nine and twelve of the pilot; however, the 12-month follow-up survey was slightly modified to collect additional relevant information.

The follow-up survey had 12 questions including a Health Behaviour scale adapted from Hong's research paper on Scale Development for Measuring Health Consciousness (Hong, 2009). The Health Behaviour scale consists of a 9-item Health Consciousness measure, 9-item Health Motivation measure, 15-item Health Perception measure, and 22-item Technology Use Experience measure. The Technology Use Experience scale consists of the Garmin Tracker, Garmin Connect App, and Berkshire Wearables App Use Experience measures. The questions in the scale were both positively and negatively framed. The rankings for the negatively framed questions were reversed during collation to give a uniform aggregate score. The survey also captured responses on participants' expectations for the pilot and their weight and height measures. The 12-month follow-up survey was modified to include 5 additional items for the Technology Use Experience measure to collect responses on the sleep outcomes experienced by the participants and responses concerning participants' interest to participate in future phases of the pilot.

4.1.5 Data Analysis

Data analysis and research will enable us to understand how wearables may contribute towards individuals improving their health and wellbeing. The study was evaluated via insights into collected data, follow-up survey questionnaires, and semi-structured interviews. Insights into collected data was based on data correlations between collected data. The wearable data was collected over a year (March 2018 to February 2019) and was presented in four tables (Activities, Dailies, Sleeps, and Sleep Intervals). As the data was anonymised, there was no participant ID nor a foreign key that connected the different tables so there was no way of matching participants data (say, their physical

activity data with their sleep data). This made it impossible to have some data correlations such as the relationship between participants' job roles and their activity and sleep outcomes and the effect of achieving step goals on sleep duration and quality. The quantitative analysis was conducted using IBM SPSS Statistics 24 and Microsoft Excel 2016 while the qualitative analysis was done using Nvivo 12 Pro.

Steps and sleep data were analysed separately. Steps were measured as a daily average and sleep was evaluated as the number of hours slept. The number of hours of deep and light sleep were analysed but this was not extensively discussed because further investigation is required to ascertain the validity of these measures as indicators of sleep quality. Monthly changes in steps, sleep, MVPA minutes, floors climbed, and burned calories comparing consecutive study months were examined using Pivot-Tables in Excel. Monthly average figures for the steps, sleep, MVPA minutes, floors climbed, and burned calories were entered in SPSS and the correlation between steps and other measures were computed using the CORRELATION formula in SPSS. A regression model of sleep hours based on bedtime was designed using the SPSS REGRESSION statement to investigate the effect of bedtime on sleep duration. Measures for the Health Behaviour scale were collated in Excel and compared using pairwise comparison charts in Excel to find out which measures were the most and least important to the participants. Correlations between the measures were also computed to find out the relationship between them and these were computed using SPSS correlation statement.

The interview recordings were transcribed by members of the pilot team and sent to the researcher with the files named with the respondents' first names. The transcripts were cleaned and formatted in Microsoft Word, with each file duly anonymised and uploaded to the NVivo software for coding and analysis. The Evaluation coding method was used to thematically analyse the interviews because it is appropriate for evaluation studies implemented across multiple sites and for an extended period of time (Saldaña, 2015). Other coding methods applied to Evaluation coding method were Descriptive coding, Magnitude coding, and Recommendation Coding Tag (REC).

4.2 Sample Characteristics

In this section, I present a reasonably-detailed portrait of the sample to provide a clearer picture of the study sample; however, not all the data will be explained in detail. The participants for this study were primarily female (82.7%), had a mean age of

43.02 years, married (63%), educated up to postgraduate level (39.9%), and had never smoked (49.1%). Although the ratio of female to male participants was approximately 5:1, their BMI values were not significantly different ($p = 0.73$). Table 4.3 outlines the demographic and clinical characteristics of the study participants.

Table 4.3: Demographic and Clinical Characteristics of the Sample at Baseline

Variable	N	%	Range	Mean (SD)
Age	381	100	18-70	43.02 (11.26)
Gender	381	100		
Female	315	82.70		
Male	66	17.30		
Education	381	100		
A-level	33	8.70		
College	49	12.90		
GCSE	42	11		
Undergraduate	105	27.60		
Postgraduate	152	39.90		
Job Role	361	94.80		
Administrative	117	32.40		
Allied Health Professional	37	10.20		
Consultant	9	2.50		
Director (CCG)	2	0.60		
Doctor	5	1.40		
Manager (CCG)	14	3.90		
Midwife	5	1.40		
Nurse	58	16.10		
Operating Theatre Staff	2	0.60		
Operational Management	17	4.70		
Pharmacy	8	2.20		
Body Mass Index (BMI)	378	99.21		
Female	313	82.80	13.93-55.60	27.17 (6.01)
Male	65	17.20	19.37-39.03	27.22 (4.55)
Marital Status	381	100		
Single	99	26		

Married	240	63
Divorced	36	9.40
Widowed	6	1.60
Smoking Status	381	100
Never Smoked	187	49.10
Non-smoker	158	41.50
Occasional Smoker	19	5
Smoker	12	3.10
Trying to Stop	5	1.30
Chronic Illness		
Asthma	16	4.20
COPD	1	0.26
High/Controlled Blood Pressure	4	1.05
Underactive Thyroid (Hypothyroid)	12	3.15
Arthritis (Rheumatoid, Seronegative, Osteo, Psoriatic)	8	2.10
Hypertension	4	1.05
Diabetes	5	1.31
Gout	2	0.52
Cancer (including Non-Hodgkin Lymphoma NHL)	2	0.52
Mental Illness (Anxiety, Schizophrenia, Bi-polar, Depression)	5	1.31
Chronic pain (back, sciatica, migraine, fibromyalgia)	4	1.05
Multiple Sclerosis	1	0.26
Addison's Disease	1	0.26
Eczema	1	0.26
Inflammatory Bowel Disease	1	0.26
Blood clots (Deep vein thrombosis, blood clot on lung)	2	0.52

In terms of the lifestyle characteristics of the participants, most of them reported that their weight had not changed in the 6 months prior to joining the study, they

preferred to exercise alone, did not have a gym membership and did 15-30 minutes of moderate physical activity per day (see Table 4.4 for a description of the lifestyle characteristics of the participants). Most of the participants exercised 1-2 days a week and those who had a gym membership visited the gym 1-2 days per week.

Table 4.4: Lifestyle Characteristics of the Sample at Baseline

Variable		N	%
Weight Status	In the past 6 months, my weight has		
	Decreased	87	22.8
	Increased	138	36.2
	Not changed	156	40.9
Exercise Days	In a typical week, I exercise for		
	0 day	63	16.5
	1-2 days	161	42.3
	3-4 days	99	26.0
	5 or more days	58	15.2
Exercise Style	I prefer to exercise		
	Alone	212	55.7
	In a group	31	8.1
	Both alone and in a group	138	36.2
Gym Membership	Do you have a gym membership?		
	No	245	64.3
	Yes	136	35.7
	How often do you visit the gym per week?		
	0 day	16	11.8
	1-2 days	75	55.1
	3-4 days	40	29.4
	5 or more days	5	3.7
MPA Minutes	Minutes of moderate physical activity (MPA) done per day		
	0 min	13	3.4
	<15 mins	91	23.9
	15 - 30 mins	137	36.0
	30 mins - 1 hour	107	28.0
	>1 hour	33	8.7

Before joining the pilot, most of the participants had not used a fitness app or a

wearable device. Some of the participants had used a wearable device before joining the pilot but had stopped using the device. The most common reasons for this were because the device broke, and the participants saw no change in their fitness (see Table 4.5).

Table 4.5: Previous Use of Fitness Apps and Devices

Variable	N	%
Have you used a fitness app before?		
No	233	61.15
Yes	148	38.85
Have you used a wearable device before?		
No	239	62.73
Yes, and I still use it	66	17.32
Yes, but I stopped using it	76	19.95
Why did you stop using it?		
Saw no change	11	
Got bored	9	
Lost the charger	4	
Got tired of charging it	8	
Achieved my goal	1	
Found effective alternative	1	
It broke	36	
Other: Inaccurate readings	8	
Other: Lost device	5	

Participants who had previously used a fitness method were asked to rate the effectiveness of those methods. The most common fitness methods used were Slimming clubs, Exercise, Online Groups, Fitness Apps, Wearable devices, and Dieting. Other fitness methods used include meditation, weight loss programmes, dancing, video games, and weight loss clinics. Participants reported exercise as the most effective fitness method they had used and online groups as the least effective method (see Table 4.6). Effectiveness score ranges from 0 (least effective) to 5 (most effective).

Table 4.6: Effectiveness of previously used fitness methods

Fitness Method	Number of responses	Effectiveness Score
Slimming Clubs	91	3.075
Exercise	337	3.279
Online Groups	30	1.825
Fitness Apps	131	2.375
Wearable Devices	94	2.975
Other: Dieting	27	2.775

4.3 Proposed Design Framework

4.3.1 Motivation

At the beginning of my Ph.D. programme, my research interests were on further exploring the role of interactivity (system and user interactivity) and social connectedness in the engagement of users of preventive health applications (following on from my M.Sc. dissertation). I had proposed three circles/levels of interaction, which when provided, can keep users of electronic PHRs engaged with the app – interaction within the system, within a care team, and within a community of users. In the first year of my programme, I conducted a systematic review on the impact of Information and Communication Technology (ICT) interventions on social support measures with reference to health (Nnabuko and Anderson, 2018). I discovered that ICT interventions have a significant positive impact on social support measures; specifically, social network (including social media) was found to have the most impact on these measures.

Most users of health applications prefer the use of social media in such applications. Fisher and Clayton administered a descriptive survey which was completed by 111 patients in the United States and they reported that 83% of the respondents use some form of social media in their healthcare (Fisher and Clayton, 2012). They also found that 56% of the respondents wanted their health provider to use social media and among respondents who do not use social media, 41.6% of them would consider using social media if their provider used it (ibidem). But, most healthcare professionals are slow to adopt the use of social media for professional purposes. A survey completed by 4,000 physicians revealed that while more than 90% of the respondents use social media for personal activities, only 65% use it for professional reasons (Ventola, 2014b).

However, this low adoption of social media for professional purposes would depend largely on the policies and practices of the healthcare system wherein the healthcare professionals work. In any case, there appears to be a mismatch in the value for the use of social media for healthcare between patients and healthcare professionals. Hence, this suggests that the use of social network affordances in healthcare applications will be more effective at the individual level than at the healthcare institution level.

Despite the popularity of the Internet as a vital source of medical information, most individuals still prefer to consult their GPs for information or diagnostic services. A study conducted by Kwon *et al.* found that the study participants reported hospital physicians as the most trusted source of health information (Kwon *et al.*, 2015). Individuals generally perceive physicians as a more credible source of health information than online sources which are sometimes inaccurate; however, some individuals supplement health information from their physicians with online health information (Swoboda *et al.*, 2018). For instance, more individuals check online for specific health information first before going to their physicians than those who first go to their physician (Swoboda *et al.*, 2018). Hence, individuals value the “trustedness” of the information source when combining health information.

Thus, people are motivated to participate in some process if it generates value for them. Even in very direct constructs like the value that *fitness freaks* get from measurement of steps, there is significant increase in use if there is a social dimension; for instance, a study conducted by (Canhoto and Arp, 2017) reported social interaction within a community of users as one of the determinants for sustained use of health and fitness wearables. People integrate resources, information, diagnostics, and other measures to create value for themselves and in this case, we are particularly interested in value in terms of prevention (what this is can differ significantly for different people). Value creation within a social group produces value that incentivises the creation of more value. So, we are interested in social production and value is a good way of capturing different sorts of co-produced processes. So, the focus of this research is on the cocreation of value in the context of prevention and we need to take account of the institutional setting because it has a significant influence on the participation of all the different classes of users.

The Berkshire Wearables pilot offered a unique opportunity to investigate such processes because it consists of diverse user groups that co-produce value for health and care processes within the NHS. The institutional setting within the NHS provided a useful platform to investigate the role of institutions in the cocreation of healthcare

value in the context of preventive health practices (the use of wearable fitness trackers). My expectation was for the pilot to clearly indicate the effect of social incentives and value flows within the institutional setting on the co-production of value in preventive health practices. I also expected to be able to test the validity of some of the *simple* models (e.g. gamification) via the pilot study. The pilot was able to highlight some observations about the simple models of gamification, social networks, and nudges (e.g. their ability to motivate individuals towards using the technology, although these motivations are not majorly intrinsic), but it failed to indicate the underlying value flows via the technology as the underlying value flows were not easily surfaced during the pilot. Some of these failures are due to shortcomings that are attributable to the tech design and study methodology used. For instance, the direct and indirect users of the patient portal app developed were not sufficiently involved in the design of the app. This contributed to participants' non-use of the app during the pilot as they did not find it useful (results from the study are described in detail and presented in Chapter Five). So, it was necessary to analyse the data from the pilot study to point out that the participants' behaviour in the Berkshire experiment was complex and the importance of a model that helps understand this complex behaviour and institutions.

While considering the development of such a model, the existing VSD framework was first considered as a viable framework to account for the investigation of institutional arrangements during technology design and implementation. But this framework did not account for some of the observations from the pilot as it tends not to extensively look at institutions underlying individuals' values and institutions, to some extent, give a home to value. On the other hand, SDL focuses on the coproduction of processes while taking into account the institutions and institutional arrangements that underlie the services that users exchange to coproduce value. In the next section, I will propose what I see as a viable approach that allows us to address this design and implementation issue.

4.3.2 Value Cocreation Design (VCD) Framework

We know that value is important and that in health systems, cocreation is an essential part of the creation of value. VSD suggests an overall framework for a design process that is effective (from the literature) but quite generic. A viable model will be one where co-production of value is a seemingly dominant mode and one that can help tackle longstanding issues of non-participation of users or stakeholders. Some of

the features that are distinctive from the Berkshire Wearables pilot and need ways of tackling are:

1. There are highly diverse groups we are aiming to ensure can cocreate sufficient value to motivate continued participation. Some of those groups are professional health and care personnel and all groups have different skills and motivations.
2. These groups interact in complex ways and the dominant mode of interaction is via participation in service exchange.
3. Resource (and resource contention) is a critical element and health and care interactions are often about integrating resource to support the services to be delivered via the service exchange process.
4. These interactions are set in an environment of complex interlocking institutional arrangements which shape them.
5. There are multiple different ecosystems where people play different roles depending on the ecosystem they are participating in.

The SDL framework provides a way of conceptualising these features which match quite well with the SDL diagram in Figure 4.2. So, this suggests looking at SDL as a particular implementation of VSD where the generic VSD stages are translated into identifying elements in the SDL framework. This provides a structure for keeping track of the complex service ecosystems that emerge from the use of and are transformed by digitalisation within a specific context.

Despite the shortcomings of the VSD framework, it provides an integrative and iterative technology design process that accounts for the conceptual, empirical, and technical aspects of the technology. Due to the iterative nature of SDL, it can be integrated into all three investigations of the VSD. So, the approach for the VCD framework is also highly iterative in that its stages are repeatedly iterated through a release cycle. Thus, the stages are incremental and, to some extent, each stage sets the agenda for the next stage and provides insight on how identified issues can be resolved in the next iteration of the design process.

Table 4.7 provides an initial description of how the VSD framework is extended to incorporate the concepts of SDL to move from simply creating value to cocreating value in technology. References to the SDL diagram in Figure 4.2 are made in the conceptual investigation to help the reader to identify how bits of the SDL model



Figure 4.2: Match between SDL diagram and Berkshire pilot features

have been used in the VCD model. Like the VSD framework, the VCD model is an iterative process designed to be applied in different contexts of use and can be started at any investigation stage; a description of its application to the Berkshire Wearable Technology Pilot is discussed in Chapter Six. A revised version, following evidence and learnings from the empirical study, is presented in Chapter Seven.

Table 4.7: VCD as an Extension of VSD

Value Sensitive Design Model	Value Cocreation Design Model (VSD + SDL)
Conceptual Investigations	
The conceptual investigation focuses on the design of the technology and is useful for determining what the initial hypothesis might be. This involves identifying the stakeholders and their pre-existing values that can be implicated by the technology, working out	When conceptualising the design of new technology, it is limiting to see user needs/values as pre-existing constructs that can be recognised and realised (Hyysalo, 2003). Because value in technology is mostly implicated through use of the technology, we propose doing an analysis of

which values are important, how these values should be supported in the technology design process and how they can be affected. Attempts are also made to resolve any conflicting values. This investigation is conducted through an analysis of concepts.

how the intended technology could be used instead of analysing the stakeholders' pre-existing values which differ by individual, even when such individuals are within the same actor group. This involves analysing the actors/stakeholders who will use or be affected by the technology¹, what services they exchange² and the resources they need to complete that exchange³ (while considering the social norms that guide the service delivery by the actors⁴). This also involves an emphasis on the existing institutional frameworks (the kinds of value already being cocreated and the sorts of service exchange taking place⁴) and an analysis of the resource integration and resource conflicts³ that are more or less well-managed via institutional arrangements⁴. A service map of the initial model of the ecosystem is produced⁵ and used to probe (in)directly for the services to be exchanged (including new services identified via a prospective view), the actors who provide those services, the resources required and what implicit values such services can provide for the actors.

Empirical Investigations

The empirical investigation is useful for checking a conceptual design against real life scenarios. At this stage, the value identified during the conceptual investigation is checked to determine whether it captures the range of value held by the stakeholders and this is done by observations,

Like the VSD model, under the proposed model, this phase involves gathering feedback from the actors to confirm or disprove the assumptions that have been conceived via the conceptual investigations. It is important to have a prototype or naïve version of the proposed technology ready at this stage to determine whether the actors

interviews, surveys, and measurements of user behaviour and human physiology. A prototype or version of the technology is used at this stage.

require the services identified during the conceptual stage, any necessary services that were not initially identified, and determine how the actors' social norms support or constrain these services to resolve any conflicts. This involves observing how actors use the prototype provided and obtaining their subjective and objective responses through surveys, interviews, and measures of user behaviour & physiology. Although the design process can be initiated from any of the three investigations, it might be more efficient to begin with the conceptual investigation because it can help identify the data that needs to be collected and how to collect it.

Technical Investigations

The technical investigation is useful for implementing and integrating the technology into existing processes. This is made up of two parts: being actively involved in the design process to create the technology that supports the important values determined and finalised in the conceptual and empirical phases; and analysing existing technologies' support of values as opposed to building new ones.

The VCD model will also execute this investigation in two parts. The first part will entail modifying the prototyped technology to incorporate the findings from the empirical investigation and the second part will focus on how the new technology can be embedded into existing practices. These can be done simultaneously. In this proposed model, conducting the second part will entail understanding the underlying service ecosystems of actors that already exist in the system, their existing institutions and institutional arrangements (i.e. social norms and rules of the game) and the current way that services are exchanged within those interlocking and nested service ecosystems. This will provide a more complete understanding of how the new

technology needs to be embedded into the system or perhaps where the existing technologies just need to be modified instead.
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In summary, people give up on apps because they are not getting what they want or need from them. This motivates an analysis of the situation from the perspective of value, exploring how to identify transfers of value and different types/forms of value and value exchange. Using the VCD framework, it is possible to give plausible accounts of failure of digitalisation efforts in terms of failures to take account of value flows. This approach is intrinsically social because value is constituted through social action. The approach taken in the VCD design framework is validated to some extent by the insight it provides into the Berkshire Wearables pilot. Value is a useful design tool because it gives us an analytical framework that provides some insight into how systems might be designed to work better.

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Chapter 5

Results: Empirical Evidence

In this chapter, the results and findings from the empirical study that support the development of the proposed design methodology are presented. The evidence includes findings obtained from the wearable data, periodical surveys completed by the participants, and semi-structured interviews with twenty participants.

5.1 The Place of Value in the Use of Health Apps

The VCD framework takes the analysis, tracking and utilisation of value as perceived by different user groups as a fundamental part of app design and development. Because value is intangible and subjective, it is hard to identify and measure. So, it may be easier to think about benefits which might be a more concrete term when we talk about value in this section. In this study, participants' diverse values influenced their reasons for joining the pilot and the way they have used the wearable device and preventive health apps. In the onboarding survey, participants were asked about their motivation for joining the pilot (see Appendix B.2). Their main motivations, ordered by frequency, were (1) to adopt a healthier lifestyle, (2) to monitor exercise, (3) to get better health outcomes, (4) out of general interest or curiosity, (5) to monitor sleep, (6) to monitor diet, and (7) out of interest in its connection to Connected Care patient portal.

During the study design, there were suggestions to pre-assign participants into cohorts based on their activity level or motivations for joining the pilot. Each cohort would then be provided with a social network on the Garmin Connect app to which consenting participants would be added. However, this suggestion was not implemented due to Information Governance (IG) concerns. Although it is unclear the proportion of participants who would have opted into joining these social network. This

was an underutilised opportunity to observe participants' response to social networks at the workplace.

Various research has been conducted to investigate the effect of the use of nudges, social networks, and gamification techniques in health applications and this effect has varied across different studies. For instance, Hummel and Maedche reported that 62% of the nudging treatments they had reviewed were statistically significant (Hummel and Maedche, 2019). Similarly, Johnson *et al.* discovered that 59% of the reviewed papers that report empirical evidence on the effect of gamification on health and well-being reported positive effects (Johnson *et al.*, 2016). The variation in the effect of these techniques in the reviewed studies could be attributable to their different study designs and procedures as well as the different values of the study participants for the use of such design techniques. The interview respondents of the Berkshire pilot also had different values for the use of these design mechanisms in preventive health applications.

Nudging: The concept of nudging was used in the pilot study to try to encourage study participants to be more active. The nudge was in the form of vibration on the Garmin watch and a message on the screen of the watch which says "Move!" Participants could turn the move alert on/off through the settings on the Garmin device or Garmin Connect app.

Although most of the participants joined the pilot because they were motivated to adopt a healthier lifestyle, some of the respondents still valued an extra "push" or encouragement from the app to support them in accomplishing that goal. This push could mean different things to different users (see P15's comment) and this includes the concept of nudging.

P15: "[No disappointments]... other than the fact that it [Garmin tracker] can't make me do things; give me an electric shock if I don't do something that I should do."

There were some respondents (60%) who responded positively to the nudges and would mostly go on a brief walk around the office building to clear the move alert bar. For instance, P18 would print information individually, instead of in bulk, so she would get up and walk to the printer each time.

However, some respondents reported valuing the nudging at the beginning of the pilot because it made them aware of their lack of movement and offered them the choice to respond to the nudge. But they grew increasingly annoyed by it especially

when the device nudges them to move when they want to relax (25%), were moving or had just moved (30%), were busy at work or in a meeting (35%) or while in transit (10%). Some respondents learned to ignore or get used to the nudges especially when they were busy, but few respondents (15%) switched them off. It seemed that the novelty of the device contributed to participants' acceptance of the nudging, but as this waned it appears the participants' values became more apparent (because values are mostly stable). Some of the underlying values identifiable from individuals' *negative* reactions to the nudges were the value for autonomy and value for trust and reliability of the device to nudge appropriately (see P2's comment). P20 referred to the nudges as "nagging" because she wanted to perform activities when she felt she could (see comment below).

P2: "Right, from the device perspective, I would probably get cross because it does nudge me and tell me to move, so I am not going to be told to move by a device, and equally I might be doing something, and it's telling me to move, and I am already moving – stupid thing. If that is nudging, then it didn't work for me. Again, that's me being pedantic, I don't know."

P20: "It wouldn't have made any difference to my behaviour. If I can walk, then I do. If I can't walk, then I don't."

The biggest challenge that respondents faced with nudges was the device's inability to appropriately sense when they needed to be nudged. They would prefer the device to be sensitive enough to know when they had just moved or were unable to move (like while in transit) and adjust its notification frequency when they have achieved their daily step target.

P11: "I think it's good when I'm not moving but when I'm actually moving it does infuriate me. It's like 'I am actually moving, shut up!' It's like 'Stop telling me to move when I'm actually doing it' So I do find that quite irritating or when I'm actually getting ready for bed and it tells me to move."

Social Networks: Although the opportunity to investigate the participants' use of social networks in preventive health apps was not utilised, respondents' perception on the use of social networks in health apps were analysed. Sixty percent of the respondents thought an integrated social network on the Garmin Connect app and/or Patient Portal app would help them maintain healthy behaviours. They thought it will be useful for the following reasons:

- **Connection with Familiar People:** Four respondents thought social networks would be beneficial to them if they knew the people they were connected to

(like colleagues and friends). P5 thought this will drive him to change his health behaviours although he would not be open to sharing his data. This highlights the underlying value of these respondents for connectedness with the people in their existing social circles.

- **Motivation and Social Incentive:** P1, P6 and P18 thought that being a part of a social network can serve as an incentive for them to maintain healthy lifestyles because other members of the network can encourage and keep them accountable in reaching their health goals. P11 and P18 both perceived themselves as competitive people and would prefer that the social network utilises competitive elements to help them maintain healthy behaviours. Similarly, P13 thought competing with other users can motivate her to keep up with them. These respondents seem to find social network useful because they value social solidarity - the interdependence between individuals with shared interests.
- **Weekly Events and Meetups:** P10 thought that the social network will be useful for organising weekly walks or runs and meeting more people within the workplace, probably because he values routine.

On the other hand, some of the reasons that other respondents (30%) thought a social network will not be useful to them are:

- P15 would prefer access to health information and support via the Internet.
- P14 uses social networks independently and feels they should not be mixed with work; she has not joined any social network groups at work and says privacy and security issues are some of the reasons why she treats social networks in such manner.
- P4 thought it can easily become a grumbling forum which would not be beneficial to her.
- P7 says it will not encourage her to maintain healthier behaviours because she thought “that would be a distraction rather than a benefit” as there already are multiple platforms available to her.
- P8 said it will not be useful to him because he is not a heavy social media user.
- P9 thought using the social network would be oversharing for her.

The use of social networks in health applications has been discovered to have a positive impact on individuals' social support measures which, in turn, can improve clinical outcomes and assist in the adoption of healthy behaviours (Nnabuko and Anderson, 2018). However, from the pilot findings, some of the factors that could limit individuals' use of social networks in health applications include security and privacy concerns, technical acumen, and age. The average age of respondents who think social networks in health applications would not be useful to them was 50.71 years while that of those who think it would be useful was 44.17 years; however, this difference is not statistically significant (p -value = 0.25). This points to the possibility that the younger users might be more predisposed to use social networks compared to their older counterparts. Individuals' underlying values could also limit their use of social networks. Some of these values that could be identified from the respondents' comments include greater value for informational support than social support (P15), value for data privacy, security and control (P14, P9), and value for a single identity rather than multiple identities (P14, P7).

Gamification: The Garmin Connect app utilised some gamification features such as weekly steps challenge with other users, leaderboards, badges and levels. Users are awarded badges for completing specific activities (such as running, steps, or using certain app features) which can earn the users points to help them level up in Garmin Connect. Users are automatically signed up to weekly step challenges with 7-12 other Garmin Connect users in their challenge group to achieve a certain weekly step goal based on their current activity level. The lowest weekly step goal is 15,000 steps.

A few respondents had learned about the weekly step challenge and used it – some more actively than others. P11 used it for personal challenges which she had set for herself but did not connect with any other users. P6 had learned about it after setting up her device but had not done much with it since then. P16 only used it once when another user set up a challenge with her. P12 only used it in the first couple of days of joining the pilot and P13 had only just learned about it during the interview. P7 and P19 did not actively use it because they did not realise that they had been automatically signed up to it. The respondents mostly exhibited more value for social incentives (competition and connectedness) received through the weekly step challenges than point-based incentives via levels and badges. In fact, few respondents (15%) described their opinions concerning levels and badges.

However, four respondents thought the weekly step challenge was not for them.

P17 felt she had a busy enough schedule already and did not see joining the challenge as her purpose for wearing the device. P8 did not participate in the weekly challenges because he generally does not value challenges, but he liked the badges and level gamification features.

P1: “You have got to build up pressure on yourself. How you build up that pressure is up to your own psychology, but part of that pressure is sometimes other people saying you don’t look great or look how many steps you didn’t do. If that is what motivates you then you do double the amount of work. That motivates me.”

Some respondents (50%) thought the gamification features in Garmin Connect have had a positive impact on their activity level and behaviours. P1 thought the step challenge will work well in incentivising people to be active. P2, P3, P4, P13 and P16 described it as a motivator. P18 said it had helped her keep up her healthy behaviour of moving more and she had gone on to do more running. At the time of the interview, P9 thought it was still early to say whether the weekly challenge had had any impact on her wellbeing.

These varying interests and preferences of the respondents in the use of nudging, social network, and gamification features highlight users’ varying (sometimes conflicting) values for preventive health applications and the affordances they provide to support behaviour change. Hence, the importance of the use of value as a design tool to provide insight into how to design systems that users will find valuable. Furthermore, the way users’ implicated values are discovered during the technology design phase influences the extent of how these values are cocreated while using the technology.

5.1.1 The Effect of Institution on Value Creation

In Chapter three, a discussion on the importance of identifying values through the lens of the institutions and social norms that guide the different stakeholder groups was presented. Individual values are often influenced by individuals’ intrinsic beliefs and principles which are usually determined by their underlying culture, exposure, and social context. For instance, some users of the Garmin device could find the quantitative presentation of their step count valuable while some might find it more valuable to learn how their decision to walk instead of driving to work could influence the level of CO2 emission in the environment. To some extent, this variance in value can be accounted for by the variation in individuals’ underlying social norms and principles.

In the next paragraph, we will discuss the influence of institutional settings on individuals' values.

There are existing analyses on the role of institutions in IT innovation adoption failures in health organisations. Institutions in this case represent the established diverse (and often, inconsistent) norms that guide work practices prevalent within the organisation. Bunduchi *et al.* suggested that the decision and success of the adoption of IT innovations depend on the alignment between the innovation and the institutional characteristics within the adopting organisation (Bunduchi et al., 2015). They investigated the institutional factors that influenced the (non)adoption of a telehealth innovation designed to support glaucoma care and enhance the connection of the public hospital-based Eye Clinic to the private optometry practices. They discovered that unreconciled institutional misalignments within and between the two sectors made it difficult to produce a cohesive approach towards deploying the telehealth which eventually led to the abandonment of the IT innovation.

Similarly, Klecun *et al.* investigated the dynamics of institutional pressures on the implementation of national electronic health records (EHRs) in two countries, Singapore and England (Klecun et al., 2019). Although similar top-down system implementation methods were used for both programmes, different outcomes were observed. The EHR in Singapore was more successfully adopted and implemented than in England where clinician groups (supported by professional bodies) were able to resist the EHR implementation. These outcomes were mostly due to institutional pressures from the stakeholders and how these conflicting institutions were managed and resolved. The scale and context of the population might have played a role in the outcomes of the EHR implementation programme in both countries. The population of England (about 56 million) is approximately 10 times the population of Singapore (about 5.6 million) (Klecun et al., 2019). Hence, England has a greater number of healthcare providers than Singapore and thus, more complex institutional arrangements and pressures. Also, Singapore is a highly centralised state (compared to England), which provides a supportive frame for the successful implementation of a national EHR programme.

Hence, when working with large-scale systems and applications within the health-care service, any approach to the design of such applications that does not consider the underlying institutional framework risks adoption and implementation failures. So, this motivates the decision to take the institutions into account at the innovation design stage.

For the Berkshire wearable pilot, there exists a complex set of frames wherein decision-making sits – institutional arrangements around the individuals, GPs, social care services, and Berkshire NHS Trust as an employer. Little consideration was given to these institutional arrangements during the design of the Patient Portal as the stakeholders were not appropriately engaged in the design stage; this will be discussed further in section 5.2. Involving the necessary stakeholders during the design of the technology (and pilot study) would have highlighted the varying (and often, conflicting) institutions of the stakeholders (which can determine their values) and offered the opportunity to resolve these conflicts to ensure the programme is valuable to all stakeholders.

As previously stated, in addition to varying institutions within the workplace, individuals have varying beliefs and principles which can also influence their interpretation of value in technology. Like the institutional arrangements, little consideration was given to the effects of these beliefs and principles during the design stage of the Berkshire wearable pilot.

5.1.2 Service Exchange as a Tool for Value Elicitation

Existing VSD methods elicit value that can be implicated from using technology by performing a philosophical analysis of the universal values possessed by the stakeholders of the technology. However, the problem with these methods is their neglect of context. So, the proposed method of determining implicated values through service exchange is a more bias-proof method as the values to be considered in the technology design phase are implicated through a philosophical analysis of existing and potential service exchange processes within the context of use (which are influenced by the institutions and institutional arrangements already in place). Value elicitation via the analysis of service exchange gives more permanency and relevance to the technology designed as stakeholders' interpretations of their values and the technology in question may change over time (Yetim, 2011).

When considering service exchange in SDL, service (eco)system is a term that often emerges (Edvardsson et al., 2011). A service system in this context could be people, technology, or organisations that co-produce value through the exchange and application of resources with other service systems (ibidem). So, technology can be engaged in the process of service exchange to produce value. The study respondents often associated gained value with a service received or rendered via the Garmin device

and app. For instance, they applied resource in the form of tracked fitness data which the Garmin app analysed to provide summaries and insights that individuals could interpret to inform their health decisions. Consequently, informational support was one of the values co-produced via the services exchanged between the individuals and the app. For instance, the app provided data analysis and presentation services that presented tracked data in an intuitive format for the users to better understand their data while the users provided the data to the app, via use of the tracker, which the app could collate to produce population data useful for data sharing with other users and organisations. Hence, service exchange produces value.

P17: “Yes, definitely – my sleep wellbeing, my overall general wellbeing actually, not just sleep. That was part of it because, you know, having proper quality sleep meant that I would have a good day, I would wake up feeling good and also it just made me conscious of how active I was, you know, from the activities recorded... and you get a good feel factor from that, you know, when you can see oh yes, I have been quite active today and it motivates you to do it again.”

Since value can be created via service exchange, it is logical to use service exchange as a tool for eliciting value when creating or modifying new technology. This can be done in two ways – by analysing the prospective opportunities for service exchange while using the technology and by analysing existing service exchange procedures in the context of use where the technology will be introduced. For instance, analysing existing service exchange processes concerning how NHS employees maintained/encouraged physical activity while at work would have highlighted their use of social groups to support fitness and healthy practices while at work (see P1’s comment below). Knowing this might have encouraged the project commissioning team to prioritise the provision of a social network to support healthy practises among employees within the workplace. However, it is likely that the study participants did set up an online and/or in-person social group to support each other during the trial study.

P1: “Definitely, definitely – it [social network] would be a good idea to have, particularly because of our little community here with our watches. We have got our NHS group because we all know each other and that would be an incentive. We had a thing before, which we had at work, in which you had these cards that you had to use. They set up monitors on lamp posts in the area and you’d hit it with your card, and it would tell you how many steps you had done. You would have little teams and there was a table of how everyone was doing... we did it for a couple of years, but that seemed like a much more complex process than just having watches to be honest because you have to set monitors to all of the lampposts. But

once you have got the watches I am sure you could quite easily do that sort of process, so we could all see how we are doing and comparing with other people, and have a bit of a laugh really because I remember when we did that, there was a lot of competition. People were saying, ‘Right, I’ve got to go out this lunchtime because we have fallen 2000 steps behind’ and everyone would go out in their little group, and you would find out when we’d got back that the other group had done the same, but it was part of the fun of it really.”

5.2 The Role of Resource Integrators in the Design and Deployment of Health Apps

Resource integration is essential for service exchange to occur and this is performed by the relevant actors and service systems involved in the value cocreation process. Hence, it is important to actively involve these actors/stakeholders in the design of the technology as they can stifle the adoption of the new technology if they are unable to effectively exchange services using the technology. For instance, from the research conducted by Klecun *et al.*, the Singapore case experienced more positive stakeholder interactions – IT employees in the hospitals and senior doctors with technical knowledge were involved in the initial design of the EHR and their feedback helped shape the design (Klecun *et al.*, 2019). This resulted in limited pushbacks or resistance from the health professionals to the EHR implementation. Whereas in England, the engagement of the healthcare professionals with the EHR was initiated too late and became problematic as meetings with the clinicians were arranged after important system procurement decisions were already made. Despite subsequent efforts to engage them in the implementation process, clinicians still felt that they were not involved in determining the direction of the EHR implementation. This contributed to low adoption rates of the EHR across the healthcare sites in England and the abandonment of the development of the integration solution for primary care.

P4: “So, what my question would be is, we are doing this as a pilot to look at integrating information and pull data back into Connected Care, specifically through GP surgeries, but actually how have GPs been involved in the project from the start of when it happened in February? I can’t see that other than being notified that I am doing it [the pilot], they can’t see any of the benefits of it... so it’s a trick that has been missed.”

As mentioned in a previous section, the stakeholders of the Patient Portal app used in this pilot study were not appropriately included in the design of the technology (refer

to P4's comment regarding the non-involvement of GPs in the pilot). Appropriate involvement of stakeholders in this case entails including representative stakeholders in the planning, design, and implementation phases of the pilot study. This failure in involving the stakeholders during the design stage evidently influenced participants' use of the patient portal as they did not find the app valuable. After the initial setup of the app on their smartphones, most of the participants did not log into the app again. The main reason for this low usage rate was that respondents did not understand the purpose for the app nor the project team's expectations concerning their [the participants'] use of the app. They also did not find the design appealing or the app interesting/useful as it did not offer them any additional information that they did not already know from the Garmin Connect app (see Figures 5.1 and 5.2 for some screenshots of the patient portal app).



Figure 5.1: Landing Page Summary

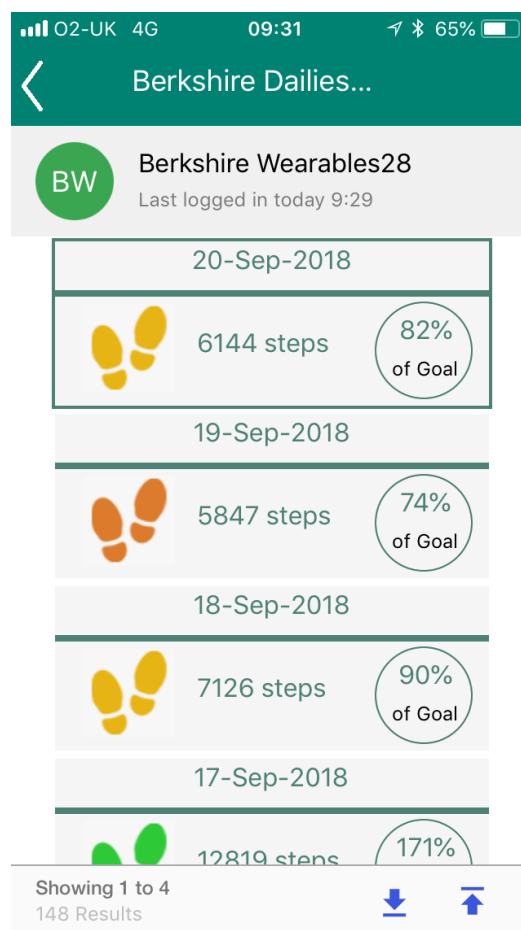


Figure 5.2: Steps Summary

In the implementation of a large-scale IT innovation programme, there usually are resource integrators (who might not easily be described as users or developers of the

technology) that are instrumental in the successful appropriation of the new technology. These resource integrators are called intermediaries and they are involved in the persuading, advising and regulation of the consumption or use of new technology (Stewart and Hyysalo, 2008). For this pilot study, the project managers and team served as the intermediaries. However, respondents did not think this role was well utilised as some of them said they would have appreciated a bit more support from the team (at least, some sort of update from the team and encouragement to keep moving).

P12: “I think we were all thinking what’s happening, what’s going on with it and we didn’t know what was happening, and perhaps that was intentional. I assumed that we’d get more updates like during the programme to tell us what’s going on.”

In (Klecun et al., 2019), the key mitigators of challenges brought on by competing institutional logics in the Singapore EHR implementation case were the senior doctors familiar with IT who acted as *boundary spanners*. A boundary spanner is an “individual who is able to facilitate the sharing of knowledge by connecting two or more groups of people separated by location, hierarchy, or function” (Klecun et al., 2019). The pilot project managers had identified some *project champions* (similar to boundary spanners) who were senior staff from the participating organisations to act as exemplary study participants and help connect the participants to the pilot team. But these project champions were not properly engaged with throughout the study nor involved in the programme design stage of the project. Engaging them in the programme design stage might have highlighted the need to choose a wearable device more suitable for people with limited mobility for the pilot study (see P4’s comment below). Careful consideration was not given concerning this functionality while choosing the wearable device for the pilot as outlined in section 4.1. P4’s comment mainly addresses the issue of equality, diversity, and inclusion; however, not including the appropriate resource integrators in the study design process contributed to the failure in identifying this issue as a valuable component of the device and study design.

Also, involving the project champions in the planning of the pilot could have uncovered the underlying institutions at play within the participating organisations. These institutions could have been considered while designing the pilot study, ensuring that the patient portal app encapsulates the underlying values of the stakeholders.

P4: “It [Fitbit] recognises my movement, it recognises my mobility, but on Garmin it doesn’t and that is not just me as a wheelchair or crutches

user, it's my colleagues' experience too. They could have done a five-mile run and they will stop for two minutes and then it will tell them to move again... I manually have to add every activity I do and the activities that are listed within the Garmin Connect are only suitable for those doing gym sessions or athletics, so don't cover any of the activities I do as a disabled sport's person. So, for example, swimming, although it has a swimming option, it doesn't register when I am swimming because of the way I swim. It doesn't measure for me as wheelchair sport's person when I am playing table tennis or basketball, it doesn't measure me when I am doing wheelchair dance, it doesn't register me when I am doing archery, or anything, anything like that. I have to manually upload every single activity that I am doing, which is between five and eight sessions a week."

In an environment of conflicting institutional logics (mainly, logics of professionalism vs managerialism), IT implementation can be better appropriated with the help of boundary spanners (Klecun et al., 2019); unfortunately, this role was not fully articulated and utilised in the pilot study.

5.3 Other Study Measures

5.3.1 Impact of Pilot Participation on Health Behaviour and Health Outcomes

After 12 months of the trial, study participants (hereafter, participants) had lost close to 1 KG (mean = 0.914 KG) and this weight loss was found to be statistically significant ($p = 0.041$). Similarly, there was a reduction in BMI by 0.249; however, this change was not significant ($p = 0.126$). Although participants generally lost weight after 12 months, it appears that the female participants lost more weight than their male counterparts although this difference was not significant ($p = 0.652$). Similarly, there was no significant between-group change in BMI difference by month 12 ($p = 0.739$). See Table 5.1 for the weight and BMI outcomes.

Table 5.1: Descriptive Statistics for Weight and BMI Outcomes

Variable	N	Mean	SD	Difference	Effect p-value
Weight (KG)	104				
Onboarding		77.348	17.081		
9-month follow-up		76.855	17.485	-0.493	0.233

12-month follow-up		76.434	16.661	-0.421	0.181
BMI	104				
Onboarding		27.197	5.240		
9-month follow-up		27.291	6.066	0.094	0.666
12-month follow-up		26.948	5.192	-0.343	0.075
Gender x Weight Difference	104				
Male	20	-0.503	2.965		
Female	84	-1.012	4.806	0.509	0.652
Gender x BMI Difference	104				
Male	20	-0.138	1.052		
Female	84	-0.276	1.768	0.138	0.739

Before joining the pilot, some participants thought they were already active but then discovered they were overestimating their activity levels and needed to be more active. By the end of the study, 77.8% of participants said the pilot has had a positive impact on their health and wellbeing. Fifty percent of the interview respondents (hereafter, respondents) reported noticing changes in their health behaviours since using the Garmin watch in terms of their increased awareness of their physical activity, its impact on their heart rate and health and the effects of their diet on their sleep.

P2: “I think, to be fair, it has reaffirmed what I already knew. So, if I have alcohol, I don’t get good quality sleep and I always knew that, but what this gives me is a pictorial image of how it actually impacts on my sleep, so it has probably made me more aware and it may be that if I have something pressing the next day, where it would be good to get a good night’s sleep, I would not drink the night before, or I would not eat late in the evening because I found that had an impact as well, so it has made me more aware... it has probably changed my lifestyle a little bit.”

Thirty percent of the respondents had observed that they have exercised more or have an increased desire to exercise more. Four respondents (20%) had devised and adopted techniques to help them increase their daily physical activity by achieving their daily step goals. Some of these techniques include joining the gym, using the stairs more, parking the car farther away from their destination, walking to people in the office instead of sending an email, taking short walks during lunch time at work, and cleaning round the house. Two respondents reported having better sleep habits and patterns and two others reported becoming more competitive since wearing the device; P8 was motivated to do extra activity to get to the next Garmin level and gain a badge. Three respondents (15%) reported not noticing any change in their health behaviours.

Most respondents also reported having an increased consciousness of their health, exercise and physical activity levels. About 45% of the respondents reported observing significant health outcomes or effects due to their change in health behaviours. P9, P10, and P17 reported having improved physical activity levels and general wellbeing and better sleep; P9 was so impressed with the Garmin's effect on her sleep outcomes that she plans to get her stressed-out teenage daughter to wear the device to observe her sleep patterns. P10 noticed that when he has engaged extensively in physical activity, his sleep changes and is lighter than usual. P6 said since using the Garmin, she had lost a stone and her sugar levels are down (as she is diabetic). P18 reports having increased energy and is not sluggish/tired anymore. Six respondents (30%) said it is difficult to tell if there has been any effect on their health. One respondent said there has not been any effect while two others reported noticing an effect on their fitness and physical activity levels but not on their general health and wellbeing.

P9: "Yes this was something I'd not anticipated at all. I've always thought of myself as someone who has really bad sleep, I always wake up a lot in the night and I have long periods of insomnia. I wore the Garmin and was checking my sleep every day for the first 4 or 5 days and couldn't believe how much sleep it was recording. Now I know you can fool it into thinking you're asleep, but you're lying on the sofa watching telly and it will tell you you're asleep and I know I'm not. But even putting that to one side, I can see how much sleep I was getting at night and that it was far higher than I'd ever anticipated. And that shocked me. At first I thought it was just the Garmin, but when you keep getting this every day and then I thought hang on a minute, I am sleeping more than I think I'm sleeping and then I started to change my own perception of my sleep. And when you've had insomnia for your whole life or at least I have for the last 30 odd years, when you have this change in your perception, it does have this impact on your sleep... I'd not seen that one coming. It's absolutely revolutionised my sleep from that perspective. It's absolutely brilliant. On average, I do about 3 hours deep and 4 hours light [sleep]"

By the end of the pilot study, participants had lost weight and experienced a decrease in their BMI outcome. However, these findings were not statistically significant. Weight loss was consistent over the 12 months, but BMI outcomes increased slightly by month 9 and had decreased by the end of the trial. This could be an indication of the long-term benefits of practising sustained preventive health. There is evidence for the impact of participating in the pilot on individuals' health behaviour, although the extent of this impact could depend (to some degree) on how much value the participants placed on the tracked data.

5.3.2 Wearable Data Analysis

The mean daily step count for participants across the trial period was 7,622.88 steps. The greatest mean daily step was in June while the least was in December (see table 5.2). Step count was lowest in December probably due to the Christmas/winter holiday and unfavourable weather conditions, and the step count started to increase again in January probably due to New Year resolutions of the participants to live healthier. The mean sleep hours across the pilot period was 7.767 hours and the sleep duration did not change significantly over time.

Table 5.2: Monthly Summary of Steps, Sleep, MVPA Minutes, Floors, and Active Calories

Timeline	Average Steps	Steps Difference (<i>p</i> -value)	Average Sleep Hours	Hours Difference (<i>p</i> -value)	Average MVPA Minutes	Minutes Difference (<i>p</i> -value)	Average Floors Climbed	Floors Difference (<i>p</i> -value)	Average Active Calories	Calories Difference (<i>p</i> -value)
March	7,425.49	-	7.997	-	21.15	-	7.27	-	712.84	-
April	7,666.38	240.89 (0.016)	7.983	-0.014 (0.995)	23.48	2.33 (0.091)	7.78	0.51 (0.020)	704.49	-8.35 (0.639)
May	8,079.54	413.16 (<0.001)	7.856	-0.127 (0.948)	25.70	2.22 (0.152)	8.43	0.65 (0.013)	730.72	26.23 (0.14)
June	8,148.36	68.82 (0.529)	7.775	-0.081 (0.967)	25.89	0.19 (0.912)	8.19	-0.24 (0.380)	741.65	10.93 (0.565)
July	7,893.81	-254.55 (0.020)	7.590	-0.185 (0.928)	23.16	-2.73 (0.111)	8.30	0.11 (0.658)	712.18	-29.47 (0.126)
August	7,533.22	-360.59 (<0.001)	7.758	0.168 (0.938)	19.28	-3.88 (0.007)	9.18	0.88 (0.001)	633.11	-79.07 (<0.001)
September	7,600.05	66.83 (0.521)	7.636	-0.122 (0.958)	17.49	-1.79 (0.112)	10.88	1.70 (<0.001)	655.91	22.80 (0.179)
October	7,389.74	-210.31 (0.050)	7.695	0.059 (0.979)	19.61	2.12 (0.100)	11.39	0.51 (0.168)	641.96	-13.95 (0.432)
November	7,536.38	146.64 (0.169)	7.660	-0.035 (0.987)	20.52	0.91 (0.526)	11.55	0.16 (0.669)	678.80	36.84 (0.047)
December	7,171.58	-364.80 (<0.001)	7.718	0.058 (0.979)	19.91	-0.61 (0.641)	11.27	-0.28 (0.405)	693.34	14.54 (0.465)
January	7,420.83	249.25 (0.018)	7.708	-0.01 (0.996)	20.25	0.34 (0.768)	11.35	0.08 (0.814)	681.05	-12.29 (0.547)
February	7,654.64	233.81 (0.037)	7.762	0.054 (0.981)	21.62	1.37 (0.239)	11.33	-0.02 (0.954)	680.32	-0.73 (0.972)

From the data, changes in average steps were not always consistent with changes in average MVPA minutes, floors climbed, and active calories burned. Although step count was found to be positively correlated with MVPA minutes ($r = 0.81$, $p = 0.001$)

and active calories ($r = 0.62, p = 0.033$), it was found to be negatively correlated with floors climbed ($r = -0.54, p = 0.07$).

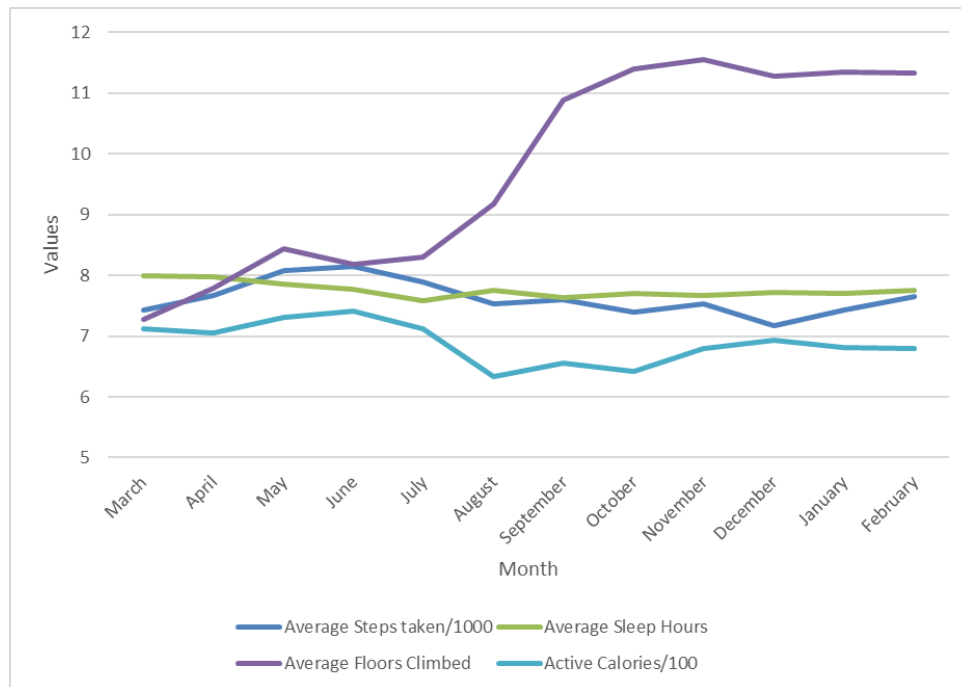


Figure 5.3: Fitness Data Trends by Month

Also, the trend for the floors climbed data was significantly different from other variables as the average number of floors climbed consistently increased over the 12-month period (see Figure 5.3). These irregularities in the data point to the likelihood of the device's inaccuracy in tracking the users' activities (particularly, the floors climbed data), which limits the reliability of the tracked data. This finding is consistent with findings from the interview where 85% of the respondents described the accuracy and sensitivity of the Garmin tracker as unsatisfactory, although the respondents had a fifty-fifty response concerning the accuracy of the sleep data.

The sleep data was an important part of this analysis. Physical activity in the form of steps taken was found to be positively correlated with hours of sleep, although this correlation was weak and not statistically significant ($r = 0.062, p = 0.849$). To facilitate further investigation into the sleep data, the records were categorised into bedtime cohorts which constituted the range of time when participants went to sleep (see Table 5.3).

There were no records with bedtime between 9 AM - 6 PM; hence, only cohorts 1-5 were used in the analysis. Does bedtime influence sleep duration and quality? Sleep duration was found to be negatively correlated with bedtime cohort ($r = -0.327$,

Table 5.3: Categorisation of Sleep Data into Bedtime Cohorts

Bedtime Cohort	Bedtime Range
1	6 – 9 PM
2	9 PM – 12 AM
3	12 – 3 AM
4	3 – 6 AM
5	6 – 9 AM
6	9 AM – 12 PM
7	12 – 3 PM
8	3 – 6 PM

$p < 0.001$); sleep duration tends to decrease as bedtime range increases. A regression model of sleep hours based on bedtime was designed and it was discovered that a unit increase in bedtime cohort (e.g. increasing bedtime from between 6 – 9 PM to 9 PM – 12 AM) reduces sleep hours by an average of 45.13 mins (CI = 43.83 – 46.44 mins). Participants who went to bed between 6 – 9 PM slept the longest (mean = 8.75 hours) while those who went to bed between 3 – 6 AM slept for the shortest amount of time (mean = 5.51 hours), see Figure 5.4. Generally, the earlier participants went to bed, the longer the hours they slept at night.

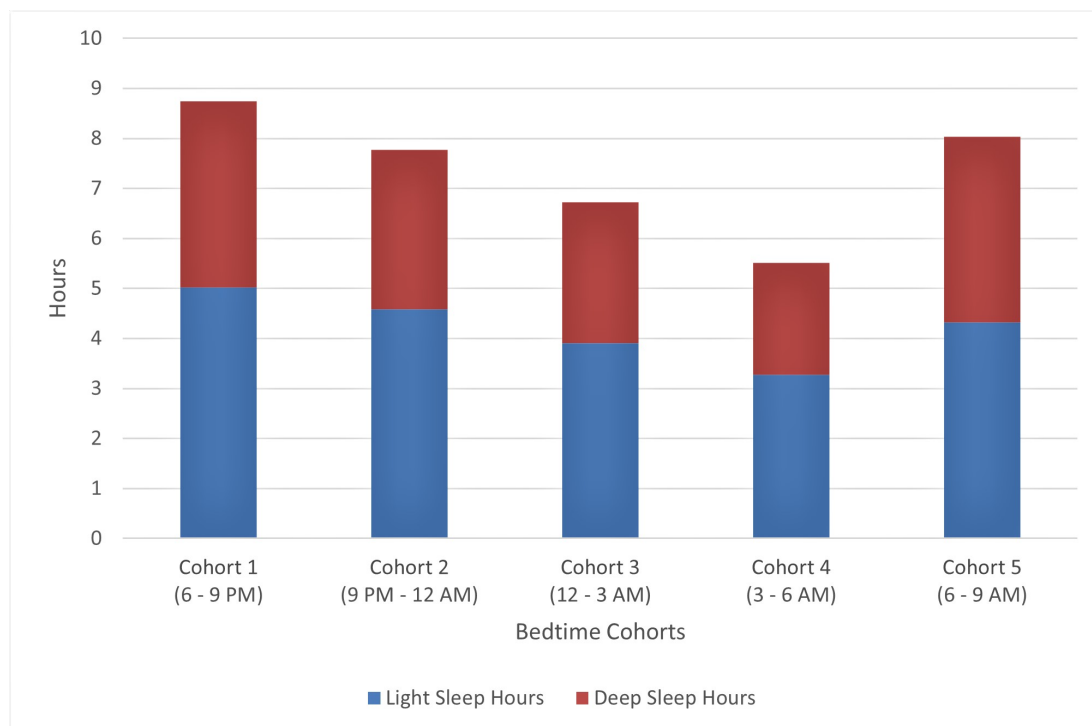


Figure 5.4: Distribution of Sleep Duration by Bedtime Cohort

However, participants with bedtime between 6 – 9 AM slept longer (mean = 8.03 hours) than those in cohorts 2 to 4. It is likely that these participants had worked a night shift the night before or did not have to be at work that morning and hence could stay in bed longer. But this bedtime cohort (6 - 9 AM) appears to have experienced the poorest sleep quality because it presented the greatest level of irregularity in sleep hours. That is, the trend of sleep for this cohort was less constant than that of other cohorts over the months (see Figure 5.5). The range of the difference in sleep hours for other cohorts is approximately less than or equal to 1 hour while that of the 6 - 9 AM cohort is approximately 2 hours. This highlights the fact that greater sleep duration does not always translate to better quality of sleep.

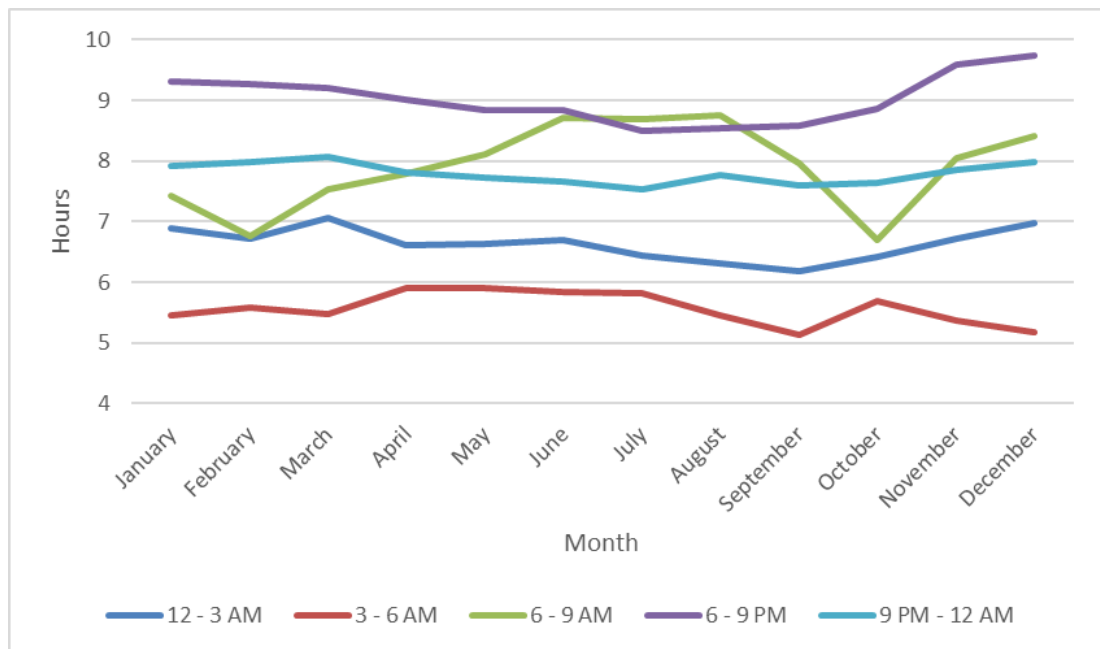


Figure 5.5: Trend of Monthly Sleep Duration by Bedtime Cohort

From the beginning of the pilot, step count consistently increased each month, but started to decline as the device's novelty wore off. Unexplained irregularities in the tracked data point to the likely inaccuracy of the device in tracking users' floors data. Because the wearable data was not grouped by participant ID, no links between participants' tracked data and their responses to the surveys could be established. So, it was not possible to determine some of the motivations behind participants' responses. The relationship between physical activity and hours of sleep is yet to be fully explored and further research in this field is required. Similarly, research on deep and light sleep and their implications for health and wellbeing is encouraged as participants did not understand how they were supposed to interpret such figures.

In this chapter, the relationship between the empirical evidence and the proposed design methodology was discussed. There exists a diverse set of individuals, values and motivations involved in the use of health apps and there is an obligation to cope with such diversity and (where possible) motivate everyone in some way to use these apps. Studying individuals' values and motivations presents a viable approach that contributes to methods for fulfilling this obligation. Participants' perceptions and implementation failures observed in the technology and study design formed a strong evidence for a value-based technology design methodology which takes the underlying institutions and institutional arrangements into consideration. Other study measures obtained via the surveys and fitness trackers were also presented to establish the trustworthiness and credibility of this research.

Chapter 6

Application of VCD: Berkshire Wearable Technology Pilot as a Case Study

In this chapter, the VCD framework is applied to the hypothetical implementation of a preventive health technology innovation within the healthcare organisation – specifically, the Berkshire Wearable Technology Pilot. Although there were two preventive health apps used for the pilot, we will focus on the design and implementation of the Berkshire Patient Portal app because it is an innovative preventive health technology designed to be adopted by the organisations within Berkshire NHS unlike the Garmin device and Garmin Connect app which are universally-recognised preventive health technologies. This analysis exemplifies the application of the proposed VCD model in a real-life design scenario and addresses some of the failures observed in the pilot study and discussed in Chapter 5.

6.1 Conceptual Investigation

6.1.1 Analysis of Relevant Stakeholders/Actors and their Existing Institutions

The VCD model, like the VSD, is designed to be implemented as an incremental and iterative process which makes it able to support the addition of different types of stakeholders, institutions, rules and resources to the system design over time. The implementation of an IT innovation within a service ecosystem that is influenced by multiple

institutions and institutional arrangements (such as the healthcare organisation) would require the analysis of all related stakeholders – including those who are not necessarily the users of the technology but who can (in)directly influence the policies and strategies of the tech design and implementation.

There are direct and indirect actors involved in the design, development and adoption of the Patient Portal app. The direct actors are users (NHS employees, in this case) and GPs who work in GP surgeries while the indirect actors are family & friends, IT suppliers (such as Microsoft and GraphNet – organisations involved in the development of the Patient Portal app), Garmin (because it provides tracked personal data uploaded to the Patient Portal app), and the healthcare organisation (e.g. NHS Trust). The local authorities who provide social care are also indirect actors because they will influence the implementation and adoption of the patient portal, even though they will not use the app. However, the local authorities will not be captured in this example because they were not included in the Berkshire Wearable Technology pilot. The long-term goal is to make the Berkshire Patient Portal app accessible to social care professionals in order to give all members of the care team a complete picture of an individual's healthcare status; but for this pilot, data access was restricted to GPs only. See Figure 6.1 for a better understanding of the roles the actors played in the Berkshire Wearable Technology Pilot.

6.1.1.1 What do we know about each group of actors', often overlapping, institutions?

Berkshire NHS operates as an NHS Foundation Trust which means it is a semi autonomous healthcare provider within the National Health Service in England. Although NHS Foundation Trusts are subject to NHS standards and principles, they can direct and commission new services that reflect local needs and priorities (Boyle, 2011, p. 188). As a Global Digital Exemplar, they can commission and implement new technologies to transform patient care¹. As mentioned in Chapter Four, the participating organisations within Berkshire NHS include FHFT, RBFT, BHFT, Berkshire West CCGs, and Berkshire East CCGs. The General Practitioner (GP) is the main point of contact for healthcare and is commissioned by the NHS to provide core healthcare services to its patients (Royal College of General Practitioners, 2011). GP practices generally operate as small independent businesses; but some GPs work directly for the NHS or

¹<https://www.berkshirehealthcare.nhs.uk/about-us/>

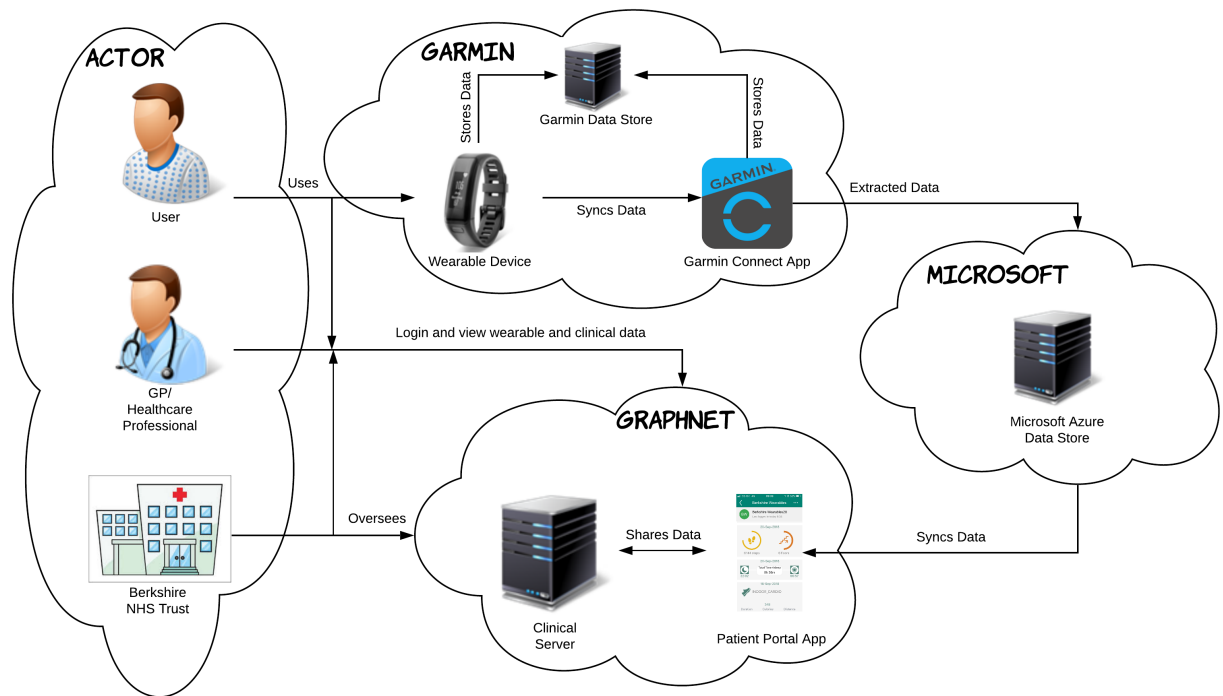


Figure 6.1: Actor Groups, Apps, and App Development Teams involved in the pilot

private healthcare providers. However, despite these various work arrangements, they receive a similar training as GPs.

The development of the Patient Portal is part of a broader plan for a centralised patient record shared among health and social care providers within Berkshire. Hence, the implementation of the Patient Portal will be influenced by the participating organisations and partners within Berkshire NHS ecosystem. Thus, increasing the magnitude of potential endogenous and exogenous institutional clashes and competitions.

From existing literature, medical professionalism and managerialism have been identified as the two key co-existing and competing institutional logics within the healthcare organisation (Klecun et al., 2019). The GPs are mostly guided by institutions of medical professionalism, whose behaviours and values have been shaped by institutions such as the medical schools where professionalism is encouraged and promoted (Kuhlmann and von Knorring, 2014). They are taught to rely on their professional knowledge and expertise to advise (supposed inexperienced) patients about their health and wellbeing (Brommels, 2010). During the professional dominance era in the UK healthcare system, clinicians had a level of autonomy to define their working practices, including the choice of technologies adopted and used across the field (Berwick, 2016). As the healthcare system has moved on to the era of managerialism

and (now) market mechanisms, the GPs have maintained their struggle for professional autonomy (ibidem). Thus, they are usually in opposition to the adoption of any IT innovation that they perceive is being imposed on them by the government, management, or IT providers (ibidem).

Prior to the late 1990s, IT implementation across the NHS was decentralised or division-based (that is, different establishments or regions had control over their IT implementation processes) and this resulted in inconsistent IT developments which did not link to the wider NHS (Boyle, 2011). The decentralisation of IT implementation in the NHS necessitated the involvement of IT companies who play the role of *standardisers* in the design and implementation of IT innovation. In the late 1990s, the government introduced an integrated governance structure to standardise IT systems across the NHS using local IT providers who ensure that local IT systems comply with national standards (Boyle, 2011). But, Garmin devices are designed to be personalisable for the users who have some (or complete) autonomy on the personal data and records they create and delete. On the other hand, users do not have autonomy over their healthcare records generated by their GPs; however, they can choose (to some extent) how the records are shared. Also, GraphNet is required to ensure that applications used within the NHS comply to the national guidelines and standards which limit users' ability to personalise such apps. These different institutions influence the way users interact with the apps.

Hospital managers are mostly influenced by institutions of managerialism which encourage a business-like approach to healthcare. This is partly because these managers who once received their training from schools of hospital administration have been replaced by healthcare executives who have been trained in business schools or more recently, the New Public Management approach (involving government metrics like waiting times) which lays an emphasis on increasing managerialism and efficient delivery of healthcare (Veronesi et al., 2013). Consequently, the hospital managers tend to apply market mechanisms to healthcare and focus on patient satisfaction and the provision of cost-effective healthcare (Klecun et al., 2019). This usually puts the institutions of the managers in conflict with those of the health professionals whose work practices are more motivated by their values of service and compassion than the criteria of healthcare cost and efficiency (Brommels, 2010). However, there might exist complex underlying values that drive GPs' work practices. Since funding is fixed, professionals might take a utilitarian approach that considers the cost and impact of healthcare on patients (e.g. "I want the NHS to deliver the best for its patients") than a

service-based approach (e.g. “I want to ensure the best treatment for my patient”). In this case, tradeoffs are important; for instance, some cancer drugs might be too costly to be considered viable options for treatment. Also, GPs feel like they are underfunded (Iacobucci, 2017), so they resent the government’s central spending on such IT innovation. This tussle is usually fought out on a more managerialist ground than the professional perspective based on values of service and compassion.

Also, despite the drive for the NHS to have a more patient-led focus in its service delivery, it has mostly maintained a top-down approach and formal governance structure to the design and introduction of IT innovation which is not compatible with the institutions of the healthcare professionals who feel left out of the decision-making process concerning a technology that they are expected to use. With the autonomy of local NHS Foundation Trusts (such as Berkshire NHS) over the commissioning and development of new technology within their establishments, their management and project administrators can evade the occurrence of this conflict.

With a more patient-centred outlook by the NHS, patients are encouraged to get better informed about their health and are more knowledgeable about their symptoms and treatment options. The implementation of the patient portal aims to enhance information/knowledge sharing among the patient and healthcare professionals, but medical professionalism granted (and probably still grants) the health professional monopoly over the use of their medical knowledge base (Byyny, 2018). Also, GPs may feel threatened by the capture of data by the patients because it potentially undermines their unique role of routine patient contact. Hence, some healthcare professionals might be averse to the use of a technology that disseminates sensitive health records to patients, citing data security and privacy concerns (Klecun et al., 2019). And GPs’ adoption of the technology influences patients’ perception and use of the technology.

The Information Governance (IG) initiative within the NHS guides the confidentiality and access of patient records and it can both encourage and stifle the use of IT innovation. IG within the NHS seems professionalised - involving a mix of professional IT experts, medics and other employees who have a career in IG (e.g. Cladicott Guardians are senior healthcare personnel that ensure the confidentiality of patient records is maintained). The highly professionalised nature of IG within the NHS contributes to its execution as a standardised *one-size-fits-all*, *tick-box* procedure which can limit the successful implementation and adoption of IT innovation in the NHS (as observed during the Berkshire pilot study).

These conflicts in the institutions of the stakeholders can constrain the implemen-

tation and adoption of the patient portal if they are not well understood and ways to manage them are not adopted. There are three main ways of managing conflicting institutions within the organisation during the implementation of an IT innovation.

- Find a greenfield site (e.g. a low-population site) outside of the institution and first implement the technology there. After successful implementation in the greenfield site, the technology can then be introduced on a larger scale. However, the need to secure assent and improvements consistent with existing health care systems means that IT implementations will often align with, rather than radically transform, existing business processes (Ericsson, 2014). Thus, change in the NHS is often incremental rather than disruptive and its professional and bureaucratic structures leave little scope for greenfield development.
- Identify any redundant institutions and cut these out from the technology design and implementation process (disintermediation). An example is travel agencies which have been cut out of the travel booking system since most booking sites now offer the opportunity for users to book all their trip essentials like flights, hotels, and transport on the same site. An example of disintermediation in the healthcare system is individuals' preference to first find health information on the Internet, even though doctors are considered the most trusted source of health information (Swoboda et al., 2018).
- Introduce a tool or infrastructure to change the channels of mediation between the conflicting institutions. An example is the use of teledermatology to reduce patients' waiting time of seeing a dermatology specialist by real-time videoconferencing or sending a digital image of the skin condition to dermatology centres of excellence (Pala et al., 2020). Another example is the Babylon Health app which also reduces patients' waiting time for in-person consultation with their GP by offering users direct access to a doctor through virtual video consultation and a symptom checker powered by Artificial Intelligence (AI) (Burgess and Kobie, 2019).

It is important to identify and decide the most effective strategy for managing conflicting institutions at the conceptual stage.

6.1.2 Service Exchange and Resource Integration

The next thing to do in the methodology is to conduct an analysis of the existing service exchange framework within the health organisation to identify the services the stakeholders exchange to cocreate value. As value is implicated via use of a technology, analysing the services exchanged by actors and the resources these services require can help highlight what kinds of value are being cocreated by the involved actors. This activity will be executed via three stages – service identification, service refinement, and service map development stages.

Service identification: The first step is to identify the services that are exchanged within the service ecosystem. Preventive health, like healthcare, is not practised in isolation; hence, it is not unusual that individuals will exchange social support services between themselves and their family & friends. Social support is multifaceted, and it involves components of emotional support (e.g. encouragement), informational support (e.g. referral and advice), instrumental support (e.g. active participation), and validation support (e.g. compliment) (Chaparro-Díaz, 2013).

GPs can also exchange social support services among themselves in the form of validation and emotional support. GPs primarily offer expert health information and feedback to individuals and their family/friends and in turn, via the patient portal, they can gain access to personal and fitness data that can support their diagnosis and feed into population data for research and data modelling for best practices in healthcare. Healthcare organisations provide individuals and their families/friends with healthcare delivery services and obtain funds and data to maintain the health institutions. See Table 6.1 for an outline of services exchanged by actors using the patient portal app.

Some of the potential actors and services have been omitted from the table because this framework application is restricted to the actors described in section 6.1.1. Some of the omitted actors include other healthcare professionals (like nurses, etc.), social workers, and other home care workers and a range of services are also omitted e.g. Assistance for Daily Living like cleaning, shopping, and transportation to and from hospitals.

Service Refinement: In this stage, a precedence graph is constructed to refine the service list to the most important or foundational services. To do this, services that act as a resource to another service, are a component of another service or a direct outcome

Table 6.1: Services Exchanged by Actors

Actors	Individuals	Family & Friends	GPs	Healthcare Organisations
Individuals	Social Support	Social Support	Personal/Fitness data tracking and sharing	Research and planning data provision, Healthcare fees payment
Family & Friends	Social Support	Social Support	Personal data sharing	Healthcare fees payment
GPs	Expert health info & feedback	Expert health info & feedback	Social Support, Data sharing	Reputation, Expertise, Data sharing
Healthcare Organisations	Organised healthcare delivery	Organised healthcare delivery	Workplace structuring, Wages payment	Data sharing

of another service are dropped from the service list (see Figure 6.2).

This step ensures that the technology is not overladen with features that could be redundant or unnecessary and helps identify the critical elements in the service ecosystems of actors for the patient portal. Hence, data sharing, expertise, reputation, payment, and structure are excluded from the service list. This produces a service list that includes social support, research & planning, organised healthcare delivery, expert info & feedback provision, and personal/fitness data tracking. It is obvious from the precedence graph that personal/fitness data tracking is central to the service exchange process associated with the patient portal app because it supports the greatest number of services.

Service Map Development: The next step is to develop the service exchange map, using the refined service list, which will outline the actors, the services they exchange, the resources required for those services and the values implicated through the service exchange process (see Figure 6.3). Considering the definition of operand resources as resources “on which an act or operation is performed” and operant resources as “those that act on other resources” (Madhavaram and Hunt, 2008); the operand resources the identified services will utilise include devices (Garmin fitness

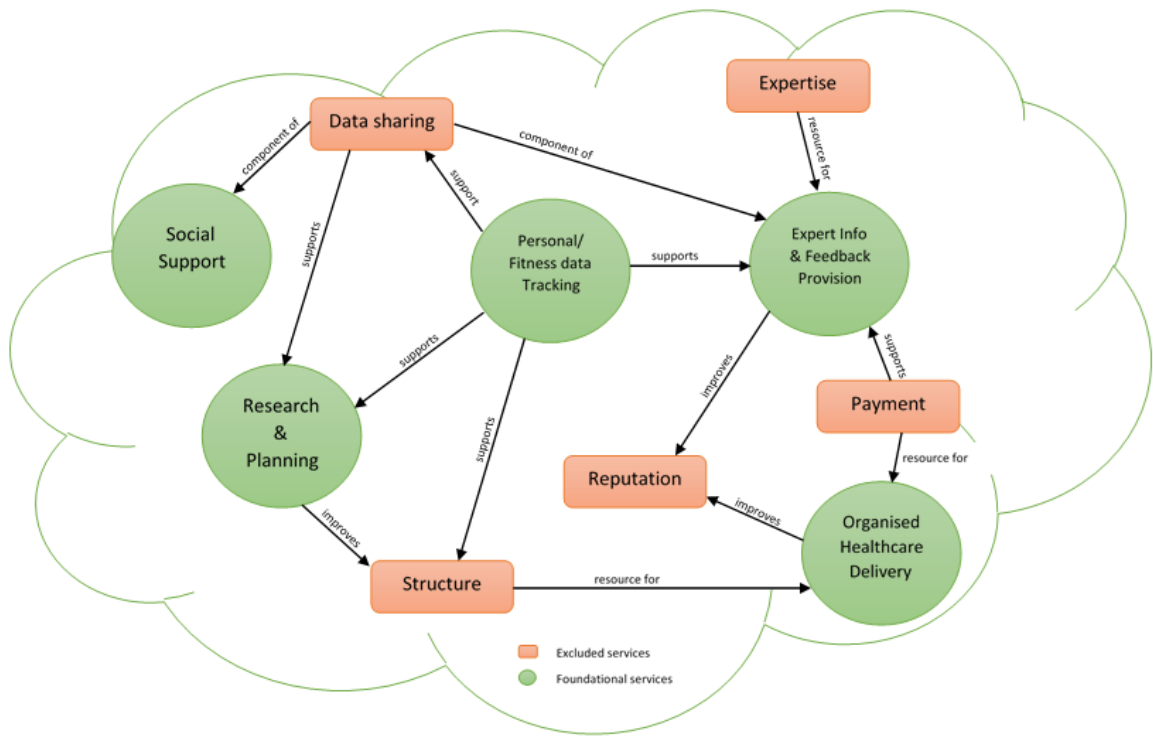


Figure 6.2: Precedence Graph for the Service Refinement Stage

tracker, smartphones, and computers which house the Garmin Connect and Patient Portal apps), time, funds, data collected (personal, fitness, experiential, clinical, and population data), infrastructure (e.g. buildings, servers), algorithms and infrastructure for data storage, maintenance, sharing and security, while the operant resources are the users and staff/personnel and the expertise and knowledge they use while performing services.

There are some services that utilise similar resources for their exchange which creates the opportunity for these services to compete for such resources. For instance, services to deliver an organised healthcare and research and planning both integrate human resources and funds. This highlights the need for an assessment of the allocation of resources for these services.

The NHS is responsible for allocating financial resources to individual Foundation Trusts/Trusts and Clinical Commissioning Groups (CCGs) to cover healthcare costs across the NHS sites. As a Foundation Trust, Berkshire NHS is responsible for managing allocated resources to deliver quality healthcare services. To avoid potential competition for resources, it is essential for all participating organisations within Berkshire NHS to work together to ensure the health organisation has separate and sufficient provision for funds and personnel for day-to-day operation of the organisation and for

research and development. Are there personnel and finance reassignment changes that need to take place? Are additional personnel and finance resources required? If yes, when and how can they be secured?

Another way to resolve such resource conflicts is to manage them within the app by providing support for resource integration required for one service (as opposed to both conflicting services) in the app. The selected service can be chosen based on [influential] actors' opinions, relevance, or related cost.

6.1.3 Technological Affordances to Support Service Exchange

Here, technological features that need to be incorporated into the app based on the services, resources, and values highlighted in the service map are identified. The first task is to identify any underlying institutions, rules and constraints which can contribute to shaping the technological features of the system.

Institutional rules, constraints and affordances are often carried along implicitly and incorporated into the system. This means these are not understood and some features get built in that will definitely inhibit transfer or scaling up of the system. Hence, it is important to identify which rules and constraints should be implicitly and explicitly designed into the system. One of such implicit scenarios is the overlapping relationship between the institutions of the GP surgeries and NHS Trusts; they are different organisations with a contractual relationship and share data with each other.

Given the sensitivity of the data shared, data security should be a priority. There should be data access and sharing control procedures to ensure users' private data are not violated. There exists an institutional framework that, for instance, approves the systems GPs use and controls the network. In this case, the existence of appropriate infrastructure and procedures to ensure data security during information exchange can be assumed. Hence, there might be no need for the development of new infrastructure/procedures for data security during the system design. A few market studies have reported that some users of health information technologies are not too concerned about the data sharing and privacy implications of using such technologies as long as they find them beneficial (Cocosila and Archer, 2014). But the institutional arrangements concerning data security within the NHS are based on the strictest interpretation of data protection and that inhibits free exchange of information. These institutional arrangements ought to take the users' varying (and often, conflicting) perspectives into account as they are the principal actors.

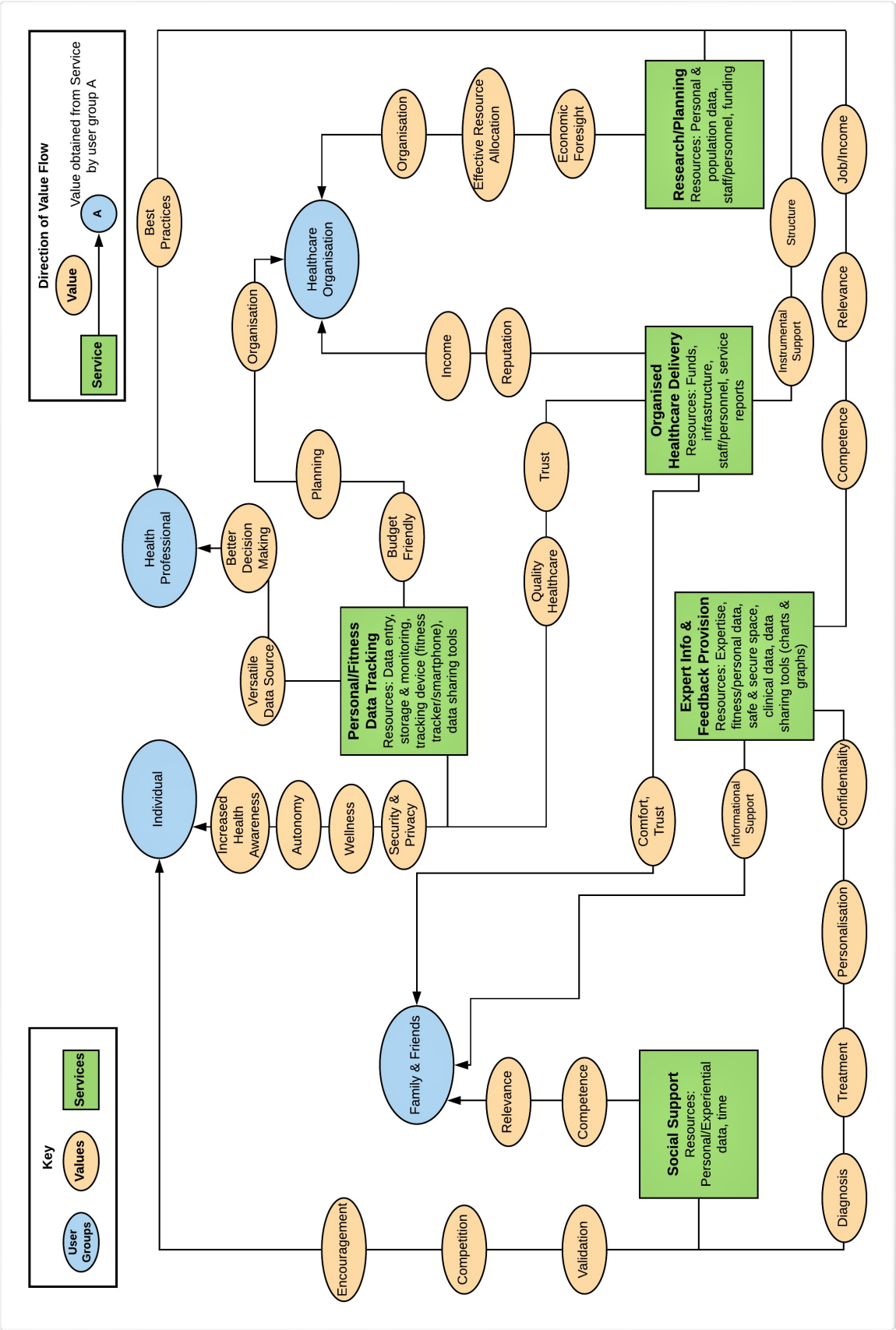


Figure 6.3: Service Exchange Map

A more explicit scenario arises when considering how the Garmin Connect app interacts with the Patient Portal app to share fitness data. The organisations involved in this interaction and their roles are:

- **Garmin** manages the tracking and collecting of fitness data.
- **Microsoft** hosts the wearable data extracted from the Garmin Connect app on Microsoft Azure software.
- **GraphNet** supplies the Electronic Patient Record, the CareCentric Patient Portal, where patients' clinical records are kept.
- **Berkshire NHS Trust** serves as the healthcare organisation that oversees the patients' data collection and sharing. This consists of the participating organisations outlined in section 6.1.1.1 with their diverse (and often, conflicting) institutions and institutional arrangements.

Given the various institutions involved, a risk assessment needs to be conducted at the system design stage to work out how this data will be transferred and stored by the various organisations. Consideration should be given for how the data will be extracted, stored, and synced between the two platforms. Should the data be temporarily stored in a holder and then permanently saved on the patient portal app at a certain time of the day? Should the patient's record refresh each time wearable data is synced to the patient portal app? What are the implications of these data transfer decisions for the speed and scalability of the app?

The focus at this point will be on the features needed by the direct users of the app (individuals and GPs) and some features that could be useful for the indirect users of the app (family/friends and healthcare organisations). Qualitative evidence obtained from the empirical study also supports the choice of the features discussed below.

Data Collection, Analysis, and Visualisation: The fitness data for steps, sleep, diet, heart rate, activities, and calories burned is collected using a fitness tracker or smartphone. This data gets synchronised with the Berkshire Wearable patient portal app. The app should have features for effectively analysing and visualising the data in a format consistent with most fitness apps and easy enough for the user to intuitively understand. The app should also allow the users to enter other relevant personal health and fitness data like diet, mood, etc. (the original patient portal app did not have these features).

P4: “I think, transferring the data from the Garmin app across to the Patient Portal app, it would be good to see it in the same sort of format that you have actually entered it in the Garmin. It needs to be visually easy to read and historic at the same time...”

The patient portal will serve as an integration point for users’ personal and clinical data to give a more complete picture of individuals general health and wellbeing. Thus, the app could appropriately analyse and combine data from the various sources to provide personalised health advice and wellness tips which will help guide individuals better on how to maintain healthy behaviours. The original patient portal app did not give participants access to their clinical data. Ideally, the app will grant users access to their clinical records including GP notes, prescriptions, allergies, etc. However, user rights to modify or delete these records will be restricted from the patients or users to maintain the integrity of the clinical data.

P17: “You want it to really be able to replicate the information from the, you know, the gadget to the app, you know, and then from the app to the Berkshire platform. So yeah, it just makes life easier and you have continuity, don’t you? You just go on there and you’ve got your data already in the format that you are accustomed to and then you can just look at it to see what useful tips or information is available to help you along, you know, any further exercising regimes according to your routine, you know?”

Users can share any part of their data as they choose; however, data sharing with their GP is not optional if they choose to use the app. They should be able to also determine whether they want their data to be captured for research and planning purposes. In line with the General Data Protection Regulation (GDPR) legislation, all optional data sharing access will be switched off by default until the user enables them. Consideration for effective data storage and retrieval will also be taken into account when designing this feature.

Expert Information and Feedback Provision: Despite the popularity of the Internet as a vital source of medical information, most individuals still prefer to consult their GPs for information or diagnostic services. A study conducted by Kwon *et al.* found that the study participants reported hospital physicians as the most trusted source of health information (Kwon et al., 2015).

P15: “I suppose, if it’s about sharing data with my GP and stuff, it would be interesting to know, how that would be of use to either of us, in terms of having a conversation about my health and fitness.”

Patients are usually interested in making the interaction with their GP easier and timely. Hence, it is important to provide expert information and feedback to users via secure messaging or call features. This feature can provide cost-effective and convenient healthcare services to the app users. It can potentially reduce waiting time for individuals to see a GP.

P20: “I guess in an ideal world, I would like access to my GP records... yeah, even like the ability to make an appointment, be able to order prescriptions, renewable prescriptions. I think it [Patient Portal app] could have very wide-ranging use – send a message to the surgery.”

Given the existing workload for GPs which might make it difficult for them to dedicate time to use the app, the app should support virtual consultation and appointment booking which can be synced to the GP’s calendar. This will ensure that the GP is not overworked, and it can help reduce the frequency of in-person visits especially in these times of social distancing and reduced physical contact. Alternatively, the system can triage and use paramedics or nurses for health cases in their competence. When the system design gets scaled up to include social care services, it will be necessary to work out how social care services and health care services will interact in terms of referral and coordination of care.

Social Support Features: The support for behaviour change is provided by the sharing culture of social networks as wellness (like treatment) is not practised in isolation. Hence, the provision of social support features in the form of online forums, private messaging, and gamification elements such as competitions/challenges, digital rewards, levels and leaderboards, and cooperation for positive behaviour-reinforcement will be instrumental for driving value cocreation in the app. One of the respondents from the empirical study suggested fitness competitions between employees of the different NHS Trusts.

P13: “It might be nice if there were other staff members umm that were also using it to sort of maybe do those challenge elements, might be nice, rather than just doing them with people you didn’t know or something like that. Erm maybe get a Trust competition going or something like that might be cool.”

These interactions should be moderated and access to personal information should be restricted by the user. Consideration for the institutional structures guiding different actor groups is essential. For instance, older users might prefer more face-to-face interactions (like Lunch clubs) than their younger counterparts. In which case, the app

should be able to leverage such preferences and provide features to support these preferences.

Report Generation: This feature will make it easier for GPs to extract population or personal data views for research and planning purposes. This will only capture the records of users who have opted into anonymously sharing their health data for such purposes. This will be facilitated by effective data collation and analysis algorithms to ensure the production of different data snapshots and some basic data analytics reports. These anonymised reports can then be securely shared online or printed out. This will facilitate information and findings sharing between health professionals and with the healthcare organisations.

There are different views concerning what the app might do for the different participants and this needs to be negotiated. For instance, linking clinical and personal data probably does provide better service in terms of health but it also potentially compromises privacy. So, there will be competing views across the actors and quite possibly users are not uniform in their attitudes to these views. Hence, it is important to conduct an empirical investigation to discover and understand the different views held by the actors concerning the app features that have been described above.

6.2 Empirical Investigation

6.2.1 Technology Design

This entails the development of the app to encapsulate the features identified to facilitate service exchange and value cocreation between actors. The app design tools and platforms are considered and designed at this stage, integrating the usability heuristics necessary for mobile health apps. Design decisions can either reinforce or undermine institutional arrangements. Design decisions concerning moderation of the online interactions (especially the online forums) should be considerably made to avoid trolls or the dissemination of false or inappropriate health information. Who should have access to these interactions? Whose responsibility would it be to moderate the forums? Does the healthcare organisation have a duty of care for the users of the app? These questions will need to be addressed to aid the design stage. There might also be a need to balance any competing institutional arrangements at this stage. For instance, the GPs might have an idea concerning how the data should be stored and used while the

hospitals might have a different perspective. Additionally, IG units within the NHS trust might have further different views. It is important to balance such conflicting views before designing the app.

It is necessary to consider the affordances needed in order to embed the technology into existing work processes. This will require a holistic understanding of the underlying service ecosystems of actors that already exist in the health system, their existing social norms and the way services are currently exchanged between them. For instance, an understanding of the current doctor-patient relationship helps identify any lapses in that relationship and ways the app can be explored to model the existing relationship and improve it. An understanding of the hospital doctor/GP relationship is also necessary because GPs may feel threatened as hospital doctors will gain more information about the patient via data and this could undermine the GPs' role as a gate to hospital services. Also, knowing that healthcare professionals do not appreciate being excluded from the design of a technology they will be expected to use, it is important to actively involve them (and representatives of the other stakeholder groups) at this stage (preferably during the conceptual investigation) to obtain relevant feedback before the technology design is finalised. This is different from the empirical study which is the next stage after completing the technology design; this is more like a focus group meeting to ensure all stakeholders are on board with the design and implementation of the new technology.

Complex IT apps are rarely the outcome of ab initio design but emerge through a process of reconfiguration of already-designed elements. That is, tech design outcomes are inevitably unfinished due to evolving complex user requirements (Stewart and Williams, 2005). Hence, considering the existing underlying service ecosystem could highlight some existing tools or software within the health organisation that support an identified service; for instance, report generation. In that case, an analysis should be conducted to determine whether this feature should be excluded from the patient portal app and use of the existing tool continues or the tool gets integrated into the patient portal app or the existing tool gets replaced by the feature provided by the patient portal app.

6.2.2 Execution of an Empirical Study

This involves a small-scale pilot study to test the app and observe how individuals use it. Software testing is useful for detecting defects in technology which can then

get fixed (Khan and Khan, 2014). Hence, it is important to extensively test any new technology before it is rolled out for use (especially at large-scale). It is necessary to ensure that all the actor groups are represented in the study sample. During the empirical study, the study participants' perception of the identified services and features are obtained, and any missing services and unintended positives identified. Also, any conflicts between the use cases for the different actors are identified and resolution methods sought. These responses can be obtained via surveys, interviews, and measures of user behaviour and physiology. Depending on the time and budget constraints, a small sample of participants can be observed while they use the app. However, there are some factors that might not be easily observable from a small-scale study. For example, systems involving data collection in particular tend not to show their potential benefits until they are used by many people.

Some important questions that will be helpful in completing this empirical investigation are:

- How do people value one service against other services? This can be useful for developing a hierarchy of service preference.
- Were there any services that were used most?
- Were there unanticipated ways (unintended positives) that the technology has been used? Perhaps that is an indicator for what is lacking in the design.
- Are the available resources sufficient for effective service exchange?
- Did the technology provide the necessary support for the actors' social norms and institutions?
- Was service exchange via the app constrained or enabled by such support for social norms?

6.3 Technical Investigation

6.3.1 Modifications to the Technology Design

At this stage, the app is modified to adopt the changes identified during the empirical investigation. Any conflicts between the actors' service exchange processes are resolved and new features introduced for any newly identified services. The app should

be tested after each modification exercise to ensure no existing processes have been broken.

6.3.2 Embedding the Technology into Existing Processes

The more embedded the patient portal app is into NHS' existing work processes; the more likely it is for the app to be used effectively. For the app to be successfully embedded into existing work practices, it is important to understand the underlying service ecosystem, institutions, rules and constraints that influence its implementation and the perception of the actors. Since this exercise had been done during the conceptual investigation stage outlined in section 6.1, this step entails executing the findings from the conceptual investigation and empirical study concerning the role of underlying institutions and systems and technological limitations in embedding the technology.

Some useful questions to ask at this stage of the technical investigation include:

- What are the ethical implications of integrating this technology? If an ethical issue is important, it should have been captured in the analysis of individuals' values and flagged up as important. However, there could be ethical issues that may have missed out during the conceptual stage but then highlighted during the empirical study. For instance, in the Berkshire wearable technology pilot, the issue of equality, diversity, and inclusion which was not recognised during the study design stage was highlighted by one of the study participants during the empirical study (see Section 5.2).
- How does the innovation interact with the existing service ecosystem? It is a responsible move to be able to audit the way the innovation interacts with the ecosystem. This will enable some oversight of the effects of the change on existing processes.
- Are there some properties of the technology that limit its ability to be properly embedded into existing norms and practices?
- Are there alternatives for such properties, what trade-offs are required for proper adoption and utilisation?

Each time the app is modified, it is important to revisit the empirical investigation stage to study the effect of these changes on the app and its users. This process is repeated until the app gets properly integrated into NHS Berkshire's work practices; at

which stage, value via the app would have been cocreated by all relevant actors.

In this chapter, the proposed VCD model was applied to the design and implementation of the Berkshire Patient Portal app. Steps for conducting the conceptual, empirical and technical investigations were outlined. Findings from the model's application to a real-life design problem helped inform the development of a revised version of the VCD model. This version is outlined in the next chapter.

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Chapter 7

Revision of the VCD Framework

In this chapter, we present the revised, step-by-step implementation of the VCD framework which was developed based on the evaluation of the initial framework by empirical evidence and findings from its application in a real-life design scenario.

7.1 Shortcomings of VCD framework

While testing the framework, some shortcomings in the execution of the framework were identified. First, the debate concerning the sequential execution of the three investigations of VSD (as discussed in Chapter 3) poses a problem for the execution of the VCD as it inherited the structure of the VSD. As earlier stated, I argue that the conceptual investigation ought to be the starting point for both new and existing design projects. Beginning with the conceptual investigation of an existing project can help identify any lapses in the way the project had been introduced and implemented (such as the exclusion of a relevant actor). So, to avoid any confusions concerning the flow of the framework, it becomes necessary to explicitly specify the stepwise execution of the framework. Secondly, there are multiple components involved in each investigation and if not properly outlined, some components might receive little or no attention during the implementation of the framework. Finally, given that VCD (like VSD) is an iterative model, designers can get stuck in a loop of system modification even though the appropriate decision might be to discontinue or re-conceptualise the project.

7.1.1 Soft Systems Methodology

Soft Systems Methodology (SSM) is a social research approach for addressing problematic situations in the everyday world (Checkland and Poulter, 2020). This method-

ology was developed due to failures in trying to apply a Systems Engineering approach (which ignores the varying underlying worldviews) to 'soft' problems which are characterised by the presence of clashing worldviews (perspective on life) and social complexities. SSM takes the complex situations of the real world and creates rational models (based on various worldviews on the situation) for comparison to help create an improved response to the issue that accounts for the different worldviews (Burge, 2015). An earlier representation of this model consists of seven stages in a circular process as illustrated in Figure 7.1.

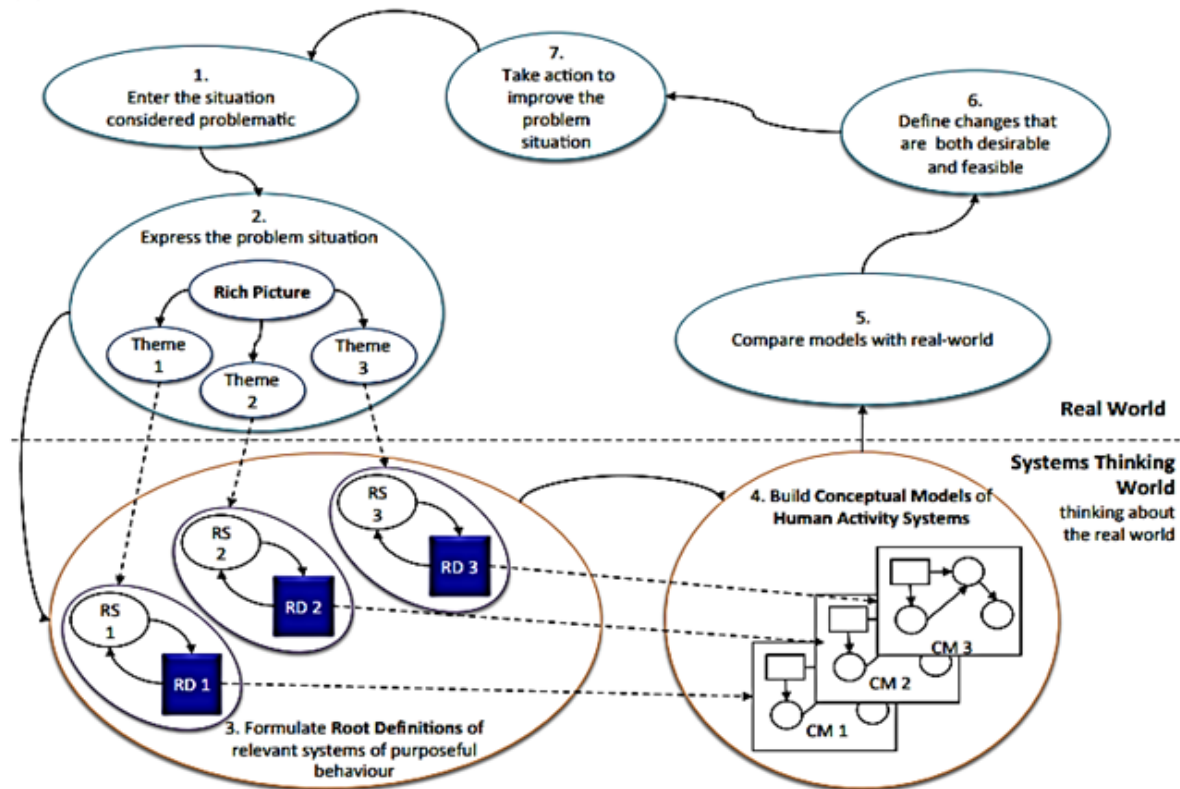


Figure 7.1: Soft Systems Methodology (Burge, 2015)

These stages consist of real world and abstract activities. Stages 1 and 2 involve identifying a problematic situation which requires improving, entering the situation, learning about it, and expressing its nature by identifying themes that adequately represent the situation. In Stage 3, these themes (various purposeful behaviours or worldviews) are used to form root definitions of the situation which are statements of purpose that capture the essence of the situation (Burge, 2015). In Stage 4, these root definitions inform the construction of conceptual models (use cases) that account for the different human activity systems identified in stage 2. The models are compared with the real-world scenarios in stage 5 and this helps structure further research of the

situation. A decision on changes that are both 'desirable in principle' and 'feasible to implement' to improve the situation will be made in stage 6. These decisions are then put into action in stage 7, and the cycle can begin again.

In a later publication, the SSM was presented as the four-activities model (Checkland, 2000) as these activities are

1. Learn about all aspects (including cultural and political implications) of a problem situation.
2. Formulate the relevant activity models.
3. Compare the models with real-world situation seeking to identify
 - (a) changes that are desirable and culturally feasible which would improve the situation, and
 - (b) the common ground between conflicting interests and views which will enable action for improvement to be taken.
4. Take action to bring about improvement.

While SSM is a useful model that helps tackle complex real-world problematic situations in both small and large organisations by taking into account the clashing human activity systems (worldviews), the effectiveness of the "system thinking" outputs (that is, the root definitions and conceptual models) increasingly depends on the knowledge and experience of the participants (Hanafizadeh and Aliehyaei, 2011). This dependency is particularly an issue because there is no guarantee that the methodology will facilitate the open and honest dialogue needed to validate the conceptual models (Proches and Bodhanya, 2015). This might make it harder to come up with an effective solution to the problematic situation.

7.1.2 Deming's PDSA Cycle

Deming's PDSA Cycle stands for the Plan - Do - Study - Act iterative process for the continuous improvement of processes and products (Moen and Norman, 2011). The PDSA management method is outlined in Figure 7.2. Although PDSA has its origins in product manufacturing and market mechanisms, it is a useful tool for planning and implementing any process within any context of use.

The four steps involved in this cycle are:

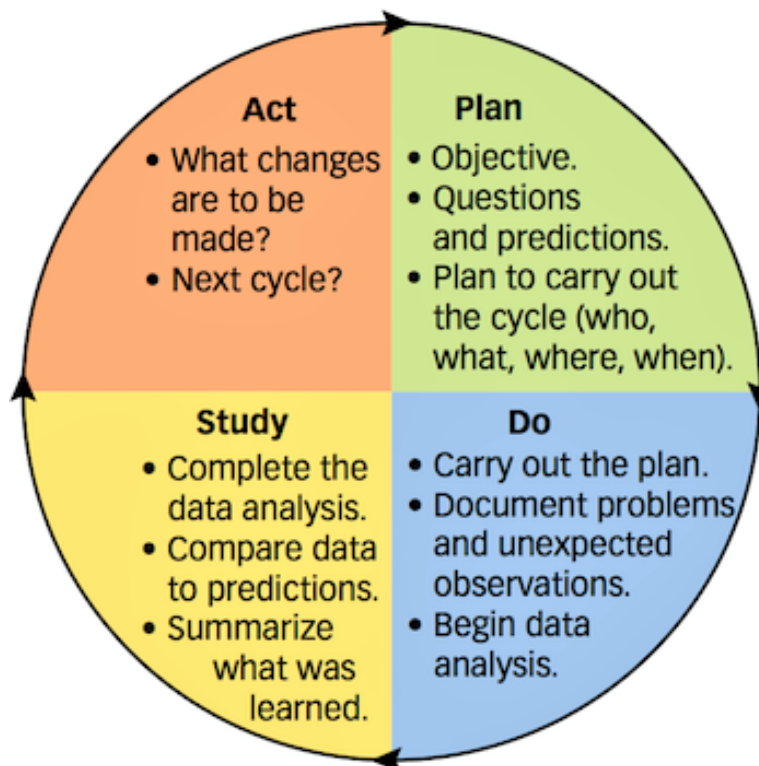


Figure 7.2: Deming's PDSA Cycle (Moen and Norman, 2011)

1. **Plan the intended change or process:** This involves outlining the objectives of the innovation, relevant questions and predictions concerning the innovation and its implementation, and how the plan will be carried out (who will be responsible for what stage, what tasks are involved, where will each task be performed and when does it need to happen?)
2. **Do or Carry out the plan:** This is preferably done on a small scale and then introduced on a larger scale, when successful. This involves actioning all the plans laid out during the planning phase, including plans for implementing the innovative change. Interestingly, the data analysis begins at this stage because there might be lessons learned and changes made at this stage which need to be documented for future use.
3. **Study the results:** The results in this case are outcomes or reactions by involved individuals to the execution of the plan and might entail user evaluation methods such as empirical study. Data analysis continues and is completed in this stage, producing a comprehensive description of lessons learned. These findings are then compared to the predictions made during planning to identify potential changes to the process or system.

4. **Act on the results:** At this stage, a decision is taken concerning which changes need to be made. This could mean making modifications to how the plan is carried out, running through the cycle with a new plan, or abandoning the project.

Although the four steps of the PDSA cycle are similar to the four-activities model of the SSM, the PDSA cycle will be used to guide the step-wise implementation of the Value Cocreation Design model to address the shortcomings identified in the execution of the framework. The PDSA cycle was chosen over the SSM because it is a more definitive method as opposed to the SSM which is a more flexible methodology that cannot necessarily be reduced to a sequence of steps (Checkland and Poulter, 2020). Since the shortcomings of the VCD framework highlighted the need to explicitly specify the stepwise execution of the VCD framework, the PDSA cycle appeared to be the preferred method to provide such structure.

In addition to addressing the discussed shortcomings, the PDSA cycle also introduced some insights into the execution of the VCD framework such as considering how the innovation implementation plan will be executed and conducting data analysis throughout the empirical investigation and not just during the empirical study.

7.2 How does VCD Differ from other Value-Centric Approaches?

Most value-centric approaches directly focus on identifying stakeholders' value for the process being designed whereas VCD focuses on the existing services and value flows which are driven by the stakeholders' institutions (rules of the game, power relations, principles). Because value is intangible and can change over time usually due to circumstances, it is harder to elicit and measure. On the other hand, services are more tangible actions which when analysed, can present the rules that guide them and the value individuals derive from them. Because value is diverse and can change over time, most value-centric approaches are intentionally designed to be flexible (van de Poel, 2018). VCD, although flexible enough to be applied in different use contexts, aims to be more clear and practical in its use and application. As VCD is interested in the cocreation of value and not just its creation, it is the exchange of services between actors that highlights where value is being created and by whom. This gives opportunities for the discussion on the effects of unbalanced service exchange on users' acceptance, adoption, and continued use of (especially, preventive) health technologies.

VCD also differs in the way it puts a lens on the institutions and institutional arrangements that underpin processes at various levels of the design problem throughout the design process. It brings to light the different layers of institutions and institutional arrangements that can be nested and interconnected to either constrain or support the users' preferences and actions. Neglecting or not understanding such institutions can stifle the successful integration of IT innovations into existing processes (Bunduchi et al., 2015). This is even more important when design is done at a large scale, consisting of various organisations and/or technologies because there are increased opportunities for institutional conflicts within and between organisations. With regards to the practical design process, VCD provides a more explicit way to discuss these underlying institutions than the SDL model. Also, VCD framework provides a way of better managing the discussion between stakeholders by putting value on the agenda. It is a useful document for running workshops with users.

7.3 The Revised VCD Framework

In this section, the step-by-step implementation of the VCD framework is outlined. It consists of the four stages of the PDSA cycle with sub-steps to guide the planning, execution and review of the technology design and implementation process.

Stage 1: Plan the new technology design and implementation using prediction and associated theory

At this stage, the researcher identifies the (in)direct actors and their underlying institutions, the services each actor receives in exchange for his/her services, the resources needed for service exchange, technological features and affordances to support service exchange, and details for conducting the project. Some thought on how best to embed the technology into existing processes will also be required as this will inform design decisions for Stage 2.

Step 1: Identify Actors and their Institutions

Direct actors are individuals who will use the technology while indirect actors are individuals who will be affected and/or can influence the design and use of the technology. Institutions are social norms or rules that guide the groups of actors within a given context. The questions below will aid further investigation into this concept.

- What do you know about each group of actors', often overlapping, social norms

(institutions)?

- How do those institutions conflict and can such conflicts be resolved?

Step 2: Map the Service Exchange Process

This step involves identifying all the relevant services exchanged by the actors to elicit the values that could be cocreated through the service exchange process. This is conducted in three sub-steps.

- Service Identification:** Identify all the existing and potential services that direct and indirect actors [can] exchange within the service ecosystem.
- Service Refinement:** Using a precedence graph, refine the service list to the most fundamental services. This entails eliminating redundant/duplicate services that act as a resource to another service, are a component of another service or a direct outcome of another service. Such services might still be featured in the technology as a part of its parent service or completely removed from the technology. In either case, retain these services on a separate list for future reference as findings from the empirical investigation could support the reinstatement of a previously discarded service.
- Service Map Development:** Using the refined service list, develop a service exchange map (adapted from the Value Constellation model). An example of a service exchange map is outlined in section 6.1.3. This map clearly outlines the actors, the services they exchange, the resources required for those services and the values implicated through the service exchange process.

Some useful questions to aid proper investigation during this stage are:

- How do the actors' institutions predefine their service exchange behavioural characteristics?
- Do these institutions enable or constrain the exchange of identified services?
- Are there any service ecosystems that arise within nested or interlocked institutions? If any, how do they modify the institutions involved?
- What resource integrator roles can be seen in the provision of services?
- What resources do these resource integrators need?

- Are there any competing or conflicting resources in need of a resolution?
- How do you resolve the competition/conflict(s)?

Step 3: Identify technological affordances to support relevant services

In this step, identify the technological features that need to be incorporated into the app based on the services, resources, and values highlighted in the service map. This consists of two sub-steps.

- (a) Identify any underlying institutions, rules and constraints which can contribute to shaping the technological features of the system. Some useful questions for this step are:
 - How do these institutions enable or constrain the embedding of the technology in existing processes?
 - What trade-offs in the institutions are required to support the embedding of the technology?
- (b) Identify relevant features to be provided in the technology to facilitate actors' service exchange. Some useful questions include:
 - How do affordances of the technology contribute to the infrastructure supporting service exchange?
 - What are the critical elements in the service ecosystems of actors for this technology?
 - Are there services or features that should be provided to support these elements?

Step 4: Draw out plans for executing the project

Although this is usually more of an administrative role, it is important to ensure that such plans have been specified because they contribute to the success/failure of a technology implementation project. It is useful to consider all the tasks involved in the conceptual, empirical and technical investigations of the technology to ensure there are individuals responsible for each task. Ensure that these individuals know what is expected of them, where and when they are required to perform their tasks and what support is available to them for completing the task.

Stage 2: Do or execute the technology design plan

This stage involves the design of the technology based on the findings from stage 1. During the design phase, it is important to document the problems encountered and any alternatives taken to resolve those problems.

Step 5: Design the technology

This entails the development of the technology to encapsulate the features identified in step 3 to facilitate service exchange and value cocreation between actors. The design tools and platforms are considered and designed at this stage, integrating the usability heuristics necessary for tech development. How do the design decisions reinforce or undermine the underlying institutional arrangements?

Step 6: Test the technology

It is necessary to thoroughly test the technology to identify any initial design faults before proceeding to the next stage. Testing the technology only during the empirical investigation can contribute to a higher participant dropout rate as users can be discouraged from using the technology due to system failures and errors (Hermesen et al., 2017).

Stage 3: Study the results and compare with the initial plans

At this stage, an empirical investigation is conducted to confirm or disprove the predictions made during stage 1. Depending on the time and budget constraints, it would be worthwhile observing a small representative sample of participants while they use the technology. Findings from this investigation should be properly analysed and documented.

Step 7: Conduct an empirical study This involves a small-scale pilot study to test the technology and observe how individuals use it. The study participants' perception of the identified services and features should be obtained; any missing services and unintended positives should also be identified. Any conflicts between the use cases for the different actors should be identified and resolution methods sought. These responses can be obtained via surveys, interviews, and measures of user behaviour and physiology.

Some important questions to aid the empirical investigation are:

- How do people value one service against other services? This can be useful for developing a hierarchy of service preference.

- Were there any services that were used most?
- Were there unanticipated ways (unintended positives) that the technology has been used? Perhaps that is an indicator for what is lacking in the design.
- Did the technology provide the necessary support for the actors' institutions?
- Was service exchange constrained or enabled by such support for institutions?
- Are the ecosystems of actors properly nested and interlocked? For instance, healthcare professionals can also be patients.

Stage 4: Act on the results Here, a decision based on the findings from stages 2 and 3 is taken. This decision can entail discontinuing the project, running through the design cycle again with a different, more relevant idea or adopting the changes identified.

Step 8: Modify technology

The technology is modified to adopt any required changes identified from findings of the empirical investigation. Any conflicts between the actors' service exchange processes are resolved and new features introduced for any new services. Return to step 6 and re-test the technology to ensure no existing processes have been broken. It might be worthwhile to retain a subset of the empirical study participants who would be willing to reuse the technology after it is modified to provide feedback. If there are no modifications, then proceed to step 9.

Step 9: Embed technology into existing processes

New applications and technologies sometimes do not get used properly after they are introduced because they are not well-embedded into existing processes. This step utilises findings from step 3a concerning the role of institutions in the embedding of the technology and step 4 concerning plans for executing the project. Some useful questions to ask at this stage of the technical investigation include:

- What are the ethical implications of integrating this technology? It is a responsible move to be able to audit the way the innovation interacts with the ecosystem. This investigation can help the researcher make ethical judgements concerning the way the technology interacts with the environment (the socio-technical and political context).

- Are there some properties of the technology that limit its ability to be properly embedded into existing norms and practices?
- Are there alternatives for such properties, what trade-offs are required for proper adoption and utilisation?

There are three main outcomes that could happen at this stage. Two of these outcomes lead to the termination of the design cycle; the technology can either be successfully embedded into existing work practices or completely discontinued due to irreversible circumstances (e.g. a policy change effected during the design process that makes the integration of the technology irrelevant or illegal). A new approach or idea might need to be explored to execute alternatives that will facilitate proper adoption and utilisation of the technology; in this case, the design cycle needs to be restarted with the new approach or idea. This process is repeated until the technology gets properly integrated into existing work practices. The framework is outlined in Figure 7.3.

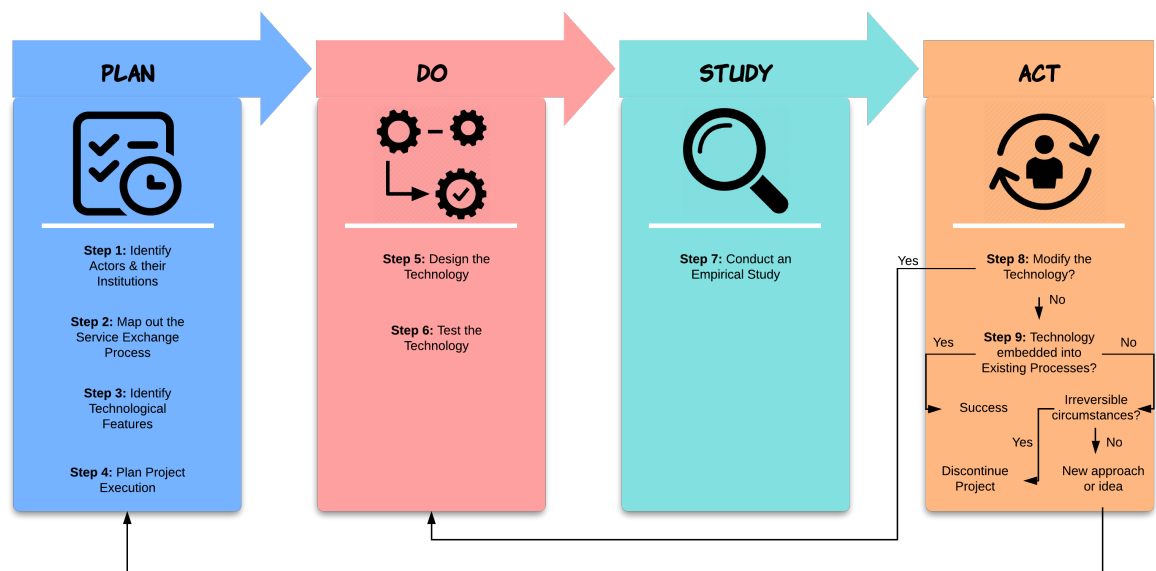


Figure 7.3: The VCD Framework

In this chapter, we have outlined the step-by-step implementation of the VCD framework. Developers and organisations might be worried about the cost of implementing the technology in this manner because a substantial amount of time is spent on the planning stage but the VCD framework seeks to reduce the cost of reiterating the VSD investigations because by the end of the VCD technical investigation, the technology would have addressed the institutional conflicts or competitions that often stifle the use of new technology.

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Chapter 8

Conclusion

8.1 Summary

After completing a Masters' dissertation on the design of a Personal Child Health Record, eRedbook, using social interaction and team-oriented models, I decided to continue with a Ph.D. research on the factors that motivate individuals to use Personal Health Records (PHRs). In the first year of my Ph.D. programme, I conducted a systematic review on how Information and Communications Technology influences users' social support measures with regards to their healthcare and I found that they have a statistically significant positive impact on social support measures. This further piqued my interest in the role of social networks in preventive health applications. After fine-tuning my research proposal, the focus of my research shifted from PHRs to fitness trackers - particularly, my focus was on the high dropout rate in the use of these technologies. Becoming a part of the Berkshire Wearable Technology Pilot presented the unique opportunity to obtain versatile data to provide some insight on why individuals stopped using their fitness trackers. My initial goal was to test the impact of social networks on users' motivation to use the fitness trackers and obtain further evidence for the design of fitness and wellbeing technologies.

However, due to data security concerns there was no social network component in the study and I had to refine my goal. During the pilot study, I observed some shortcomings in the way the pilot was conducted (such as, lack of engagement with the study participants, failure to include the users in the design process, and little consideration of the existing institutions that guide the practices of the participating NHS employees) which contributed to a high user dropout rate and participants' non-use of the Patient Portal app. These shortcomings drew my attention to the design frame-

works that guide the design of IT innovations and how they contribute to the success or failure of the adoption and use of these innovations. Hence, my goal was to investigate existing design frameworks and, from lessons learned from the pilot study, design a novel value-integrating design framework for the development of preventive health applications as motivational technologies. I was able to achieve this goal and my contributions as recorded in the chapters of this thesis are described below.

A review of some existing design models was conducted in Chapter 2 and they were found to be more focused on the usability of preventive health technologies; but for technology to be properly adopted and used by individuals, they need to find it valuable. This necessitated the consideration of design models that implicate individuals' values and underlying value systems in preventive health technologies to achieve behaviour change at a population level.

Further research was conducted on some existing value-centric design frameworks (Chapter 3) and Service-Dominant Logic (SDL) was discovered to be an appropriate framework for the design of technology that provides affordances that can support users in the cocreation of value through service exchange and resource integration. SDL differs from the Value Constellation Model and Value-Sensitive Design (VSD) in the way it takes the institutions and institutional arrangements (which influence and are influenced by actors' values) into account.

A viable design model will be one where co-production of value is a seemingly dominant mode and one that can help tackle longstanding issues of non-participation of users or stakeholders. Thus, in Chapter 4 we proposed a novel design framework, named Value Cocreation Design (VCD), that extends the VSD framework to incorporate the concepts of SDL to move the approach of design from simply creating value to cocreating value in technology. We also described the empirical methodology for the Berkshire Wearable Technology Pilot and the characteristics of the study sample in this chapter.

The development of the VCD framework was motivated, to an extent, by some of the shortcomings observed in the pilot study that are attributable to the technology design and study methodology used. In Chapter 5, we presented the results and findings from the empirical study that support and validate the development of the proposed VCD framework. Other study measures obtained via the periodic surveys and fitness trackers were also presented to establish the trustworthiness and credibility of this research.

The proposed VCD model is designed to be applied in different contexts of use. To

exemplify its application in a real-life design scenario, it was applied to the hypothetical implementation of a preventive health technology innovation within the healthcare organisation – specifically, the Berkshire Wearable Technology Pilot (Chapter 6). The steps for conducting the conceptual, empirical and technical investigations for the technology implementation project were outlined in this chapter.

Finally, in Chapter 7, the VCD model was revised based on the evaluation of the initial framework by empirical evidence and findings from its application in a real-life design scenario. Deming's PDSA management cycle was used to guide the stepwise implementation of the Value Cocreation Design model to provide a defined structure for the execution of the model. The VCD model seeks to address the cultural and social barriers that often stifle the design and use of new technology.

8.2 Research Contributions

Although I had described the contributions recorded in the chapters of this thesis in the previous section, I will like to explicitly describe in this section the main contributions of my research to the wider literature and the use of preventive health applications within the health sector.

Over the years, the socio-technical design approach had been extended - producing numerous co-design and value-centric frameworks as scholars appropriate new ways to provide equal consideration for the social and technical issues involved in designing new technology and work systems. At the heart of this design approach exists the importance and relevance of the needs and value of the users of the technology. The novel Value Cocreation Design developed in this research fits into this broader literature by its focus on the involvement of all relevant actors in the IT system design and development stage, and extends it by merging VSD and SDL to provide a more practical framework that highlights the underlying institutions and institutional arrangements that influence the actors' value systems and value flows. The VCD was also applied, as a thought experiment, to the hypothetical implementation of the Berkshire Wearable Technology Pilot to provide, for subsequent researchers, an example of its application in a real-life design scenario.

The research also contributed to the existing knowledge on the use of wearable fitness trackers and its impact on users' health outcomes and behaviours by presenting the empirical evidence obtained from the Berkshire Wearable Technology pilot. The empirical evidence from the research supported and contributed to the development of

the VCD framework as the findings highlighted the place of value in health applications, effect of institution on value creation, use of service exchange as a tool for value elicitation, and role of resource integrators in the design and deployment of health applications. Some of the main findings from the wearable data include the impact of bedtime on sleep duration and sleep quality, and the relationship between physical activity and sleep hours.

Finally, the research tested the integration of data from the Garmin fitness app into the Berkshire Patient Portal app. The integration of data from multiple sources and formats within the health sector is essential because it helps to provide a richer picture of an individual's health and wellbeing to the health professionals. Hence, successfully transferring wellness data from the Garmin app to the patient portal app is an important outcome of this research as it offers invaluable opportunities to get a step closer to achieving integrated healthcare within the NHS.

8.3 Limitations

There were numerous delays that occurred in the course of the empirical study. Employees started to receive invitations to volunteer for the pilot in June 2017 and recruitment continued across the participating organisations for six to seven months. The recruitment strategy was successful because about 950 volunteers completed the recruitment survey. However, delays in the completion of the patient portal app contributed to delays in onboarding participants for the pilot study. The onboarding process started in January 2018 and continued till March 2018. However, the patient portal app development was completed in February 2018 and participants were remotely onboarded and set up on the app in April 2018. These delays in onboarding participants contributed to a high dropout rate of participants before and during the onboarding process. The planned sample size for the study was 400 but 381 volunteers completed the onboarding survey and 208 participants were successfully set up on the patient portal app. So, the initial sample size for the study was never reached and this was a limitation because the pilot began with an inadequate number of participants.

At the beginning of the patient portal app design process, it was established that the app would only work on iOS smartphones. Hence, participants were required to have an iPhone in order to be eligible to participate in the pilot study. However, this iOS requirement changed towards the end of 2017 and volunteers with Android smartphones were also eligible to participate in the study. This change in smartphone requirements

meant that the recruitment window had to be extended to give owners of Android smartphones a chance to complete the recruitment survey. This was a limitation because the study had already precluded this group of volunteers at the beginning of the study and may have, as a result, excluded a representative sample of the population.

The pilot was designed to observe the way participants would use the Garmin tracker in their natural setting, so there was little or no interference from the project team. This also caused a limitation for the research as most participants thought this was too much autonomy and would have appreciated occasional updates concerning the progress of the pilot, encouragement to continue tracking fitness and wellness data or recommendations of fitness activities to try. This contributed to the high dropout rate of participants during the pilot; 138 participants completed the 12-month follow-up survey.

There were features that were discussed during the study design phase which were eventually dropped from the study. This was limiting as these features, if implemented, would have been beneficial for the study and would have provided useful insight on

- the role of social networks in user retention for fitness trackers (and preventive health applications), and
- the relationship between physical activity, sleep, and diet outcomes.

During the patient portal design process, the app was planned to address the areas of physical activity, sleep, and diet. But the diet component was later dropped, probably because of the complexity of tracking and recording diet. Having this diet tracking feature on the patient portal app could have encouraged participants to use the patient portal app more as the Garmin app (which was used alongside and fed data into the patient portal app) did not directly provide this feature. Also, not including social network feature(s) to the study led to lower levels of user engagement and a miss-out on the unique opportunity to obtain useful data and insight on how much value users place on social networks for the adoption and retention of healthier behaviours. As noted earlier, data privacy and security concerns by the key study leaders was the main reason why social network features were not used in the study.

There were other limitations which influenced the way the wearable data were collected and stored which limited the type of analysis that could be done on the data. The data collected from the Garmin tracker was not saved by participant ID; hence, it was not possible to link a participant's entry across different tables (for instance, the dailies and sleep tables). This made it difficult to effectively run some analyses,

such as correlation or regression models, on the raw data collected. It was difficult to keep track of the number of participants whose data were being collected with relation to the number of participants completing the study surveys. Also, it was impossible to identify gaps in the data by discovering the participants that required a reminder to sync their Garmin tracker with the Garmin app. I had asked for the data to be stored anonymously with a randomly assigned participant ID to at least, keep track of the number of participants responding and link their entries across different database tables but I was informed that the wearable data was stored this way in the database primarily due to Information Governance (IG) adherence concerns.

This raises an interesting question about the impact of IG and data security policies on the effective administration of such studies (particularly, within the NHS), as the last two limitations described above were as a result of these concerns.

8.4 Future Work

Further research on the relationship between physical activity, sleep and diet outcomes is encouraged to better support individuals in monitoring and managing their health. In the area of sleep, research on the effects of deep and light sleep and how they influence the quality of sleep is particularly encouraged as most users of wearable trackers do not know how to interpret this data.

The participants of the Berkshire Wearable pilot were NHS employees who already had some understanding of the practices within the NHS and hence, might not appropriately represent the general patient or user population. Thus, it is necessary to conduct such a pilot with a sample representative of the general population as the employees' involvement in the NHS might have influenced their responses to the study materials.

In Chapter 6, a thought experiment of how the VCD model can be applied to a real-world scenario was presented. In the near future, I would like to test the VCD model in the design and implementation of an IT innovation (preferably, preventive health technology) within the healthcare organisation. I am particularly interested in testing the service exchange map design and implementation process as this is the part of the framework that is most novel (and thus, I am least confident about). I am curious to know what will happen when it is applied in the real world. Will it be effective in highlighting the underlying institutions and institutional arrangements? Will it help to resolve (or address) conflicting institutions? Will the service exchange map implicate

the relevant user value? Will it support the successful embedding of IT innovation into existing practices?

In the longer run, I would like to apply the model in a use context different from the health sector to test its validity across multiple contexts of use.

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Appendix A

Consent Form

The consent form for the Berkshire Wearable Technology pilot is outlined in the next page. Participants were expected to complete the form electronically and return to the wearable pilot team via email.



Participant information and consent form

Please complete and return this form if you consent to be part of the Berkshire Wearable Technology pilot and for the project team to start setting you up.

Your full name		
Your date of birth		
Your email address To receive set up instructions and contact from project team*.		
<i>We will use these details to link your Connected Care Record to your Patient Portal and give you access to your Patient Portal. We will keep these details confidential and only for the 12 months of the pilot and will only use them again if we need to make changes to your setup. All research analysis and reporting will use anonymised data.</i>		
Choose handover meeting Please select 1 st and 2 nd choice options and we will confirm your invitation by email. You will only need to drop in for 15 mins within the time window shown.		29 Jan 11-3, Bath Road, Reading 5 Feb 12-2, Royal Berkshire Hospital, Reading 6 Feb 12-2, Royal Berkshire Hospital, Reading 20 Feb 12.30-3, Fitzwilliam House, Bracknell 21 Feb 12-4, St. Marks Hospital, Maidenhead 23 Feb 11-3, West Berkshire Community Hospital 26 Feb 11.30-2.30, Wexham Park Hospital 27 Feb 11-3, King Edwards VII Hospital, Windsor 28 Feb 11.30-2.30, Heatherwood Hospital, Ascot 5 March 11.30-2.30, Frimley Park Hospital
Confirm consent By returning this form you are confirming that you consent as follows:		
1) I consent for data from my Garmin Vivosmart HR activity tracker to be shared with the pilot's Chief Investigator for the purpose of analysing at an aggregated level the impact of using the device on lifestyle indicators e.g. does the data show an increasing or decreasing pattern in number of steps or hours sleep. All reported data will be anonymised.		
2) *I consent for a member of the project team to contact me directly via email for the purpose of sending me quarterly surveys, inviting me to an interview, and/or to check the device is working correctly.		
3) I consent for the data from my Garmin Vivosmart HR activity tracker to be linked and shared with my Connected Care Record within my Patient Portal.		

We will provide you with a paper copy of this form at the handover meeting when you receive your Garmin activity tracker, so that you can provide us with your signature to confirm receipt of your Garmin Vivosmart HR activity tracker and consent.

If you have any questions or concerns please contact Wearable.Pilot@nhs.net

Appendix B

Pilot Survey Materials

The survey materials for the Berkshire Wearable Technology pilot consist of the Recruitment survey, Onboarding survey, 9-month Follow-up Survey, and 12-month Follow-up Survey. All survey materials were hosted on SurveyMonkey.

B.1 Recruitment Survey



Recruitment Survey: Berkshire Wearable Technology Pilot

Introduction

Please complete this survey to volunteer for the Berkshire Wearable Technology Pilot.

We are looking for a range of volunteers, in terms of current activity levels and type of job, from across Berkshire NHS CCGs and Trusts. We will use completed questionnaires to select participants.

The Berkshire Wearable Technology pilot will test the impact of a wearable device, a Garmin Vivosmart HR Activity Tracker, with NHS staff volunteers over 12 months.

We will test how data from wearable technology can be:

- included within the Berkshire shared care record system (Connected Care).
- used to encourage participants to take actions to improve their own health.

All responses will be treated as confidential and the email address provided will only be used to identify and contact eligible participants.

Please click “Next” to start this survey.

Demographic Data

* 1. What is the name of your organisation?

- ☐ Berkshire Healthcare Foundation Trust
- ☐ Bracknell and Ascot CCG
- ☐ Frimley Health Foundation Trust
- ☐ Newbury and District CCG
- ☐ North and West Reading CCG
- ☐ Royal Berkshire Foundation Trust
- ☐ Slough CCG
- ☐ South Reading CCG

☐ Windsor, Ascot and Maidenhead CCG

☐ Wokingham CCG

☐ Other (please specify)

*** 2. What is your age?**

☐ 18 to 24

☐ 25 to 34

☐ 35 to 44

☐ 45 to 54

☐ 55 to 64

☐ 65 to 74

☐ 75 or older

*** 3. Are you male or female?**

☐ Male

☐ Female

*** 4. Please provide your nhs.net email address.**

This will be used to contact you about the pilot.

Job Role

*** 5. Are you a permanent or contract staff?**

☐ Contract

☐ Permanent

*** 6. What is your job role?**

- ☐ Doctor
- ☐ Consultant
- ☐ Nurse
- ☐ Operating Theatre Staff
- ☐ Pharmacy
- ☐ Administrative
- ☐ Operational Management
- ☐ Ambulance
- ☐ Dental
- ☐ Allied Health Professional
- ☐ Midwife
- ☐ Estates/Ancillary
- ☐ Manager (CCG)
- ☐ Director (CCG)
- ☐ Other (please specify)

Berkshire GP Registration

*** 7. Are you registered with a Berkshire GP?**

- ☐ Yes
- ☐ No

Verify Response

You have answered "No" to the question "Are you registered with a Berkshire GP?" Please verify your response.

*** 8. Are you sure you have the correct response? (Answering “No” will take you to the previous page)**

☐ Yes

☐ No

Health-related Questions

*** 9. Are you registered with a Berkshire GP?**

Other (please specify)

*** 10. In a typical week, how many days do you exercise for 30 mins or more?**

☐ 0

☐ 1-2

☐ 3-4

☐ 5+

*** 11. Do you have a chronic health condition?**

☐ Yes

☐ No

Chronic Health Condition

*** 12. Please specify chronic health condition**

☐ Diabetes

☐ Cardiovascular Disease

☐ Cancer

☐ Other (please specify)

iPhone Ownership

* 13. Do you currently have an iPhone?

☐

Yes

☐

No

☐

Plan on getting one next month

Verify Response

You have answered “No” to the question “Do you currently have an iPhone?” Please verify your response.

* 14. Are you sure you have the correct response? (Answering “No” will take you to the previous page)

☐

Yes

☐

No

Wearable Ownership

* 15. Do you currently own a wearable device?

☐

Yes

☐

No

Wearable Device

* 16. What type of wearable do you have? (select all that apply)

☐

Garmin Vivosmart HR

☐

A different model of Garmin

☐

Fitbit

☐

Misfit

☐

Withings

☐

Xiaomi Mi Band

☐

Smart watch

☐

Other (please specify)

Participant Consent

*** 17. Are you willing to participate in a short handover meeting scheduled at a convenient time between July-September 2017?**

☐ Yes

☐ No

*** 18. Are you prepared to participate in some additional surveys or interviews at 4, 8 and 12 months?**

☐ Yes

☐ No

*** 19. Do you consent to sharing data from the wearable to your record in the Connected Care system?**

☐ Yes

☐ No

*** 20. Do you consent to the pilot's project team setting up your Garmin account remotely using your NHS staff ID number as the one-off answer to your security question for setup?**
We will provide you with details in your welcome pack if you are selected to participate.

☐ Yes

☐ No

B.2 Onboarding Survey



Berkshire Wearable
Technology Pilot

Onboarding Survey

Introduction

Thank you for agreeing to participate in the Berkshire Wearable Technology Pilot.

Please complete this onboarding survey which is a prerequisite for receiving your Garmin at your handover meeting. The survey should take about 15 minutes to fill, but it is very important to complete it before we can give you the Garmin.

All responses will be treated as confidential and the email address provided will only be used to identify participants who have completed the onboarding survey.

Please click “Next” to start this survey.

Demographic Data

* 1. What is your age?

* 2. Are you male or female?

☐

Male

☐

Female

* 3. Please provide your nhs.net email address.

This will be used to verify survey completion.

*** 4. What is your highest level of education?**

- ☐ GCSE
- ☐ A-level
- ☐ College
- ☐ Undergraduate
- ☐ Postgraduate

*** 5. What is your weight in stones and pounds?**

*** 6. What is your height in feet and inches?**

*** 7. What is your marital status**

- ☐ Single
- ☐ Married
- ☐ Divorced
- ☐ Widowed

Health Status

*** 8. What is your current smoking status?**

- ☐ Smoker
- ☐ Occasional smoker
- ☐ Non-smoker
- ☐ Never smoked
- ☐ Trying to stop

*** 9. Please list any chronic illness that you have that may affect your participation in the pilot**

If this question does not apply to you, write "none"

*** 10. In the past 6 months, your weight has**

- ☐ Increased
- ☐ Decreased
- ☐ Not changed

Health Habits

*** 11. How many days per week do you have at least one alcoholic drink?**

- ☐ 0
- ☐ 1-2
- ☐ 3-4
- ☐ 5 or more

*** 12. What is the average number of alcoholic drinks you have per day in a week?**

- ☐ 1
- ☐ 2-4
- ☐ 5-6
- ☐ 7 or more
- ☐ Does not apply to me

*** 13. In a typical week, how many days in a week do you exercise?**

- ☐ 0
- ☐ 1-2
- ☐ 3-4
- ☐ 5 or more

* **14. On average, how many minutes do you exercise in a day?**

☐

0

☐

Less than 30 mins

☐

30 mins to 1 hour

☐

More than 1 hour

* **15. How do you exercise?**

☐

Alone

☐

In a group

☐

Both alone and in a group

* **16. On average, how many hours do you sleep each night?**

☐

Less than 4 hours

☐

4-6 hours

☐

7-8 hours

☐

8 or more hours

* **17. Describe your sleep and how you feel afterwards.**

☐

My sleep is interrupted severally at night

☐

I sleep all through the night until I wake up in the morning

☐

I wake up in the morning feeling rested

☐

I wake up in the morning feeling tired

☐

Other (please specify)

* **18. How often do you see your GP?**

☐

More than once a month

☐

Once a month

- ☐ More than once every 6 months
- ☐ Once every 6 months
- ☐ Once a year
- ☐ Less than once a year
- ☐ Never

*** 19. Do you have a gym membership?**

- ☐ Yes
- ☐ No

Health Habits (Gym)

*** 20. How often do you go to the gym in an average week?**

- ☐ 0
- ☐ 1-2 days
- ☐ 3-4 days
- ☐ 5 or more days

Health Monitoring Experience

*** 21. How have you previously tried to improve your health and well-being?**

Please select all that apply

- ☐ Slimming clubs
- ☐ Exercise
- ☐ Online groups e.g. social media
- ☐ Apps
- ☐ Wearable devices
- ☐ Have not previously used other methods
- ☐ Other (please specify)

Health Monitoring Tools Effectiveness

* 22. How effective were those methods?

	Not effective	Somewhat effective	Definitely effective
Slimming clubs	☐	☐	☐
Exercise	☐	☐	☐
Online groups e.g. social media	☐	☐	☐
Apps	☐	☐	☐
Wearable devices	☐	☐	☐
Have not previously used other methods	☐	☐	☐
[Insert text from Other]	☐	☐	☐

Internet & Social Media Use

* 23. How often do you use the Internet at home per week?

0

Number of days

7

* 24. On average, how many hours per day do you spend on the Internet while not at work?

- ☐ Less than 1 hour
- ☐ 1-2 hours
- ☐ 2-3 hours
- ☐ 3-4 hours
- ☐ More than 4 hours

* 25. How often do you look for health information (not job-related) on the Internet?

- ☐ Everyday
- ☐ More than once a week
- ☐ Once a week

- ☐ Once a month
- ☐ Less than once a month
- ☐ Never

*** 26. How would you rate your expertise in the use of Internet?**

- ☐ Novice
- ☐ Intermediate
- ☐ Expert

*** 27. Which social media do you use?**

Please select all that apply

- ☐ Twitter
- ☐ Facebook
- ☐ Instagram
- ☐ SnapChat
- ☐ WhatsApp
- ☐ LinkedIn
- ☐ None
- ☐ Other (please specify)

*** 28. How often do you log into Social Media for personal use per week?**

0 **Number of days** 7

*** 29. How long have you used social media?**

- ☐ Less than 1 year
- ☐ 1-5 years
- ☐ 5-10 years

☐ More than 10 years

Wearable Device Use

*** 30. Do you use an app to monitor your physical activity (e.g. Strava, MyFitnessPal)?**

☐ Yes

☐ No

If yes, please specify

*** 31. Have you ever used a wearable device like a Fitbit, smart watch, etc.?**

☐ Yes, and I still use it

☐ Yes, but I stopped using it

☐ No

Wearable Device Non-use

*** 32. Why did you stop using the wearable device?**

Please select all that apply

- ☐ Did not notice change in health outcomes
- ☐ Got bored with it
- ☐ Could not find the device charger
- ☐ Got tired of charging it
- ☐ Achieved my desired goals
- ☐ I found a more effective alternative e.g. gym, food diary, etc.
- ☐ It broke
- ☐ Other (please specify)

Participant Expectations

* 33. What is your motivation for joining Berkshire Wearable Technology Pilot?

Please select all that apply

- ☐ General interest/curiosity
- ☐ Interest in its connection to Connected Care patient portal
- ☐ Better health outcomes
- ☐ Healthier lifestyle
- ☐ To monitor sleep
- ☐ To monitor exercise
- ☐ To monitor diet
- ☐ Other (please specify)

* 34. Would you be interested in participating in a Garmin virtual online group centered around a social community?

Note: This is an online group within the Garmin app that can offer you support in achieving your goals.

- ☐ Yes
- ☐ No

* 35. Would you be willing to be one of the project champions (these are individuals willing to partake in quarterly interviews concerning the use of their wearable device)?

- ☐ Yes
- ☐ No

36. Is there anything else you would like to share with us?

B.3 9-month Follow-up Survey

Introduction

Thank you for participating in the Berkshire Wearable Technology Pilot.

Please complete this follow-up survey which will give us a better understanding of your experience so far and how you have used the Garmin and apps over the past six months. The survey should take about 10 minutes to complete.

All responses will be treated as confidential.

Please click “Next” to start this survey.

Demographic Data

*** 1. Please provide your nhs.net email address.**

This will be used to verify survey completion.

*** 2. What is your current weight in stones and pounds?**

*** 3. What is your current height in feet and inches?**

Health Consciousness Measure

* 4. On a scale of 1 (strongly disagree) to 5 (strongly agree), please rate the following statements

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I'm very proactive in managing my health	☐	☐	☐	☐	☐
I'm generally aware of my emotions and feelings about my health	☐	☐	☐	☐	☐
I worry about my health all the time	☐	☐	☐	☐	☐
I notice how I feel physically as I go through the day	☐	☐	☐	☐	☐
I take responsibility for the state of my health	☐	☐	☐	☐	☐
I only worry about my health when I get sick	☐	☐	☐	☐	☐
Living life without disease and illness is very important to me	☐	☐	☐	☐	☐
My health depends on how well I take care of myself	☐	☐	☐	☐	☐
Living life in the best possible health is very important to me	☐	☐	☐	☐	☐

Health Motivation Measure

* 5. On a scale of 1 (strongly agree) to 5 (strongly disagree), please rate the following statements

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I am very aware of common risks that may affect my health e.g. smoking, alcohol, high fat diet, being overweight, inactivity	☐	☐	☐	☐	☐
I don't worry about common health risks until they become a problem for me	☐	☐	☐	☐	☐
I have changed my behaviour to take account of health risks since starting the pilot	☐	☐	☐	☐	☐
I don't worry about common health risks until they affect my family	☐	☐	☐	☐	☐
I don't take any action to prevent ill health until I know I have a problem	☐	☐	☐	☐	☐
I like to keep myself up to date on health risks and how to mitigate them	☐	☐	☐	☐	☐
I would rather enjoy life than worry about avoiding ill health	☐	☐	☐	☐	☐
There are so many illnesses that can affect my health, I am not going to worry about them	☐	☐	☐	☐	☐
I feel I have a duty to look after my health for the sake of my family	☐	☐	☐	☐	☐

Health Perception Measure

* 6. On a scale of 1 (strongly disagree) to 5 (strongly agree), please rate the following statements

Since I started using my Garmin,

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I exercise more now	☐	☐	☐	☐	☐
My daily meals are more nutritionally balanced	☐	☐	☐	☐	☐
I don't use it every day	☐	☐	☐	☐	☐
I try to avoid high levels of fat in my diet	☐	☐	☐	☐	☐
I try to sleep at least 8 hours a day	☐	☐	☐	☐	☐
I have lost weight	☐	☐	☐	☐	☐
I found it hard to relate what the Garmin measures to actions I can take to improve my health	☐	☐	☐	☐	☐
I attempt to avoid stressful situations	☐	☐	☐	☐	☐
I monitor the nutritional value of my food	☐	☐	☐	☐	☐
I have adopted healthier behaviours (e.g. taking the stairs)	☐	☐	☐	☐	☐
I don't understand what the Garmin measures	☐	☐	☐	☐	☐
I try to exercise at least 30 minutes a day, 3 days each week	☐	☐	☐	☐	☐
I participate more actively now in maintaining my health	☐	☐	☐	☐	☐
I don't trust the way the Garmin works	☐	☐	☐	☐	☐
I've stopped using my Garmin	☐	☐	☐	☐	☐

Technology Use Experience

* 7. On a scale of 1 (strongly disagree) to 5 (strongly agree), please rate the following statements

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The Garmin tracker is easy to use and sync	☐	☐	☐	☐	☐
I find wearing my Garmin uncomfortable	☐	☐	☐	☐	☐
I sync my Garmin to the Garmin Connect app at least twice a month	☐	☐	☐	☐	☐
The nudges I received from my Garmin motivated me to be more active	☐	☐	☐	☐	☐
My Garmin tracker was accurate	☐	☐	☐	☐	☐
I found nudges generated by the Garmin irritating	☐	☐	☐	☐	☐
I would recommend the Garmin Vivosmart HR+ tracker to family and friends as a way of improving their health	☐	☐	☐	☐	☐
I would recommend a different fitness tracker to family and friends as a way of improving their fitness	☐	☐	☐	☐	☐

* 8. On a scale of 1 (strongly disagree) to 5 (strongly agree), please rate the following statements

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Seeing my wearable data motivates me to live a healthier lifestyle	☐	☐	☐	☐	☐
I don't understand how Garmin Connect works	☐	☐	☐	☐	☐
The Garmin Connect app is user-friendly	☐	☐	☐	☐	☐
The insights provided on Garmin Connect motivated me to improve my fitness activities	☐	☐	☐	☐	☐
A social network on the Garmin Connect app or Berkshire Wearables app will better motivate me to live healthier	☐	☐	☐	☐	☐
I find my wearable data depressing	☐	☐	☐	☐	☐
I found the Garmin Connect app useful	☐	☐	☐	☐	☐

* 9. On a scale of 1 (strongly disagree) to 5 (strongly agree), please rate the following statements

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I understand what the Berkshire Wearables app is for	☐	☐	☐	☐	☐
Syncing my wearable data on the Berkshire Wearables app was easy	☐	☐	☐	☐	☐
The Berkshire Wearables app is user-friendly	☐	☐	☐	☐	☐
I find the relationship between the Garmin tracker, Garmin Connect and Berkshire Wearables app confusing	☐	☐	☐	☐	☐
I found the Berkshire Wearables app functional and useful	☐	☐	☐	☐	☐
I feel comfortable sharing my wearable data with authorised users (project team) via the Berkshire Wearables app	☐	☐	☐	☐	☐
When I think about my health, I'm not sure where to look for helpful data	☐	☐	☐	☐	☐

Participant Expectations

* 10. Do you think your expectations for joining this pilot have been met so far?

Please provide details in the comment box.

☐

Yes

☐

No

Please provide details

*** 11. What goals do you hope to achieve in the next 6 months?**

12. Is there anything else you would like to share with us?

B.4 12-month Follow-up Survey

Introduction

Thank you for participating in the Berkshire Wearable Technology Pilot, and for completing our follow-up survey in November.

As we near the end of the pilot please now complete this survey. You will notice many of the questions are familiar because by asking some of the same questions, we can track any changes over time.

Completing this survey will give us a better understanding of your experience so far and how you have used the Garmin and apps over the past three months. This survey should take about 10 minutes to complete.

All responses will be treated as confidential. Please refer to the pilot's data policy for more details about how we process your data and keep your data private.

Please click "Next" to start this survey.

If you have any questions about the Berkshire Wearable Technology Pilot, please email the team at wearable.pilot@nhs.net

Demographic Data

- * **1. Please provide your nhs.net email address.**
This will be used to verify survey completion.

- * **2. What is your current weight?**
Select below whether to answer using stones/pounds or kilograms.

My weight in stones and pounds (st & lb) is

OR My weight in kilograms (kg) is

*** 3. What is your current height?**

Select below whether to answer using feet/inches or centimetres.

My height in feet and inches (ft & in) is

OR My height in centimetres (cm) is

Health Consciousness Measure

*** 4. On a scale of 1 (strongly disagree) to 5 (strongly agree), please rate the following statements**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I'm very proactive in managing my health	☐	☐	☐	☐	☐
I'm generally aware of my emotions and feelings about my health	☐	☐	☐	☐	☐
I worry about my health all the time	☐	☐	☐	☐	☐
I notice how I feel physically as I go through the day	☐	☐	☐	☐	☐
I take responsibility for the state of my health	☐	☐	☐	☐	☐
I only worry about my health when I get sick	☐	☐	☐	☐	☐
Living life without disease and illness is very important to me	☐	☐	☐	☐	☐
My health depends on how well I take care of myself	☐	☐	☐	☐	☐
Living life in the best possible health is very important to me	☐	☐	☐	☐	☐

Health Motivation Measure

* 5. On a scale of 1 (strongly agree) to 5 (strongly disagree), please rate the following statements

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
I am very aware of common risks that may affect my health e.g. smoking, alcohol, high fat diet, being overweight, inactivity	☐	☐	☐	☐	☐
I don't worry about common health risks until they become a problem for me	☐	☐	☐	☐	☐
I have changed my behaviour to take account of health risks since starting the pilot	☐	☐	☐	☐	☐
I don't worry about common health risks until they affect my family	☐	☐	☐	☐	☐
I don't take any action to prevent ill health until I know I have a problem	☐	☐	☐	☐	☐
I like to keep myself up to date on health risks and how to mitigate them	☐	☐	☐	☐	☐
I would rather enjoy life than worry about avoiding ill health	☐	☐	☐	☐	☐
There are so many illnesses that can affect my health, I am not going to worry about them	☐	☐	☐	☐	☐
I feel I have a duty to look after my health for the sake of my family	☐	☐	☐	☐	☐

Health Perception Measure

* 6. On a scale of 1 (strongly disagree) to 5 (strongly agree), please rate the following statements

Since I started using my Garmin,

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I exercise more now	☐	☐	☐	☐	☐
My daily meals are more nutritionally balanced	☐	☐	☐	☐	☐
I don't use it every day	☐	☐	☐	☐	☐
I try to avoid high levels of fat in my diet	☐	☐	☐	☐	☐
I try to sleep at least 8 hours a day	☐	☐	☐	☐	☐
I have lost weight	☐	☐	☐	☐	☐
I found it hard to relate what the Garmin measures to actions I can take to improve my health	☐	☐	☐	☐	☐
I attempt to avoid stressful situations	☐	☐	☐	☐	☐
I monitor the nutritional value of my food	☐	☐	☐	☐	☐
I have adopted healthier behaviours (e.g. taking the stairs)	☐	☐	☐	☐	☐
I don't understand what the Garmin measures	☐	☐	☐	☐	☐
I try to exercise at least 30 minutes a day, 3 days each week	☐	☐	☐	☐	☐
I participate more actively now in maintaining my health	☐	☐	☐	☐	☐
I don't trust the way the Garmin works	☐	☐	☐	☐	☐
I've stopped using my Garmin	☐	☐	☐	☐	☐

If you have stopped using your Garmin, please provide details of when you stopped and why

Technology Use Experience

* 7. On a scale of 1 (strongly disagree) to 5 (strongly agree), please rate the following statements

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The Garmin tracker is easy to use and sync	☐	☐	☐	☐	☐
I find wearing my Garmin uncomfortable	☐	☐	☐	☐	☐
I sync my Garmin to the Garmin Connect app at least twice a month	☐	☐	☐	☐	☐
The nudges I received from my Garmin motivated me to be more active	☐	☐	☐	☐	☐
My Garmin tracker was accurate	☐	☐	☐	☐	☐
I found nudges generated by the Garmin irritating	☐	☐	☐	☐	☐
I would recommend the Garmin Vivosmart HR+ tracker to family and friends as a way of improving their health	☐	☐	☐	☐	☐
I would recommend a different fitness tracker to family and friends as a way of improving their fitness	☐	☐	☐	☐	☐

* 8. On a scale of 1 (strongly disagree) to 5 (strongly agree), please rate the following statements

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Seeing my wearable data motivates me to live a healthier lifestyle	☐	☐	☐	☐	☐
I don't understand how Garmin Connect works	☐	☐	☐	☐	☐
The Garmin Connect app is user-friendly	☐	☐	☐	☐	☐
The insights provided on Garmin Connect motivated me to improve my fitness activities	☐	☐	☐	☐	☐
A social network on the Garmin Connect app or Berkshire Wearables app will better motivate me to live healthier	☐	☐	☐	☐	☐
I find my wearable data depressing	☐	☐	☐	☐	☐
I found the Garmin Connect app useful	☐	☐	☐	☐	☐

*** 9. On a scale of 1 (strongly disagree) to 5 (strongly agree), please rate the following statements**

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I understand what the Berkshire Wearables app is for	☐	☐	☐	☐	☐
Syncing my wearable data on the Berkshire Wearables app was easy	☐	☐	☐	☐	☐
The Berkshire Wearables app is user-friendly	☐	☐	☐	☐	☐
I find the relationship between the Garmin tracker, Garmin Connect and Berkshire Wearables app confusing	☐	☐	☐	☐	☐
I found the Berkshire Wearables app functional and useful	☐	☐	☐	☐	☐
I feel comfortable sharing my wearable data with authorised users (project team) via the Berkshire Wearables app	☐	☐	☐	☐	☐
When I think about my health, I'm not sure where to look for helpful data	☐	☐	☐	☐	☐

*** 10. On a scale of 1 (strongly disagree) to 5 (strongly agree), please rate the following statements**

Since I started using my Garmin

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree
I sleep more now	☐	☐	☐	☐	☐
I am less worried about my sleep	☐	☐	☐	☐	☐
The insights provided by the Garmin Connect app help me sleep better	☐	☐	☐	☐	☐
I am more worried about my sleep	☐	☐	☐	☐	☐
I have adopted healthier behaviours to improve my sleep	☐	☐	☐	☐	☐

Participant Expectations

*** 11. Overall has this pilot had a positive impact on your health and wellbeing?**

Please provide details in the comment box.

☐

Yes

☐

No

Please provide details

*** 12. Have you gained anything from taking part in this pilot that you didn't expect when you volunteered?**

Please provide details in the comment box.

☐

Yes

☐

No

Please provide details

*** 13. What goals do you hope to achieve in the next 3 months?**

14. Is there anything else you would like to share with us?

*** 15. The wearable pilot ends on 31 March 2019. Can a member of the Berkshire Wearable Pilot Team email you after March to invite you to participate in future phases of the pilot?**

☐

Yes

☐

No

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Appendix C

Interview Script

1. Objectives of Interview

- i Explore participants' understanding of the purpose for the pilot and their expectations for the pilot
- ii Explore participants' experience with pilot onboarding process
- iii Explore participants' experience with using Garmin fitness tracker
- iv Explore participants' experience with using the Garmin Connect and Patient portal apps
- v Any suggestions for improvement

2. Interview

A Introduction

Thank you for agreeing to participate in an interview. My name is (interviewer's name). The purpose of this interview is to help us evaluate the effectiveness of the Berkshire Wearable Technology pilot. It is important that you respond to all the interview questions based on your experience and perspective as a participant. Do you have any questions before we begin?

This interview will focus on the technologies and how you have used them. Do you have any pressing comments on the conduct of the trial to feed back to us before we start the main questions?

B Interview questions related to objectives i and ii

- i From your perspective, what would you say is the main purpose of the wearable pilot?

- ii What do you expect participation in this pilot to do for you?
- iii How would you rate the onboarding process for this pilot? What do you think went well and what went badly?
- iv What changes in your behaviour do you think have come about from using the Garmin watch?
- v Do you think these changes have had any effect on your health?
- vi Would you say you're more conscious of your health or have adopted healthier behaviours (e.g. improved physical activity or monitoring diet or sleep) since you began this pilot?

C Interview Questions related to objectives iii and iv

- i Have you used your Garmin Fitness Tracker?
- ii How have you used the Garmin fitness tracker? Did you establish a routine?
- iii What did you like about the Garmin?
- iv What aspects of the Garmin do you feel could be improved?
- v What has been particularly good or bad?
- vi Have you used the Garmin Connect App?
- vii How often do you use the Garmin Connect App?
- viii What did you like about the Garmin Connect App? What do you feel could be improved?
- ix Are there functions that you feel are missing from the app?
- x Have you used the Patient Portal App?
- xi How often do you use the Patient Portal app? What did you like about the Patient Portal? What do you feel could be improved?
- xii Are there functions that you feel are missing from the app?
- xiii Have you heard of nudging? (If not then explain)
- xiv Did you receive nudges on your device to move? How did you respond to these messages?
- xv Do you use Social Media? (explain if they don't)
- xvi If the Apps had an integrated social network, do you think the presence of a social network would help you maintain healthy behaviours?

D Interview questions related to objective v

- i What did you expect from participation in the pilot? What expectations were met by your participation? Are there any disappointments?
- ii Do you have any suggestions for improvement on the fitness tracker and apps?

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Appendix D

Characteristics of Interview Respondents

Participant	Gender	Organisation	Age Group	Job Role
P1	Male	Berks West	55-59	Manager (CCG)
P2	Male	BHFT	45-49	Operational Management
P3	Female	RBFT	40-44	Administrative
P4	Female	BHFT	50-54	Administrative
P5	Male	RBFT	40-44	Emergency Preparedness, Resilience & Response
P6	Female	Berks West	30-34	Project Support Officer
P7	Female	Berks West	45-49	Manager (CCG)
P8	Male	RBFT	55-59	IM&T
P9	Female	Berks East	50-54	Manager (CCG)
P10	Male	FHFT	35-39	Nurse
P11	Female	BHFT	45-49	Deputy Supervisor
P12	Male	Berks East	40-44	Manager (CCG)
P13	Female	FHFT	25-29	Administrative
P14	Female	FHFT	55-59	Administrative
P15	Male	Berks East	45-49	Project Manager
P16	Female	FHFT	50-54	Operational Management

P17	Female	BHFT	55-59	Allied Health Professional
P18	Female	RBFT	45-49	Cardiac Physiologist
P19	Female	RBFT	45-49	Administrative
P20	Female	BHFT	50-54	Allied Health Professional

Key:

P – Participant

BHFT – Berkshire Health Foundation Trust

RBFT – Royal Berkshire Foundation Trust

FHFT – Frimley Health Foundation Trust

Berks – Berkshire

CCG – Clinical Commissioning Group

IM&T – Information Management & Technology

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