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AN INVESTIGATION INTO USERS' PERCEPTIONS OF VALUE TOWARDS TELEMEDICINE SYSTEMS OVER TIME

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Originality Statement

I, Christopher Lemon, certify that this thesis, An Investigation Into Users' Perceptions of Value Towards Telemedicine Systems Over Time, is my own work. It is based on original data gained from my own research. It contains no material that has been written or published by another person, except where acknowledgement is made. This work has not been submitted or accepted for the award of any other degree or diploma. All research practices involved with this thesis were approved by the University of Sydney and Nepean Clinical School Human Ethics Committees.

Christopher Lemon.

31/3/2016

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Papers and Presentations Arising from This Thesis

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Journal Articles

The main content of this thesis has not yet been published. At present, two journal articles are planned for publication in either *The Medical Journal of Australia* or telemedicine-specific journals, such as *Telemedicine and e-Health* and *The Journal of Telemedicine and Telecare*.

The first article will describe how the telemedicine system in this thesis was built and evaluated. An overview of the customised design and implementation process will be given as a guide for future system development and research. The paper will demonstrate how users' perceptions of value towards telemedicine

systems are variable, and can change dramatically over the course of regular usage. This can influence how systems are used and the potential for anticipated benefits to be realised. The paper will therefore call for the need to avoid relying on single evaluations of users' perceptions of value as part of assessment processes for telemedicine systems, especially if they are only conducted at the outset of regular usage. Ongoing and rigorous evaluation of perceptions of value is needed to help maintain the longevity of systems, and to ensure benefits continue to be achieved.

The second article will elucidate and examine the factors that influence users' perceptions of value towards telemedicine systems over time. Data obtained from evaluations of the system built in this thesis will be explored and analysed through reference to seminal theories on how humans use technology. This analysis will reveal how individual, technological and contextual factors can shape the ways in which telemedicine systems are perceived and used over time. This will form the basis of a set of recommendations for the improvement of design, implementation and support of telemedicine systems, and through this, the achievement of greater overall benefits.

Abstract

Users' perceptions of telemedicine systems can influence how they are used. However, understandings of the nature of users' perceptions remain limited. One area seldom examined is perceptions of value. This study aimed to investigate how perceptions of value towards telemedicine systems change over time, the underlying factors that influence them, and how this knowledge can be used to improve usage.

A customised telemedicine system was introduced to the Nepean Outreach Service (NOS), Nepean Hospital, Australia. The system was built according to the preferences of medical, nursing and administrative NOS staff. Perceptions of value were assessed using the System Usability Scale (SUS). The factors that influenced them were determined from semi-structured interviews that were based on the SUS.

10 NOS mobile nurses (Mean age = 44.40 years old, *SD* = 13.13 years, 1 male), with an average of 3.05 years (*SD* = 2.31 years) of experience with similar technology used the system for the first time for the duration of a single shift in October 2013. Each nurse completed the SUS and semi-structured interview immediately afterwards. In November 2013, the system was implemented for regular use. Minor technical updates were made, including a desktop storage system. 18 months later, 8 of the original 10 nurses (Mean age = 48.50 years-old, *SD* = 13.3 years, 1 male) with a mean of 5.43 years of experience with similar technology (*SD* = 2.92 years) answered the SUS and same interview questions again. The results were compared.

After first use, the SUS mean was 84.69 (*SD* = 9.01), indicating excellent usability. This represented high perceived value. After 18 months of consistent use, the SUS mean significantly declined to 64.00 (*SD* = 14.25), indicating OK usability ($p < 0.05$, 95% CI). This represented a significant reduction in perceived value over time. Analysis of individual SUS questions showed that over time, users had less desire to use the system frequently ($p < 0.05$, 95% CI). They found it more complex ($p < 0.05$, 95% CI), the functions to be not as well integrated ($p < 0.05$, 95% CI) and had a stronger sense of inconsistency in it ($p < 0.05$, 95% CI). The meaning of these findings was further clarified in the analysis of interview data.

Three superordinate themes emerged from the interview data. These themes represented how individual, technological and contextual factors influenced perceptions of value over time. The first, experience as the standard, highlighted the importance of individual factors. Users apply preformed personal expectations about technology from past experiences to evaluate telemedicine systems. Expectations concerned their experience as an individual user, and their perception of how their health care team as a whole responded to the system. Expectations also played an important role in users' sense of complexity in using the system. Failing to recognise and meet expectations over time can contribute to declining perceptions of value.

The second theme, design and demand, emphasised the importance of technological factors. Users make judgements about whether the design of a telemedicine system is appropriate according to its ability to help them navigate the demands of their daily tasks. Judgements concern physical and functional features, as well as the degree to which they are integrated to work together as a whole. A weak relationship between design features and demands of workplace tasks can influence users to perceive less value in using a telemedicine system over time.

Contextual constraints revealed how the significance of the context of use becomes greater over time. Users evaluate how well they believe a system functions in accordance with bureaucratic requirements and other technologies in the workplace. Difficulty in using the system due to bureaucratic requirements or inability to use it in synchrony with other technologies can contribute to a sense of inconsistency and help lead perceptions of value to decline over time.

In light of these findings, this study recommends that to help improve usage, users' perceptions of value should be continuously and comprehensively assessed. In general, design processes should be dynamic and fundamentally guided by users' expectations and changing workplace demands. Similarly, implementation should be gradual rather than static, and focus on regularly reassessing and working with the impact of workplace bureaucratic and technological factors on users' experiences. Technical support should be as responsive as possible, but also empowering to equip users with attitudes and skills to work around design and implementation problems when assistance may not be immediately available.

Abbreviations

ICT	Information Communication Technology
NOS	Nepean Outreach Service
PMR	Patient Medical Record
SUS	System Usability Scale
TAM	Technology Acceptance Model
DOI	Diffusion of Innovation
TTF	Task-Technology Fit
ISO	International Organisation for Standardisation
EPR	Electronic Patient Record
QUIS	Questionnaire for User Interaction Satisfaction
PDA	Personal Digital Assistant
MPUQ	Mobile Phone Usability Questionnaire
PMR	Patient Medical Record

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Chapter 1: Introduction

Contemporary health systems are currently under substantial strain. Populations are rapidly aging, life expectancy is increasing and chronic, non-communicable diseases have risen in prevalence. Existing models of care have previously given significant focus to providing short-term care for acute illnesses. However, patients now often require long-term care that targets the effects of more enduring diseases. The high level of demand, combined with the limited availability of appropriate resources have made it difficult for health systems to adapt effectively. As a result, there is now an imminent need for health research efforts to help make models of care more comprehensive, efficient and sustainable than ever before.

Telemedicine, the use of advanced telecommunication devices to exchange health data over distances and other barriers is one of the most exciting and promising areas of new health research that forms a significant part of efforts to improve models of care. Telemedicine seeks to make health care more comprehensive, efficient and sustainable by introducing new sophisticated and personalised technologies that focus on transforming how information is used in health care. Telemedicine technologies, such as smart phones installed with health care software enable users to enhance the acquisition, interpretation and transfer of information. The integration of high quality images and video with text enables health data to become more comprehensive than what could be collected using past methods. Through uses of the Internet to facilitate rapid transfer of complex patient data and to enable remote video-linked clinical interactions, health care can become more efficient, especially when doctors and patients live significant distances apart. Using such systems can also lessen costs associated with having to travel long distances, enabling health care to become more efficient.

Research is rapidly growing to enhance models of health care for patient needs through use of telemedicine systems. A large proportion of the literature seeks to improve technical design. As technologies become more sophisticated, the possible methods for addressing health challenges also expand and become more dynamic. Equally as important, other research is instead focusing on how to clearly

determine the impact telemedicine is having on health systems. Some studies have shown how telemedicine can improve clinical outcomes for patients with a range of chronic diseases. Others have demonstrated that telemedicine systems can allow health providers to can enhance continuity of care and teamwork. Studies have also shown how telemedicine can help shorten length of stay and overall costs of care. However, there are also a substantial number of studies that have been conducted with similar focuses demonstrating that telemedicine systems offer no such benefits at all. Some literature has even demonstrated that telemedicine can be detrimental in various ways, such as increasing emergency department waiting times. This has led to ongoing discourse questioning the role of telemedicine in health care, and how it can best be utilised. Understanding what factors may have contributed to these conflicting findings is an important part of resolving such discussions.

There are a number of problems commonly cited in telemedicine studies that may help account for discrepancies in the literature. Some studies have revealed that the uptake of telemedicine systems is not always complete, and that this can affect their ability to obtain certain benefits. There is also wide variation in the types and quality of methodologies used to assess telemedicine, which can make it difficult to clearly understand and compare the ways in which they are impacting health systems. Furthermore, a large proportion of studies have been conducted over time periods of less than 6 months. This has resulted in limited insight into the longevity of telemedicine for health providers and patients, which is important for maintaining efficiency and sustainability of models of care.

Throughout the telemedicine literature, only a small number of studies have considered trying to develop an understanding of the user's experience. This can be shown to be a potentially significant part of each of the problems outlined. Determining why uptake is incomplete requires an understanding of how users perceive telemedicine systems when they are introduced, as well as the motivations they have for the ways in which they use them. Study methodologies that do not sufficiently assess how users respond to technologies and their features may neglect to find and analyse crucial information that can help explain why some systems are

associated with the achievement of more benefits than others. Similarly, studies that are conducted over short time periods are not able to consider how long-term needs may differ from short-term needs in relation to telemedicine systems, and the factors that may contribute to such differences. Without greater understanding of the user's experience, problems in the literature may not be overcome, and the full potential of telemedicine systems may not be realised.

The limited numbers of studies that have given consideration to understanding the user's experience of telemedicine systems have often done so through simple conceptual focuses, such as user satisfaction. Although such studies provide some level of insight into the user's experience, when such simplistic and specific research focuses are used, the meaning and implications of their findings remain limited. One of the more complex aspects of the user's experience that has received almost no attention in the literature is the ways in which users perceive value in telemedicine systems. Perceived value concerns how a user weighs up benefits and sacrifices that may be involved in evaluating the utility of a system. This may play a crucial role in the problems outlined above. Differences in perceptions of value may lead some users to be more willing to try using telemedicine systems than others, leading to discrepancies in adoption. Similarly, users may perceive more value in particular systems instead of others, and this may help them generate greater motivation to achieve associated benefits. Whether perceptions of value are the same after short-term and after after long-term use may also play a key role in determining the longevity of telemedicine systems.

Given the small amount of research in this area, these ideas are mostly speculative. However, their discussion highlights the importance of investigating perceptions of value as part of understanding the users' experience of telemedicine, and the implications of this. Examining users' perceptions of value may enable greater understanding of the role of telemedicine in health care, conflicting findings within the literature, as well as how systems can best be utilised.

With this in mind, the main aim of this research is to develop and introduce to the literature an understanding of the way users' perceive value in telemedicine

systems. This aim will be achieved by completion of two main tasks, each focusing on a particular aspect of perceptions of value. The first concerns how perceptions of value vary with time. Understanding this may help in ensuring telemedicine systems are used effectively and consistently by their users over long periods of time. Therefore, the first task of this thesis is to develop an understanding of how users' perceptions of value towards telemedicine systems change over time.

The second focus concerns understanding the ways in which such changes may be enabled to occur. Perceptions of value may be influenced by a number of different factors that are parts of the users' experience. Determining the role and manner in which this influence occurs is important for understanding how users engage with telemedicine systems over time, and forms the basis of approaches to improving how they are utilised. Thus, the second task of this thesis is to explore and examine the factors that influence users' perceptions of value towards telemedicine systems over time. Completion of both tasks and hence the aim of the thesis will enable development of recommendations on how to improve telemedicine usage.

With this in mind, the plan of this thesis is as follows. Chapter 2 begins by providing an overview of telemedicine in the context of contemporary health care challenges. Following this, appraisal of existing approaches towards understanding the users' experience of telemedicine, and the need to explore and examine users' perceptions of value is discussed, with emphasis on how usability methodologies and existing views on the way humans use technology are important tools for doing this effectively. The utility of examining perceptions of value within a particular clinical context is then discussed. Chapter 2 concludes by bringing each of these areas of literature together as part of the rationale for investigating how perceptions of value towards telemedicine systems change over time, and the factors that influence such changes.

Chapter 3 gives a detailed justification and description of the methodologies used in this thesis, including how a telemedicine system was designed, implemented and evaluated. Details are given on the use of a quantitative usability methodology and phenomenological approach for analysis of qualitative data as part of

completing the tasks of the thesis.

Chapter 4 presents and discusses the implications of the findings from completing the first task. Chapter 5 presents and discusses the findings from completing the second task, as well as integrates and further elaborates on some of the results from Chapter 4.

Chapter 6 gives the conclusions of the thesis and explains how the main aim was achieved. Following this implications for progress are discussed and recommendations on how to improve design, implementation and support of telemedicine systems are presented. The thesis concludes with discussion of strengthens and limitations as well as suggestions for future research.

Chapter 2: Literature Review and Thesis Rationale

2.1 Overview

In this chapter, I will critically appraise a number of areas of literature relevant to the topic of perceptions of value in telemedicine. This appraisal will reveal why further research is needed, and the ways in which this research should be conducted. I will review existing literature on telemedicine and argue for the need for research into perceptions of value, emphasising the importance of using particular research approaches, as well as provide background on why outreach care is an appropriate context for doing this. I will then provide the rationale and research questions for this thesis. I will now provide a brief overview of this section.

The ageing population, rise in chronic disease and increasing cost of health care has resulted in a need for new models of care that are more comprehensive, sustainable and efficient than ever before. The use of telemedicine systems has the potential to help develop these models of care in a broad range of ways, such as enhancing the quality and accessibility of patient data.

Although the potential for telemedicine to benefit health systems has been recognised, there remains no clear consensus on whether it facilitates mainly benefits or costs. There are a number of explanations for this, including problems with uptake and study design. One of the common overriding themes in these explanations is that there is a limited understanding of the importance of the users' experience of telemedicine systems. Specifically, while much research has considered the value of telemedicine systems for health performance measures, few studies have examined the way users' form their own perceptions of value, an aspect of telemedicine use that may help account for the lack of consensus on benefits and costs. If users aren't seeing value in telemedicine systems, they may not be using them properly, and hence may not be achieving intended benefits.

Understanding perceptions of value requires consideration of how value is a fluid concept that can change over time and through the influence of various factors that are part of the users' experience. Examining how value changes over time requires robust quantitative research tools, such as the SUS. Exploring the factors

that may influence this change requires a qualitative approach that integrates and extends existing theories on the way people view and use technology, such as the TAM, DOI and TTF models.

Conducting research into perceptions of value must be done in a health care context where telemedicine is known to be able to facilitate benefits. Outreach care helps reduce mortality and rehospitalisation in a number of patient groups. Telemedicine may enhance the ability for these benefits to be achieved through improvements to overall quality of care and communication. Outreach is thus a useful context for this study.

The literature review will conclude with the rationale for this thesis, including development of two key research questions. The way these questions address existing issues in the literature, and contribute to future directions will be highlighted.

2.2 Information Communication Technology in the Modern Health Care Environment

2.2.1 Terminology

ICT has become a ubiquitous part of the health care environment. It is used in metropolitan, rural and remote contexts, as well as in both high and low-resource settings. ICT has also become a significant part of a number of medical specialties. In psychiatry, for instance, the use of ICT to deliver care is referred to as 'telepsychiatry' (Al-Qirim, 2007; Bashshur, Shannon, Krupinski, & Grigsby, 2011; W. A. Kaplan, 2006; van Dyk, 2014).

With this growing interest, a number of terms used to describe the use of ICT in health care have emerged. The most common are 'telehealth', 'telemedicine', 'm-health' and 'e-health'. Though each describe a particular aspect of ICT use in health care, each refers in some way to using technology to substitute or support physical methods of communication and care between patients, providers and the health system (Bashshur et al., 2011).

This thesis will specifically focus on telemedicine and m-health. There is ongoing debate about the exact definitions of these terms. For the purposes of this thesis, however, and to maintain particular relevance to the Australian health care context, 'telemedicine' and 'm-health' will be defined according to The Australian Government, International Organisation for Standardisation and the World Health Organisation.

Telemedicine will be defined as the 'the use of advanced telecommunication technologies to exchange health information and provide health care services across geographic, time, social and cultural barriers' (Australian Government, 2012). m-Health is a type of telemedicine. m-Health will be defined as medical and public health practices supported by mobile devices, such as mobile phones, patient

monitoring devices, personal digital assistants (PDAs), and other wireless devices. 'Mobile devices' are portable devices that can be used to remotely share health information in text, video and audio formats. They achieve this transmission via a particular set of transmission systems, including general packet radio systems (GPRS), 3G and 4G networks connectivity, global positioning systems (GPS) and Bluetooth-based functions, the mechanisms of which are beyond the focus of this research (Bashshur et al., 2011; W. A. Kaplan, 2006; Wild et al., 2008; World Health Organisation, 2011).

2.2.2 Challenges in modern healthcare and Telemedicine

The modern health care environment faces a number of important challenges. Communities around the world are changing in how their health care needs and consumption of resources. Populations are ageing and life expectancy is increasing. With this comes a rise in the prevalence and impact of diseases that are chronic, non-communicable and disabling, rather than acute and fatal (Queensland Department of Health, 2013). As a result, people now have a greater need for ongoing long-term management of complex, concurrent health conditions over and above acute short-term care for single disease episodes. This has begun to exhaust health care resources and placed enormous strain on primary care services. This is especially pronounced in rural and regional communities, where the chronic disease burden is higher, on average, relative to urban populations. To meet the needs of contemporary populations, health systems have had to adapt to provide models of care that are more comprehensive, sustainable and efficient than those that have been used in the past (Armstrong, Gillespie, Leeder, Rubin, & Russell, 2007; Bennett, 2013; Brooks, 2003; Hamilton, Gibberd, & Harrison, 2014; Reeve et al., 2015).

The use of telemedicine has been recognised as having the potential to help develop such models of care that meet contemporary health care needs. Technology can improve the accessibility, quality and breadth of patient data. More information about patients can ensure can be more effectively tailored and comprehensive. Telemedicine can also improve the sustainability of health systems by reducing

strain on primary care services. Remote monitoring of patients can help prevent unnecessary use of time and resource as well as encourage preventative health activities. Furthermore, telemedicine systems can encourage greater collaboration amongst health providers for complex patient needs without the need to spend time and money travelling significant distances (Ackerman, Filart, Burgess, Lee, & Poropatich, 2010; Cormick et al., 2012; Hyde & Murphy, 2012; Jaarsma, Brons, Kraai, Luttik, & Stromberg, 2012; McGowan, 2008; Mitchell, Tieman, & Shelby-James, 2008; Whetton, 2005). This recognition has lead academic and government bodies to invest in increased research into how using telemedicine systems can benefit health systems.

2.3 Overview of Telemedicine Literature

There are many different groups of people involved in health care, patients of whom are the most important. Others such as providers and health administrators are also important, but they too ultimately work towards optimising the experience of health care for patients. Providers in this context are understood as anyone that is trained to give health care to patients (Jain, Mishra, & Pandey, 2016; Strasser, Kam, & Regalado, 2016) Health administrators in this context are considered those who manage financial and human resources in health care (Woldemariam, 2016; Yuceler, Kaya, & Ileri, 2014).

Each of the groups of people involved in health care have their own set of interests and priorities that fundamentally relate back to patient care. Differences in these interests and priorities mean that the significance of telemedicine systems can vary between these groups. Therefore, to provide a clear overview of the current trends in telemedicine literature, it is best that studies are grouped and reviewed according to whether their primary focus is the impact of systems on patients, providers or administrators (Brown & Shaw, 2008; Porter, 2010; Walker & Whetton, 2002; Whetton, 2005).

There is a growing body of evidence to indicate that telemedicine systems can benefit patients. There have been a number of clinical benefits reported for chronic conditions. Studies have demonstrated that telemedicine systems can improve care outcomes, such as lowered mortality and morbidity in patients with chronic heart failure who use a remotely managed implantable cardiac defibrillator and lowered blood glucose levels in patients using remote management diabetic telemedicine systems, both of which are associated with a lower cost in terms of fewer instances of complications (De Simone et al., 2015; Istepanian, Jovanov, & Zhang, 2004; Istepanian et al., 2009). Telemedicine has also been shown to improve engagement with evidence-based treatments in post traumatic stress disorder patients and reduced emergency hospital admission in patients with chronic obstructive pulmonary disease (De Simone et al., 2015; Fortney et al., 2015;

Steventon et al., 2012). Telemedicine systems can also improve the quality of follow-up consultations and patient satisfaction (Kobb, Hoffman, Lodge, & Kline, 2003; Sutherland, Sutphin, Rawlins, Redican, & Burton, 2009; Vanagas, Žaliūnas, Benetis, Šlapikas, & Smith, 2008; Winkler et al., 2011).

However, there is also evidence indicating that telemedicine systems can add no benefits to patients. In contrast to the literature discussed previously, one study found that telemedicine for remote monitoring for adults with multiple diseases in conjunction with care from their primary care doctor did not reduce emergency department presentations or hospitalisations (Takahashi et al., 2012). Furthermore, another found that use of telemedicine systems in conjunction with primary care for remote monitoring in patients with diabetes, COPD and irritable bowel syndrome had no effect on health outcomes or service use (Kennedy et al., 2013).

There evidence on the benefits of telemedicine systems for providers is equally mixed. Studies focusing on providers have examined how telemedicine systems can be used to improve documentation procedures, teamwork and patient management. Some literature indicates that electronic medical record systems can be useful in ensuring good continuity of care in multidisciplinary services. Similarly, computerised medical records are associated with increased comprehensiveness of nursing records, as well as enhanced quality of communication and support among multidisciplinary team members. They can also improve the ability of providers to more efficiently manage care complications and more effectively educate patients on how to take medications (Chang et al., 2011; Chen et al., 2013; Hyde & Murphy, 2012; Shepard et al., 2014).

However, other literature with a similar focus has shown that telemedicine provides no benefit or is even detrimental for providers. One study demonstrated that telemedicine systems were only of useful to providers in certain contexts, such as in the remote management of moderate trauma patients, but no in other cases (Westbrook et al., 2008). Another study has demonstrated that using a telemedicine system in an emergency department resulted in worse performance on key performance indicators, such as increased waiting times (Mohan, Bishop, & Mallows, 2013).

There is also variable evidence on the benefits of telemedicine for health administrators. Most studies that have focused on health administrators' have examined how telemedicine can help create financial savings. Some literature indicates that telemedicine and m-health systems have reduced health system costs by lowering the need for patient and provider travel and accommodation, shortening lengths of stay and lowering the frequency of hospital admissions for some patient groups (Scherr et al., 2009; Thaker, Monypenny, Olver, & Sabesan, 2013; Wade, Karnon, Elshaug, & Hiller, 2010; Young, Foster, Silander, & Wakefield, 2011) Savings can also be achieved by reducing the need to transfer patients, prisoners and nursing home residents to emergency departments, physicians' offices and between healthcare facilities. Other research suggests that telemedicine systems can also help lower the use of repeated unnecessary tests (Cusack et al., 2008).

However, as is the case with the evidence for patients and providers, there is also literature to suggest that telemedicine systems only facilitate financial savings in certain contexts. In one study, telemedicine consultations for psychiatry and dermatology were cheaper for patients than face-to-face consultations. However, when implementation and maintenance costs were considered, using telemedicine was more expensive for administrators than when face-to-face consultations were used (Persaud et al., 2005). Similarly, another study found that telemedicine systems were more cost-effective than face-to-face consultations in only some respects. Video services between local hospitals and primary care providers in a rural context, one of the most appealing functions of telemedicine systems, were shown to not be cost-effective (Wade et al., 2010).

2.3.2 Explaining the Variability in the Telemedicine Literature

The literature examined above shows that there is no clear consensus on whether or not telemedicine provides benefits for patients, providers or health administrators. There are a number of key problems with how telemedicine is being implemented and researched that may account for this. One of the factors that may

help account for these problems is that a significant proportion of the literature focuses on technology development, rather than how people use the technology. Greater understanding of the ways in which telemedicine users engage with systems may help account for some of the variation in the literature.

One significant challenge in the telemedicine literature is incomplete implementation and uptake of new systems. This is especially important when considering the potential economic benefits of telemedicine. In cases where not all potential users are engaging with a new system, economic analyses are likely to misrepresent the balance between clinical benefits and financial costs. Explaining why incomplete implementation and uptake occurs boils down to how users engage with technology. When new systems are introduced for the first time, providers and administrators need a certain level of technical competence to operate them successfully. Without this level of expertise, they are misunderstood, misused and abandoned quickly for alterantive existing routines. Linked to this is a need for clinical and adminstrative leaders to be motivated by clear understandings of the benefits of telemedicine. Failure of leadership leads to failure of telemedicine use and hence inconsistent evidence on its benefits patients, providers and administrators. Greater understanding of how to equip and empower users to fully engage with new systems is needed (Cusack et al., 2008; Pearce & Haikerwal, 2010).

Problems in how research into telemedicine is conducted also further emphasises the need for greater understanding of the ways in which people engage with technology rather than the technologies themselves. There are multiple methodological problems in the telemedicine literature. In particular, there is significant disparity in approaches to economic assessments, selection and sizes of participants for studies and methods of workflow anlayses (de la Torre-Díez, López-Coronado, Vaca, Aguado, & de Castro, 2015; B. Kaplan, 2001; Mistry, 2012; Pan et al., 2008; Perera & Chakraborti, 2015; Whetton, 2005; Wootton, Vladzymyrskyy, Zolfo, & Bonnardot, 2011). The lack of consistency in these aspects of previous research designs highlights a fundamental lack of understanding of the factors that need to be considered as part of a telemedicine study, as well as careful analysis of how each affects the way users experience technologies.

These factors may account for some of the variation in the findings in the telemedicine literature. However, another perhaps more important factor is the duration of previous studies. Many telemedicine studies focus on examining the benefit of systems for patients requiring long-term management for chronic illnesses, such as heart failure, diabetes and chronic obstructive pulmonary disease. However, the median length of telemedicine studies is only 6 months. This is an insufficient amount of time to capture the full breadth of potential benefits and costs associated with use. Studies must be conducted over years rather than months if this data is to be accurate and useful (Whittaker, Merry, Dorey, & Maddison, 2012; Wootton, 2012).

Studies with a short duration may also fail to capture how benefits and costs related to telemedicine may change over time. Indeed, the sustainability of systems continues to be an ongoing challenge. Overcoming this requires a greater understanding of how telemedicine can affect all aspects of health care services over time, as changes in benefits and costs are encountered (Bashur, Shannon, Krupinski, & Grigsby, 2013) Although understanding aspects of initial adoption is important, it is possible that a new system can provide benefits in the short-term, but not in the long-term due to changes in the way it is used in the workplace. The ultimate success of any telemedicine system is contingent upon its ability to consistently achieve benefits with limited costs over extended time periods (DeLone & McLean, 1992; Rai, Lang, & Welker, 2002).

2.3.3 Users' Perceptions of Value in Telemedicine

The studies mentioned previously have largely focused on how telemedicine can facilitate operational benefit for patients, providers and health administrators. Operational benefits refer to how using a system can improve performance (Brear, 2006). Although this evidence is important, literature indicates that if users themselves see no value in using telemedicine systems, anticipated operational benefits are less likely to be achieved (Ayatollahi, Zahra Poufard Sarabi, & Langarizadeh, 2015; B. Kaplan, 2001; Lorenzi, 2004; Zaliani, Gilani, Nikbin, &

Iranmanesh, 2014) Therefore, understanding how users form this sense of value and how it may change over time is key to ensuring telemedicine is able to provide enduring potential benefits for patients, providers and health administrators.

Overall success in telemedicine begins with adapting systems to the needs of those using them through careful negotiation with complex human factors, including culture changes, stakeholder engagement, as well as slow and considerate implementation processes (Colera, 2013; M. Gagnon et al., 2012). Adapting to the needs of users requires an understanding of how perceptions of value towards systems are formed. Developing this understanding can help ensure successful adoption, longevity and improve the ability of system to positively address local healthcare needs (Broens et al., 2007; M.. Gagnon et al., 2005; Hu, Chau, Liu Sheng, & Yan Tam, 1999; Orruño, Gagnon, Asua, & Abdeljelil, 2011; Wootton et al., 2011). Similarly, failure of users to perceive value in systems can also be a major obstacle to successful implementation and the maintenance of necessary performance standards (Kim, Chan, & Gupta, 2007; Zhang, Cocosila, & Archer, 2010).

However, determining how users form perceptions of value is a complex task with many challenges. The first is defining what is meant by perceived value. The concept of value in the literature is most often defined in economic terms as a balance between benefit and cost. In the case of health care, this relationship is usually framed as the difference between clinical benefits per unit of expenditure (Porter, 2010). However, the fundamental relationship between benefit and cost can be more generally adapted to understanding users' perceptions of value. There are many approaches to doing this. However, Zeithaml (1988) provides the most commonly used definition. According to Zeithaml (1988, p. 14), perceived value is defined as the utility a user attributes to something based on their 'perception of what is received and what is given' as a user. What is received refers to benefits, whereas what is given refers to sacrifices. Further adapting from economic literature, something can be considered to have high value if its benefits are perceived to be greater than its sacrifices, and low value if its sacrifices are greater than its benefits (Bolwell & Khorana, 2016; Pellikka, 2014; Porter, 2010; Zeithaml, 1988).

Value is best understood as a fluid concept that can vary according to different factors. Users may perceive benefits and sacrifices differently at particular time points during their engagement with something. Therefore, any investigation into perceived value must include consideration of how this perception may change over time (Prebensen & Rosengren, 2016; Sànchez, Callarisa, Roríguez, & Moliner, 2006; Zeithaml, 1988).

Finally, once this has been achieved, in order to make use of findings on perceived value, an understanding of the factors that influence this perception must be formed. This requires investigation into the ways in which users judge the relationship between benefits and sacrifices. There may be many factors involved, each related to their experience in different ways. This kind of analysis goes beyond simply citing operational benefits and sacrifices, and instead focuses on how the user goes about forming their own understanding of this relationship (Yang, Yu, Hangjung, & Choi, 2016). This understanding can then be used to improve the way telemedicine systems are designed and supported to optimise users' perceptions of value.

2.4 Examining Users' Perceptions of Value

2.4.1 Examining Perceptions of Value Through Usability Methodologies

There are many ways in which users' perceptions of telemedicine have been assessed. These have included examining user opinions of aspects of design aspects of technology, usage intentions and desired outcomes, as well as overall user satisfaction (Albertazzi, Okimoto, & Ferreira, 2012; Gordon, Hoeber, & Schneider, 2012; Hornbaek, 2006; C. A. Lin, Neafsey, & Strickler, 2009; Petter & Fruhling, 2011; Sangwon, 2013). It is difficult to use any of these approaches to understand perceptions of value. There are two key reasons for this. Firstly, as highlighted above, perceptions of value fundamentally relate to perceived utility. While opinions on design, usage intentions and outcomes and overall satisfaction may yield some useful findings, their link to perceptions of utility is difficult to define. Secondly, as perceived value is a fluid concept, a clear way of tracking changes in value is needed, of which is not clearly provided by these approaches.

Utility, as Zeithaml (1988) defines it, is the subjective measure of the usefulness that results from consumption. Intrinsic within this idea is the notion of having a goal. It follows then that something is useful if it can be used to achieve a predefined goal. Therefore to understand users' perceptions of value towards telemedicine, an approach that factors in goal-orientated ideas is needed. Usability research, an area beginning to become a significant part of the telemedicine literature is one approach that can be clearly linked to perceived utility through goal-orientated ideas. In addition, it can be used to explore perceptions of value as a fluid concept that changes over time.

In contrast to many studies that measure satisfaction or simply ask for users' opinions, usability has a universally agreed upon definition. According to the ISO, usability may be defined as the extent to which a product can enable a user to complete a predefined goal with effectiveness, efficiency and satisfaction (ISO,

2002). The focus on goal-orientated ideas in this definition allows a clear link to Zeithaml's (1998) utility-based definition of perceived value, allowing usability to be an effective approach for measuring perceptions of value.

There is a broad range of ways in which usability can be assessed, including through both quantitative and qualitative methods. Many of the most common methods used, however, do not focus on users' perceptions of a system. For instance, effectiveness is often measured using quantitative measures of performance such as rates of error, spatial accuracy, prevision, ability to recall information presented, completeness and the overall quality of the final outcome of usage. Efficiency measures are also often quantitative. They may include recording the time taken to complete tasks, number of actions required to complete a task, rate of input, mental effort expired during use, frequency of use, amount of information accessed, resources used in communication, users' ability to learn to use the interface as well as the degree of deviation from the optimal usage pattern. Satisfaction can also be examined using quantitative measures through standardised questionnaires or ratings of preferences for versions of a product (Albertazzi et al., 2012; Brooke, 1996; Hornbaek, 2006).

However, there are a small number of effective usability methods that clearly focus on users' perceptions of systems. In particular, questionnaires that measure overall understandings of usability can be quite effective for examining users' perceptions. Furthermore, these methods can be used at multiple time points during the iterative design of new systems to track how perceived usability is changing over time (Bangor, Kortum, & Miller, 2008; Kortum & Bangor, 2012). Through the established relationship between Zeithaml's (1998) definition of perceived value and usability, this kind of method provides a useful way of understanding how users' perceptions of value may change over time.

Usability research also has a strong focus on qualitative methods. These include interviews, observation and representative focus groups for observation during controlled tests or within intended environments. In addition, the 'think aloud' method, which requires users to elicit personal thought processes and feedback during use can also provide useful qualitative data (Hornbaek, 2006; ISO,

2002; Svanœs, Andreas Alsos, & Dahl, 2010). Qualitative methods used alongside quantitative measures provide particularly useful insight into the role of context and personal differences in perceptions of value (Svanœs et al., 2010; Trafton et al., 2010; Young et al., 2011). Qualitative usability methods can therefore also be a useful way of understanding the factors that influence perceptions of value, and the ways in which this can improve how telemedicine technology can be utilised.

2.4.2 Telemedicine Studies with Usability Considerations

It is important to note that there is great variation in how usability research is conducted. Despite the existence of a universal definition, what is meant by usability is largely determined by the ways in which it is measured (Hornbaek, 2006) Therefore, before highlighting which particular usability approaches are most useful for investigating users' perceptions of value towards telemedicine, it is worthwhile demonstrating why some approaches may not be appropriate.

The first problem with a range of usability studies in telemedicine is a lack of reliability and validity in the use of some methods. In one study by Luxton, Mishkind, Crumption, Ayers and Mysliwiec (2012), observations, interviews about past history of technology use and a usability questionnaire that examined ease-of-use, comfort and preferences was used to assess the usability of a smartphone-based m-health remote management system. A 'think aloud' method was also used while the functions of the system were tested. This method, Luxton et al (2012) claimed, allowed them to discover that the quality of the Internet connection and screen size of the m-health device affected usability (Luxton, Mishkind, Crumpton, Ayers, & Mysliwiec, 2012). The validity and reliability of the methods used in this study were not declared. Without this, it is difficult to determine the quality of the relationship between the study's findings and the concept of usability. For the purposes of this thesis, this also makes the results difficult to use to understand perceptions of value.

In another study by Rajput, Mbugua, Amadi, Chepnǵeno, Saleem, Anokwa, Hartung, Borriello, Mamlin, Ndege and Were (2012) the usability of a smartphone record-keeping system for community health workers who provide home-based care

to patients with human immunodeficiency virus (HIV) was analysed. Field-test comparisons, the 'think aloud' technique, semi-structured interviews, group discussions, a cost-analysis and a questionnaire revealed number of design problems. These included that the smartphone's font size was too small and that navigating between the device's functions was not intuitive. Revisions were made and the same methodology was used again to reveal other problems, such as the need for functions that can record if a patient is not home when the health worker arrives (Rajput et al., 2012).

While Rajput et al's (2012) study recognises that usability can change over time; the lack of reliability and validity of their research approach again makes it difficult to determine the relationship between their findings and usability. Hence although it may seem tempting to use these methods as a way of exploring perceptions of value as a fluid concept, without adequate reliability and validity, their use is limited.

Another study by Svanœs, Alsos and Dahl (2010) explored how usability was affected by contextual factors. Svanœs et al (2010) built a handheld EPR system with several alternative user interfaces and a usability laboratory that represented the hospital environment for which the device was designed. A desktop EPR review system was also built in to patients' bedsides for their own access. A usability-focused interview was used to enable doctors and patients to compare the user interfaces and the usability of the entire system. The findings of this interview indicated that using telemedicine can result in patients feeling as if their doctor is paying less attention to them and that screen sizes need to be appropriately large to show full medication lists to patients on their bedside systems (Svanœs et al., 2010). The focus on context and qualitative usability methods may seem like an appealing usability methodology for exploring factors that influence perceptions of value. However, although validity is discussed in the context of having different groups of users assess iterations of a telemedicine system, as in Luxton et al (2013) and Rajput et al's (2012) studies, the lack of declaration about the reliability and validity of the methods used to make conclusions about the usability of the system in the study makes it hard to determine the relationship between its findings and the concept of

usability. Furthermore, this makes it difficult to use such an approach to investigate perceptions of value.

Thus, the analysis of each of these studies highlights the importance of recognising that usability research approaches in general may not be useful for trying to improve understandings of users' perceptions of value. Specific usability methods that are both valid and reliable must be used to achieve meaningful conclusions.

2.4.3 The System Usability Scale and Telemedicine

One of the most well-recognised and popular approaches to measuring usability is the System Usability Scale (SUS), which was developed by Brooke (1996). Brooke (1996) designed the questionnaire as a valid, reliable and easily administered measurement of overall usability. The SUS has 10 items, and can be given immediately after using a system to provide an overall usability score ranging from 0 to 100 (Brooke, 1996).

There are a few reasons why using the SUS is particularly appealing for understanding perceptions of value. Firstly, the SUS is a method that makes the link between usability and perceptions of value, as defined by Zeithaml (1988) easy to understand. The SUS score out of 100 represents a clear index of overall usability. Overall usability incorporates perceptions of utility. Perceptions of value are fundamentally based on perceptions of utility.

Secondly, although in its original design, the meaning of the SUS score was unclear, a number of adjunct scales have been introduced to improve interpretation of overall usability. Bangor et al, (2009) designed a subjective rating scale to allow meaning to be applied to certain ranges of SUS scores. This has been shown to be a reliable method of analysing SUS scores. Bangor et al indicated that the minimum reasonable score usability score is 70. Bangor et al (2009) highlights that products that score between 70 and 80 are better, while those that score above 90 are superior. Products that score below 70 require improvement and should be considered marginal. Products that score below 50 are unacceptable. However,

products scoring above 70 may still encounter challenges when used in the field. The subjective rating scale can be used to track usability changes over time or to compare the usability of multiple systems designed for the same purpose (Bangor, Kortum, & Miller, 2009). Using these ranges can further strengthen the link between SUS scores and perceptions of value. Using Bangor et al's (2009) scale, the higher the SUS score, the higher the perceived value, and vice versa.

Finally, the SUS is also particularly useful for investigating perceptions of value as a fluid concept that may change over time. The SUS can be used at multiple time points during the iterative process of designing a system. This means it can be used to index how usability is changing over time. Through the conceptual link established between the SUS and Zeithaml's (1988) definition of perceived value, the SUS can be used at different time points of when a telemedicine system is being used to track how perceptions of value are changing over time (Bangor et al., 2009; Brooke, 1996).

Furthermore, the SUS has been effectively used in literature that focuses on users' perceptions of telemedicine. Gormley, McGlade, Thomson, McGill and Sun (2011) used the SUS to examine the usability of telemedicine education software for medical students. Free-text comments were also used to capture qualitative feedback. This allowed users to comment on any aspect of the system to help improve design. The software was built to teach and test students' understanding of the daily tasks of primary care physicians. The system received a SUS score average of 88.8. In their free-text comments, users emphasised the value of the user-centric design and how the system enabled them to try making clinical decisions as if they were a real primary care physician (Gormley, McGlade, Thomson, McGill, & Sun, 2011). The SUS score given can be further interpreted by Bangor et al's (2009) adjective rating scale to indicate that the system had high levels of usability. Extrapolating further, this can be used to suggest that users' perceived high value in the telemedicine system.

Fritz, Balhorn, Riek, Breil and Dugas (2012) used the SUS with Bangor et al's (2009) adjective rating scale and semi-structured interviews to examine the usability of a mobile patient questionnaire system. The questionnaire was designed to allow

patients to report on key health outcomes, such as quality of life. The system had a SUS score of 80.34. Using Bangor et al's (2009) scale, Fritz et al (2012) therefore concluded that the system had a high level of usability. Interview data indicated that the perceptions of usability were affected by the layout of information on the interface and the way the record improved the ability of users to access information compared with alternative methods (Fritz, Balhorn, Riek, Breil, & Dugas, 2012). Similar to Gormley et al (2011), the findings of this study can be extrapolated to represent that users' perceived high value in using the system.

Of particular relevance to this thesis, Trafton, Martins, Michel, Lewis, Wang, Combs, Scates, Tu and Goldstein (2010) showed how the SUS, 'think-aloud' and interview methods can be used to compare how usability may change with iterative development of a new system in response to user feedback. Trafton et al (2010) examined the usability of 2 versions of a clinical decision support system over a 3-month period. The first version received a SUS score was 74.00. 'Think aloud' and interview data that were paired with the SUS evaluation suggested that users needed better education on how to use the system and clearer, more succinct organisation of clinical information on the interface. After these changes were made, and the updated version was evaluated, the SUS score rose to 84.00 (Trafton et al., 2010). Extending further from these results, Trafton et al's (2010) study provides important insight into how perceptions of value can change. Their study demonstrates how the SUS can be used to effectively examine how perceptions of value can change over time.

These studies demonstrate how the SUS can be used as an effective index of users' perceptions of value. However, SUS scores alone provide little insight into how users form perceptions of value. An understanding of this is required in order to achieve overall improvements to how telemedicine systems are used. The ways in which this can be done will be discussed in the following section.

2.5 Understanding the Factors that Influence Perceptions of Value

As highlighted at the outset, perceived value is defined as the perceived utility of something according to its ability to provide benefits and requires sacrifices (Zeithaml, 1988). Understanding how a telemedicine user understands the relationship between benefits and sacrifices to form their perception of value requires the addition of another more comprehensive research methodology that allows development of insight to explain quantitative findings. This can be achieved using qualitative research approaches. Qualitative approaches are important for exploring factors that can influence phenomena, but may not be captured by quantitative methods (Black, 1994; Boeije, 2010).

There are multiple ways in which quantitative and qualitative methods can be used together to yield more comprehensive findings than when used alone. A useful approach is to combine questionnaire and interview data. This has been done in a number of previously mentioned studies where SUS scores have been explained using interview findings to develop deeper understandings of users' perceptions of value towards telemedicine systems. In one study by Fritz et al's (2012), interview data was used to explain that physicians gave high SUS scores for a certain telemedicine system because it allowed them to more immediately access important patient information and improve patient care. The link made between SUS scores and interview findings suggests that one of the factors underlying physicians' perceptions of value towards a telemedicine system is their understanding of how well it benefits their access to clinical information. Similarly Trafton et al's (2010) study linked SUS scores with interview data to conclude that time-restricted physicians will be less interested in using a system if it does not make workplace tasks more efficient. This suggests that one of the underlying factors in physicians' perceptions of value is their understanding of its ability to provide the benefit of improved efficiency without significant sacrifice.

The combination of qualitative and quantitative findings in Fritz et al (2012) and Trafton et al's (2010) studies has useful implications for future design, implementation and support of telemedicine systems. For instance, with these findings in mind, systems can be designed with greater emphasis on improving how clinical information is utilised in the workplace. They can be implemented in ways that target making specific tasks more efficient. Support can focus on training users to view clinical information effectively and efficiently to free up time for other workplace demands. Thus, this research shows that quantitative and qualitative methodologies can provide more useful findings in trying to understand how perceptions of value are formed than when either are used alone.

However, despite the potential utility of these existing findings, there is significant room to improve the usefulness of this methodology and enhance understandings of how users form perceptions of value. Neither Fritz et al (2012) or Trafton et al (2010) related their qualitative results to existing theory on the factors that influence technology use and innovation. Theory is an important element of any qualitative study. Theories are ideas that help the researcher to understand, unite and explain phenomena. They are not laws, but rather are integrations of academic, social and cultural elements to help explain findings within a contemporary context (Boeije, 2010; Ezzy, 2002). Without theoretical underpnnings, Fritz et al (2012) and Trafton et al's (2010) findings provide little guidance on improvements to the way telemedicine systems are used other than for specific operational benefits. They do not provide sufficient insight into how perceptions of value have been formed, and how this can be manipulated.

In light of this, the following section will therefore detail the most useful theoretical approaches to explaining the factors that influence the way humans use technology. Each will be related to the specific focus of understanding how perceptions of value towards telemedicine are formed.

2.6 Views on How Users Perceive Technology

To understand the factors that influence users perceptions of value towards telemedicine, theories on how humans use technology use must be considered. Three of the most influential theories on technology use are the Technology Acceptance Model (TAM), Diffusion of Innovation (DOI) and the Task-Technology Fit (TTF) model. TAM, DOI and TTF have been applied to telemedicine in a variety of ways. Although none of these have specifically focused on understanding how users form perceptions of value, each makes mention of a different set of factors that can be related to users' perception of benefits and sacrifices. No single approach can explain all the factors that influence technology use, but when multiple theories are combined together, powerful insights can nonetheless be gained (Goodhue, 1995).

TAM, DOI and TTF each focus on different aspects of the users' experience of technology. TAM focuses on how users come to accept technology, whereas DOI aims to explain how innovations such as technologies are adopted in populations and TTF is used to understand how technology affects performance (Goodhue & Thompson, 1995; Rogers, 2003; Venkatesh & Davis, 2000). I will now provide a critical evaluation of each and how the factors they discuss can be related to understanding how perceptions of value are formed towards telemedicine systems.

2.6.1 Technology Acceptance Model

The Technology Acceptance Model (TAM) is one of the most highly regarded and empirically supported views on the factors that influence users' experiences of technology. TAM is concerned with technology adoption and longevity of use. Applied to the focus of perceptions of value, TAM suggests that the main factors that influence the users' sense of the benefits and sacrifices involved in using

telemedicine are perceived usefulness and perceived ease of use (Venkatesh & Davis, 2000).

TAM is based on the Theory of Reasoned Action (TRA). TRA claims that the performance of behaviours is determined by behavioural intentions. Behavioural intentions are the product of an individual's attitude and the subjective norm concerning the behaviour. Attitude consists of beliefs about the consequences of the behaviour and associated value judgements. Subjective norm refers to one's perception of what people of perceived importance think they should do. All other factors that influence the performance of certain behaviours do so indirectly by influencing either attitude or subjective norm. Behavioural intentions about how to behave are then produced or adapted to certain contexts (Davis, Bagozzi, & Warshaw, 1989; Fishbein & Ajzen, 1975; Hu et al., 1999).

TAM adapts key principles of TRA to explain user acceptance of technology. TAM argues that two beliefs, perceived usefulness and perceived ease of use are the key factors involved in acceptance of technologies. Perceived usefulness refers to the sense of how using technology will increase job performance in a working context. Perceived ease of use refers to the amount of effort the user thinks is required to use the system successfully (Venkatesh & Davis, 2000). Applied to perceptions of value, perceived benefits may therefore be benefits relating to improvements to job performance, while sacrifices may be related to challenges associated with ease of use.

TAM focuses on the relationships between a specific behaviour, its target and context. The behaviour is usage, the target is the technology and the context is the workplace. Building on TRA, TAM claims that behavioural intention is determined by attitude towards using the technology and perceived usefulness. In the workplace, behavioural intentions are mainly concerned with increasing job performance (Venkatesh & Davis, 2000).

Venkatesh and Davis (2000) extended TAM to more closely examine the influence of social factors on usage intentions. They claimed that perceived ease of use and perceived usefulness are strong determinants of usage behaviours over time. Subjective norm, however, initially influences intention to use but it's influence

fades over time. Yet overall, in contexts where use of a certain technology is mandatory, usage intentions are more strongly influenced by subjective norm than perceived usefulness and perceived ease of use. Other factors shown to influence usage intentions include desire to gain status in a working context, degree of relevance to job performance and the extent to which a system produces a demonstrable result (Venkatesh & Davis, 2000). These factors may also be considered as benefits users' use to form their perceptions of value towards a technology.

Venkatesh and Bala (2008) further extended TAM to examine how increasing levels of experience with new systems influences usage behaviours. They claimed that as experience increases, a user's perceived ease of use remains an important determinant of perceived usefulness, but becomes less important for behavioural intention to use the new system (Venkatesh & Bala, 2008).

TAM has been used to examine how telemedicine is used. Hu et al (1999) examined physicians' intention to use telemedicine technologies shortly after they had been implemented in clinical settings. They found that perceived usefulness strongly affected physicians' intention to adopt telemedicine technology. Attitude was also found to significantly affect behavioural intention. However, perceived ease of use had no effect. Hu et al argue that this may represent that physicians are more concerned with how telemedicine can be used to solve problems rather than how easy it is to use (Hu et al., 1999). Problem-solving may therefore be a key benefit involved in the formation of perceptions of value.

Chau and Hu (2002) developed a specific model based on TAM and the Theory of Planned Behaviour (TPB) to explain telemedicine acceptance by physicians. TPB extends TRA by adding that behavioural intentions are also influenced by perceived behavioural control in cases where an individual has no control or resources to complete a task (Ajzen, 1991). Building on these ideas, Chau and Hu (2002) argue that physicians' intentions to use telemedicine are formed from a combination of individual, technological and implementation factors. Individual factors include attitudinal assessment and feeling of control over the technology. Technological factors include perceived usefulness and ease of use. These can also

affect individual factors. Implementation context factors include compatibility and peer influence. Compatibility represents the degree to which a technology is aligned with the tasks of the physician user, and has a particularly strong effect on technology acceptance. Implementation factors can also influence technological context factors (Chau & Hu, 2002).

Chau and Hu (2002) built a questionnaire to test their model. The results allowed them to contribute a set of recommendations about how to facilitate physicians' acceptance of telemedicine technologies. They emphasise the need to develop positive attitudes towards the usefulness of telemedicine systems in potential users. Users should be shown the utility of systems alongside their potential to enhance workplace performance. Emphasis should also be placed on the availability of support. Chau and Hu's (2002) findings also indicate that it is important to focus on optimising the compatibility between telemedicine systems and the tasks of physicians. Abolishing existing practises should be avoided. Telemedicine should be integrated into existing routines (Chau & Hu, 2002). Applied to the concept of perceptions of value, users' understandings of perceived benefits and sacrifices may be shaped by individual, technological and implementation factors. They may be influenced by whether users have positive attitudes, understand workplace utility and have a sense of support in adapting to a new system.

Likewise, Cranen, Huis in't Veld, Ijzerman and Vollenbroek-Hutten (2011) used a questionnaire based on TAM to investigate how users' perceptions of usefulness, ease of use and attitude towards web-based telemedicine services changed over time. Similar to Hu et al (1999), Cranen et al (2011) found that users would accept the technology if their affect towards it was positive, they perceived it as useful and it was easy to learn and implement. In particular, they also found that increasing a user's level of experience could enhance positive affect a new technology. Cranen et al (2011) therefore argued that users should be given plenty of opportunities to gain experience and see how new systems are useful, easy to learn to use and easy to implement to ensure successful adoption (Cranen, Huis in't Veld, Ijzerman, & Vollenbroek-Hutten, 2011). With this in mind, as in the extension

of the findings from Chau and Hu's (2002) study, perceived benefits and sacrifices may relate to underlying attitudes, ease of use and implementation as well as whether users had the opportunity to test new systems.

TAM is a persuasive approach to understanding the ways in which people use technology, particularly telemedicine systems. It has been shown that there are a number of ways in which this theory can be used to help develop and understanding of how users perceive benefits and sacrifices and form perceptions of value. However, it must be noted that TAM is focused on explaining intention to adopt technologies rather than actual usage patterns. The theory aims to predict usage behaviours rather than understand existing behaviours or perceptions of value. There are also a host of other factors that may also influence the way users engage with technology. Therefore, TAM cannot be used alone to develop understandings of how users' perceive value in using telemedicine systems. Further theoretical input is warranted.

2.6.2 Diffusion of Innovation

An alternative to TAM for understanding technology use is Rogers' (2003) Diffusion of Innovation (DOI) theory. DOI is a classic theory originally proposed in 1995 for understanding how humans utilise innovations. The theory has since been revised in 2003, but continues to be influential, and has been applied to examine technology and telemedicine usage patterns.

In contrast to TAM, DOI is focused on explaining patterns of innovation adoption. As technologies such as telemedicine systems are one of the most influential innovations in contemporary, DOI is often used to explain aspects of usage. As in the case of TAM, the principles that underlie the DOI theory can also be extended and applied to understanding the factors that influence users' sense of benefits and sacrifices in the formation of perceptions of value.

Rogers (2003) argues "diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social class". Users' actual adoption and usage patterns of an innovation can be

fundamentally explained by how it can be used in a particular context, the way in which information about it is communicated, the time period in which that information is disseminated and the nature of the social network in which it is being used (Rogers, 2003). Therefore, unlike TAM, DOI can be used to understand perceptions of value towards telemedicine by focusing more on the role of context of use and how this shapes the user's experience.

Rogers (2003) argues that a user's perception of how an innovation can be used in a particular context is influenced by relationships between five factors. These are the innovation's ability to give the user advantage over other methods for the same task ('Relative advantage'), the extent to which it aligns with values, past experiences and needs of users ('Compatibility'), the degree of difficulty in understanding and using it ('Complexity), the extent to which the innovation can be trialled without commitment ('Trialability') and the degree to which results that emerge from use can be observed by others ('Observability'). Rogers (2003) argues that innovations that are high in relative advantage, compatibility, trialability and observability, but low in complexity, will be adopted by a group more quickly than other alternatives (Rogers, 2003). Similarly, it may also be the case that such attributes will allow a system to have significant benefits and limited sacrifices. Thus, these may also influence the formation of perceptions of value.

Communication channels are ways in which knowledge about an innovation is transmitted between individuals in a social context. In the case of using an innovation, communication channels require a new idea, a person with knowledge or experience in using the idea, another person that does not have this knowledge, and a means by which the knowledge can be transmitted between such persons. There are different types of communication channels. One type, interpersonal channels, where individuals share face-to-face knowledge or experience with an innovation are particularly relevant for explaining the use of telemedicine, where technologies need to be adopted by entire multidisciplinary teams for them to be effective. Rogers (2003) argues that most users make the choice to adopt an innovation based their perception of how others who are similar to them have experienced it. This understanding is formed from use of communication channels.

However, importantly, this can also mean that when one individual has knowledge or skill in relation to a new idea that far surpasses that of another person, it can be difficult for the idea to be adopted by an entire group. This can be the case in contexts where group members have vastly differing levels of technological competence, as may be the case in multidisciplinary health care teams (Rogers, 2003). Applied to the concept of perceptions of value, this part of Rogers' (2003) theory suggests that perceived benefits and sacrifices of using a telemedicine system may be influenced by how others perceive them.

Time according to Rogers (2003) concerns the process of moving from knowledge of an innovation to adoption or rejection. The process involves knowledge, persuasion, decisions, implementation and confirmation of completion of the process. Time also includes the concept of innovativeness. Innovativeness refers to the extent to which a person adopts an idea earlier than others. People can be categorised as different types of adopters based on their level of innovativeness. There are five categories. These are innovators, early adopters, early majority, late majority and laggards. Innovators are the first to adopt. They have the highest level of innovativeness and can manage greater degrees of uncertainty about an innovation than others. Early adopters have more innovativeness than the general public, but are not as quick to adopt as innovators. Early adopters are often followed and give momentum to others to adopt a new idea. The early majority may initially be sceptical, and eventually adopt. However, they do not lead others in the adoption process. The late majority adopt new ideas shortly after the average person in a social system. This can be due to peer pressure or a sense of economic need. Laggards are the final group. They tend to decide on the future based on traditional values and what has been done previously. Laggards require very little uncertainty about an idea before they adopt, and may never adopt at all (Rogers, 2003). This part of Rogers' (2003) theory applied to the concept of perceptions of value indicates that understandings of benefits and sacrifices may be influenced by individual characteristics of the user's ability to engage with innovations.

Rogers (2003) explains that the social network in which an innovation is used consists of individuals, groups or organisations that work together to achieve a

common objective. The social system affects how an innovation is adopted through its structure, the presence and ability of members of the system to lead in the adoption process. Adoption in a social system can be lead by an individual, consensus or individuals with some degree of power or influence over others, or a mixture. The consequences of adoption that occur for individuals or groups can also shape whether a new idea is accepted or rejected (Rogers, 2003). This indicates that perceived benefits and sacrifices can be shaped by aspects of the context in which a new telemedicine system is being used.

Some studies have applied Rogers' (2003) DOI to understand usage patterns of telemedicine systems. In one study, Walker and Whetton (2002) used an earlier but similar version of the DOI theory that has been discussed here. Therefore, their focus may seem not to utilise some of the key ideas from the 2003 version. Nonetheless, they still demonstrate how DOI can effectively contribute to understanding how users use telemedicine technology.

Walker and Whetton (2002) focus on the role of the social network in the uptake of telemedicine for remote care between urban and rural providers. They argue that telemedicine offers a relative advantage to rural communities receiving care, but not to the urban communities providing it. Communities providing the care may view telemedicine as requiring cost sacrifices, but not providing direct benefits (Walker and Whetton, 2002).

Walker and Whetton (2002) also highlight that the hierarchies within health social networks create difficulties for telemedicine uptake. Walker and Whetton (2002) claim that the social network for telemedicine use requires the addition of new protocols and for its members to have certain skills in IT. Therefore, health professionals at the top of the hierarchy in the social network who do not have experience with such protocols or IT skills may feel threatened by telemedicine. They are empowered to lead groups to resist adoption (Walker & Whetton, 2002). Extended to the concept of perceptions of value, this suggests that perceived sacrifices can be in the form of giving time and resources to the task of acquiring new knowledge to lead in the use of new systems.

Based on the DOI theory, Walker and Whetton (2002) argue for the importance of trialability and ensuring that users can understand how telemedicine can provide advantages for job performance. They suggest that telemedicine systems must be first trialled in their actual context of intended use in ways that cause minimum disruption to working relationships and structures before adoption is attempted. Systems must also be presented as being critical to optimum job performance in order to encourage participation in training, management of technical problems and overall uptake. Telemedicine systems must also account for individual workplace needs of particular health services, and recognise that each department may have different requirements (Walker & Whetton, 2002). In considering the concept of perceptions of value, this suggests that perceived benefits and sacrifices may be influence a user's sense of how a telemedicine system may impact on job performance and disrupt workplace structures.

Grigsby, Rigby, Hiemstra, House, Olsson and Whitten (2002) used similar aspects of the DOI as Walker and Whetton (2002) to explain divergent patterns of telemedicine adoption. Girgsby et al (2002) argue that for large tertiary urban care centres, investing in telemedicine services may provide relative advantage in the form of allowing providers to conduct more consultations and hence generate more revenue. Providers in smaller rural centres, however, may see the cost of establishing telemedicine services as providing too little of a relative advantage to create a worthwhile investment (Grisby et al., 2002). Applied to the concept of perceptions of value, this emphasises how perceived benefits and sacrifices may be specific to contexts of use. The context of use may shape how aspects of use can be perceived as a benefit in some cases, but a sacrifice in others.

A more recent view proposed by Vuononvirta, Timonen, Kienänen-Kiukaanniemi, Timonen, Ylitalo, Kanste and Taanila, (2011) built on Rogers' (2002) DOI by arguing for greater importance placed on compatibility in understanding telemedicine adoption. Vuononvirta et al analysed interviews of people from varying medical and non-medical backgrounds who were involved in telemedicine projects (Vuononvirta et al., 2011). Analysis of interview transcripts revealed that compatibility signficantly affected telemedicine adoption in three ways. Individual

compatibility was affected by skills with technology, quality of communcation between users using devices and cooperation between members of the healthcare team. Process compatibility was affected by how telemedicine systems altered scheduling of patients and consults, availability of resources and the complexity of selecting the right patients and equipments for telemedicine consultations. Organisational compatibility was affected by the amount of motivation and need for telemedicine services in health workplace contexts (Vuononvirta et al., 2011).

Like Chau and Hu (2002), Vuononvirta et al (2011) also contributed a set of recommendations for facilitating telemedicine acceptance. They argued that optimising compatibility is required for successful telemedicine adoption. This can be achieved by maximising functionality and ease of use. Supplementary devices such as cameras can help improve functionality. Ensuring equipment is readily available can help reduce time commitments and organisational barriers. Making sure that patient medical records can be accessed and edited remotely is also important for optimising compatibility of telemedicine systems (Vuononvirta et al., 2011). Extended to the concept of perceptions of value, this suggests that percieved benefits and sacrifices may be influenced by a sense of the compatibility of the system for individuals, processes and organisations.

A more contemporary study by Olsson, Skovdahl and Engström (2016) used the DOI to explain how persons with mild dementia perceive telemedicine systems. Olsson et al (2016) interviewed patients after they had tested a remote monitoring alarm system. The DOI theory was used to categorise and interpret interview responses.

Using DOI, Olsson et al (2016) found that patients found relative advantage in using remote monitoring device by increasing their sense of safety, while also maintaining autonomy. Through using the system, patients can be monitored for problems related to dementia such as falls, but delay the need for a constant carer. The main issues relating to compatibility were the cost of using telemedicine technology and the degree to which patients were able to decide for themselves if they needed to use it. Furthermore, systems need to be compatible with both the patient and carers who may use it to receive remote monitoring information.

Complexity could be minimised by lowering the responsibility of patients to ensure the system is working. This could be achieved by making aspects of the system either automatic or requiring few commands to be operated. This was particularly important when considering how cognitive decline associated with dementia may challenge patients' ability to operate technology. In exploring trialability, Olsson et al (2016) emphasised the need for users to test new systems to ensure they could find ways of adapting to them by recognising similarities or differences with past experiences with technology. By examining interview data through Rogers' (2003) construct of observability, Olsson et al (2016) showed that users valued the idea of using telemedicine systems partly because of their awareness of how other dementia patients were using it (Olsson, Skovdahl, & Engström, 2016).

Using the constructs of the DOI, Olsson et al (2016) were able to highlight the importance of building telemedicine systems in collaboration with potential users. Extending from these findings, Olsson et al's (2016) use of the DOI theory helps reveal how users' perceive value in telemedicine according to their understanding of its ability to serve their specific purposes. In the case of patients with dementia, telemedicine may be perceived to provide benefits by increasing a sense of safety while maintaining autonomy. To do this, perceived sacrifices in the form of cost, challenges in learning to use new technologies and having no opportunity to test and adapt to them must be avoided. Importantly, however, although these findings are intriguing, they must be considered with caution. Olsson et al's (2016) analysis was conducted using a small sample size and participants were also only able to briefly test the system, rather than using it for a more extended period (Olsson et al., 2016).

These studies that have applied the DOI theory to explain different patterns of telemedicine adoption show the importance of considering characteristics of the usage context. Although, like TAM, DOI aims to explain adoption behaviours rather than users' perceptions of value, a number of its ideas may still be useful. Furthermore, the selection of studies discussed here show how DOI has continued to be influential over the course of telemedicine research. However, it is important to note that many of Rogers' (2003) claims are considered most convincing in understanding voluntary adoption behaviours. Adoption may not always be

voluntary in contexts of telemedicine use. Therefore, DOI cannot be used alone in developing understandings of telemedicine systems. Other theoretical views should be considered alongside DOI to ensure such understandings are appropriately comprehensive and consider the most salient aspects of the user experience of telemedicine.

2.6.3 Task Technology Fit Model

The Task-Technology Fit (TTF) model is another, simpler alternative to TAM and DOI for understanding the factors that influence technology use. TTF argues that users make judgements about technologies according to the strength of the relationships between their intrinsic characteristics and the tasks for which they are designed. Users have been shown to be good at forming well-supported judgements about this relationship in relation to certain technologies (Goodhue & Thompson, 1995). In addition to TAM and DOI, TTF offers another set of factors that may influence perceived benefits, sacrifices and hence overall perceptions of value..

TTF claims that for a technology to be useful to the performance of a task, it must first be actively utilised by its target users. The design and functionality must be appropriate and clearly useful for the completion of a target task. The task-technology fit is a qualitative indicator of the strength of this relationship. A greater fit between a technology and tasks will lead to improved performance by the user (Goodhue & Thompson, 1995). Importantly, unlike TAM and DOI, the TFF model has been demonstrated to be useful in explaining patterns of technology use in contexts where usage is either mandatory or voluntary. Furthermore, it has been shown that users are good at judging the task-technology fit of a new technology (Goodhue, Klein, & March, 2000). Applied to the concept of perceptions of value, the TTF theory suggests that perceived benefits can come from a good task-technology fit and perceived sacrifices in a poor task-technology fit.

There are a small number of studies in the literature that have used the TTF model to convincingly explore factors influencing telemedicine use. Cady and

Finkelstein (2014) used the TTF model to examine observational and interview data on the value of nurses working in outpatient clinics using telemedicine systems to provide remote care for patients at home. When examined in relation to the TTF model, the results showed that the use of visual information to communicate with patients for remote monitoring benefited the delivery of care and enabled the technology to have a strong task-technology fit. The system also helped minimised sacrifice by preventing some patients from travelling long distances for health care. This improved efficiency of the outpatient service, and made for a good task-technology fit (Cady & Finkelstein, 2014). In this instance, it seems that a good task-technology fit provided benefits for both nurses and patients, and such benefits may be used in the formation of a perception of value.

Lin (2014) used the TTF to examine the effectiveness of mobile nurses using m-health technologies to complete daily clinical tasks. She used a questionnaire to examine the fit between nurses' use of m-health technologies and task characteristics. The fit between m-health devices and nurses' individual preferences for technology was also examined. In contrast to Cady and Finkelstein (2014), Lin (2014) found that the fit between device design and individual preference was more likely to predict effective usage than the fit between device design and task characteristics. Her findings suggest that the fit between individual and technology should be given more consideration than technology and task. She argued that emphasis should be placed on optimising ease of use, learnability and training rather than the fit between technical functions and task characteristics (T. Lin, 2014). Applied to the concept of perceptions of value, this suggests that perceived benefits and sacrifices may be more concerned with the fit between individual characteristics and the features of technologies.

Despite the differences in the findings of Cady and Finkelstein (2014) and Lin (2014), both demonstrate the utility of the TTF model in explaining telemedicine usage. Both can also be used to show how the TTF theory can be used to help understand the factors that influence users' perceptions of value. As in the case of TAM and DOI, both studies also highlight how TTF continues to be useful in contemporary telemedicine research. Nonetheless, proponents of the TTF model

emphasise that task-technology fit is only one aspect of the user's experience. It should not be used alone to make global assessments of the value of a system (Goodhue, 1995). Hence, a combination of TAM, DOI and TTF is needed.

2.6.4 Summary and Synthesis of Theories on Technology Use and Their Relationship to Perceptions of Value

The TAM, DOI and TTF each explore a different set of factors that influence how users engage with technologies. TAM focuses primarily on perceived usefulness and perceived ease of use. TAM also recognises the role of social and organisational factors, as well as levels of experience. DOI focuses on how a technology can be used in a particular context; the way information about it is communicated, the time period in which such information is transmitted and the nature of the social network where it is being used. TTF emphasises the role of the strength of the relationship between the technology's functional characteristics and the demands of the tasks for which it has been designed.

Although none of these theories explicitly examine perceptions of value, they have all been applied by telemedicine studies to explain various aspects of usage. When considered in relation to the concept of value, each theory offers a number of factors that may influence how users perceive benefits and sacrifices in using telemedicine systems. Thus, they can be combined and utilised in further research into how perceptions of value are formed.

2.7 Outreach Services and Telemedicine

Outreach services are an example of multidisciplinary healthcare. Multidisciplinary care involves teams of health providers with varying professional backgrounds working together to addresses the maximum number of a patient's manageable needs through a unified, integrated care plan. The team can include many different types of health care providers, such as doctors, nurses and a wide range of allied health professionals. The composition of the team changes synchronously with the needs of the patient over the course of their illness (Bausewein et al., 2012; Jaarsma et al., 2012; Mitchell et al., 2008).

Outreach services consist of nurses, doctors and allied health staff. Short-term, long-term and terminal care is provided for patients in their home environment. Medical staff design and review care plans at the outreach headquarters. Mobile nurses travel from the headquarters to patients' homes to carry out the care plan, and then report back on progress to medical staff (Bausewein et al., 2012; Gjevjon, Romøren, Krøs, & Hellesø, 2013).

Outreach services are associated with a range of benefits to patients and the health system. They can help enable earlier discharge from hospital. They can also delay or prevent admission of frail patients to nursing homes (Bairstow, Ashe, Bairstow, & Lithgo, 1998). Outreach services can also help reduce readmission rates, mortality, cost, as well as improve access and patient satisfaction (Caplan et al., 2012; Gruen, Weeramanthri, Knight, & Bailie, 2003).

However, providing high quality outreach care can be challenging. When using paper-based systems, it can be difficult to accurately communicate a patient's condition to another member of the multidisciplinary team, such as a supervising specialist or doctor (Hong, Kim, Lee, & Kim, 2009). This is particularly important in wound care, which has become an increasingly strong focus of outreach services. In many cases, a written description of a patient with a wound living at home may not be sufficient for the specialist to provide the right treatment directive (Terry et al., 2009). Furthermore, paper-based records systems with multidisciplinary services like

outreach care can be subject to problems such as illegibility, being difficult to search for specific information and only being accessible to one provider at a time (Rodríguez et al., 2009; Wilcox et al., 2005). In addition, time spent recording notes in paper format can prevent optimum efficiency of care. Nurses must record information on paper after seeing a patient, then in many cases return to their health service headquarters and transcribe their written records into a computer database. Being required to perform these tasks can take away from providing enough time for good patient care, particularly providing emotional support for terminal patients (Hong et al., 2009).

Telemedicine systems have the potential to enable outreach services to help manage these problems. In light of this, a small but growing number of studies have begun to investigate how outreach services use telemedicine systems. Although there is yet to be a study that has considered users' perceptions of value, there is nonetheless evidence on benefits associated with using telemedicine systems in outreach care.

2.7.1 The Literature on Telemedicine in Outreach Care

Before discussing the evidence, it is important to note that a large proportion of the literature on telemedicine use in outreach care has focused on how technology can improve the role of mobile nurses as collectors of clinical information. While they may not be the group that benefits most from using telemedicine in terms of having access to high quality information to make clinical decisions, a number of the potential challenges in outreach care outlined above relate specifically to mobile nurses. Hence, the strong focus in the literature on how telemedicine can benefit mobile nurses is appropriate. With this in mind, I will now give an overview of the literature on using telemedicine in outreach care, focusing on the impact on mobile nurses.

Telemedicine systems in outreach services require the use of m-health technologies. Some of the first m-health technologies to be used in contexts similar to outreach services included digital cameras and mobile phones. These were used as adjuncts to paper-based PMRs. Literature indicates that using these devices can

improve the comprehensiveness and accuracy of PMRs by providing objective representation of wound changes. M-health technologies with short messaging services (SMS) can also improve communication between members of outreach healthcare teams (W. A. Kaplan, 2006; Wild et al., 2008). However, there are significant challenges associated with these technologies. Sharing data using digital cameras involves time-consuming processes of downloading and uploading information to a centralized PC server (W. A. Kaplan, 2006; Terry et al., 2009). SMS messages can include a limited amount of content and transmission can be delayed in areas with poor mobile bandwidth (W. A. Kaplan, 2006). Furthermore, studies have not been conducted on users' perceptions of value and how these may influence the way such technologies are used in outreach services.

Over time alternatives designed specifically for developing PMRs in mobile nursing services have emerged. Hong et al, (2009) built and tested note-taking software on personal digital assistants (PDAs) for mobile nurses. The software enabled nurses to complete preformatted digital forms for administering treatments. This helped simplify the recording and organisation of PMRs. Using the PDAs improved productivity of mobile nurses (Hong et al., 2009). However, as users' perceptions of value were not comprehensively assessed, and the duration of the study was less than 6 months, it is unclear if this improvement was enduring or short-term only.

Another study by Hsiao and Chen (2012) examined how mobile nurses' use of m-health technology affected key aspects of information use in clinical environments. They found that using the technologies enhanced nurses' ability to acquire, integrate and interpret clinical information. Hsiao and Chen (2012) also found that m-health improved nursing performance by enhancing the quality of communication between team members and patients, as well as that m-health enhanced efficiency and quality of care. However, the study explored the experiences of mobile nurses who had used m-health technologies for 3 months. There was no consideration of the benefits of using the system beyond this time, leaving open the question of whether they were enduring or only temporary (Hsiao & Chen, 2012).

Similar to Hong et al, (2009), Paré et al, (2009), developed an m-health system for oncology and palliative care outreach mobile nurses on tablets. Each tablet displayed a list of possible treatments for each patient seen in a mobile nurse's daily shift. Treatments could be selected, details planned and their completion recorded in PMRs. The software also made suggestions about future treatment options. On 3 separate occasions over an 18-month period, Paré et al (2009) examined users' satisfaction, perceived quality of care and individual and group productivity using the tablet system. Data was collected using the combination of a questionnaire that was not validated, semi-structured interviews and managerial reports. They found that over 18-months, satisfaction with the system, completeness of nursing notes, number of patients seen and time providing direct care all increased (G. Paré et al., 2009).

Paré et al, (2011) later adapted the tablet software from Paré et al, (2009) for laptops in the same context. The comprehensiveness and accuracy of PMRs improved when compared to the use of conventional methods. Patients also reported feeling that continuity of care among mobile nurses had improved (Guy Paré et al., 2011). However, in Paré et al (2009) and Paré et al's (2011) study, the focus was on user satisfaction and operational benefits gained from using telemedicine. Due to the use of methodologies that were not validated or shown to be reliable, it is difficult to accept these findings as accurately reflecting benefits associated with telemedicine use.

Zhang, Cocosilia and Archer (2010) applied the Technology Acceptance Model 2 (TAM2) to analyse factors affecting mobile nurses' tendency to adopt a PDA m-health system. They highlight that issues such as availability and appropriateness of equipment, access and usage protocols and security are major barriers to achieving the benefits of m-health in nursing practices. Zhang et al found that computer experience had little influence on mobile nurses' perceptions of usefulness, intention to use or sense of status in their workplace organisation. They also found that nurses are willing to use m-health systems if they can perceive it as useful to their job, particularly if the technology is easy to use. Factors that influence this finding included perceptions that important other members of staff feel they

should use the system and a sense that using the system improved the image of their workplace organisation. Zhang et al also found that nurses' intention to adopt a system were not influenced by the importance of using the technology for successful work performance, the quality of information produced by the system or the appearance of the results. However, importantly, similar to other literature mentioned, Zhang et al's (2010) study was conducted over a short time period of less than 1-month with nurses experiencing varying levels of exposure to the system. This makes it difficult to know whether such factors that influence how nurses respond to telemedicine systems are enduring or if they change over time with more regular and consistent exposure to using the system (Zhang et al., 2010).

In a more recent study, Castro, Favela and Garcia-Peña (2014) investigated the effect of using an m-health device on interpersonal aspects of mobile nurses' consultations. Nurses were from an in-home health care service that provided care to older patients. All involved had significant experience with the Internet and mobile phones. One group were assigned to use an m-health device to record information about patients, while the other used traditional paper-based records. Nurses who used the m-health device inputted information into a preformatted recording system that provided care recommendations based on what was recorded. Nurses communicated with patients face-to-face, over the telephone or via videoconference while using either the m-health device or paper-based records. Castro et al (2014) found that overall, when compared to those using paper-based methods, mobile nurses who used an m-health device were able to complete consultations faster, even though the same information and recommendations about care plans were given. This was explained by surmising that it takes less time to seek a nursing protocol when using a preformatted system compared with a paper-based system. However, those who used the m-health system tended to require more steps to reach the same recommendation (Castro, Favela, & Garcia-Peña, 2014)

These studies show that over time, the evidence for benefits associated with outreach mobile nurses using telemedicine is growing. There are is range of operational benefits that appear to be associated with using m-health devices, some

of which can address potential challenges in outreach care outlined earlier. However, there are ways in which the literature could be improved, including extending the duration of studies to all be at least 18-months and the introduction of more rigorous research methods to provide greater confidence in understanding the potential benefits of telemedicine systems.

2.7.2 Outreach Care as a Context to Investigate Users' Perceptions of Value

The focus of this thesis is on how users perceive value in telemedicine systems, not specifically on how mobile nurses such systems can benefit mobile nurses. Indeed, understanding this would require a more extensive research methodology that looks at how perceptions of value change over time and the factors that form them according to all members of the multidisciplinary team, especially those who use the information obtained from telemedicine systems to make clinical decisions.

However, there are a number of reasons why mobile nurses in outreach care are a useful group through which to examine the primary focus of the thesis. Mobile nurses in outreach care have been identified as having the potential to benefit from using telemedicine systems. Thus furthering the understanding of how these benefits can be achieved by understanding how they as a user group perceive value in telemedicine systems can help continue to enhance the literature. In addition, there is room to help strengthen the quality of this evidence by conducting research over longer time periods and introducing more rigorous research methods.

2.8 Summary and Thesis Rationale

This literature review began by outlining the relationship between telemedicine systems, and the growing research into how they can be utilised in response to a number of health care contexts. Following this, an overview was given of current telemedicine literature, and through this it was demonstrated that there is no clear consensus on whether such systems facilitate benefits or costs for patients, providers or health administrators.

There are a number of problems in the literature that may help account for this lack of consensus. Many studies are conducted in contexts where uptake has been incomplete. There is significant variation in methodological approaches used to examine potential benefits. The duration of many studies is also inadequate, and as a result, limited consideration has been given to how benefits and costs of telemedicine systems may change over time.

A key theme running throughout these problems and the studies examined in the literature review is the need for greater focus on how people use telemedicine systems to facilitate the achievement of benefits or the experience of costs. This requires research that goes beyond examining performance-based measures of operational value. Greater consideration of how users themselves form perceptions of value is needed. Indeed, if users themselves do not perceive value in telemedicine systems, they may be less likely to use them in ways that will be of value to health systems.

Understanding how users perceive value in telemedicine system is a complex, but worthwhile task. The development of a sound approach to achieving this addresses some of the problems in the literature that are outlined above. The result of this approach is clear guidance on how to improve the way telemedicine systems are used, and hence greater achievement of benefits for health systems.

There are a number of important components of users' perceptions of value. Two of the most important components will be considered in this thesis. The first is that perceptions of value are not constant. This means that a single isolated

assessment of users' perceptions of value at a particular point in time may be misleading. Perceptions of value can vary over time. Therefore, research question 1 of this thesis is:

1. **How do users' perceptions of value towards telemedicine systems change over time?**

In answering this question, the problems in the telemedicine literature above must be addressed, and the first useful piece of guidance on improving the way telemedicine systems are used can be obtained. Properly assessing perceptions of value requires a context in which telemedicine uptake is complete, as in a mandatory usage context. A robust quantitative methodology that can be used to represent perceptions of value at different time points, such as a usability methodology, is required to clearly examine changes over time. The duration of the investigation must also be carefully considered to ensure enough time is given to detect possible changes.

The second important component of perceptions of value considered in this thesis is the underlying factors that influence them. These factors form the basis of guidance on how to improve the way telemedicine systems are used. There may be a number of factors involved in the users' experience that lead them to a change in their perception of value. These factors must be identified, and their meaning and influence understood in order to improve how telemedicine systems are used. Hence, research question 2 of this thesis is:

2. **What factors influence perceptions of value towards telemedicine systems over time?**

As in the case of answering research question 1, developing a response to research question 2 also requires that some of the existing issues in telemedicine literature be considered. Complete uptake is required to ensure all users gain enough experience with a telemedicine system to form a perception of value, and be

sufficiently engaged with the factors that influence it. A robust qualitative methodology that integrates and builds on broad ideas from other areas of research about how people view and understand technology is needed to determine the nature of the underlying factors. Additionally, as in the case of research question 1, the duration of the study must be long enough to clearly determine how underlying factors may shape changes in perceptions of value over time.

Another important consideration is the context in which this kind of research is conducted. Not all health care contexts are appropriate for the use of telemedicine systems. Thus, this research needs to be carried out in a context where there are clear benefits that can be obtained from such technology. There is a growing amount of literature indicating that significant operational benefits can be gained from using telemedicine in outreach care settings. Outreach care can help decrease mortality, cost and readmission to hospital in a number of patient groups, and so plays a key role in the contemporary health system. Telemedicine research in this context shows that the addition of such technologies can improve productivity, communication and quality of care. However there is limited literature on perceptions of value towards telemedicine in this context. This gap in the literature, and the potential for further growth in the use of telemedicine makes outreach care an appropriate context for this study.

The final output of this research will be a set of clear recommendations on how to improve the way telemedicine systems are used. By following these recommendations, telemedicine systems can enable greater operational benefits to be achieved, and better responses to contemporary health challenges can be developed.

Chapter 3: Research Methods

3.1 Overview

In this section, I will detail the methods I used to answer each research question. These are:

1. **How do perceptions of value towards telemedicine systems change over time?**
2. **What factors that influence perceptions of value towards telemedicine systems over time?**

I will begin by providing justification for my choice of research methods. I will justify the process used to design a new telemedicine system, and my selection of the SUS for measuring changes in perceptions of value over time, and thematic analysis for exploring factors that influence perceptions of value over time. I will also justify why the system was evaluated after it had first been used, and again after 18 months of regular use.

I will outline the outreach care context in which the study was conducted. The focus on mobile nurses as users will be explained. I describe their daily tasks as key members of a multidisciplinary outreach team, and the types of patients seen. I will also explain how their use of the system related back to other members of the team, such as doctors.

Detailed explanation of the procedure of the study will be provided. This section will explain how a new telemedicine system was designed, pilot trialled and evaluated. Minor additions made between evaluations and final additions after the conclusion of the study will also be detailed. Screenshots of interfaces are provided to give insight into the users' experience. These will include screenshots of the testing module that was used to ensure all users had the same experience when evaluating the system. The content of the SUS and interview questions are also included. Justification will also be given for the tools used for data interpretation.

3.2 Justification of Research Approach

This study aimed to investigate users' perceptions of value towards a novel telemedicine system. In order to maximise the usefulness and comprehensiveness of data, a mixed-methods research question-driven approach was used.

Quantitative approaches allow abstract concepts such as users' perceptions of value to be examined through a numerical measurement. Measurement is done through the creation of variables. Variables are constructs that can have two or more values. The variables combined together make up data. Qualitative approaches, however, seek to describe and understand people's interpretation of experiences. The results of qualitative data can help explain deeper processes behind quantitative findings and help guide further research (Jarvis & Drake, 2014; VanderStoep & Johnston, 2009).

3.2.1 Design and Implementation Phases

The process of introducing a new telemedicine system followed two phases: a design phase and an implementation phase. The design phase consisted of a requirement analysis and pilot test. The requirement analysis was designed to explore preliminary needs and expectations of a novel telemedicine system. Across a number of non-structured interviews, a select group of key medical, nursing and administrative stakeholders indicated the requirements. These were adopted into a design plan, which was used to build the system. This approach has been used in previous studies of a similar nature (Hong et al., 2009; G. Paré et al., 2009; Su & Liu, 2012; Wild et al., 2008; Zhang et al., 2010).

As in previous studies, a pilot version of the telemedicine system was developed and trialled (Douglas Evans & Abroms, 2012; G. Paré et al., 2009). Given that the objective of this study was to examine user perceptions in detail, the focus of the pilot trial was simply to ensure that the system was functional and there were no major design flaws before more rigorous evaluations were to take place.

3.2.2 Evaluation Phase Research Question 1: Usability

A usability methodology was used to measure how users' perceptions of value changed over time. As discussed in the literature review, a usability methodology provides a conceptually sound, valid and reliable method of examining users' perceptions of value (Bates et al., 2003; Broens et al., 2007; Hornbaek, 2006).

The first research question of this study was answered using the System Usability Scale (SUS). There were several reasons why this measure was selected. The SUS provides a quantitative measurement of usability that has high reliability ($\alpha = 0.911$) validity over other available methods of assessing perceptions of value (Bangor et al., 2008). Furthermore, the SUS is constructed of 10 short questions, making it easy to administer the unpredictable field-test context of this study. The SUS also provides a single overall score of usability. Scores of different systems can be compared, and the usability of a single system can be tracked over time using iterative testing. This enabled more meaningful comparisons between users' perceptions of value towards the present telemedicine system and alternatives in the literature. It also ensured that perceptions of value could be reliably compared at different time points. Stakeholders can also use SUS scores to easily compare the present system with similar alternatives built for the same purpose. The scale can also be used to track how useful users find the system over time or to examine the impact of any changes made to its design. This method has been used effectively in previous similar studies (Bangor et al., 2008; Brooke, 1996; Trafton et al., 2010).

In addition, in order to determine the meaning of SUS scores, Bangor et al's (2009) adjective rating scale was used. The adjective rating scale is a validated method of categorising and interpreting certain ranges of SUS scores to help determine the level of usability of a system. The scale can be used to clearly and effectively communicate the overall value of the system according to users to stakeholders with minimal research training (Bangor et al., 2008).

3.2.3 Evaluation Phase Research Question 2: Thematic Analysis

Research question two was answered using a qualitative approach. The core focus of qualitative research is to examine for meaning beyond numerical representations. When deciding on which qualitative methodology to use, one must first consider design frameworks that are built using combinations of dimensions. The main dimensions are epistemology, ontology, methodology and methods. Ontology and epistemology are fundamental ideas on reality and the knowledge of agents within reality that drive research focuses. Ontology focuses on the nature of reality, whereas epistemology focuses on the nature of knowledge (Tracy, 2012). These dimensions are not unique to qualitative research, however they play a key role in the researcher understanding the meaning of their data.

Phenomenology is one of the most useful methodologies for understanding the human experience. In a phenomenological approach, the main focus is the participants' perceptions, feelings and lived experiences (Guest, MacQueen, & Namey, 2012). In the phenomenological methodology, the underlying epistemological stance is one of constructivism. Constructivism claims that realities are contextually derived. This means that individuals create their own sense of reality through their interaction with their context, and this can change with time, place or social interaction (Barkway, 2001). The underlying ontological stance in phenomenological methodologies can be rationalistic, which argues that there is one objective reality, or naturalistic, which argues that there are multiple realities which vary according to the interpretation of different agents (Potter, 2009). As this study examined how different users perceived value in telemedicine systems through their lived experience, and considered how factors of this experience within a particular context shaped their perceptions a phenomenological methodology based on these epistemological and ontological stances was utilised.

There are a number of types of phenomenology. These include transcendental, existential and hermeneutic phenomenology. Transcendental phenomenology focuses on trying to achieve a fundamental descriptive depiction of

a phenomenon. Existential phenomenology aims to explore everyday experiences of phenomena, as understood through the consciousness of individual agents. Hermeneutic phenomenology focuses on deriving meaning from individual's perceptions, feelings and lived experiences to determine an underlying objective nature of things (Guest et al., 2012; Kafle, 2011). As this study sought to understand how and why perceptions of value towards a system as part of an experience changed over time, a hermeneutic phenomenological approach was used to understand qualitative data.

There are numerous methods that can be used to collect qualitative data. These include interviews, focus groups or feedback forms. In a hermeneutic phenomenological approach, a strong focus is placed on language. Face-to-face interviews that encourage discussion from open and closed-ended questions provide the ideal method for respondents to give insight into their perceptions of value using their own language. Ideas can be extracted and analysed more effectively than other methods to determine their underlying nature (Guest et al., 2012).

There is also a range of approaches that can be used to analyse qualitative data through a hermeneutic phenomenological methodology. One of the most effective approaches is thematic analysis. Thematic analysis examines data for major patterns. The process of thematic analysis used in this study is as follows:

1. Interview transcripts are ready several times. Researchers write comments and observations.
2. Data is grouped according to codes. Codes are ideas of interest evident in the language of participants. Coding, the process of finding and developing codes is how the researcher makes initial sense of the data and organises it in a meaningful way (Braun & Clarke, 2006; Tuckett, 2005) Codes are reviewed, redeveloped and differentiated by referring back to the data several times. The construction of codes is intentionally influenced by the overriding research question. Multiple reviews of the codes builds sophistication, complexity and explanatory power (Kuckartz, 2014; Willig, 2013).
3. Codes are then grouped into major patterns and given a descriptive label. These are known as themes. This process is iterative and relies on the

researcher consistently referring back to the interview transcript to combine and utilise one's own biases with what was actually said by the interviewee. Themes then act as larger ideas that can link together smaller ones from within the data to create meaning (Braun & Clarke, 2006; Smith, 2008).

4. In the phenomenological methodology, overarching conceptual connections between themes are identified and summarised into superordinate themes. Superordinate themes represent fundamental theoretical and analytical relationships in the data (Pietkiewicz & Smith, 2014; Smith, 2008)

The flexibility of thematic analysis as a method as part of a hermeneutic phenomenological approach makes it ideal for helping to understand the factors that influence perceptions of value towards telemedicine over time (Kuckartz, 2014; Willig, 2013).

3.2.4 Study Duration

It has been recommended that in order to properly understand the value of telemedicine system, particularly in the case of chronic diseases, studies should be conducted over years rather than months (Wootton, 2012). Many of the studies discussed in the literature review were conducted over time periods of less than 1 year. One study on using tablet devices for palliative care mobile nurses demonstrated that users continued to be satisfied over an 18-month period despite no changes being made to the system (G. Paré et al., 2009). However, perceptions of value were not assessed using the comprehensive, valid or reliable methods in this study.

Considering this, the present study was conducted over the same time-period of 18-months. This ensured that users had sufficient time to form and change their perceptions of value towards an entirely novel system. This duration also provided enough time for a greater number of benefits and problems to be recognised than in previous literature, and allowed more meaningful comparisons with similar studies.

3.3 Setting

The setting of this project was the Nepean Outreach Service (NOS). NOS operates within the Nepean Blue Mountains Local Health District (NBMLHD). NOS headquarters are located at Nepean Hospital in Penrith, Australia.

NOS was selected because it is a combined medical nursing multidisciplinary unit with a high number of elderly patients with chronic illness and long-term care needs, as well as a smaller number of acute patients with short-term care needs. The NOS workforce consists of mobile nurses, clinic nurses and medical staff.

Mobile nurses travel from NOS headquarters to see patients in their own homes. Each nurse sees up to 9 or 10 patients in a particular region across the NBMLHD. Nurses provide care to patients determined by medical staff. They also examine and record the patient's progress, then report back to medical staff at headquarters. Medical staff interpret the information recorded by the mobile nurses and make decisions about the current approach, or escalate care if necessary. Clinic nurses work at the NOS headquarters providing infusion treatments and specialised care, such as wound treatment.

A variety of patients use the NOS. Some have been discharged from hospital but require care in the community to enable successful transition back to independent living. These patients have often recently had surgery, and have a wound that requires daily dressings. Other patients using NOS may have chronic conditions requiring regular care, such as diabetic foot ulcers. All patients return to NOS headquarters for a weekly review by medical staff.

Prior to this study, NOS nursing staff recorded patient information and communicated with other staff members using a paper-based PMR system. Nurses would immediately record their observations, actions and recommendations into PMRs after seeing patients in their home. Once all patients in a region had been seen, the nurse would return to the NOS headquarters at Nepean Hospital. PMRs would then be physically stored away until the following day. Medical staff also use PMRs when patients are seen at NOS headquarters for patient progress reviews.

3.4 Procedure

The procedure of the study had 3 phases. In Phase 1: Design, a novel telemedicine system was built for NOS. In Phase 2: Initial Evaluation and Implementation, each user evaluated the system after their first use. Phase 2 also involved the process of implementing the system for regular use by all NOS staff. In Phase 3: Review After 18-months of Regular Use, the same methods as in Phase 2 were used to re-evaluate users' perceptions of the system after consistent use over an 18-month period. I will now provide the details of each phase in the procedure.

3.4.1 Phase 1: Design

3.4.1.1 Participants

The design phase involved 2 senior doctors (1 female), 2 nurses (Both female) stationed at NOS headquarters and 2 mobile nurses (Both female) as well as 2 administrative staff (1 female). These participants were selected to ensure that all major stakeholder groups involved in the project were adequately represented and had the opportunity to contribute to the design of the system.

3.4.1.2 Requirement Analysis

Based on similar previous literature (Hong et al., 2009; G. Paré et al., 2009; Su & Liu, 2012; Wild et al., 2008; Zhang et al., 2010) a requirement analysis was conducted prior to designing the telemedicine system. There were 3 steps to this:

1. Nursing routines were observed to determine the roles of each member of the NOS team. This helped determine how information about patients was

collected and the ways in which nurses would benefit most in using a telemedicine system.

2. Documents from the paper-based PMRs were examined to influence the design and layout of the new telemedicine system, including the type of information that needed to be recorded when seeing patients.
3. A total of 3 non-structured interviews were conducted with NOS medical, nursing and administrative staff as potential users to discuss the different needs of stakeholder groups, and how they could be met by nurses using a telemedicine system.

The requirement analysis helped reveal the normal structure and routines of the NOS workforce before the implementation of the telemedicine system. Approximately 10 mobile nurses begin their shift at the NOS headquarters at Nepean Hospital at the same time. They are assigned to different parts of the NBMLHD community to provide care to groups of patients living in close proximity to one another. They then manually select the paper PMRs at the Outreach clinic. Each nurse leaves the Outreach clinic to treat a unique group of patients. They return at approximately 12:00pm. They then type up their handwritten notes from PMRs onto the hospital database system. The PMRs are stored for the next nurse the following morning.

Clinic nurses treat patients who are either receiving periodic day treatments such as infusions, or who are attending a scheduled weekly visit to have their care plans reviewed with medical and nursing staff.

Medical staff work daily to adjust treatment programs or initiate escalation strategies for patients who are attending their weekly review. Medical staff access patient information in both the hospital database system and written records. Both are required to make clinical decisions.

The typical care trajectory for a patient referred to NOS begins with the design of a care plan by medical staff at NOS headquarters on or shortly after discharge. The patient moves back to their home under the guidance of NOS nursing staff. They are then seen in their homes by nursing staff on a regular basis, typically

daily. The patient returns to NOS headquarters for weekly reviews by medical staff. These consist of a progress check and a decision about whether escalation of care is needed.

The extent of travelling required for NOS nurses to attend to patients in the NBMLHD is shown in Figure 1. The farthest point of travel is Blackheath. This journey takes approximately 1-hour by car.

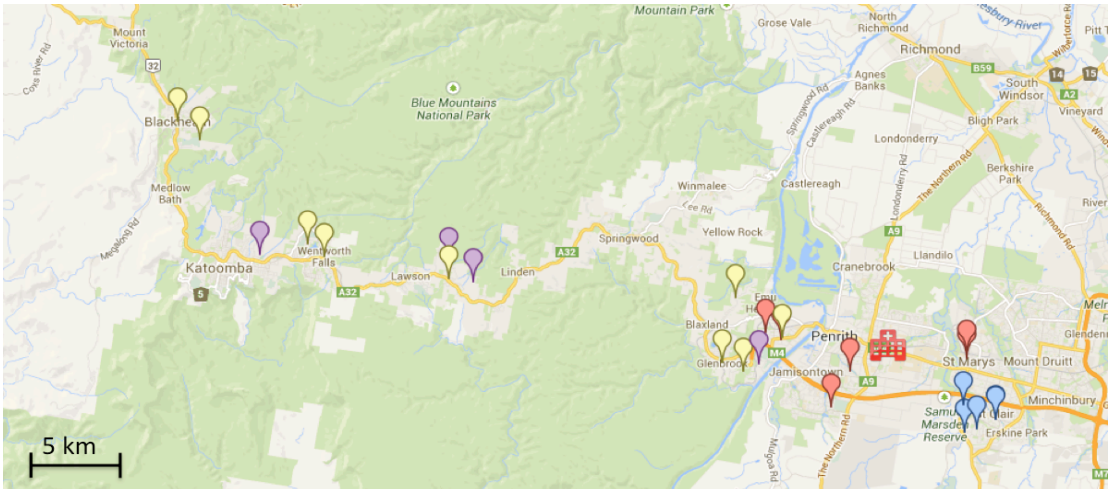

Figure 1. A map of typical mobile nursing routines. The red hospital building represents the Nepean Hospital Outreach (NOS) headquarters. Each set of coloured pins represents the locations of patients' who live within a daily regional route taken by NOS mobile nurses.

Analysis of mobile nursing records revealed a simple PMR system. Nurses handwrite notes on each patient in individual PMRs. Notes consist of the nurses' observations, actions and recommendations. Notes are signed with the author's name and the date of when the patient was seen. The same sets of notes are used by doctors for weekly reviews at NOS headquarters. Figure 3 shows a typical mobile nursing record in a PMR.

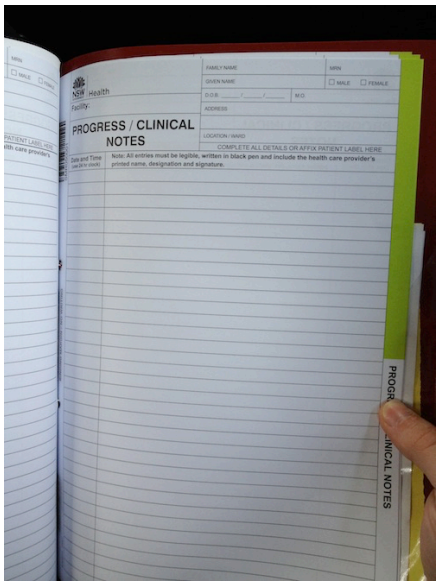

Figure 2. A blank PMR showing the space used to record notes on a NOS patient.

3.4.1.3 Requirement Analysis Outcomes

The requirement analysis revealed a number of design and implementation requirements. The system needed to feature a mobile device that was lighter and easier to transport than the existing paper-based system. It also needed to have high levels of security to ensure patient confidentiality could not be compromised if PMRs were hacked or devices stolen.

The system required a note-taking, imaging and videoconferencing system. The note-taking function would replace the paper-based system, and allow all NOS staff to record and review notes in electronic format on demand. This would help improve the accessibility of patient information. The imaging function would be used to photograph patients' wounds. This would help improve the accuracy and comprehensiveness of wound records. The videoconferencing function would allow mobile nurses to contact each other or medical staff at NOS headquarters for advice if needed. The video would allow the receiver of the call to make an assessment of the situation before providing advice.

3.4.1.4 Pilot Design

Findings from the requirement analysis guided the design of a simple Apple iPad app to replace the paper-based NOS PMR system. The app recorded electronic PMRs for each patient seen by the NOS mobile nurses. The app had three key functions. These were a 'Patient Notes' function for note taking, a 'Camera' function for wound imaging and a 'Video Call' function for videoconferencing. PMRs were stored in a desktop database.

The system was designed so that each nurse had an individual iPad with the app installed. At the beginning of each shift, electronic PMRs for the patients being seen by each nurse during a given shift were loaded from the storage desktop computer onto individual iPads. To access a patient's PMR on the iPad, users selected the patient's name from a list in the patient selection screen. The patient selection screen can be seen in Figure 3.

Figure 3. A screen shot showing a list of dummy patients for the pilot trial. Uses can touch the patient name to access the patient's PMR.

Once a patient's PMR was selected, the user would be taken to that particular patient's PMR home screen. The home screen displayed tile icons for users to access the patient's notes, wound images or the videoconference function. The user could return to the PMR selection screen by selecting the 'Patient' icon in the top left corner of the home screen. The PMR home screen can be seen in Figure 4.

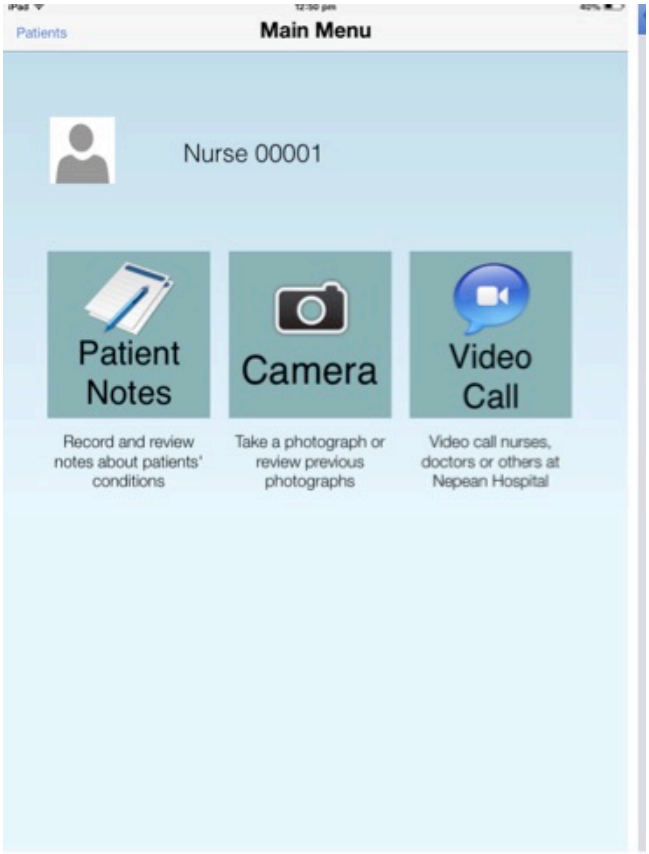

Figure 4. A screenshot of the interface of a dummy patient's PMR screen. The patient's name is displayed in the top half of the screen ('Nurse 00001' in this case), and the tiles for access to the functions displayed below.

The 'Patient Notes' function was built to enable users to review time stamped notes in lists at the same time as creating new notes. The interface of the patient notes function can be seen in Figure 5.

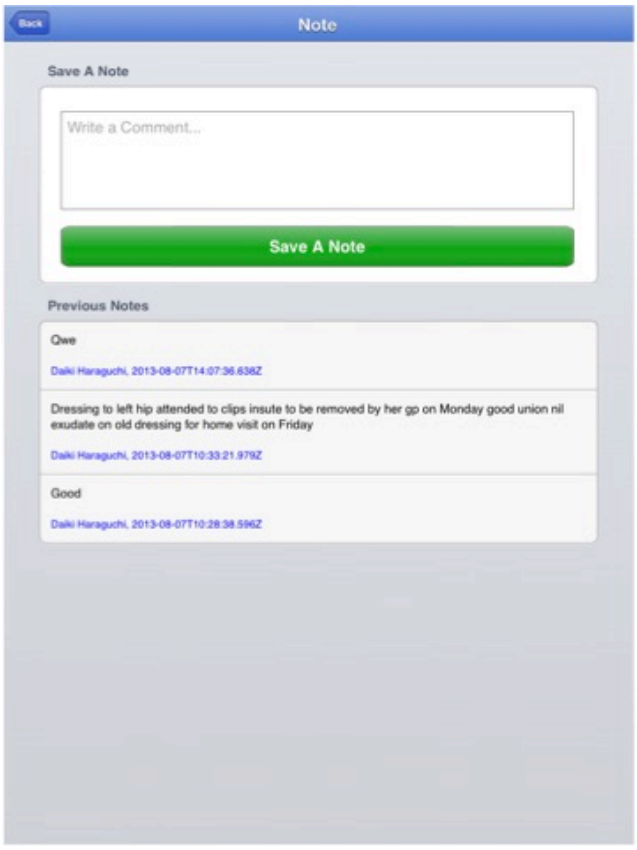

Figure 5. A screenshot of the patient notes interface. Users record patient information in the Save A Note box, press the green Save A Note bar, and the note would be added to the patient's PMR, as shown.

The 'Camera' function was built to allow users to review time stamped images of wounds. Figure 6 shows the screen where users could do this, as well as turn on the camera to photograph a wound.

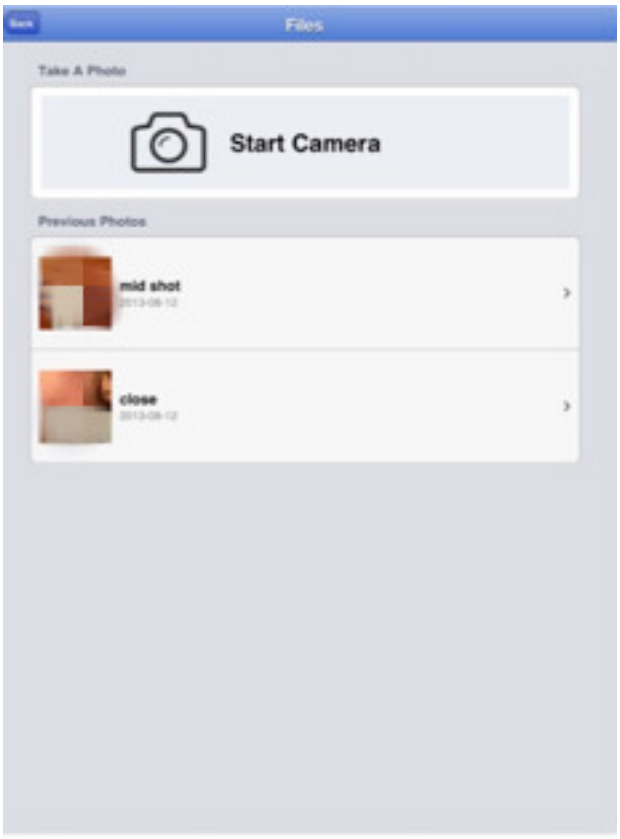

Figure 6. A screen shot of the interface for reviewing previous images of wounds. The user can touch an image to view it in full-screen mode. They can also select 'Start Camera' to capture more images and add them to the patient's PMR, as shown.

The 'Video Call' function was built to allow users to videoconference from each other or medical staff for guidance on assessing a patient. When selected, the video call function took users to a contact selection screen. Images of possible call recipients were shown. Users would tap the image of a recipient to initiate a videoconference call. This screen is shown in Figure 7. Selecting a recipient would activate the videoconferencing program Skype, and the call would be automatically initiated. At the conclusion of the call, users would then close Skype and reopen the PMR app.

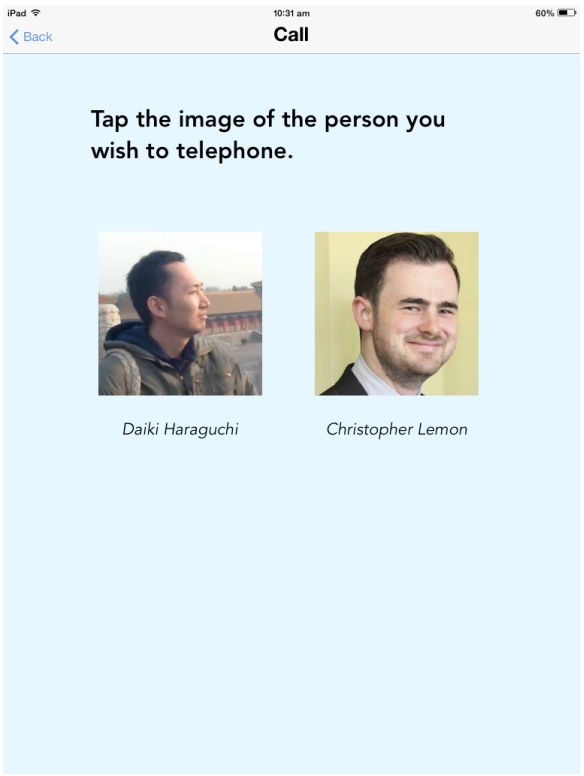

Figure 7. A screen shot of the contact selection screen with two contact images. Selecting a contact automatically initiates a videoconference call via Skype.

The app was developed on an iPad 2 with iOS6 installed. This device was selected because of its superior large screen size, which was ideal for evaluating the progress of wounds. A 3G mobile network provided Internet access.

3.4.1.5 Pilot NOS App Test

The pilot version of the NOS app was tested to determine if it met baseline functionality requirements. The test was guided by usability research. Usability research indicated that new products are best assessed in contexts that represent their area of intended use (ISO, 2002; Svanœs et al., 2010). Therefore, the NOS app was field tested by 2 mobile nurses across a single shift.

Nurses were supervised and guided on how to operate the app by experimenters. Previous research was used to train users in how to use the camera function. Each wound was photographed using one close-up to show details and one

mid-shot to allow comparison of healing tissue with surrounding healthy tissue. Nurses were told to position the device parallel to the wound. Maximum natural lighting was used. A white paper ruler was positioned adjacent to the wound as a calibration marker, and to indicate true size, ensuring any user reviewing the image could accurately assess the wound (Bradshaw, Gergar, & Holko, 2011; Buckley, Adelson, & Hess, 2005; W. A. Kaplan, 2006; Rennert, Golinko, Kaplan, Flattau, & Brem, 2009).

On seeing a patient, nurses first captured images if wounds were present. They recorded a comment about characteristic features; such as changes in size since last their last visit. Nurses then recorded notes about the patient's condition.

Both nurses were able to use the camera function to capture images that were of satisfactory quality for evaluation of wound progress. Nurses were also able to successfully use the patient notes function to record all necessary information about their patients' progress.

Use of the app increased the accuracy and comprehensiveness of PMRs. The use of images increased the ability of nurses to accurately assess the status of wounds. In addition, wound status was initially recorded in handwritten notes, and was determined based individuals' own interpretation. Differences in individual interpretation may lead to inconsistent understandings of a patient's condition and compromise the quality of patient care. The use of images helped prevent this. Furthermore, the combination of images and notes allowed nurses and medical staff at NOS headquarters to more comprehensively assess patients' progress.

3.4.1.6 Final App Design

After the pilot trial, observations and informal feedback from users guided a number of revisions. It was realised that some users may forget to take a mid and close-up shot of each wound. Therefore, the camera function now included a forcing function. This meant that every time the camera was opened, the user was forced to take a close-up followed by a mid-shot. It was also recognised that users may wish to retake images once captured. Thus, after each shot, the user was now required to

judge whether the image was acceptable for the patient's PMR. Users were also able to select and annotate a previously captured image. Figure 8 shows a user annotating a previous image captured by the app.

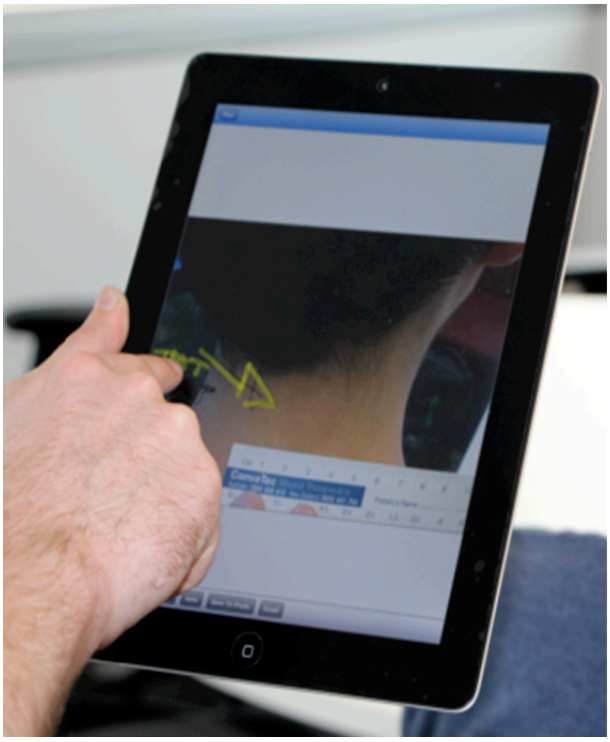

Figure 8. A user using the drawing function to draw an arrow on an image of the back of a patient's neck, which was captured using the app.

In addition, when users record notes or images, Global Positioning System (GPS) data was included to show the location of where the information was entered into the PMR. Each user was also assigned an individual account. Users needed to login before using the app and loading on PMRs. This meant that the author of notes or images could be identified. This can help when other users need clarification about data recorded in PMRs.

Security measures were considered. The app was given three levels of security. When turning on the iPad, users were prompted to type a 4 number passcode. Passcodes were different for each iPad. Each account was also protected by username and password. The 'Find my iPad' function was also activated, allowing the device to be located if misplaced or stolen.

3.4.2 Phase 2: Initial Evaluation and Implementation

3.4.2.1 Participants

The evaluation phase involved 10 mobile nurses (Mean age = 44.4 years-old, *SD* = 13.13 years, 1 male) with a mean of 3.05 years (*SD* = 2.31) of experience with similar technology. Participants were selected based on the fact that they were employed by NOS and would be potentially using the system in future. This approach has been used in previous similar studies (G. Paré et al., 2009; Guy Paré et al., 2011) The sample size was sufficient for the purposes of a usability study. Nielsen has shown that only 5 users are needed to uncover the majority of usability problems with a system, with higher numbers of users helping to uncover more problems (Nielsen & Landauer, 1993). This number of users was also the total number of nurses working at NOS, allowing all future potential users to provide their perceptions of value.

3.4.2.2 Testing Module

For the purposes of evaluation, the iPad app included a testing module. The testing module ensured that all users tested the same functions in the same order.

Tapping three times on the screen activated the testing module. The app then guided users through each of the three functions. The user was first welcomed to the testing module. They were then instructed to try using the camera to take images of wounds.

On tapping ‘Next’, the user was shown the main screen and was required to open the camera function and initiate using the camera. The user would progress to testing the next function when a close-up and mid-shot had been successfully recorded into the patient’s record. The user was then shown a feedback screen, where the record in the list was highlighted to demonstrate how it was now a part of the patient’s PMR.

Once the camera function was successfully used, the user was automatically prompted to test the app's patient notes function. On tapping 'Next', the user was taken back to the main screen and was required to open the patient notes function and record clinical notes. When a note was successfully recorded, the user was shown how the record was displayed in the patient's PMR, as in the testing of the camera function.

Once the patient notes function was successfully used, the user was automatically prompted to test the app's video call function. On tapping 'Next', the user was taken back to the main screen and was required to establish a videoconference call through one of two demonstration contacts. The user was instructed to select either contact. For the purposes of the training module, the contacts were the supervising experimenters. The user was then automatically taken to the Skype app and a videoconference call was established. The experimenter took the videoconference call. Skype was initially used as a videoconferencing solution for the trial only. Screenshots of the testing module can be seen in Figure 9.

On ending the videoconference call, the user was instructed by the experimenter on how to manually leave the Skype app and re-enter the NOS app. On re-entering the NOS App, the user was informed that the training module was complete, and was asked to await further instructions from the experimenter.

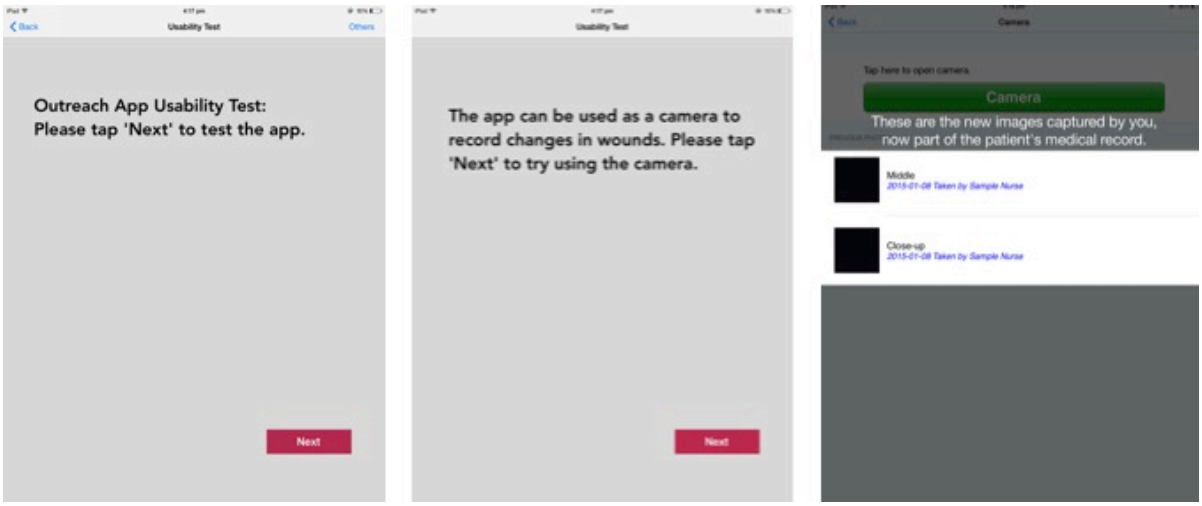

Figure 9. Screenshots of the testing module design, showing the initial welcome screen, first instruction screen and feedback screen when users successfully used the camera function.

3.4.2.3 Usability Test 1

A usability approach was adopted to evaluate the NOS app. The usability test ran for two weeks. Each day, one mobile nurse in the Outreach team would record all patient information collected during their shift using the testing module on the NOS app. Two researchers supervised the nurse. At the beginning of the day the nurse would be randomly selected and informed about the usability test. They would be informed of the requirements of the test and their consent was obtained.

The age, gender and years of experience with similar technology was recorded for each participant by the researcher asking them. These have been recognised in the literature as the most significant characteristics of individuals that influence how they interact with technology (Czaja et al., 2006; Jung, Chan-Olmsted, Park, & Kim, 2011)

After seeing each patient, the nurse would tap 3 times on the screen of the iPad and complete the testing module. Researchers would supervise the nurse to clarify instructions or manage technical problems, if needed.

Nurses were asked to complete a version of the SUS at the conclusion of their shift. The SUS assessed overall usability of the system. Some of the language in the SUS was modified. The word ‘product’ was changed to ‘application’ to ensure the target of evaluation was clear. The modified SUS can be viewed in Table 1. Responses were recorded on a 5-point Likert scale, ranging from ‘Strongly Disagree’ to ‘Strongly Agree’. A SUS score out of 100 was produced to represent overall usability.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I think that I would like to use this application frequently					
I found the application unnecessarily complex					
I thought that the application was easy to use					
I think that I would need the support of a technical person to be able to use this application					
I found the various functions in the application were well integrated.					
I thought there was too much inconsistency in this application.					
I imagine that most people would learn to use this application very quickly.					
I found the application very awkward to use.					
I felt very confident using the application.					
I needed to learn a lot of things before I could get going with this application					

Table 1. Modified SUS

SUS scores were interpreted using Bangor et al's (2009) adjective rating scale. This scale has been shown to be a robust method of interpreting SUS scores, and continues to be used in contemporary telemedicine studies (Bangor et al., 2008, 2009; Georgsson & Staggers, 2016) The relationship between SUS scores and Bangor et al's adjective rating scale can be seen in Figure 10.

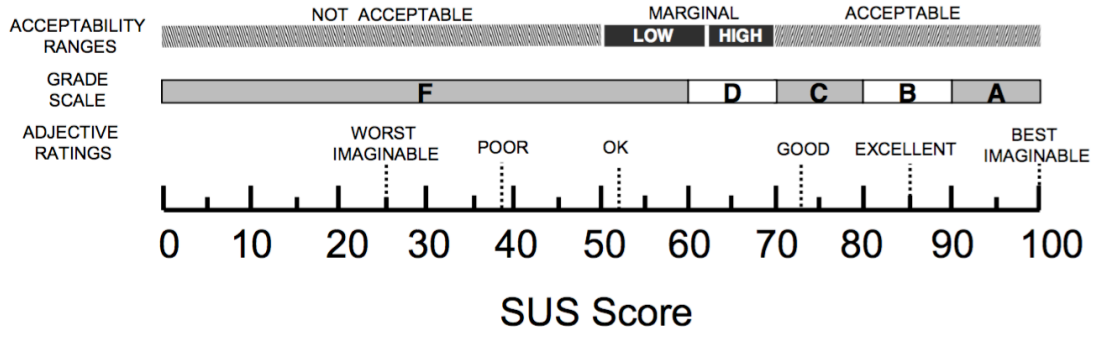

Figure 10. Bangor et al's (2009) SUS adjective rating scale

Overall SUS means after first use and after 18-months of consistent use were compared using a Student's *t*-test, as has been conducted in similar previous literature (Arbi, Ober, & Ober, 2013). Means for individual SUS statements were compared over time using the Wilcoxon rank sum test. This is an effective nonparametric approach to examining for statistical significance for scales that use magnitude-based ranks, as is the case with the SUS (Haynes, 2013). This test has been used in previous studies to examine for significant differences in individual SUS questions on over two testing occasions (Kumar, Kim, Bi, Fulham, & Feng, 2013)

3.4.2.4 Interview

On completion of the SUS, the nurse was asked by the researcher to complete a short structured interview. The interview questions were adopted from the SUS. This allowed responses to be linked to SUS scores to explain underlying factors that influenced perceptions of value. Similar approaches have been used in previous studies (Fritz et al., 2012). Although some closed questions needed to be included due to the nature of the questions in the SUS, these were merely used to

ensure the link between the content of the questionnaire and the interview questions was clear for participants. Subsequent discussion after such questions ensured answers to these questions were adequately explained. Nurses were asked to evaluate what made the app most usable, least usable and how it could be improved. They were also asked what they thought they would do if the app were to malfunction while they were using it during a mobile nursing shift, and if they would use a troubleshooting manual. Interview questions are shown in Table 2. The interviews were recorded and transcribed. Each interview lasted approximately 5 minutes.

What experience have you had with technology similar to this?
What made the app most usable?
Did you find it complex?
If you were using the app regularly, how would it change the quality of care that's given by Outreach?
What made the app least usable?
If you were using the app regularly, and it malfunctioned while you were on the road, what would you do? If given a troubleshooting manual, would you try to fix it?
How can the app be improved?
Were the functions a good substitute for normal nursing routines?
Would it be easy for someone to learn to use it?
Overall, were you satisfied?

Table 2. Interview questions asked following completion of the SUS.

Interviews were recorded and transcribed verbatim onto a transcript. Two researchers reviewed the transcript several times. Thematic analysis was used to analyse the data. Codes, themes and superordinate themes were developed with the intention of developing an understanding of the underlying factors influencing users' perceptions of value towards the telemedicine system.

3.4.2.5 Minor Revisions to the App After Initial Testing

After the conclusion of the initial evaluation, the NOS app underwent minor revisions. The testing module was removed to enable normal use. A call monitoring function was added to the videoconferencing function. This allowed the caller to record the length of the call and whether the receiver was medical or nursing staff at NOS. Skype was also replaced with the app Vidyo and Cisco 'AnyConnect' to enable a more secure connection between the users outside NOS headquarters. A dongle was

added to the iPad to allow connection to Nepean hospital's secure network away from hospital grounds.

A simple desktop computer database was added for storage of PMRs at NOS headquarters. The database was based on the content of the paper-based PMRs. At the end of each use, the iPad was connected to a desktop computer at NOS headquarters via USB, and the information downloaded and stored. The database displayed the name, date of birth, Nepean Hospital medical record number (MRN) and location of the patient. The interface of the database can be seen in Figure 11.

In addition, a number of small programming problems were also fixed as they arose. These included minor bugs that caused the system to unexpectedly crash.

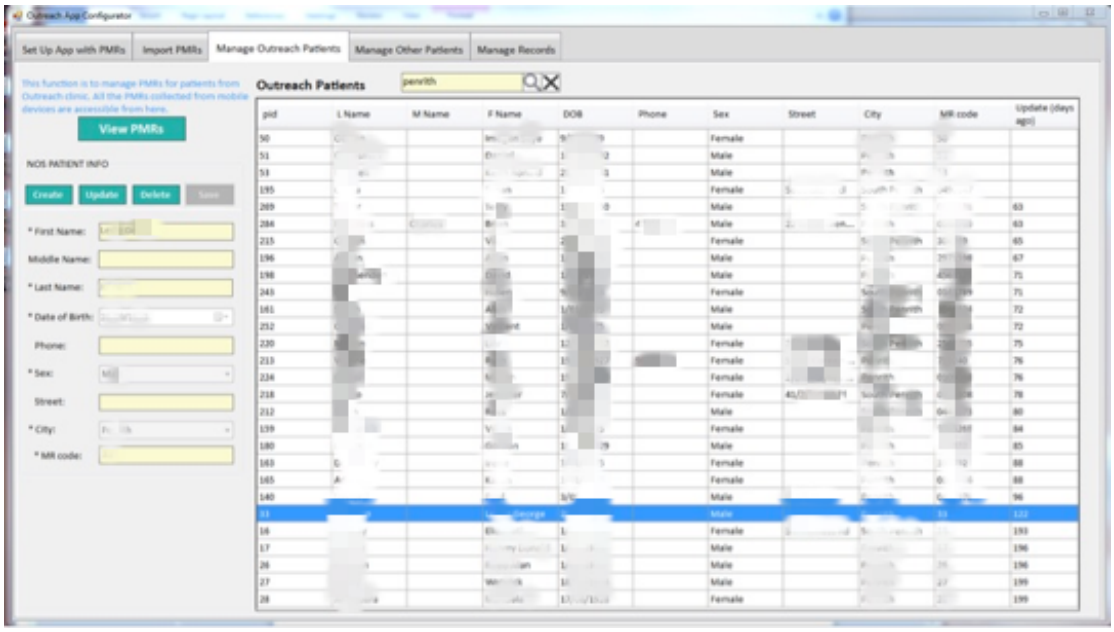

Figure 11. A screenshot of the database home screen for selecting and viewing PMRs. The panel on the left of the screen could be used to search and view PMRs in full-screen mode.

NOS staff were able to review patients' PMRs, including both notes and images on the desktop computer at NOS headquarters. When selected, all notes and images associated with the patient could be reviewed as part of one integrated PMR.

In addition, over the 18-month period where nurses were using the system consistently, a small number of minor updates were made to the system to ensure it could remain functional to a satisfactory level.

3.4.2.6 Independence Test

Once the database was installed on a desktop computer in NOS, nurses were trained in how to connect and sync data between the devices. They were then asked to use the app and database system independently, without supervision from experimenters. As there have been no major faults since the time of testing, they have continued to use the system since this time.

To ensure clinical staff remained optimistic and enthusiastic about using the system, clinical champions were appointed. One Nursing Unit Manager (NUM) was appointed as the clinical champion for nurses. This nurse was trained in how to manage minor problems with the NOS app before technical assistance is required. She was also appointed to help others to learn how to use the system. A clinical champion was also appointed for medical staff. The doctor carried out the same role as the Nursing Unit Manager (NUM), except focused on guiding other doctors in how to access PMR information on the desktop computer.

3.4.3 Phase 3: Review after 18 Months of Regular Use

3.4.3.1 Participants

The review phase involved 8 mobile nurses (Mean age = 48.5 years-old, SD = 13.3 years, 1 male) with a mean of 5.43 years (*SD* = 2.92 years) of experience with similar technologies who also participated in the initial evaluation, as 2 of the original mobile nurses were unavailable and therefore unable to participate.

3.4.3.2 Usability Test 2 and Interview 2

After 18-months of daily use, the system was re-evaluated using the same methods as Phase 2. Consent was obtained at the NOS headquarters. Nurses and doctors completed the same version of the SUS during one of their shifts. Immediately after completing the questionnaire, each user was interviewed using the same interview questions as in Phase 2. Responses were analysed and compared with initial evaluation data. Comparison of SUS scores to measure how usability is changing over time has been performed in previous literature (Bangor et al., 2008).

Chapter 4: Research Question 1

Results and Discussion

4.1 Overview

In this chapter, I will set out the findings from research question 1. In chapter 2, I highlighted how perceptions of value may be intrinsically variable with time. I argued that a usability approach, specifically the SUS was the most effective way of assessing how perceptions of value towards a telemedicine system may change with time. This lead to the development of the first research question of this thesis:

1. **How do perceptions of value towards telemedicine systems change over time?**

In chapter 3, I explained how research question 1 would be answered by having outreach mobile nurses complete the SUS after their first use of a new telemedicine system, and again after 18 months of regular use. I applied Bangor et al's (2009) adjective rating scale to interpret the meaning of SUS scores.

I will first detail the analysis and comparison of overall SUS scores after initial use, and after 18 months of regular use. The main finding from this analysis was that SUS scores significantly declined over time. This suggests that users' perceived less value in using the system over time.

I will then detail the comparison of individual SUS states after initial use, and after 18 months of regular use. The findings of this analysis were that over time users had a lower desire to use the system frequently. They found it more complex, and felt that the functions were not as well integrated. They agreed more strongly that there was too much inconsistency in the system.

I then discuss the implications of these findings in relation to previous literature on telemedicine in outreach mobile nursing and telemedicine, more generally. In considering outreach mobile nursing literature, these findings highlight the need for more research into the relationship between satisfaction, operational value and perceived value. More generally, these findings stress the importance of regularly assessing and responding to changes in perceptions of value over time.

4.2 Usability Results

4.2.1 Initial Use and 18-month Review SUS Scores

On first use, the SUS mean was 84.69 (*SD* = 9.01). Users saw an average of 4.9 patients (*SD* = 1.37). Using Bangor et al's (2009) method of SUS analysis, on initial use, the system could be considered to have 'Excellent' usability. This indicates that the system has a level of usability that is acceptable for field use (Bangor et al., 2008).

After 18 months of daily use, the SUS mean was 64 (*SD* = 14.25). A student's *t*-test revealed that this change was significant ($p < 0.05$, 95% CI). Using Bangor et al's (2009) adjective rating scale, the system could be considered to have 'OK' usability. Bangor et al (2009) indicate that scores below 70 have marginal acceptability for field use, while those below 50 are unacceptable. After 18 months of use, the system could be considered to be marginally acceptable. According to Bangor et al's (2009) scale, this means that the system required further usability assessment and that ongoing improvement was needed for it to be acceptable for field use.

Mean responses and standard deviations to individual SUS statements at the end of initial use and after 18 months of daily use can be seen in Table 4. The effects of age, gender and years of experience with similar technologies on SUS results were also considered. However, the small sample size prevented any effects from being detected.

4.2.2 Comparison of First and Second Phase Evaluations

The Wilcoxon rank-sum test was used to compare differences between users responses to individual SUS statements after initial use with those after 18 months

of daily use. Users had significantly lower desire to use the system frequently after first use than after 18 months of regular use ($p < 0.05$, 95% CI). Users also found the system to be significantly more complex after 18 months of regular use ($p < 0.05$, 95% CI). Users felt that the functions of the system were not as well integrated after 18 months of use than after initial use ($p < 0.05$, 95% CI). Users showed higher levels of agreement with the idea that there was too much inconsistency in the system after 18 months of use compared with levels of agreement after initial use ($p < 0.05$, 95% CI). These results are summarised in Figure 13. Note that Brooke (1996) does not provide definitions for complexity, integration of functions or inconsistency in the original paper on SUS. The meaning of these terms will be further explored in the qualitative analysis.

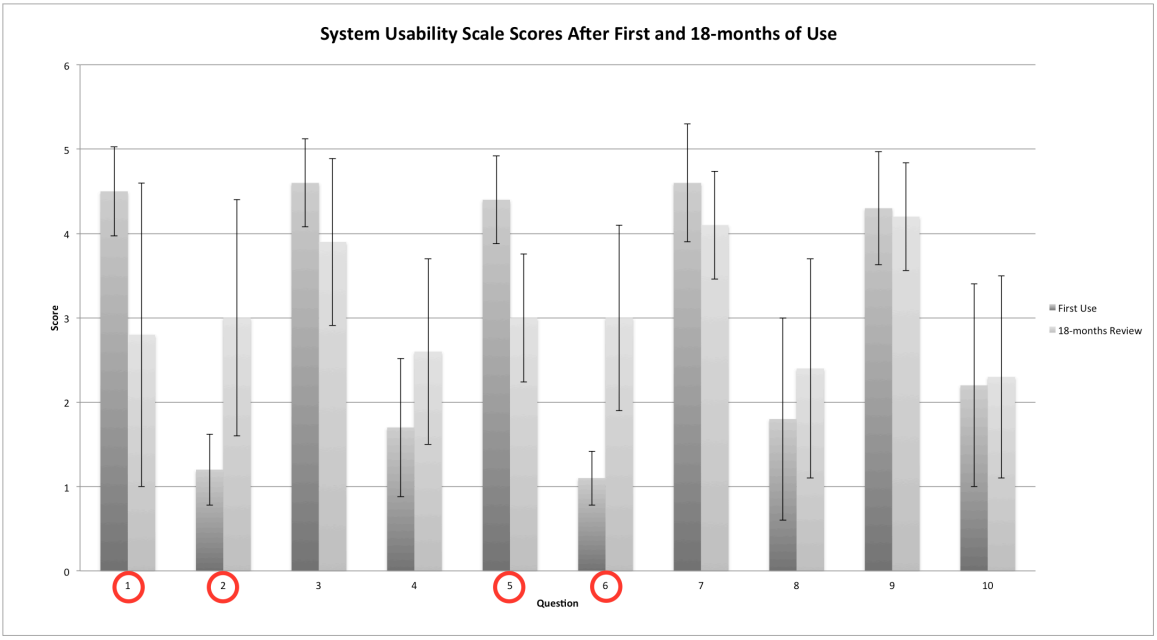

Figure 12. Mean responses to each statement on first use and after 18-months of regular use. The *red circles* indicate questions where the differences in responses were statistically significant.

4.3 Research Question 1 Discussion

Although only minor changes were made to the system over the course of the study, SUS scores indicate that users perceived it to have substantially less value after 18-months of regular use. Users found it to be more complicated and they became less interested in using it frequently. Over time they also found the system to have greater inconsistency and the functions to be less well integrated.

These findings make a number of contributions to outreach mobile nursing care. Many studies have found evidence that telemedicine systems can provide significant operational benefits to mobile nursing care, including improvements to the quality of nurses' note-taking, productivity, quality of communication and efficiency (Hong et al., 2009; Hsiao & Chen, 2012; Guy Paré et al., 2011). However, these studies have all been conducted over a limited time period of less than 1-month, raising the question of whether such benefits are enduring.

One study by Paré et al (2009) has more convincingly demonstrated that mobile nurses can be consistently satisfied with using an expert-designed telemedicine system over a period of 18-months. Using 3 evaluations over an 18-month period with no major design changes made to the system, users also reported gaining steady operational benefits from using the system, such as improved completeness and quality of care, as well as increases in the number of patients seen per shift and time spent providing direct care (G. Paré et al., 2009).

The findings of the present study do not necessarily contrast with those of previous literature. In particular, as this study did not examine for operational benefits alongside perceived value, it is not clear whether operational benefits would fade alongside perceived value over time. Nonetheless, if the previously mentioned studies were conducted over a time period of longer than 1 month, and operational benefits began to decline, the findings made here could help guide researchers to examine whether as in this study, perceptions of value of mobile nurses were also declining. Future research on the relationship between perceived value and operational benefits is needed.

Furthermore, while it is tempting to suggest that this study conflicts with Paré et al (2009), it is important to note that the focus here of perceived value through usability analyses is different to a focus on user satisfaction and operational benefits. The meaning of satisfaction remains unclear, especially when methods of examining it were not shown to be validated or reliable. Although intuitively it seems likely that satisfaction is related to perceived value, future research is needed to determine if this is actually the case.

Despite these difficulties, the present study nonetheless provides evidence that mobile nurses' perceptions of value towards telemedicine systems can change dramatically over time. It is thus important for those wanting to introduce telemedicine systems into outreach care departments to consider not only the perceptions of their users at the beginning of implementation, but also consistently over time. Simply examining initial perceptions may create a misleading representation of how users are responding to the new technology.

More broadly, some of the findings of this study build on and extend the results of previous telemedicine studies with similar methodologies. The finding that users initially perceive high value in using a telemedicine is consistent with previous studies. Gormley et al (2011) and Fritz et al (2012) also found that after initial use of telemedicine systems for education and patient health questionnaires, SUS scores were above 80. According to Bangor et al's (2009) adjective rating scale, this means these systems had 'Good' usability and are acceptable for field use, although scores in the 70s and 80s do not guarantee high field acceptability (Bangor et al., 2008, 2009).

This study extended these findings by showing that users' perceptions can change over time. In particular, the results showed that users can perceive substantially less value over time. However, these findings contrast with Trafton et al (2010), who also demonstrated perceptions of value to be a fluid concept that can change over time. Trafton et al (2010) also used the SUS to demonstrate how perceptions of value can change. However, in their study, an expert-designed telemedicine system was built and then specifically adapted based on feedback. They obtained feedback from users through a variety of methods including the SUS,

made changes to the graphical interface and then had users re-evaluate it using the same methods after 3-months of consistent use. The increase in SUS scores over this time from 74 to 84 demonstrated how adaptation of features of a system according to target users' feedback can significantly increase perceptions of value.

Yet, there are key differences between this study and Trafton et al's (2010) study. Trafton et al (2010) adapted an expert-designed system to users' feedback, whereas the system used in this study was entirely custom built according to stakeholder requirements. This may indicate that adapting an expert-built system to users' interests is a more effective way of sustaining high perceptions of value over time. However, Trafton et al (2010) also conducted their study over a shorter time period, which when considered with the findings of this study, may suggest increases to perceived value may not have been enduring.

Therefore, to clarify the relationship between the findings made here and those of Trafton et al (2010), further research is needed to examine whether users are more likely to continue to perceive significant value in using an expert-designed telemedicine system that has been adapted to their needs over longer time periods. Ultimately, however, the combination of the findings of this study with those of Gormley et al (2011), Fritz et al (2012) and Trafton et al's (2010) highlights how perceptions of value can vary over time. This emphasises the importance of regularly re-evaluating and adapting systems to meet users' needs.

In answering research question 1 of this thesis through consideration with previous literature, it appears that users' perceptions of value towards telemedicine systems can change over time. In particular, this study suggests that they can significantly decline over time. Further analysis of SUS scores suggests that this may be due to users' declining interests, sense of complexity, inconsistency and integration of functions may help explain why this was the case. However, as such terms were not clearly defined in Brooke's (1996) original paper on the SUS, it is difficult to know how such aspects of use contributed to declining perceptions of value. Other factors may also be involved. Understanding the relationship between such factors and overall declining perceptions of value declined over time is necessary for these findings to be used in productive ways to improve how

telemedicine systems are used in outreach mobile nursing and more generally throughout health care. This will be the focus of the next section of this thesis.

4.4 Summary of Results and Discussion of Research Question 1

In this chapter, I have answered my first research question:

1. **How do perceptions of value towards telemedicine systems change over time?**

There have been 6 main findings in this chapter. On initial use, the system's usability was acceptable for field use, and considered 'Excellent' by users. After 18 months of regular use the system was marginally acceptable for field use, and considered 'OK' by users.

After 18 months of use, users desire to use the system regularly was significantly less than after they used it for the first time. Users also came to perceive the system as more complex after 18 months of use. They also agreed more strongly that there was too much inconsistency in the system and that it's functions were not well integrated.

Therefore, in response to research question 1, users can perceive less value towards telemedicine systems over time. Factors that may influence this include perceived complexity, inconsistency, integration of functions and a lower desire to use the system frequently. However, the ways in which they do this remains unclear.

These findings contribute to existing literature on the use of telemedicine in outreach mobile nursing as well as telemedicine research more broadly. Previous studies on telemedicine in outreach mobile nursing studies have shown that users can continue to be satisfied and obtain operational value over time using telemedicine systems. Many others have examined perceptions on single occasions only, after users have had limited experience with new telemedicine systems, typically lasting less than 1 month.

The combination of previous research and the findings in this study highlight the need for future studies on telemedicine in outreach contexts to investigate how and why perceptions of value may change with time. Furthermore, there is a need for future research to clarify the relationship between perceptions of value, satisfaction and operational value over time. This may help explain why one study has shown how over time, operational value and satisfaction may increase, while this study has shown that perceived value may decline. Alongside this, differences in how systems are designed and evaluated also need to be considered in future research.

More broadly, the findings of research question 1 confirm that perceptions of value towards telemedicine systems are variable. Therefore, initial high perceptions of value should not be considered as representative of overall, constant perceptions of value. Furthermore, an important aspect of this study was that the system used was custom built according to the requirements of its users, and minimal changes were made once the system was implemented. Another study has demonstrated that gradual adaptation of an expert-designed system to users' needs may increase perceptions of value over time. Thus implementing expert-designed systems that are gradually implemented according to users' needs may be a more effective approach of maintaining or enhancing perceptions of value over time. However, this study was conducted over a shorter time period. Further research is needed to clarify if the same effect could be achieved over a longer time period, or if there is a point where the effect is no longer achieved.

Answering research question 1 has demonstrated how perceptions of value may change over time. However, for effective guidance on improving the way telemedicine systems used to be developed, greater understanding of the factors that may influence this change is needed. While analysis of individual SUS scores over time suggests users' perceptions may have been affected by a sense of complexity, inconsistency and poor integration of functions, the meaning of these findings remains undefined. Further understanding of the way in which users' perceptions of value change over time, and the factors that influence them will be discussed in the next results and discussion section.

Chapter 5: Research Question 2

Results and Discussion

5.1 Overview

In this chapter, I will set out the findings from research question 2. In chapter 2, I examined various theoretical models for understanding how people use technology, and the ways these could be adapted to understanding perceptions of value towards telemedicine systems. I focused on the TAM, DOI and TTF models. This lead to the development of the second research question of this thesis:

2. **What factors influence perceptions of value towards telemedicine systems over time?**

In chapter 3, I explained how research question 2 would be answered by analysing interview responses of outreach mobile nurses after they had used a new telemedicine system for the first time, and again after 18 months of regular use. I used a phenomenological methodology to explore how users perceptions of value towards the system were formed and changed over time with their increasing levels of experience. The main focus was to recognise and explore how the phenomena, the observable perceptions, feelings and lived experiences of the users and their interpretation of them, act as key factors that influence perceived value over time.

I examined how using the telemedicine system impacted users, and their ability to complete tasks and their experience of the workplace. I analysed the entire text, exploring key aspects of language, which were dissociated from the user, then recombined them to form themes and superordinate themes. This enabled me to reveal underlying value-judgements, fundamental parts of the processes used to form them, and their underlying components.

The list of superordinate themes and themes is indicative of my interpretation of the factors which influence perceptions of value towards telemedicine systems over time. I will first explain the link between research question 1 and question 2. I will then go on to describe the superordinate themes and themes in detail to answer research question 2.

5.2 Research Question 2 Discussion

5.2.1 Linking Research Question 1 and Research Question 2

In answering research question 1, it was shown that perceptions of value towards telemedicine systems can vary with time, and in particular can substantially decline. This finding has important implications for both the use of telemedicine systems in outreach mobile nursing, and in health care more generally. It may encourage future researchers to examine whether operational benefits, user satisfaction and perceived value all change in similar or different ways over time, and their relationship to each other as common aspects of the user's experience. It may also help explain why there are inconsistencies in the literature on the benefits of telemedicine for patients, providers and health administrators. However, while the methods used in answering research question 1 provide a clear and useful index of how perceptions of value change, they provide limited information on the underlying factors that may be influencing this change. Exploring and examining these factors provides a more complete and comprehensive understanding of the way in which users perceive value towards telemedicine systems. This understanding is needed as the basis for the development of effective, useful guidance and recommendations on improving the way telemedicine systems are used.

Although it seems users' sense of inconsistency, complexity and integration of functions in telemedicine systems seemed to have played some role in their declining perceptions of value, their exact meaning remains unclear. These terms were not defined in Brooke's (1996) original paper on the SUS. Thus, deeper investigation into these aspects of users' experiences as well as other factors contributing to perceptions of value over time is necessary to help gain more meaning from the answers to research question 1. Indeed, the following analysis highlights that a range of deeper, more complex factors beyond those mentioned in the SUS appear to be involved.

Thus in answering research question 2, I will also be helping to explain why the answers to research question 1 were obtained. The combination of answers to each question can then be used to develop recommendations on how to improve how users engage with telemedicine systems.

5.2.1 The superordinate-themes and themes

I will now list the overriding superordinate-themes and the themes within each superordinate-theme. I will also briefly explain their content. The superordinate themes are: 1) Experience as the standard; 2) Design and demand; and 3) Contextual constraints.

I will now give an overview of how the super-ordinate themes and themes inter-relate. Following this I will provide my detailed analysis to support my overview.

Experience as the standard describes how expectations about technology from previous personal experience are used to assess the value of telemedicine systems. The themes within this super-ordinate theme are; (i) Setting the standards for myself and (ii) Setting the standards for others.

Design and demand describes how users change their perceptions of value towards a system over time by assessing the strength of the relationship between its physical form, functionality and ability to help users complete workplace tasks. The themes within this super-ordinate theme are; (i) Physical fitness and (ii) Functional fitness.

Contextual constraints describes how users' perceptions of value towards a new telemedicine system change over time according to the quality of its relationship with its context of use. The themes within this super-ordinate theme are: (i) Bureaucratic barriers and (ii) Integrating into the infrastructure.

Figure 14 shows the connections between research question 2, the superordinate-themes and themes.

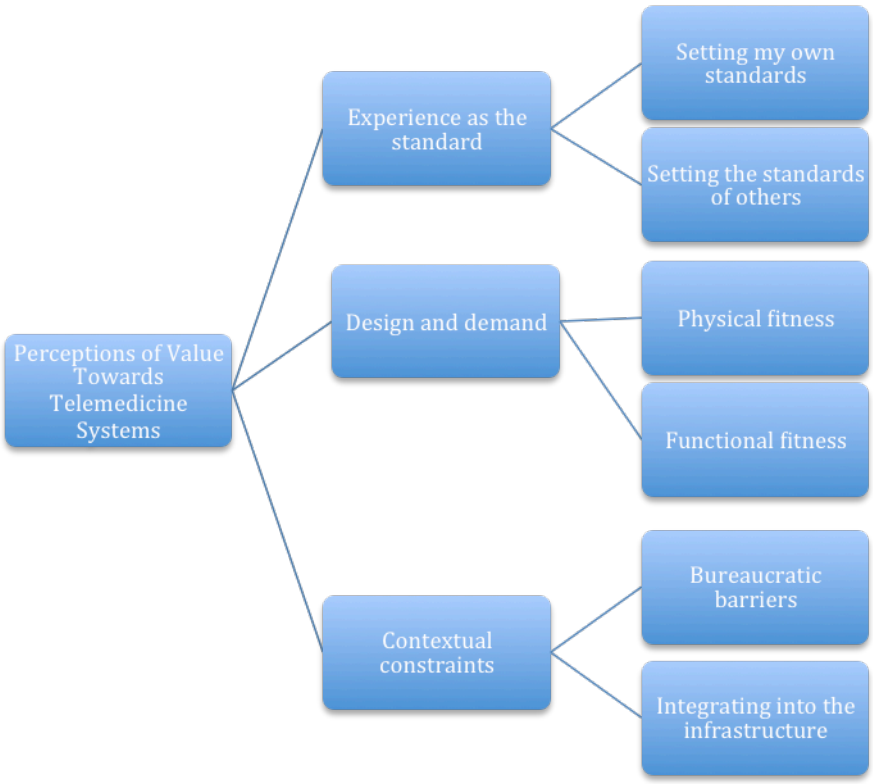

Figure 13. Factors influencing users' perceptions of value over time: superordinate themes and themes

5.2.1.1 Experience as the standard

In experience as the standard, I will discuss how users utilised their expectations of technology that have been developed from previous experiences to assess the value of new telemedicine systems. This will be done in two ways; in relation to their own personal experience of the system and in relation to their observations of others' experiences of the system.

5.2.1.1.1 Setting my own standards

This theme examines how expectations developed from previous experience with technology are used to assess the value of the telemedicine systems to the user

themselves. Users' expectations are subtle in assessing the value of the system after first use. Brian's assessment featured an implicit expectation that the system would be immediately intuitive. Brian remarked:

> *"There's no hidden pages or anything you need to do or know. It's just very easy to use"*

Brian had previously indicated that he had many years of experience with similar Apple products and apps. The fact that the telemedicine system had similar layout and navigation gave him the impression that nothing needed to be known beforehand for successful operation. By satisfying this expectation from his previous experiences of technology, the system was determined to be easy to use, an immediate benefit that required little sacrifice to be achieved. Thus, Brian perceived significant value in using the telemedicine system in the workplace.

Sandy, however, had far less experience with technology. Yet, a similar process seemed to underpin her assessment of the value of the system immediately after use. Compared with her prior negative experiences with technology, Sandy's expectations were exceeded, and met with relief when there was an underlying recognition that sacrifice in the form of having difficulty in learning to use the new system was not needed. Sandy said:

> *"It was a lot easier than I thought it would be"*

Neither Brian nor Sandy made explicit recognition of how their expectations had been met by highlighting the particular relationships between their prior experiences and the new system. However, consistent with the TAM, both indicated that their perceptions of ease of use were significant in assigning value to using the system. Yet, neither indicated that the technology would help them improve job performance, that usefulness was important or that the views of their superiors were important in forming their perceptions (Hu et al., 1999; Venkatesh & Davis, 2000). This emphasises the importance of perceived ease of use as a way of

recognising benefits that require little sacrifice and hence overall value in using a telemedicine system.

After initial experiences of use where expectations may not have been met, some users used their prior experience with technology to envisage how greater value could be assigned to the system. Cassandra recognised that although benefits could be achieved in using the system, sacrifice may come in the form of facing difficulties in typing on a touch screen in clinical settings. Therefore, she drew on her knowledge of adjunct devices for iPads to overcome this sacrifice and maximise value. Cassandra suggested:

> *"Just the Bluetooth keyboard would be good. Maybe a smaller version, like an iPad mini"*

Cassandra's suggestion for using an Bluetooth keyboard indicates she has a knowledge of technology that can help optimise the benefit of ease of use of the system, as well as improve the fit between the technology, tasks and contexts of use, which may help overcome sacrifice (Goodhue, 1995; Venkatesh & Davis, 2000). Brian, Sandy and Cassandra's assigning of value to the system based on their expectations, and willingness to find ways of overcoming sacrifices indicates an underlying optimism towards the idea of using a telemedicine system in their daily jobs. This may also be an expectation formed from their personal experience with how technology has enhanced the quality of other aspects of their lives, or from an understanding of how telemedicine has improved care in other contexts around the hospital.

Over time, the same process of determining the value of telemedicine systems by measuring them against expectations from previous use of technology was used. However, unlike in the first instance, users cited more specific aspects of the system to make their evaluations. As indicated by the quantitative findings of this study, users felt the system was more complex after using it for 18 months. Karen helped define the meaning of this sense of complexity by discussing how the system's interface and functionality did not align to her expectations from prior

experiences with technology. It was therefore difficult to navigate and required sacrifice in the form of having to confront an unwanted sense of unfamiliarity in the workplace. Karen said:

> *"It wasn't like a normal computer system. Like when I look at a program, you can kind of, any new program, you can kind of figure things out by having used a previous program. But this was set up really differently"*

Over time, Karen felt that her expectations of being able to intuitively navigate a computer program were not met when she used the telemedicine system. This lead to her feeling that the system had high complexity that required sacrifice to deal with, and therefore low value as a tool in the busy clinical environment. Karen's comment is resonates with Rogers' (2003) DOI theory that emphasises the importance of building innovations with low complexity. Systems should be easy to use and require minimal sacrifice to operate effectively. Karen's comment highlights that failure to do this will gradually lead users to perceive lower value in using telemedicine systems.

Others, however, felt that over time, their expectations continued to be met due to past experiences with similar technologies in working contexts. For these users, consistent with existing theories on the determinants of technology use, a sense of compatibility in the system remained high because of an ability to use prior experience to adapt (Rogers, 2003; Vuononvirta et al., 2011). As a result of this, unlike in Karen's case, benefits could continue to be achieved without sacrifice.

Janet highlighted that her expectations continued to be met because she already had a specific skill set required to easily adapt to the new system, and therefore avoided the need for sacrifice in the form of dealing with unfamiliarity. The system gave her the opportunity to utilise her typing skills from a previous job in a new context, allowing her to continue to see benefits and therefore overall value in long-term use:

"I'm a very fast typist because I used to be a secretary so I can type very fast"

Setting my own standards demonstrates how expectations formed from previous experiences are used over time to recognise benefits and sacrifices associated with one's own use of telemedicine in the workplace, and hence form perceptions of value. They can be used to lose perceptions of value or sustain them. This finding emphasises the need to continually engage with and utilise users' own personal expectations of telemedicine systems in order to maximise perceived benefits and minimise perceived sacrifices over time. This will help contribute to sustaining perceptions of value.

5.2.1.1.2 Setting the standards for others

This theme describes how expectations about technology from prior use can be used to judge the way others in the health care team are able to experience benefits and sacrifices from using telemedicine systems. To be effective, all members of the healthcare team must be able to perform their duties to a common standard. This allows them to rely on each other to complete tasks. Therefore, if some members are unable to perform to the common standard, the entire team may be unable to function effectively.

Using a new telemedicine effectively requires a certain set of technical abilities. Differences in these abilities can result in some team members having to make more sacrifices to use the system properly, or some achieving more benefits than others. Using expectations about technology from past experiences to recognise, understand and link these differences to the way the team functions when using a telemedicine system can influence users' perceptions of value.

First impressions about the telemedicine system involved expectations that some members of the team would respond to using it better than others based on technical abilities. Kelly used an expectation from prior experiences with technology to judge that older people can have more difficulty adapting to technology than

younger people. She felt that this was because it may take older people longer to learn new things. Thus, they may require greater sacrifice in the form of a time commitment to adapt to using a new telemedicine system.

When asked about if it would be easy for someone to learn to use the app, Kelly said:

> *"Older people, maybe not so easy…They just take a bit longer to learn things…I think people get a bit flustered, a bit overwhelmed. But overall, it should be pretty easy to learn and pick up straight away"*

Kelly recognises sacrifice may be involved for certain users based on her understanding of how age can impact technology use, but overall this seems to be a surmountable challenge. Therefore, it appears not have greatly impacted her perception of value.

Jennifer's first impressions were also influenced by a similar set of preformed expectations about how differences in technical abilities can affect the way members of a team can achieve benefits and sacrifices. However, in contrast to Kelly, Jennifer felt that this difference would explicitly enable greater benefits to be achieved. In her view, this allows for the team to perform better, and therefore gives a greater perception of value. Jennifer said:

> *"I think for some people, it's quicker to type than to write, so that could benefit us"*

The combination of Kelly and Jennifer's comments highlights how perceptions of value of telemedicine systems can be influenced by expectations about how others will achieve benefits and sacrifices. In particular, Jennifer recognises this in relation to overall performance of the health care team. This supports the idea that technology use in workplace settings is closely related to a sense of how using it may improve job performance. However, it extends upon the TAM theory, especially Walker and Whetton's (2002) interpretation, which states that a sense of job performance is important for successful telemedicine adoption.

Combined, Kelly and Jennifer's comments emphasise that a sense of team job performance is an important factor in users' perceptions of value towards telemedicine systems (Venkatesh & Davis, 2000; Walker & Whetton, 2002).

Over time, similar expectations about how others would achieve benefits or need to make sacrifices to use the system also seemed to lead to lower perceptions of value. Differences in technical abilities lead to an inability of some members of the team to engage with the telemedicine system to the same standards as others. Amanda used a similar set of expectations about the impact of age on technology use as Kelly to recognise that older team members needed to make more sacrifices than younger ones to use the system effectively. Amanda said:

> *"Like the young ones coming through today wouldn't have a problem okay? I think we've got to consider that some people aren't computer savvy, and they find it just a little bit harder"*

Although the same expectations are used as in Kelly's comment, after using the system for a longer time period, Amanda does not express the same sense of being able to overcome differences in technical abilities amongst members of the team. This creates a fundamental sense of disunity in the health care team, and means that some users don't need to make sacrifices to adapt to the telemedicine system, but others do. As the team needs to function cohesively, this difference results in a lower perception of value

In contrast to the first impressions of Kelly and Jennifer, Amanda's comment resonates with the Diffusion of Innovation (DOI) theory. DOI states that users' responses to a new idea are influenced by their perception of how others who are in similar circumstances to them have responded. This can be useful where the level of understanding between users is similar. An idea will be easily passed from one user to the next because there are few knowledge or skill barriers between them. However, as described by Amanda, there can be cases where users are in similar circumstances, but there are substantial differences in the knowledge and skills required to adopt a new idea. This can prevent the idea from being adopted across

the entire group (Rogers, 2003). Amanda's comment extends this idea to demonstrate how greater sacrifice may be required by others in similar circumstances, and this recognition is important to one's overall perception of value towards the system.

Furthermore, Amanda's comment may also be used to understand why the quantitative results of this study indicated that the system was perceived to be more complex over time. She emphasises the role of age in how users perceive value in the system. Older users may have seen greater complexity in the system due to difficulties in adapting to it over time. While more specific research may be needed to clarify this, this nonetheless emphasises the need to introduce systems with ongoing support and regular review sessions to help engage with such expectations of team functioning and differences in technical abilities. This will help entire health care teams overcome a sense of complexity and continually adapt together to the new system.

Over time users also began to recognise the importance of having personnel who were trained to provide technical support as members of their overall health team. Such personnel have a level of technical ability that extends beyond what all other team members are expected to have. Therefore, such differences can be considered acceptable in this case. However, the way those with specifically higher levels of technical abilities can apply themselves as members of the team to help others can still be important influences on perceptions of value.

After first using the system, as there were no malfunctions in the telemedicine system, so the role of technical support team members was negligible in users' perceptions of value. However, as problems arose, expectations from prior experiences of technology were used to evaluate the benefits and sacrifices associated with technical support personnel. Technical support were therefore an important part of optimum team functioning, and hence users' perceptions of value. After engaging with technical support, Wendy expressed her expectations:

> *"I guess having somebody that you know is definitely available when the problem has, does happen, like at the moment it's whether*

that person is available on demand. In the past I think it's 'well that person, for example [Sam], is going to be in on Friday, so we'll talk to them then, rather than resolving the issue here and now, remembering what the issue was, and not forgetting what it is and it's been left."

Despite never using a telemedicine system before, Wendy has an underlying expectation that technical support should be available when she needs it. She indicates a need to fix problems when they arise rather than having to sacrifice time and effort waiting for help to become available at a later date. With technical support personnel being considered a part of the overall team, their limited availability demands sacrifice from other team members and therefore may lead to a lower perception of value.

Setting the standards for others emphasises how preformed expectations about technology can be applied to judging the way others engage with telemedicine systems to form perceptions of value. Expectations are used to recognise, understand and link differences in technical abilities to the way benefits and sacrifices from telemedicine systems are experienced by the health care team. This relationship between expectations and team experiences can then influence users' perceptions of value.

5.2.1.1.3 Summary of Experience as the Standard

In this superordinate theme, I examined how expectations of technology formed from prior experiences were used to influence perceptions of value towards telemedicine systems. In setting my own standards, I described how personal expectations of technology were used to recognise benefits related to ease of use and to make suggestions for how to overcome potential problems. I explored how expectations based on previous experiences were also used to perceive sacrifices in the form of dealing with complexity and unfamiliarity in the system, but also to perceive benefits in the way of allowing some users to utilise an existing skill set to

improve job performance. The benefits and sacrifices perceived in these ways were then linked to perceptions of value.

In setting the standards for others, I described how users used preformed expectations about technology to recognise how well the health care team as a whole could obtain benefits or needed to make sacrifices for the system to be used. I described how expectations were used to recognise the role of age in requiring that sacrifices be made for some to adapt to using new telemedicine systems, but also that differences in technical abilities could allow others to help benefit overall team job performance. I also described how technical support personnel were considered important members of the overall health care team who need to be able to apply their superior levels of technical ability in ways that meet expectations of solving functional problems as they arise to avoid users' having to make time and energy sacrifices. These benefits and sacrifices were also linked to perceptions of value.

5.2.1.2 Design and Demand

In design and demand, I will discuss how users' judgements of the way features of the telemedicine system match the demands of workplace tasks influence their perceptions of value. This will be done in two ways; with respect to the relationship between the physical structure of the system and the workplace environment, and with respect to the relationship between the system's functions and the demands created by workplace tasks.

5.2.1.2.1 Physical Fitness

This theme describes the ways in which users' perceptions of value towards telemedicine systems are affected by their physical characteristics. In the first instance, users were accustomed to recording clinical notes in paper format. They needed to carry multiple folders of paper to record information about each patient. The telemedicine system offered a benefit of carrying fewer physical objects to

complete the same task. After using the system for the first time, Samantha indicated that this benefit was significant:

> *"Yeah it would be good because um it's just the one unit as opposed to holding all the files. It's all in one."*

Samantha shows an underlying recognition the benefit associated with the physical difference between the technology and the paper-system allows her to perform workplaces tasks more easily. This increases her perception of value towards the telemedicine technology. Samantha's comment resonates with the key ideas in the Task-Technology Fit (TTF) model (Goodhue et al., 2000). Extending on this model, Samantha's comment shows that the fit between the physical aspects of the technology and the requirements of workplace tasks are not only important for technology adoption, but also for users' perceptions of value.

However, although the benefit outlined by Samantha may have been enduring, after using the system for the first time, users' also saw problems in the relationship between physical design features and the demands of workplace tasks. Jane highlighted that when using the system to photograph patients' wounds, she was required to make the sacrifice of having to continually take her gloves on and off to maintain hygiene while using the device effectively:

> "*No, only sometimes when you are taking photos, um, you have to, you undress the wound then you have to take your gloves off, then take a photo, then put your gloves back on. That's the only really thing. I guess if someone can't lift their leg properly, it's hard to, I guess, but that's with I guess taking a photo, that's the only issue. That's nothing wrong with the app."*

Jane recognised having to take her gloves on and off to manoeuvre the technology to take photographs as a sacrifice, especially in cases where patients have wounds in difficult positions. However, interestingly she excused this sacrifice

as not being attributable to the app, even though she may not have had to deal with it when using the existing paper-based system. Indeed, given this sacrifice, it would seem that under the TTF model, the paper-based system would have a better fit to workplace tasks (Goodhue et al., 2000). She continues to perceive value in using the technology. This could indicate an underlying positive attitude towards other aspects of the system, such as the function of being able to record information about wounds in photographs. This would resonate with Chau and Hu's (2002) emphasis on the importance of cultivating positive attitudes in technology adoption, and extend it to demonstrate its importance in perceptions of value to the extent of being able to excuse physical design problems and the sacrifices associated in dealing with them.

However, it may also be due to a limited amount of experience with the system. Jane may not recognise that the sacrifice of taking gloves on and off especially in cases where patients have wounds in difficult locations may become more significant as her experience with the system grows over time. This may change her perception of value.

In particular, after using the system consistently, Brian continued to recognise benefits associated with the physical aspects of the system in relation to workplace demands, but also felt there were other sacrifices, which lead to a lower perception of value. Brian said:

> *"Its portability with the iPads makes it quite usable. But um, it does have a lot of negatives with being used as well."*

Brian clearly indicated that the physical aspects of the system provide clear benefits over the paper-based system. The recognition of portability as a significant benefit resonates with Rogers' (2003) notion of relative advantage, and demonstrates how this can be important in perceptions of value as well as adoption of new ideas (Rogers, 2003). However, Brian's clarifying statement after recognising this benefit suggests that overall, the improved fit between the portability of the system and workplace tasks may not be enough to continue to perceive significant value in using the system.

Furthermore, Brian's comment also helps explain why the quantitative results of this study showed that over time users wanted to use the system less frequently. In contrast to some of the comments Brian made after using the system for the first time, here he reveals an underlying pessimism towards the value of the system. After consistently using the system, he becomes unable to cite a benefit without also highlighting his global view that there are also many sacrifices. Supporting Chau and Hu's (2002) ideas, this reveals a key shift in attitude towards the system and suggests a reason for the development of a lower perception of value over time. This again emphasises the need to have ongoing support and feedback sessions to maintain optimistic attitudes and hence consistent perceptions of value.

For other users, the physical characteristics and how they matched up with workplace demands seemed to be one of the main factors involved in having lower perceptions of value. Amy explained that her ability to interact with the system was significantly restricted by difficulties in typing on the iPad screen. The sacrifice of having to deal with these difficulties encouraged a lower perception of value towards the system. Amy felt that typing on the screen was hazardous to herself and others:

> *"I was getting sore hands. And I know another nurse was complaining that her carpal tunnel was acting up with it! So that just made it a little bit tricky"*

Importantly, Amy's comment is an example of how perceptions of value can be influenced by understandings of how others in the health care team may have to make sacrifices to grapple with the relationship between physical characteristics of a system and workplace demands. This resonates with Rogers' (2003) DOI theory and his emphasis on the role of the social network in the adoption of an innovation. The DOI theory highlights that social networks enable perceptions about an innovation to spread amongst its members (Rogers, 2003). Amy's comment mentions both her own sacrifices as well as those of her colleagues. She goes further to use this

understanding of others' sacrifices of others to further support her own lowered perception of value towards the system.

In physical fitness, I described how perceptions of value are affected by physical characteristics of a telemedicine system in relation to workplace demands. The physical design is an important aspect of a new system that can be perceived as having benefits over an existing system. However, over time, such benefits can either become insufficient to maintain a perception of value or even result in sacrifices, and influence the development of a lower perception of value. Members of a social system may discuss this, and the experiences of others may be used to influence individual users' perceptions of value.

5.2.1.2.2 Functional Fit

This theme describes the way in which the relationship between the functional characteristics of telemedicine systems and the demands of workplace tasks influences users' perceptions of value. The functions of a telemedicine system can enable users to receive benefits in the form of completing workplace tasks in better ways, or even absolve them of the need to perform some tasks. However, equally systems can require users to make sacrifices in the form of making tasks more difficult or adding tasks to an existing routine.

After their first use, users described a strong relationship between the system and their existing workplace tasks. The ability to record photographs of wounds instead of recording only a written description provided the benefit of being able to make more accurate assessments about a patient's condition. Brian recalled:

> *"I especially like the function where we can take photographs, especially because we'll be able to do comparisons, and also because we don't have the same nurse seeing the patient all the time, the next nurse that comes can look back at the previous photos and see whether there's an improvement or whether there's been a deterioration"*

Brian's comment resonates with the TTF model. The task is assessing the progress of a wound over time. The technology provides the user as well as his colleagues with a tool to achieve this in a way that is superior to the previous method of written descriptions. Therefore, there is a good task-technology fit. The benefit provided from the imaging function gives Brian a sense of value in using the system. As pointed out by Lin (2014), it is particularly important that Brian as a user makes this judgement about the task-technology fit. If a designer alone made judgements of how well the functions of a technology fit workplace task, the system may not be as effective. Indeed, the individual's own judgement of the task-technology fit is a stronger predictor of the effectiveness of using a telemedicine system (Goodhue et al., 2000; T. Lin, 2014).

Also after using the system for the first time, Bridgette recognised significant value in how the imaging and videoconferencing functions could enhance wound management. She focused on how the system could provide the benefit of more immediate access to specialist opinions when users are unsure about how to proceed with wound care. Bridgette said:

> *"If we suddenly come across a patient with a wound, we could easily contact the team at the hospital, or…the wound CNC [Clinical Nurse Consultant] could be contacted for a more improved dressing that we could apply, or we could ask advice from her"*

In contrast to Brian, Bridgette sees benefit in the form of the technology providing an additional capability of gaining remote advice, which may not have been possible without the ability to photograph wounds or videoconference with colleagues. The fit between the workplace task of assessing a wound and these particular benefits provided by technology enables her to perceive value in using the system.

Extending the DOI theory, both Brian and Bridgette's comments suggest that in the first instance of use, users' sense of the relationship between the functions of the technology and the demands of workplace tasks ultimately represents their

understanding of how systems can be of advantage for job performance (Rogers, 2003; Walker & Whetton, 2002). Furthermore, the way this judgement is made resonates with Vuononvirta et al's (2011) idea of individual and process compatibility. High individual compatibility comes from how the system can be used to enhance communication among team members, as recognised by Brian. High process compatibility comes from how the system enhances access to resources for improve job performance (Vuononvirta et al., 2011).

The relationship between the functions of the system and the demands of workplace tasks was used also influence perceptions of value after the system had been used consistently. However, it is important to recognise that Brian and Bridgette cited expected benefits rather than benefits they had actually experienced after first using the system. Over time, some users began to recognise that there is a difference between potential benefits associated with functions of a telemedicine system and actual benefits. Jessica, who felt that the potential benefits cited by other users such as Brian and Bridgette were never realised, specifically mentioned this difference:

> *"If they're saying it's good, you can use access it for conferencing and that, then yes but I don't know in 12 months if any of us had that opportunity to do that"*

Jessica's comment highlights that she recognises that there may be some benefits associated with using functions of the system to perform workplace tasks. However, the failure to have an appropriate opportunity to realise these benefits rather than specific sacrifices leads to a lower perception of value in the system. To Jessica, such functional potential seems redundant. This shows that over time even if there is a strong relationship between functions and tasks, unless users are able to actually utilise this relationship, less value is perceived in telemedicine systems.

Jessica's comment builds on Hu et al's (1999) application of the TAM. Hu et al (1999) argued that physicians are more concerned about usefulness of a system rather than other factors such as ease of use or the views of their colleagues in the

adoption of telemedicine systems. Jessica's comment emphasises that the same ideas are also important users' perceptions of value. When considering the functionality of a system in relation to workplace demands, if the functions are not used, usefulness cannot be determined. Users will then not be able to perceive benefits in using the system, and will lower their perceptions of value.

Furthermore, Jessica's comment can also be used to explain why quantitative results revealed that over time users did not agree as strongly with the idea that the functions of the system were well integrated after using it consistently for 18 months. The meaning 'integration of functions' can be taken in the context of the discussion here to indicate how the functions of the system work together. In light of Jessica's comment, it seems that over time some functions were not used properly, and so benefits were not obtained. They were therefore seen as redundant, and gave an overall sense of that the relationship between the functions of the system was poor. This quantitative finding alongside Jessica's comment emphasises the need to ensure users are actively educated and given opportunities on how the functions of the system work together and can be appropriately used in workplace tasks.

However, Jessica's lowered perceptions of value based on a sense of redundancy were not universal among other users. After consistently using the system for 18 months, Bridgette still recognised the same potential for its functions to provide benefits in the form of enhancing her ability to complete workplace tasks. In contrast to Jessica, even though this potential may not have been realised, it was enough to sustain Bridgette's perception of value towards the system. Jessica said:

> *"Well, I think using the photo section particularly will enhance a patient's wound care, taking a photo when we first meet a patient and then compare it as it progresses along. Also we can show it to doctors. If we're worried about the wound, if the wound takes a turn for the worst we can take a photo again and ring up, not that I've used it for that, but I can bring a picture in a show a doctor."*

Bridgette highlights a similar set of potential benefits in using the functions of the system to complete workplace tasks as she did after using it for the first time. Bridgette feels that potential benefits are enough to perceive value, whereas Jessica requires actual benefits. The differences in these perceptions may be better explained by considering Rogers' (2003) account of the different types of adopters of innovations in a social network. Bridgette may be classed as an innovator or early adopter. She is able to tolerate greater uncertainty in using functions of the system than Jessica, and is comfortable with the idea it may take more time, experience or particular circumstances to fully realise their potential benefits. Jessica, however, may be classed as a late majority or laggard user. She is less tolerable of uncertainty and may only adopt a new idea out of peer pressure, or may never adopt it at all. Jessica can see how there is potential for the functions of the system to benefit her ability to complete workplace tasks, but is less tolerant of having to wait for an appropriate opportunity (Rogers, 2003). Distinguishing users by using Rogers' (2003) ideas helps explain why over time some are able to continue to see value in using the system, while others are not.

Functional fit demonstrates that perceptions of value are shaped by the relationship between the functions of a telemedicine system and the demands of workplace tasks. In the first instance of use, the functions of a system are seen to have the potential to benefit a user's ability to complete tasks. This potential can be enough to influence a perception of value towards the system after the first instance of use, and over longer periods of time for some users. For others, however, the failure to realise the potential benefits of a telemedicine system can influence a lower perception of value. The difference in whether potential benefits or actual benefits are needed to maintain a perception of value over time may depend on the way particular users approach new ideas.

5.2.1.2.3 Summary of Design and Demand

In this superordinate theme, I explored how the relationship between physical and functional characteristics of a telemedicine system and workplace tasks

can influence perceptions of value. In physical fitness, I described how users perceptions were shaped by the way physical aspects of a telemedicine system can provide benefits in the form of making it easier to carry and access patient information. However, they can also create sacrifice by making some aspects of daily tasks difficult, such as wound assessment. Over time the physical benefits of using a telemedicine system may not be enough to sustain perceptions of value, or may even end up requiring sacrifices for some users.

In functional fit, I described how users recognise that the functions of a telemedicine system can benefit them in the form of improving their ability to perform workplace tasks. However, this judgement may stem from an understanding of potential benefits rather than actual benefits. For some users, potential benefits may be enough to sustain perceptions of value over time; while for others there may be greater need for experience of actual benefits. Differences amongst users be may related to how they approach new ideas.

5.2.1.3 Contextual Constraints

In contextual constraints, I will discuss how the context in which a system is used can shape users' perceptions of its value. This will be done in two ways; by considering the impact of bureaucratic restrictions on telemedicine use in the modern health workplace, and by examining users' understandings of challenges associated with integrating a new telemedicine system into existing health technology infrastructure.

5.2.1.3.1 Bureaucratic Barriers

This theme describes the way in which bureaucratic requirements of the modern health workplace influence users' perceptions of value. Bureaucratic requirements can place limits on the ability of benefits of technologies to be realised. Protocols and procedures may have to be developed to ensure systems

satisfy administrative requirements in particular health workplaces. Managing these requirements can result in users having to make sacrifices to use telemedicine systems.

The influence of bureaucracy on users' perceptions of value towards a telemedicine system develops over time. The need for protocols and specific procedures to meet bureaucratic requirements may not be clear when a system is being used for the first time, especially if no similar systems have been used in the past. However, in the initial evaluations of the system, some users recognised that bureaucratic requirements may their ability to gain benefits form using the system. Kate understood that the telemedicine system was designed to replace the paper-based system due to the way it can improve how patient notes are recorded. However, when asked about the system being able to substitute paper-based methods, Kate said:

> *"It will be a good substitute. I don't know whether the hospital will make us do paper notes as well"*

Kate's demonstrates a degree of hesitation about how the bureaucratic requirements of the hospital may result in sacrifice in the form of having to keep both electronic notes on the telemedicine system and paper-based notes. This hesitation represents an awareness of how the introduction of new ideas must comply with bureaucratic hospital demands, but also that these demands may restrict the ability to achieve benefits from engaging with them. Kate's perception of value may therefore be influenced by a degree of anticipation about how bureaucratic requirements may result in more sacrifices rather than benefits being associated with using a telemedicine system.

Over time, the role of bureaucratic requirements of the health workplace in users' perceptions of value became more significant. Legal requirements meant that paper-based PMRs needed to be kept alongside records made with the telemedicine system. This meant that some of the true benefits of using the telemedicine system could not be realised. Instead, users' workloads were doubled. This meant that time

needed to be sacrificed to maintain two PMRs without any obvious benefit. Even though this was the result of the context of use rather than the system itself, the significant sacrifice needed to maintain the proper use of the system influenced the development of lowered perceptions of value. Sarah said:

> *"It was just a complete waste of time. Whereas before we'd just write our handwriting in the paper notes and that was that. I feel like it's taking twice as long to do something that needn't be. So I don't really think it was that effective"*

Sarah's view is based on a comparison between the existing paper-based system and the telemedicine system. As she has had experience with the existing system that was compliant with all bureaucratic requirements, Sarah is able to link her sense of sacrifice in devoting double the amount of time to the same task to having to use the telemedicine system rather than the nature of its context of use.

Kate and Sarah's comments resonate with and build upon Chau and Hu's (2002) emphasis on the need to avoid disruption to existing routines in a health workplace when adopting new telemedicine systems, an idea developed from extending TAM. Chau and Hu (2002) stress the need to develop attitudes in users that shows how using the system can benefit workplace performance. In this case, Kate and Sarah's comments highlight how bureaucratic requirements can restrict the development of such attitudes and lead the system to demand sacrifice of its users without clear benefits. Failure to minimise disruption to existing routines by managing bureaucratic requirements leads to lowered perceptions of value.

Cassandra went further than Sarah to explain how the time sacrifices involved with using the telemedicine system simultaneously with the paper-based system due to bureaucratic requirements lead her to question her role in the workplace. Cassandra said:

> *"I don't actually whinge about the technology part of it. It is the time. And my biggest beef is I didn't go to uni to be a stationary or a*

clerical girl and pull folders apart every day and put them back together again and all this jazz"

Having to perform tasks she feels are not to be associated with her role as a nurse is a level of sacrifice leads Cassandra to perceive little value in using the telemedicine system. However, unlike Sarah, Cassandra recognises this to be a result of using the system with the constraints of the workplace context, rather than the technology itself.

Cassandra's sense of the sacrifices involved in using the system affecting her role within the workplace extends Vuononvirta et al's (2011) notion of individual compatibility, based on the DOI model. Individual compatibility refers to how well the system improves communication and cooperation between users, as well as the amount of technical knowledge required to operate it. The findings of this study suggest that in addition to these elements, when considered in relation to the concept of perceptions of value, individual compatibility may also include how using the system in a given context affects one's understanding of their role within a healthcare team. If their role is diminished as a result of sacrifices involved with use, as in Cassandra's case, less value is perceived.

Bureaucratic barriers highlights how perceptions of value are influenced by the relationship between a telemedicine system and the bureaucratic aspects of its context of use. The influence of bureaucratic requirements on the users' experience emerges with time and experience. Bureaucratic requirements of health workplaces can limit a user's ability to fully realise the benefits of a new telemedicine system. They may also result in greater need to sacrifice time and resources for effective use, or even result in changing one's sense of their role within the workplace.

5.2.1.3.2 Integration into the Infrastructure

This theme describes how the relationship between a new telemedicine system and the existing technological infrastructure of a workplace can influence users' perceptions of value. As with the previous theme, this theme emerged over

time as users gained more experience with using the system. In the first instance, users had no understanding of how a telemedicine system may fit into the hospital's technological infrastructure. No users made any relevant comments. Over time, however, users became frustrated with how the system could not be integrated. Brian said:

> *"At the moment, it's just a stand alone unit, and so you sort of feel like it's a waste of time, so whether it's going to be integrated into the hospital system, I don't know. But it just, I feel like we're really wasting our time at the moment."*

Brian's comment reveals an underlying assumption that telemedicine systems should be a logical extension of the pre-existing hospital technological infrastructure. Failure to satisfy this assumption leads Brian to feel that true benefits cannot be obtained and there is redundancy in using the technology. Brian therefore perceives little value in using the system.

Brian's realisation reinforces and extends previous theories of telemedicine adoption which highlight the need for systems to cause minimal disruption to existing workplace infrastructure (Chau & Hu, 2002; Walker & Whetton, 2002). Brian's comment not only shows how this also applies to perceptions of value, it also demonstrates how minimising disruption involves building a system that is a clear extension of the existing hospital infrastructure. This avoids the possible sacrifice of having to navigate two different systems to record and examine information, and can help foster a greater perception of value.

Brian's comment may also help explain the quantitative finding that users felt there was greater inconsistency in using the system after 18-months than after first use. Brian's comment suggests that users may have felt that there was inconsistency in terms of how the system was integrated into the existing technological infrastructure of the hospital. Navigating between two different systems may create a sense of inconsistency towards the overall use of technology in the workplace. This further emphasises the need to build and maintain new telemedicine systems as

extensions of existing technical infrastructure in the health workplace. This will help users see greater consistency in design and use, which may contribute to perceptions of value.

The introduction of a new telemedicine system also relies on the development and utilisation of additional supportive technological infrastructure. In order to ensure new systems are integrated seamlessly, there must be enough resources to allow all users to achieve attain benefits. Building on Brian's comment, Jenna recalls that there was only one desktop computer at NOS headquarters. The computer needed to be shared amongst nurses trying to download patient medical records from mobile devices and doctors reviewing patient information. This meant there was competition for resources, which hindered the ability of nurses to complete their workplace tasks and achieve benefits from using the system. Jenna said:

> *"Um there's only one computer to access the lot. In clinics, doctors are using those computers. We can't use them. We can't print out notes. We can't even sometimes write notes. We need more than one computer at least if we're going to continue with this. It's just not practical to have just one."*

Jenna's comment resonates with and builds upon Vuononvirta et al's (2011) concept of process compatibility. Vuononvirta et al (2011) highlight that in order to maximise the compatibility of a telemedicine system with a workplace, it must require minimal additional supportive resources. Jenna's comment demonstrates that when enough resources are not available to support intended use, not only does the system become less compatible with its context of use; users also perceive less value in using it.

When some users encounter challenges related to the way the system is integrated into the existing technological infrastructure, instead of simply perceiving less value in using it, they may altogether begin to perceive no value and simply avoid it. Like Brian and Jenna, Samantha recognised that little benefit was being

obtained without the system being integrated into the hospital infrastructure, so she just reverted back to the existing paper-based system. Samantha said:

> *"Sometimes we would come back and try and type it on the computer, but if the computer was taken up by other people, which often happened being only one computer that had the program on it, we would just write it in the notes, and it would be fine."*

Samantha's comment highlights the importance of Rogers' (2002) concept of relative advantage. This concept refers to the extent to which utilising an innovation is more beneficial than not or using an alternative. Insufficient supportive technologies in a workplace context can restrict the ability of users to benefit from using the system. In recognising the same problems as Brian and Jenna, Samantha's comment shows how her sense of relative advantage is also an important influence on perceptions of value. Her comment also shows how failure to achieve relative advantage as a result of incomplete integration into a workplace's technical infrastructure can lead to no value being perceived in a system, and complete avoidance of use.

Samantha's comment also helps explain the quantitative finding that over time users wanted to use the system less frequently. In light of the analysis made here, this may have been because there was still a strong understanding of the value of the alternative, previous paper-based system. Therefore, as Samantha has highlighted, if the existing system can be used more effectively, users may feel less of a desire to use the telemedicine system frequently.

However, in contrast to Brian, Jenna and Samantha, some users felt that while the supportive technological infrastructure was not completely adequate, there were still enough benefits to be obtained to maintain a perception of value. Rhonda said:

> *"And then the one on the computer, it was fairly easy, like there was a couple like little ups and downs where there like, but it was like, so*

what, me using it not hearing stuff from other people, I thought it was pretty good."

Like Brian, Rhonda's comment suggests an underlying assumption for how telemedicine systems should operate. She accepts that there may be sacrifices associated in dealing with problems with integrating the system into the existing technological infrastructure, but sees this as part of the process of adopting new ideas into the workplace. With this in mind, she maintains a perception of value towards using the telemedicine system.

More importantly, however, Rhonda's comment resonates with both Rogers' (2002) and Venkatesh and Davis' (2000) ideas on how others in a context of use can affect individuals' perceptions of value. Rogers' (2002) highlights how the social network in a workplace affects the adoption of a new system through the ability of its members to lead in its uptake. Venkatesh and Davis (2000) emphasise how one's understandings of the opinions of others of perceived importance in a workplace can affect their tendency to adopt a new technology. Rhonda's comment extends these ideas to show how perceptions of value can be affected by the opinions of others within a workplace. With this in mind, the contrast between the Rhonda's and the previous comments demonstrates the importance of encouraging those who see value in using the system to lead and influence others towards perceiving value.

Integration into the infrastructure highlights how perceptions of value are influenced by the user's understanding of how well a telemedicine system forms part of the technological infrastructure of the workplace. The failure of a system to be perceived as an extension of existing technical infrastructure and the need to provide additional supportive technologies can lead users to perceive less value in using it. However, the way a user's chooses to respond to such problems, whether by avoiding them, being influenced by others or accepting them as part of the process of introducing new ideas into the work can also influence perceptions of value.

5.2.1.3.3 Summary of Contextual Constraints

In this superordinate theme, I explored how the context in which a telemedicine system is used can influence perceptions of value. The role of context is one that is mostly realised as users become more experienced with using a new system. Bureaucratic barriers focused on how bureaucratic requirements of a context can influence whether benefits can be achieved. I also described how they can create the need for significant time sacrifices and redundancy in use. As a result of this, by virtue of the context in which it is being used, telemedicine systems can challenge the workplace roles of some users. All these factors can lower perceptions of value.

Integration into the infrastructure focused on how technological elements of a context can influence perceptions of value towards a telemedicine system. In this theme, I described how users require systems to be experienced as extensions of existing technological infrastructure. I also explored the need for systems to be introduced in with sufficient supportive technologies. Failure to integrate the system effectively or provide enough technological support can prevent benefits from being achieved. It may also result in some users perceiving no value in using the system, and abandoning use. In addition, I described how some users are able to see beyond challenges related to integrating the new telemedicine system into the infrastructure, and how they should be encouraged to lead and influence others' perceptions of value.

5.3 Summary of Results and Discussion of Research Question 2

In this chapter, I have presented the results and discussion of research question 2:

2. **What factors influence perceptions of value towards telemedicine systems over time?**

I have given my interpretations of the answers to this question, and developed them through reference to current literature on how people view and understand technology. I have highlighted 3 superordinate themes; experience as the standard; design and demand; and contextual constraints, and summarised the most important points at the end of each superordinate theme section. These superordinate themes represent the factors that can influence perceptions of value over time.

In experience as the standard, I described how expectations about technology formed from prior experiences are utilised by users to evaluate telemedicine systems over time. Personal expectations were used as the basis of judgements about benefits and sacrifices one could experience from using the system. These judgements related to ease of use and job performance, ideas that were explored through reference to aspects of TAM. Perceived complexity and unfamiliarity were also important in understanding benefits and sacrifices, and were developed through consideration of DOI.

Prior experiences of technology were also used to form expectations about how the health care team as a whole should gain value from using a telemedicine system over time. Expectations were used to predict and understand how differences in technical skills among users could affect the achievement of benefits and sacrifices related to the team's overall ability to adopt technology and enhance

job performance. These ideas were recognised and developed through reference to TAM and DOI. Expectations about technical support staff as key members of the health care team who should provide timely and appropriate advice to maintain team functioning when technical problems were encountered were also an important influence on perceptions of value over time.

In design and demand, I described how users' appraisals of the relationship between physical and functional characteristics of telemedicine systems and the demands of workplace tasks can influence perceptions of value over time. Through reference to the TTF model, the ability to transport and access patient information, as well as perform important workplace tasks, such as recording wound progress were understood as fundamental to users' experience of benefits and sacrifices associated with physical aspects of the system.

The ability to perform tasks more accurately, such as wound assessment and communication among team members for overall team job performance were key to users' perceptions of benefits and sacrifices linked to functional features of the system. These ideas were developed through reference to TTF and DOI. Other key components of this superordinate theme included notions of redundancy in design and how users' can be categorised according to patterns in how they engage with innovations. These were developed through consideration of TAM and DOI.

In contextual constraints, I described how the context in which a telemedicine system is used can influence how value is perceived over time. This can be difficult to recognise when a system is being used for the first time. As experience grows, however, the role of bureaucracy and existing technological infrastructure in perceptions of value can become quite clear. Bureaucratic restrictions can limit the benefits that can be gained from a system, and even lead a sense of redundancy, or the need for high levels of sacrifice to achieve enduring successful usage. These ideas were developed through reference to Chau and Hu's (2002) adoption of TAM to understand telemedicine usage. Furthermore, by consideration of Vuononvirta et al's (2011) notion of individual compatibility, an extension of the DOI model, users showed how bureaucratic requirements associated with usage of telemedicine

systems can lead to confusion towards one's understanding of their role within health care teams.

Perceptions of value are also shaped by how well a telemedicine system can Perceptions of value are also shaped the way a telemedicine system is seen to fit into existing technological infrastructure. As recognised through reference to DOI, key to this is the extent to which a system is supported by other devices in the workplace. Telemedicine technologies need to be seen as part of a larger overall system to allow users' to feel like adaptation is natural and logical. Whether a user can successfully adapt is also influenced by their ability to see beyond immediate technical difficulties, and recognise that integrating into existing technological infrastructure is a dynamic, time-consuming process that may involve several difficult, but surmountable challenges. This idea was developed through consideration of aspects of DOI and TAM.

In combination with my answers to research question 1, the answers given here to research question 2 demonstrate how perceptions of value towards telemedicine systems are complex, and influenced by a number of factors over time. I will now synthesise my findings into conclusions, discuss their implications and provide recommendations on how to help improve the way telemedicine systems are studied and utilised in future.

Chapter 6: Conclusions and Recommendations

6.1 Overview

The main aim of this thesis was to investigate the ways in which users' perceptions of value towards telemedicine systems change over time. Formulated from my review of existing literature on this topic in chapter 2, the two research questions that underpinned this aim were:

1. **How do users' perceptions of value towards telemedicine systems change over time?**

2. **What factors influence users' perceptions of value towards telemedicine systems change over time?**

In chapter 3, I explained how a novel telemedicine system was built, implemented and evaluated to develop answers to these research questions. In chapter 4, I detailed my analysis of questionnaire data, and found that perceptions of value can significantly decline over time. In chapter 5, I detailed my analysis of interview data, and found three main factors that influenced change in perceptions over time. These were the use of pre-existing experiences with technology to judge the ability of the system to satisfy individual needs and the needs of others, evaluations of how well the physical and functional aspects of the system met the demands of clinical tasks, and appraisal of how well the system functioned within the constraints of existing bureaucratic and infrastructural workplace characteristics.

In this chapter, I will highlight and summarise the main conclusions of this thesis in relation to each research question. Following this, I will outline the main implications for health care stakeholders and researchers interested in telemedicine systems. I will then provide a list of recommendations based on my findings for improving how telemedicine is used through the enhancement of design, implementation and support of new systems. I will then give suggestions for further research.

6.2 Changes in Perceptions of Value Over Time

The main finding in answering research question 1 was that users perceive less value in using a telemedicine system over time. In particular, as experience with a system grows, users can come to perceive more complexity and inconsistency, become less willing to use it frequently and feel that the functions are not as well integrated. These findings are of significance for telemedicine use in outreach mobile nursing as well as telemedicine use and research in general.

This study demonstrated that mobile nurses perceive significantly less value in using a telemedicine system over time. Previous studies have shown that over short time periods of one month or less, mobile nurses can gain a range of operational benefits from using telemedicine systems, particularly in productivity, efficiency and quality of communication (Hong et al., 2009; Hsiao & Chen, 2012; Guy Paré et al., 2011). The findings of this study raise the question of whether these effects would be enduring generally, and in the context of users' gradually perceiving less value in a system overall. Further research is needed to explore this, and to determine the relationship between the achievement of operational benefits and perceptions of value. The findings of such research may be useful for improving how telemedicine systems are monitored, and determining how user feedback can be best utilised to improve usage.

The results of this study also highlight the need to clarify relationships between perceptions of value and other ways of understanding the users' experience. Paré et al (2009) demonstrated that mobile nurses can be consistently satisfied and continue to achieve operational benefits when using an expert-designed telemedicine system over an 18-month period. It may be the case that satisfaction and operational benefits can be achieved even if users begin to perceive less value in a system with time. Alternatively, it could be that being satisfied with a system means that users also see some degree of value in using it. However, whether either of these situations are actually the case, or whether Paré et al's

(2009) findings contrast with those of this study requires further research into defining the relationships among such aspects of the users' experience. Achieving this will assist future implementers of telemedicine systems in better understanding and monitoring the users experience to improve overall usage.

More generally, this study supports other literature that demonstrates how perceptions of value towards telemedicine systems can vary with time. In particular, this study further highlighted the importance of findings from previous research that show how users can initially perceive high value in using a telemedicine system after using it for less than 6 months (Fritz et al., 2012; Gormley et al., 2011). Other studies have shown how perceptions of value can increase when design aspects of an expert-built system are changed according to user preferences over a 3-month period (Trafton et al., 2010). However, this study showed that over an 18-month period, perceptions of value towards a system built based on user preferences in the first place with minimal changes made over the course of regular use can substantially decline. These findings together stress the importance of examining users' perceptions of value beyond simply the time of first use. They show how there may be a honeymoon period in using a telemedicine system that can fade in as little as 18-months of consistent use, and should be followed up with ongoing monitoring. These findings also call for more research into whether using an expert-designed system that is gradually adapted to users' needs, as was the case in Trafton et al's (2010) study, is a more effective way of consistently maintaining or enhancing perceptions of value over time than building and implementing a system guided from the outset by users' requirements.

Answering research question 1 generated an important set of conclusions and ideas about how perceptions of value towards telemedicine systems change with time. However, the basis of such conclusions and ideas was not addressed by answering this research question. Analysis of SUS questions suggested that users' sense of complexity, inconsistency, feeling that functions were not as well integrated and overall willingness to use the system frequently are involved in shaping perceptions of value over time. However, the nature and meaning of this involvement remains unclear when it is explored only through analysis of

questionnaire data. It is important to further examine and define the role of these and other factors in users' perceptions of value to more effectively understand the conclusions generated in response to research question 1. Furthermore, this deeper understanding of how perceptions of value change with time can also be used to form the foundation of useful recommendations about how to improve the way telemedicine systems are used. These realisations guided the conclusions generated in response to research question 2 and recommendations for future studies and telemedicine projects, which will be discussed in the upcoming sections.

6.3 Factors Influencing Changes in Perceptions of Value Over Time

The main finding of research question 2 was that users' perceptions of value towards telemedicine systems are influenced by preformed expectations about technology, design features and context of use. My data revealed three superordinate themes: experience as the standard, design and demand, contextual constraints. The interpretation and meaning of these themes was achieved by building on previous literature that has explored the ways in which users perceive technology and telemedicine systems.

In experience as the standard, my analysis revealed that users bring with them a set of expectations about how both themselves and the health care team as a whole should be able to use a telemedicine system. These expectations are formed from prior personal or professional experiences with technology. They are used to see benefits and sacrifices associated with using the system, which ultimately influences their perception of value.

For individual users using a system for the first time, building on the TAM and TTF theories, benefits may be perceived through the satisfaction of expectations about ease of use and the potential overcoming of sacrifices by the introduction of adjunct devices (Goodhue, 1995; Venkatesh & Davis, 2000). For users who have used the system for the first time and are considering its effect on the functioning of their health care team, building on the TAM, perceptions of value are influenced by perceived benefits for the overall team's job performance (Venkatesh & Davis, 2000; Walker & Whetton, 2002).

Over time, preformed expectations about technology still influence perceptions of value. However, over time the nature of this influence changes. For individual users, systems can begin to appear unfamiliar based on design aspects failing to meet expectations. This can give users a sense of complexity over time, as found in analysis of data for answering research question 1, and may require sacrifice in the form of learning to use it in ways that do not allow one to utilise

previous technological experience. Building on the DOI theory, this demonstrates that for perceptions of value to be maintained over time, users expectations of being able to overcome complexity through drawing upon past experience should be satisfied (Rogers, 2003).

Other aspects of use can be involved in understanding how perceptions of value change when considering users' expectations of how their health care teams use telemedicine technologies. Over time, expectations about how older people may not be as well equipped to adapt to technology can be used to recognise sacrifices related to effective team functioning when using a new system. As technical problems arise over the course of regular usage, expectations about technical support may also influence how associated benefits are perceived. Both of these aspects of use impact on how well a health care team can function when using a telemedicine system. Building on the DOI theory, managing differences and the technical support needs among members of a team are important components in how users' perceive benefits, sacrifices and value over time (Rogers, 2003).

In design and demand, my analysis described how perceptions of value are influenced by the degree to which the physical and functional attributes of a telemedicine system align with the demands of workplace tasks. This theme extends the ideas of the TTF model to demonstrate how the relationship between a telemedicine system and the tasks of its users is an important influence on how benefits and sacrifices are perceived over time (Goodhue et al., 2000; T. Lin, 2014).

In the first instance of use, users can perceive benefits in the form of a telemedicine system making it physically easier to transport and access patient information compared with a paper-based system. Functions of the system, particularly the imaging function can also provide benefit in the form of improving how wounds can be assessed through more accurate recording of information and greater access to supportive resources. Even if there are potential sacrifices associated with attaining these benefits, such as having to continuously take gloves on and off to maintain hygiene, so long as users understand there is an overall better relationship between the technology and the demands of workplace tasks compared with the existing paper-based systems, value is perceived (Goodhue et al., 2000).

Furthermore, building on Vuononvirta et al's (2011) idea of individual and process compatibility, these ideas also demonstrate how the ability of a system to potentially improve communication among team members and job performance are also important influences on users' initial perceptions of value (Vuononvirta et al., 2011).

Over time, the relationship between physical and functional attributes of telemedicine systems with workplace tasks continues to be a strong influence on perceptions of value. However, as experience with a system grows, while a good match between physical design and workplace demands may still be seen as a benefit, it may not be enough to sustain perceptions of value in the face of other problems and sacrifices associated with use. Physical aspects of systems may even come to make existing tasks such as recording notes more difficult than before, requiring sacrifice in form of dealing with physical discomfort when trying to record patient notes on an iPad screen.

Furthermore, over time users become focused on highlighting the difference between actual benefits and potential benefits associated with using a telemedicine system. To maintain perceptions of value, some require regularly demonstrable actual benefits, while others continue to see value due to an ongoing understanding of the significance of potential benefits, even though they may not yet have experienced them. Distinguishing between actual benefits and potential benefits may come in the form of recognising that some functions give the user a clear and immediate sense of benefits while others may not. Users respond to such realisations by feeling that the functions of a telemedicine system are therefore not well integrated, as was detected in data collected in response to research question 1. Building on the DOI theory, this highlights that differences in the way users feel they need to experience benefits can change perceptions of value over time (Rogers, 2003).

In contextual constraints, my analysis explored the influence of context of use on perceptions of value. In contrast to the other areas of my analysis, the role of context only became significant after the system had been consistently used for an extended period.

Bureaucratic requirements became a strong influence on perceptions of value as users came to realise that workplace protocols required them to record patient information using both the existing paper-based method and the telemedicine system. This prevented benefits from being achieved and created a sense of redundancy, which resulted in lower perceptions of value over time. Building on Chau and Hu's (2002) study, this emphasised the need to ensure that systems benefit workplace performance while causing minimal disruption to existing routines (Chau & Hu, 2002). Due to the need to sacrifice time to maintain use of both systems, some users came to see no value in using the telemedicine system, and responded by simply avoiding using it altogether. Extending Vuononvirta et al's (2011) idea of individual compatibility, this response can form from the way in which bureaucratic requirements can cause users to have additional workplace tasks which they feel are not part of their job responsibilities, and hence lead to an overall lower perception of value towards new systems (Vuononvirta et al., 2011).

In addition, the way that a system is integrated into an existing technological infrastructure in a workplace can also influence perceptions of value over time. Again building on Chau and Hu's (2002) idea of the need to minimise disruption to workplace routines, users felt that in order for true benefits to be gained from a system, it needed to be experienced as a logical, consistent extension of the existing hospital technological infrastructure (Chau & Hu, 2002). This may also help prevent users from feeling there is inconsistency in the system over the course of usage, as was detected in data obtained in response to research question 1. In addition, building on the idea of relative advantage from the DOI theory, there must be enough supportive technologies, such as desktop computers to store patient information from iPads, for true benefits to be obtained over the existing paper-based system (Rogers, 2003). If this is not achieved, users may feel less of a desire to use the system frequently, as found in data on research question 1. This can lead them to avoid use and perceive less value in the system over time. However, in some cases, users may recognise how there will always be difficulties in integrating a new system into an existing infrastructure. As emphasised by the DOI theory and TAM, users who develop such positive attitudes should be encouraged to lead others and

encourage a communal ongoing perception of value towards new telemedicine systems over time (Rogers, 2003; Venkatesh & Davis, 2000).

6.4 Implications for Progress

This research reveals that users' perceptions of value towards telemedicine systems are variable and influenced by a combination of preformed expectations, design features and the context of use. These findings have important implications for the ways in which stakeholders and researchers in health care explore the use of telemedicine systems in workplaces.

The finding that perceptions of value can decline over time emphasises the need for stakeholders to continually assess users' responses to telemedicine systems over the course of their use. It is not sufficient to commit a health care team to using a new system based only on users having a high perception of value after initial or short-term use. Failing to recognise how perceptions of value may be declining over time can lead users to feel there is an increasing sense of complexity, redundancy and may even lead to complete avoidance of the system altogether. This may lead to a decline in operational benefits associated with a new telemedicine system, but future studies are needed to clarify this.

In addition, the finding that perceptions of value are influenced by multiple factors opens up a range of new areas that must be considered by stakeholders and future telemedicine researchers. Stakeholders must be aware of how users can perceive benefits and sacrifices in using telemedicine systems according to preformed expectations about technology, design features and context of use. These have been shown to be factors of a user's perception of value that are sustained over time, but manifest themselves in in different ways as experience with a new system develops. Similarly, researchers who are designing and implementing telemedicine systems must be aware of these factors, and endeavour to explore more deeply the ways in which they affect perceptions of value. Improved understanding of such factors can enhance the way systems are designed and implemented into the workplace, and potentially help achieve greater operational benefits for patients, providers and administrators.

6.5 Recommendations

Listed in this short section are the recommendations that I have developed to improve the design, implementation and support of telemedicine systems in general. These recommendations have been developed from the results of my research questions and conclusions drawn from the data.

6.5.1 Telemedicine System Design

Potential users' should be given a regular forum through which to express preformed expectations about telemedicine systems in the workplace and inform stakeholders about the ways in which they need to be designed to meet workplace demands over the course of use. Although it can be difficult to meet every user's expectations about technology, some of which may plausibly be unreasonable, it is important to provide a context in which there is opportunity for them to be expressed. This can open up a dialogue between researchers, stakeholders and users to ensure that telemedicine systems are being built to be familiar and meet users' needs. Systems that are built to be familiar and well fitted to workplace demands can help enable users to cite benefits and overcome sacrifices more easily. An ongoing, regular reassessment of whether this is being achieved by the design of the system is important, as expectations and workplace demands may change over time. This can help sustain perceptions of value towards telemedicine systems.

6.5.2 Telemedicine System Implementation

The implementation of telemedicine systems should be seen as a dynamic process that requires continual adjustment to accommodate bureaucratic requirements and integration into existing technological infrastructures. Users' perceptions of value are influenced by the ways in which a system fits in with

aspects of its context of use. It is important to recognise that adapting a new technological system to a particular workplace context can be an ongoing process where challenges related to existing protocols and procedures arise over time. It can be difficult to know the impact of these before a telemedicine system is introduced, so a dynamic approach of continually developing design features or guidance on how best to use the system in a particular workplace is the best approach to overcoming such challenges, and helping maintain users' perceptions of value over time.

Furthermore, implementing systems in ways that allow them to synchronise with the existing technological infrastructure, such as PMR computer programs can help ensure that users perceive telemedicine systems as simply extensions of technologies they have used before, further emphasising a sense of familiarity. Providing enough supportive technologies, such as desktop computers is also critical for ensuring that all users are able to use the system properly without having to compete for needed resources in the workplace. Implementing systems with these considerations in mind can help maintain users' perceptions of value over time.

6.5.3 Telemedicine System Support

Support for the implementation of telemedicine systems is crucial for successful use. Users must be given continual support in the form of active guidance on how to optimise their experience and ability to use new systems. This should come in two important forms that must be maintained over the course of usage.

Personnel with advanced levels of knowledge about technical design and optimum use of telemedicine systems must be considered part of the health care team. Users must become familiar and comfortable with these members of the team to ensure they are able to benefit from their expertise. Technical support personnel must be equipped to solve problems related to technical functioning in a way that is timely and effective. Opportunities to solve technical problems should also be used to facilitate the skilling of other users with lesser levels of expertise to ensure they are better equipped in future to solve overcome similar challenges themselves. Users will therefore not become reliant on technical support personnel, and can

become confident and empowered to manage potential problems themselves. This can help ensure that problems related to the technical functioning of telemedicine systems have limited impact on perceptions of value over time.

In addition, support should also come in the form of recognising users who continue to perceive value in telemedicine systems when others may not. These users may have unique perceptions of the value of systems over and above their faults, or insight into how they can be overcome. They should be sought out from groups of users, and encouraged to work with stakeholders and technical support staff to inspire, empower and lead others to find ways of continuing to perceive value in telemedicine systems over time.

6.6 Strengths and Limitations of this Research

A retrospective assessment of this study gives insight into the strength and limitations of these findings and helps provide guidance for future research in the area of telemedicine.

6.6.1 Strengths

A number of problems with existing telemedicine research were identified in the literature review. These included incomplete uptake, poor methodological design and inadequate study duration. Each of these problems was addressed in this study.

At the outset, uptake was complete, as using the system was a necessary part of working at NOS. This ensures that the results obtained are relevant and useful for stakeholders considering introducing telemedicine systems in contexts where users themselves may not have decision-making power. However, in such contexts, this study stresses the importance of providing users with opportunities to influence other aspects of use, including design and implementation in order to ensure perceptions of value are maintained over time and usage is optimised.

The methodological approach of this study was robust and comprehensive, employing well-recognised quantitative and qualitative approaches. Robust methodologies have not always been used in telemedicine research. In addition to providing more useful and insightful results, the use of such methodologies in this study opens up the possibility of clear, meaningful comparisons with research that has used similar approaches. In particular, SUS scores for various products and systems designed for the same purpose can be compared (Bangor et al., 2008). This means that if other studies also use the SUS for examining perceptions of value,

stakeholders may be able to contrast different systems for the same purpose and make more informed choices about introducing telemedicine systems.

In response to the large number of studies that have been conducted over short time periods of less than 6 months, this study was conducted over an 18-month period. This ensured that a broader scope of benefits and sacrifices as part of users' perceptions of value could be realised and investigated. This extended time period also gives stakeholders and future users of telemedicine systems a better understanding of the importance of regularly reassessing and adapting systems to particular health workplaces. The study's duration was key in the development of the recommendations that emphasise how designing, implementing and supporting telemedicine systems is an ongoing, dynamic process. It has been shown that it cannot be expected that a telemedicine system can be introduced successfully over a short period, then left to achieve benefits over time.

6.6.2 Limitations

It is important to recognise that there are multiple ways of exploring and understanding telemedicine users' perceptions of value. There are several alternative definitions of perceptions of value available in other literature. The definition employed in this thesis was considered most appropriate because a strong link could be made with robust usability methodologies for measurement of change in perceptions over time, as well as for ease of qualitative analysis. This does not mean that other definitions and their associated approaches would not also yield interesting results. Indeed, a users' understanding of utility through benefits and sacrifices could be examined a number of different ways, many of which would help further develop the meaning of perceptions of value.

Furthermore, while this study demonstrated how perceptions of value changed over time, and the factors that influenced this, the time point at which such changes occurred across an 18-month period of testing was not specifically established. This is an important consideration for stakeholders in knowing when and how to assess users' perceptions of value over time when introducing a new

telemedicine system. Gathering this more precise information can help improve the way new systems are managed in order to optimise their benefits in the workplace.

6.7 Suggestions for Further Research

In light of the findings, strengths and limitations of this study, a number of suggestions can be made for future research. Subsequent studies may consider conducting a longitudinal approach to assess how perceptions of value change at different time points or in response to certain alterations in the design of the system. This may allow for the development of more precise understandings of how, why and when perceptions of value change. Recommendations developed from these findings may enhance the ways in which systems are designed and maintained over time, helping more clearly identify and avoid sources of problems for users.

The use of randomised controlled trials (RCTs) may also help refine understandings of how certain factors in the users' experience influence perceptions of value towards telemedicine systems. This study found that perceptions of value were shaped by characteristics of the individual, system itself and the context of use. An RCT that examines how variation of these characteristics more directly influences perceptions of value may be useful in strengthening the evidence to support their involvement. A quantitative approach that either uses measures such as the SUS or others that are more specifically designed to represent perceptions of value in telemedicine could help stratify which aspects of the users' experience are most important in optimising design, implementation and support of systems. A study of this kind may also help determine how the influence of such factors may change with time. This knowledge would be particularly important in contexts where stakeholders do not have sufficient resources to incorporate all the recommendations made in this study.

In addition, while this study has shown that usability measures and phenomenological methodologies are useful for investigating perceptions of value, there is still a need for the development of a telemedicine-specific evaluation framework. This framework could include all factors that appear to influence the value of a telemedicine system, such as cost, potential clinical outcomes and users' perceptions of value over time. Such a framework would be invaluable to

stakeholders unsure of how to know whether new telemedicine systems are of value, or are unsure of whether to make a commitment to implementing new systems.

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