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# Examining the Post-Adoptive Infusion of Mobile Technology in a Healthcare Domain: Determinants and Outcomes

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September 2013

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The Author declares that, except where duly acknowledged, this thesis is entirely her own work and has not been submitted for any degree in the National University of Ireland, or any other University.

## DEDICATION

*This dissertation is dedicated with love and affection to:*

*My loved ones, Geraldine, Mossie, Christine, Alison, Matt, Ciaran (O' Connor), Gearoid Fitzgerald, and extended family, without whom this dissertation would have not been completed. I thank you all for your continued support, guidance and love throughout the PhD process.*

***

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***

*The memories of those who have passed away, you are always in my mind and in my heart and will never be forgotten.*

***

## ABSTRACT

The healthcare industry is beginning to appreciate the benefits which can be obtained from using Mobile Health Systems (MHS) at the point-of-care. As a result, healthcare organisations are investing heavily in mobile health initiatives with the expectation that users will employ the system to enhance performance. Despite widespread endorsement and support for the implementation of MHS, empirical evidence surrounding the benefits of MHS remains to be fully established. For MHS to be truly valuable, it is argued that the technological tool be infused within healthcare practitioners work practices and used to its full potential in post-adoptive scenarios. Yet, there is a paucity of research focusing on the infusion of MHS by healthcare practitioners. In order to address this gap in the literature, the objective of this study is to explore the determinants and outcomes of MHS infusion by healthcare practitioners.

This research study adopts a post-positivist theory building approach to MHS infusion. Existing literature is utilised to develop a conceptual model by which the research objective is explored. Employing a mixed-method approach, this conceptual model is first advanced through a case study in the UK whereby propositions established from the literature are refined into testable hypotheses. The final phase of this research study involves the collection of empirical data from a Canadian hospital which supports the refined model and its associated hypotheses. The results from both phases of data collection are employed to develop a model of MHS infusion.

The study contributes to IS theory and practice by: (1) developing a model with six determinants (Availability, MHS Self-Efficacy, Time-Criticality, Habit, Technology Trust, and Task Behaviour) and individual performance-related outcomes of MHS infusion (Effectiveness, Efficiency, and Learning), (2) examining undocumented determinants and relationships, (3) identifying prerequisite conditions that both healthcare practitioners and organisations can employ to assist with MHS infusion, (4) developing a taxonomy that provides conceptual refinement of IT infusion, and (5) informing healthcare organisations and vendors as to the performance of MHS in post-adoptive scenarios.

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# CHAPTER 1: INTRODUCTION

This chapter gives an introduction to the research investigated in this thesis. It provides the theoretical foundations of this study (Section 1.1), identifies the research objective, questions and methodology (Section 1.2), outlines the key contributions established from this research (Section 1.3), and presents the structure of this thesis (Section 1.4). Finally, Section 1.5 provides the published findings from this study to date, in association with the relevance each paper makes to this thesis.

## 1.1 Theoretical Foundations of this Study

Many researchers (Mitchell and Sullivan, 2001; Freudenheim, 2004; Heinzelmann et al., 2005; Bhattacherjee et al., 2007; Dwivedi et al., 2007; Kirsch et al., 2007; Puentes et al., 2007; Kharrazi et al., 2012) have documented the success of Mobile Health Systems (MHS). However, a review of this literature revealed that these success studies were primarily conducted at early stages of IT implementation. What began to emerge in the literature were studies (e.g. Tschopp et al., 2002; Heeks, 2006; Tang and Carpendale, 2008; Standing and Standing, 2008) pertaining to MHS failure, albeit not explicitly utilising the term 'failure'. The common argument across these studies was that Mobile Health Systems (MHS) are often under-utilised following adoption, thus resulting in failure. It is therefore important to investigate post-adoption use of MHS to fully appreciate long term utilisation of these technological tools. Yet, there is a paucity of research focusing on the latter stages of MHS implementation. This scarcity in extant research needed to be addressed. Hence, the focus of this research is to study post-adoption use of MHS by healthcare practitioners, specifically their infusion.

Infusion is commonly recognised as the last phase of the Cooper and Zmud (1990) stage model of IT implementation (referred to as the Technological Diffusion Model) in organisations and remains one of the least studied facets of IT post-adoption in the IS field (Beaudry and Pinsonneault, 1999; Meister and Compeau, 2002; Jasperson et al., 2005; Ng and Kim, 2009; Tennant et al., 2011). Since its emergence in the IS literature in the mid-1980s numerous definitions exist for IT

infusion. This lack of consensus on an agreed definition for what constitutes the term 'infusion' has resulted in confusion among scholars and inconsistent results. In the context of this study, infusion can be identified as the extent to which individuals incorporate and use the IT artefact in a comprehensive manner (i.e. feature, integrative, exploratory use respectively[1])".

Analysis of the literature further reveals that infusion has primarily been empirically investigated at an organisational level of analysis, with less attention focused towards the individual level (Peijian and Lihua, 2007). Research on individual level infusion is imperative as individuals are the primary users of the IT that underpins many organisations (Tennant et al., 2011) and it is individual infusion that is a prerequisite to organisational infusion (Peijian and Lihua, 2007; Sundaram et al., 2007; Tennant et al., 2011). Although understanding infusion at the organisation level is important, the researcher perceived that it is first necessary to understand individual infusion.

Moreover, analysis of the literature reveals that the majority of research on IT infusion has primarily focused on applications run on stationary desktop computers, which are different from mobile technologies. Therefore, little is known on the determinants of mobile infusion by individuals and subsequent outcomes. Also notable, analysis of the literature reveals a dearth of infusion studies conducted in the healthcare domain.

Despite the wide endorsement and support for the implementation of MHS, Black et al., (2011) argue that empirical evidence surrounding the benefits of e-health remains to be firmly established. Although researchers (Zmud and Apple, 1992; Beaudry and Pinsonneault, 1999; Sousa and Goodhue, 2003; Fadel, 2006; Ramamurthy et al.,

---

[1] *Feature Use:* "The degree to which healthcare practitioners use the technology's (i.e. MHS) features/functionality to complete any given task" (adapted from Oakley and Palvia, 2012).

*Integrative Use:* "The degree to which healthcare practitioners organise their work tasks to fulfil their role using the MHS" (adapted from Meister and Compeau, 2002; Saga and Zmud, 1994).

*Exploratory Use*: "The degree to which healthcare practitioners' actively seek novel usess of the MHS within their work environment" (adapted from Saeed and Abdinnour-Helm, 2006).

2008) argue that the full benefits of IT artefacts can only be obtained through infusing MHS, a dearth of research currently exists which examines the outcomes of IT infusion. The researcher identified six papers which investigate various outcomes of IT infusion. From these six papers, one was theory-based and not empirically examined; four focused on the organisational level of analysis and thus concentrated on organisational outcomes. The remaining paper examined IT infusion at an individual level of analysis but focused on IT-enabled performance (i.e. Salesperson and Administrative Staff in the Sales Sector). It is evident that there is relatively little empirical evidence to substantiate the beneficial claims made about infusing IT artefacts. More research is therefore required to understand what benefits, if any, can be achieved through the infusion of IT artefacts in a healthcare domain.

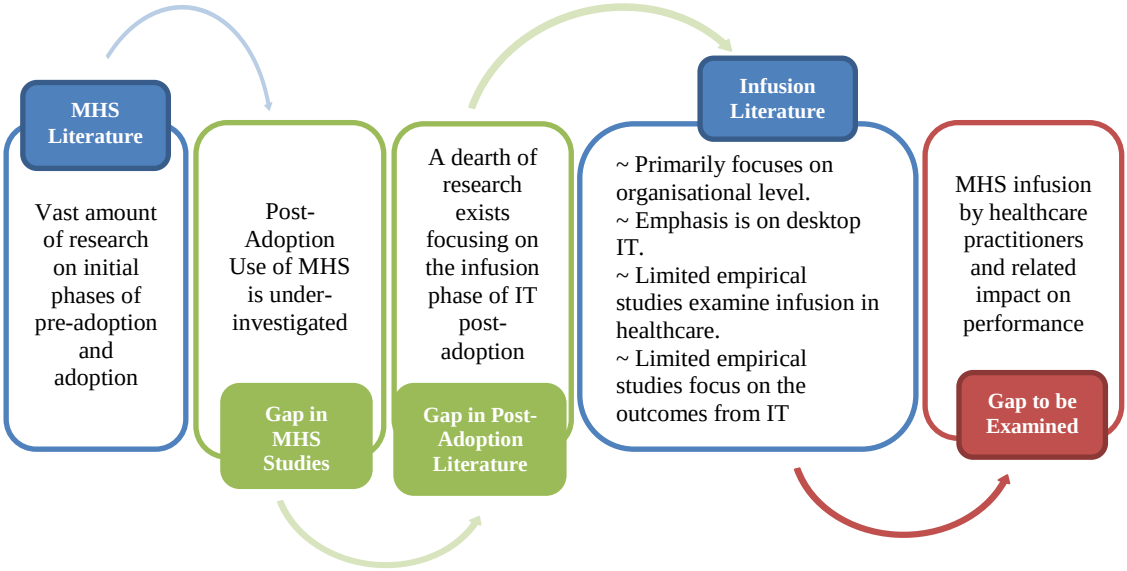



**Figure 1-1: Visual Depiction of Gap in Literature**

Therefore, based on the limitations of extant literature outlined in this section (depicted in Figure 1-1), it has been concluded that the literature on the determinants that impact upon healthcare practitioner MHS infusion and subsequent healthcare practitioner related outcomes is underdeveloped.

## 1.2 Research Objective, Questions and Methodology

To address the gap in literature, the **objective** of this research is to explore:

*The determinants and outcomes of MHS infusion by healthcare practitioners.*

In operationalising the research objective, four research questions were formulated:

- **Research Question 1:** What are the determinants of Mobile Health Systems infusion?
- **Research Question 2:** What are the outcomes of Mobile Health Systems infusion by healthcare practitioners?
- **Research Question 3:** To what degree do these determinants impact upon Mobile Health System infusion?
- **Research Question 4:** To what degree does Mobile Health System infusion impact upon healthcare practitioner outcomes?

All research questions presented here are exploratory in nature. The rationale for employing an exploratory approach is that the literature on MHS infusion at an individual level of analysis is scarce. Moreover, employing an exploratory approach facilitates for a richer understanding of a domain which is under-investigated. In doing so, existing knowledge will be enhanced.

In order to examine these research questions a post-positivist, mixed-method approach is employed. An important consideration in using a mixed-method approach is the way in which the qualitative and quantitative methods are combined (Brannen, 1992). The arrangement of research methods is selected based on the research questions formulated to achieve the research objective. Thus, in the first phase a qualitative approach is undertaken to delve deeper into the concept of MHS infusion (research questions 1 and 2). This enables the researcher to examine the conceptual model derived from literature, advance the model based on the findings and refine the propositions established into testable hypotheses. It is then in the second quantitative phase that these hypotheses are further explored to understand

the extent to which each determinant impacts MHS infusion and subsequent healthcare practitioner outcomes (research questions 3 and 4). Findings from both qualitative and quantitative research in one study provide for rich insights into, and contributions to, literature which are subsequently discussed.

## 1.3 Key Contributions

This thesis contributes to the academic community (Section 1.3.1) in terms of MHS infusion research (Section 1.3.1.1) and IS research (Section 1.3.1.2). It also makes contributions to the practitioner community (Section 1.3.2). The key contributions to the two domains are presented in the subsequent sections, with a more detailed overview presented in Chapter 7.

### 1.3.1 Key Theoretical Contributions

The study's findings contribute to two domains of academic research. It first contributes to the MHS infusion domain (Section 1.3.1.1). Contributions to MHS infusion research include: (1) developing a model of MHS infusion, (2) examining of undocumented determinants and relationships, (3 and 4) identifying prerequisite conditions that both healthcare practitioners and organisation can employ to assist with MHS infusion and (5) demonstrating the outcomes of MHS infusion.

This study also contributes to the IS domain (Section 1.3.1.2) by: (1) examining the infusion of mobile IT as opposed to stationary desktop IT, (2) corroborating extant research which highlights the importance of resource availability, self-efficacy, habit, systems and content quality for IT usage, (3) illustrating how a theory building approach can provide rich insights into an under-investigated area of extant research and (4) developing a taxonomy that provides conceptual refinement of IT infusion.

#### 1.3.1.1 Contributions to MHS Infusion Research in Academia

The study's findings make a number of theoretical contributions to MHS infusion research. Prior to this study and at the time of writing, two papers were identified which empirically researched the phenomenon of MHS infusion (White et al., 2005;

Idowu et al., 2006). This study contributes to the MHS infusion domain by providing both qualitative and quantitative empirical evidence to an area of research which has gone relatively unnoticed in extant literature. In doing so, additional insights of MHS infusion are presented which enhance the current understanding of scholars in relation to this domain.

*Model of MHS Infusion*

A model is established in this thesis which highlights six determinants (i.e. Availability, MHS Self-Efficacy, Time-Criticality, Habit, Technology Trust and Task Behaviour) of MHS infusion. In establishing this model a clear definition of MHS infusion is provided. It further establishes that MHS infusion leads to improvements in healthcare practitioner performance in terms of Effectiveness, Efficiency and Learning. To date, a model depicting determinants of MHS infusion and individual performance-related outcomes are extremely limited in the MHS infusion literature.

*Undocumented Determinants and Relationships*

This model examines previously undocumented determinants and relationships which provide additional insights into the infusion of MHS. Two previously undocumented determinants in the MHS infusion domain were examined in this study; namely, Time-Criticality and Task Behaviour (established from the qualitative case study). A number of under-investigated relationships between various determinants in MHS infusion research (i.e. [a] Time-Criticality and Infusion, [b] Technology Trust and Time-Criticality, [c] Task Behaviour and Time-Criticality, [d] Task Behaviour and Habit, [e] Availability and Technology Trust, and [f] Availability and Habit) were also revealed. Moreover, the study's findings reveal that Perceived Risk in Technology does not impact MHS infusion and that Knowledge Creation is not an outcome of MHS infusion.

*Healthcare Practitioners' Role in MHS Infusion*

For MHS infusion to occur, this study demonstrates that healthcare practitioners should (i) first be willing to use the MHS in urgent situations, (ii) establish habitual routines which facilitate infusion in the routinization phase (as per Cooper and Zmud, 1990), (iii) acquire procedural knowledge (i.e. how to perform clinical activities using the MHS) and knowledge of the various features/functionality of MHS to develop their skill-set for infusing MHS within their daily activities and (iv) work in a group environment which facilitates infusion. It also demonstrates that healthcare practitioners who can anticipate how that particular artefact will respond under different conditions (e.g. operate reliably) are more confident in their ability to use MHS. Therefore, trust in the MHS technology is required.

*Healthcare Organisations' Role in MHS Infusion*

The study reveals that healthcare organisations must (i) provide IT support and technological, time and financial resources, and (ii) prepare for infusion via change management control and leadership (organisational readiness). Healthcare organisations should invest in MHS of high system and content quality which provide value to healthcare practitioners. For more contributions to the practitioner community see Section 1.3.2.

*Outcomes of MHS Infusion*

The model of MHS infusion identifies three healthcare practitioner performance-related outcomes of embedding MHS within their daily work practices; namely, Effectiveness, Efficiency, and Learning. This study provides empirical evidence to substantiate the beneficial claims made about infusing MHS artefacts (i.e. infusion of technological solutions can lead to improvements in individual performance).

#### 1.3.1.2 Contributions to IS Infusion Research in Academia

This study makes a number of theoretical contributions to wider IS research[2]. It answers recent calls for the investigation of IT infusion (Tennant et al., 2011). It addresses an under-investigated area of extant research pertaining to mobile infusion at an individual level of analysis. This study differs from the majority of extant literature which examines the infusion of stationary desktop technologies at an organisational level of analysis.

*Confirms Existing Knowledge in Extant Literature*

This study confirms IS research which highlights the importance of resource availability, self-efficacy, habit, and system and content quality for IT usage by individuals. It also confirms research which identifies that (i) perceived risk in technology is a concern at early stages of IT implementation and (ii) IT usage is necessary for improvements in effectiveness, efficiency and learning. The study's findings further reveal that individuals may be unconsciously influenced by others, which diverge from research which examines subjective norms in IS research.

*Model of MHS Infusion*

This study illustrates how a theory building approach can provide rich insights into an under-developed area of extant literature. Furthermore, it highlights the importance of examining the context in which IT artefacts are used. As a result, this study moves beyond examining 'willingness to use IT' in a wider context to the examination of 'willingness to use IT' in a specific context (i.e. urgent situation). This study contributes to IS research as there is a lack of empirical research which examines the outcomes of infusing IT artefacts. Therefore, it provides empirical evidence surrounding the benefits of MHS.

[2] Wider IS research, for example, includes mobile technologies in the healthcare domain at other phases of implementation (i.e. not the infusion phase of implementation, refer to Table 2-3), post-adoption studies of IT usage, and general IS material which was referenced in the infusion literature.

*Taxonomy for Examining IT Infusion*

Prior to this study and after two decades of research on the concept of infusion, there existed uncertainty surrounding the definition and operationalisation of infusion. From reviewing and synthesising the literature it is evident that infusion is defined at two levels: (i) Incorporating and Using the IT Artefact in a Comprehensive Manner; and (ii) Outcomes of Incorporating and Using IT Artefacts Comprehensively. This study reveals that different indicators pertaining to IT infusion can be used at each level and as a result, a taxonomy for examining IT infusion has been developed. This taxonomy provides conceptual refinement of infusion and categorises keywords and indicators for each level of IT infusion to ensure that infusion is assessed accordingly to support future research.

Building from this, Section 1.3.2 presents the contributions this thesis makes to practice.

### 1.3.2 Key Practical Contributions

This study informs healthcare organisations and vendors as to the performance of MHS in a healthcare organisation by clearly demonstrating that infusion leads to improvements in clinical care, workflow and individual learning. It further contributes to the practitioner community by establishing that training must be provided regularly and continues in the post-adoption phases, especially if features/functionality of MHS changes frequently. Building from this, a dedicated team should be formulated within a healthcare organisation (consisting of both clinical and IT personnel) to promote the use of MHS to achieve infusion. Finally, for infusion of MHS to occur it is imperative that healthcare practitioners have access to available MHS to gain knowledge on how to embed the technological artefact within their daily work practices. Ultimately, this might require the healthcare organisation to invest significantly in MHS. Having outlined the contributions that this study makes to theory and practice, Section 1.4 outlines the structure of the thesis.

## 1.4 Thesis Structure

This thesis is composed of seven chapters which are outlined as follows:

**Chapter two** reviews the state-of-the-field of IT use in healthcare literature by describing the progression of IT usage from paper-based approaches to stationary desktop IT right through to MHS. It reveals that studies of MHS have primarily been examined at initial phases of IT implementation and identifies that post-adoption research is scarce in this area. Identifying this gap in literature the chapter subsequently examines post-adoption research in a wider mobile commerce context. Examining this literature (i.e. post-adoption) reveals the second gap in IS research; infusion, as a post-adoptive stage, is currently under-investigated. This paves the way to a review of the infusion literature. This examination exposes that there lacks consensus on the definition and operationalisation of infusion. Moreover, extant infusion research primarily focuses on stationary desktop IT at an organisational level of analysis. Through describing various models currently employed in the infusion domain it becomes apparent that these models fall short of explaining MHS infusion by healthcare practitioners. As a result, this chapter concludes that a theory building approach is required for developing more insights into the determinants and outcomes of MHS infusion by healthcare practitioners.

- Outcome: A new model is required for exploring healthcare practitioners' infusion of MHS.

**Chapter three** builds on chapter two by commencing with the theory building process. The chapter examines existing theories in wider IS research and revisits models utilised in infusion based research. In doing so, theoretical development of constructs is described resulting in the development of two propositions. Concluding this chapter is a conceptual model which visually represents these constructs and propositions.

- Outcome: Two propositions and an *a-priori* model for exploring MHS infusion.

**Chapter four** justifies and outlines the research methodology employed in this study. The model derived in chapter three guides the study's two-phased, sequential mixed-methods data gathering approach. This chapter establishes why a post-positivist mixed-methods approach is exercised during this research study. It outlines the qualitative and quantitative phases, describing in detail the data collection, analytical and validation processes employed. The chapter concludes with an overview of the methodology undertaken.

- Outcome: Mixed-methods approach is outlined and deemed appropriate for achieving the research objective.

**Chapter five** presents the case study findings. It commences by explaining various determinants which were found (not) to impact MHS infusion by healthcare practitioners. Subsequently, this enables for the refinement of the first proposition established in chapter three into eight testable hypotheses. Furthermore, it explains healthcare practitioner outcomes of the infusion of MHS which results in an additional hypothesis surrounding proposition two. This chapter enabled the researcher to gain a better understanding of MHS infusion by healthcare practitioners. Thus, the chapter concludes with a refined conceptual model and a total of nine hypotheses.

- Outcome: Refinement of propositions into nine testable hypotheses and conceptual model for explaining MHS infusion.

**Chapter six** presents the survey findings using the derived conceptual model and hypotheses from Chapter five. The chapter commences with an assessment of the survey administration. Using Partial Least Squares (PLS) the model derived in chapter five is evaluated in terms of its measurement and structural model. As a result, the significance of relationships between constructs in the model are assessed and hypotheses are (dis)confirmed. The chapter also outlines the impact of timeframe (i.e. the length of time healthcare practitioners are using MHS) on survey findings. Concluding this chapter is a revised model of MHS infusion by healthcare practitioners.

- Outcome: Conceptual model for explaining MHS infusion derived from Chapter five is examined and validated. A final model for explaining and predicting the determinants impacting MHS infusion and healthcare practitioner related outcomes is presented.

**Chapter seven** presents an integrated analysis of the research study findings whereby the findings from the qualitative and quantitative phases of the study are reported. These findings are also discussed with respect to existing literature. Subsequently, the chapter discusses the major contributions of the study and its key implications for both research and practice. Lastly, the chapter acknowledges the limitations of the study and provides recommendations for future studies in MHS infusion and IS research.

- Outcome: Contributions and implications for theory and practices, and future research opportunities.

## 1.5 Published Findings from the Study

During the research investigation a number of papers were published in peer-reviewed papers/journals in the Information Systems (IS) and medical informatics field. These publications and their relevance to this thesis are as follows:

*i.* **Paper (Published)**: *O'Connor, Y., O 'Donoghue, J. and O'Reilly, P. (2011). Understanding Mobile Technology Post-Adoption Behaviour: Impact upon Knowledge Creation and Individual Performance. Tenth International Conference on Mobile Business (ICMB): 275-282.*

Relevance to Thesis**:** This paper presented the theoretical work underpinning the research topic of some of the concepts from Chapter 2 and 3.

*ii.* **Paper (Published):** *O' Connor, Y., O' Reilly, P. and O' Donoghue, J. (2012) Individual Infusion of M-Health Technologies: Determinants and Outcomes, ECIS 2012 Proceedings, Paper 164.*

Relevance to Thesis**:** This study presented the theoretical foundations (Chapter 2 and 3) and the qualitative findings explored in the first phase of the research investigation (Chapters 5 and 7) from this thesis.

*iii.* **Paper (Published):** *O'Connor, Y., O'Donoghue, J., and O'Reilly, P. (2012) Infusion of Mobile Health Systems in the NHS: An Empirical Study. In 6th European Conference on Information Management and Evaluation, Academic Conferences Limited: 226-233.*

Relevance to Thesis**:** This study presented critical success determinants surrounding MHS infusion by healthcare practitioners (derived from Chapter 5).

*iv.* **Paper (Published):** *O'Connor, Y., O'Reilly, P. and O'Donoghue, J. (2013). M-Health Infusion by Healthcare Practitioners in the National Health Services (NHS). Health Policy and Technology, 2(1):26-35.*

Relevance to Thesis**:** This study presents the findings (Chapter 5) and aspects of discussion (Chapter 7) from this thesis. It builds on the ECIS 2012 paper and provides a more detailed analysis of the findings.

v. **Paper (Published):** *O'Connor, Y., O' Donoghue, J. and O' Reilly, P. (2013). A Survey of Mobile Health System Infusion among Healthcare Practitioners, ECIS 2013.*

Relevance to Thesis**:** This study presents the refined model and its associated hypotheses from the first phase of this research (Chapter 5) and the quantitative findings explored in the second phase of the research investigation (Chapter 6 and 7) from this thesis.

# CHAPTER 2: LITERATURE REVIEW

## 2.1 Introduction

This chapter analyses and synthesises existing literature pertaining to Information Technology (IT) infusion. It applies the concept of infusion to healthcare practitioners, utilising Mobile Health Systems (MHS) at the point-of-care. It begins (Section 2.2) by examining the evolution of stationary information systems with a move towards more portable technologies, the outcome of which has been the emergence of MHS. Over time, the traditional pen and paper approach for recording and exchanging patient-related data in healthcare environments have progressed towards digitisation. The resulting impact is represented in the Information Systems (IS) field through extensive research focusing on electronic (e-) health. MHS are playing an integral role in the daily lives of healthcare professionals, the typology of which are presented. Analysis of the literature pertaining to mobile IT, however, reveals a lack of consensus on the definition of mobile artefacts. Such ambiguity challenges the manner in which MHS are understood. Thus, a definition is provided which will be utilised throughout this study.

The chapter continues (Section 2.3) by analysing the literature pertaining to success and failures of mobile IT implementation in a healthcare context. This analysis reveals that the majority of success studies were investigated at an early stage of implementation. Building on these findings, the literature pertaining to the failures of MHS indicates that such technological tools are often under-utilised following adoption, thus resulting in failure. To understand what is meant by post-adoption, the Cooper and Zmud (1990) model is reviewed. Building upon this, analysis of the literature reveals that the infusion phase of implementation (as per Cooper and Zmud, 1990) remains one of the least studied facets of mobile IT in post-adoptive scenarios. If MHS are not infused within an individual's work practice, then such technological artefacts may deliver only limited benefits. These limited benefits, according to Sousa and Goodhue (2003), may not compensate for what is usually a costly and difficult implementation process. Therefore, it is imperative to investigate infusion of MHS to fully understand the long term utilisation of, and benefits from, these technological tools within a healthcare domain.

Building on the previous findings from the literature, the chapter continues (Section 2.4) by discussing the conceptualisation (origins, definitions and characteristics) of IT infusion. This section argues that mainstream IS research on IT infusion has predominantly focused on the organisational level with the exception of a few studies. Moreover, it reveals that definitions and operationalisation of infusion differ across studies and thus, a taxonomy for future research is provided. This section also examines current infusion models in the IS field, the outcome of which argues that such infusion models are unsuitable for investigating healthcare practitioners' infusion of MHS. Acknowledging the rapid growth of mobile computing in the healthcare industry and consequently the large investment spent on the implementation process, this section discusses the rationale for a new theory to explain and predict MHS infusion at an individual level of analysis. The research objective is presented, thus concluding this section.

## 2.2 From Stationary Systems to Mobile Technology in Healthcare

This section discusses the evolution of systems to support healthcare practitioners' clinical needs at the point-of-care. It begins (Section 2.2.1) by discussing the role of IT in healthcare, commonly referred to as e-health in the IS field. Definitions of e-health are reviewed (Section 2.2.1.1) and the history and utilisation of IT in the medical field is presented in Section 2.2.1.2. Over a number of decades, various technologies have evolved and been utilised in healthcare. Recent developments have succumbed to the emergence of mobile technology (Section 2.2.2). However, extant literature reveals that the term mobile is often used interchangeably with other terms such as wireless, portable, and ubiquitous to describe the relative diversity of mobile technology (Section 2.2.2.1). To reduce this uncertainty a definition for what constitutes mobile IT, in the context of this research study, is provided. Furthermore, a typology of MHS is outlined to depict the array of mobile technological tools in active use (Section 2.2.2.2). This typology is leveraged by the researcher to derive a definition for MHS in this study. This section concludes by arguing that IT in healthcare is becoming more mobile.

### 2.2.1 E-Health: Role of IT in Healthcare

IT has been adopted in many industrial sectors (for example, shipping, retail, manufacturing, financial and healthcare). Developments in IT have brought about a period of profound opportunity and potential for global advancement in healthcare (Kwankam, 2008) in terms of saving money (Fischer et al., 2008), and assisting in the reduction of medical errors (Ortiz and Clancy, 2003). IT, therefore, constitutes an important element in reforming healthcare services (Green et al., 2007) as the general use of IT globally is a powerful driver for change across the health care industry.

#### 2.2.1.1 What Constitutes the term E-Health?

The term e-health, or electronic health, has been in use since the year 2000 (Eysenbach, 2001). From a review of the literature, there is a lack of evidence as to the existence of a comprehensive definition of e-health. This lack of consensus on the meaning of e-health has led to uncertainty among healthcare professionals, academics and patients (Pagaliari et al., 2005). In view of these uncertainties, researchers have reviewed and analysed the definition of e-health. For example, Pagliari et al., (2005) identified thirty six different definitions for e-health whereas Oh et al., (2005) established fifty one different definitions in existing literature.

DeLuca and Enmark (2000) define e-health broadly as *"any electronic exchange of health-related data collected, generated, or analysed"* (p.4) and argues that e-health comprises of three domains (p. 6) i.e.

1. Business e-health – Financial and administration transactions to conduct the daily operations of healthcare.

   For example, e-health:

   - *"Refers to the adaptation and leveraging of internet technology by healthcare organisations to manage their medical supply chains"* Wickramasinghe, et al. (2005 p. 322).
   - "*Is the digital transformation of the practice of medicine, as well as the business side of the health industry"* Coile (2000, p. 8).

2. Clinical e-health – Transactions which involve the collection, transmission and analysis of electronic health-related data.

   For example:

   - "*Electronic health (e-Health) refers to health-related electronic services delivering a range of content, connectivity, and clinical care"* Chang and Wang (2011, p.232).
   - *"E-health refers to the Internet-enabled healthcare applications involving management of personal health records or information, and other Internet-based services including* e-*Pharmacy etc."* Hu et al., (2010, p.275).

3. Consumer e-health – Combines business and clinical e-health but also incorporates the consumer (i.e. patient) in health activities.

   For example:

   - *"E-health is defined as the interaction between patients with chronic diseases and their health care providers by means of internet"* Eland-de Kok et al., (2011, p.2998).
   - *"Offers the rich potential of supplementing traditional delivery of services and channels of communication in ways that extend the healthcare organization's ability to meet the needs of its patients"* Nazi (2003, p.4).

Based on these three categories of e-health, numerous scholars define e-health differently. In the context of this research study, e-health is viewed from a clinical perspective. That is, it focuses on transactions which involve the collection, transmission and analysis of health-related data (DeLuca and Enmark, 2000). One reason for looking at clinical e-health over the other two domains (i.e. business and consumer e-health) is the argument that the number of healthcare organisations adopting IT in healthcare is low, specifically clinical e-health systems (DesRoches et al., 2008; Jha et al., 2009). Moreover, the successful implementation of clinical e-health systems with high utilisation studies is rare in extant literature (Bangert and Doktor, 2003; Abbass et al., 2011; Huerta et al., forthcoming 2013). Finally, clinical systems have a more direct impact on healthcare practitioners' performance, an area under-investigated in extant literature (Black et al., 2011).

Reviewing and synthesising existing clinical e-health definitions, however, reveal a number of recurring limitations (Table 2-1). That is, the majority of clinical e-health definitions are too broad/generic in nature, while some fail to identify the stakeholders involved. Furthermore, a similar thread across the definitions is that the internet is required for e-health purposes. However, this is not always a necessity as clinical applications can be stand-alone applications, independent from the internet (Sweidan et al., 2010).

**Table 2-1: Limitations of Clinical E-Health Definitions**

| Definition | Author | Limitation |
|---|---|---|
| *"Electronic health (e-Health) refers to health-related electronic services delivering a range of content, connectivity, and clinical care."* | Chang and Wang (2011, p.232). | Too generic. Stakeholder focus is not specified. |
| *"Refers to the Internet-enabled healthcare applications involving management of personal health records or information, and other Internet-based services including e-Pharmacy etc."* | Hu et al., (2010, p.275). | Too broad. Implies that internet is required for clinical purposes. Stakeholder focus is not specified. |
| *"E-health is the use of emerging information and communication technology, especially the Internet, to improve or enable health and healthcare."* | Eng (2004, p. 238). | Too generic. Implies that internet is required for clinical purposes. Stakeholder focus is not specified. |
| E-health is *"the integration of the internet into health care."* | Watson (2004, p.1155) | Too simplistic. Implies that the internet is required for clinical purposes. Stakeholder focus is not specified. |
| E-health is characterised as *"not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked, global thinking, to improve health care locally, regionally, and worldwide by using information and communication technology."* | Eysenbach (2001, p.e20) | Too broad. Encompasses many aspects of e-health activities. Stakeholder focus is not specified. |
| *"E-health isn't just the Internet… it is all that's digital or electronic in the healthcare industry."* | Tieman (2001, p.36). | Too broad. Stakeholder and technology focus is not specified. |
| *"E-health refers to all forms of electronic healthcare delivered over the Internet, ranging from informational, educational and commercial "products" to direct services offered by professionals, non-professionals, businesses or consumers themselves."* | McLendon (2000, p. 22) | Too broad. Encompasses all categories of e-health. Implies that the internet is required for clinical purposes. |

Based on the work of Mitchell (1999), Della Mea (2001, p. e22) defines e-health as *"the use in the health sector of digital data - transmitted, stored and retrieved electronically - for clinical, educational and administrative purposes, both at the local site and at distance"* via IT. Borrowing and adapting this definition, e-health is defined for the purposes of this study as:

> *"The use of information technology by healthcare practitioners which transmits, stores, searches, and retrieves digitised data electronically for clinical purposes."*

In borrowing and adapting the work of Della Mea (2001) the definition of e-health, in the context of this study, overcomes limitations of existing definitions identified by the researcher. As a result, the definition of e-health is suitable for this study as it clearly identifies the category of e-health (i.e. clinical) and the stakeholders involved (i.e. healthcare practitioners). Moreover, it moves beyond a specified information and communication technology, such as the internet, to wider IT to enable the applicability of the definition in future research.

As the utilisation of technology in the medical field is well established, the history of IT in healthcare is described in Section 2.2.1.2.

#### 2.2.1.2 History of IT in Healthcare

Since the advent of 'e-health', healthcare authorities internationally are continually striving to implement new programs designed to improve patient care (Mohr et al., 2008) and support workflow activities of healthcare professionals (Safran and Goldberg, 2000). For example, the British National Health Services invested £12.8 billion in a National Programme for Information Technology and the Obama administration in the United States (US) has similarly committed to a US$38 billion e-health investment in health care (Catwell and Sheikh, 2009).

As the utilisation of technology in the medical field is well established, this section provides a short history of IT within healthcare by depicting and reviewing the evolution of e-health technology, in each decade, since the 1960s to the present time.

IT in healthcare has progressively evolved from primarily administration and business-oriented applications (termed "business e-health" by DeLuca and Enmark, 2000) to clinically oriented systems (clinical e-health) that are now in routine daily use (Giuse and Kuhn, 2003; Wilson and McEvoy, 2011).

IT in healthcare originated with the need for hospitals to maintain and manage business-related data (Nemeth et al., 2005). As observed in Figure 2-1, IT in healthcare emerged in the late 1960s and its use and capabilities has evolved throughout the decades. Since the 1960s, advancements in information and communication technology have permitted the use of technology in the healthcare sector. Experiments with computerised medical recordkeeping commenced in the 1960s (Goldschimdt, 2005). Simultaneously, the concept of health informatics was becoming a topic of interest amongst academic interest groups (Wilson et al., 2004).

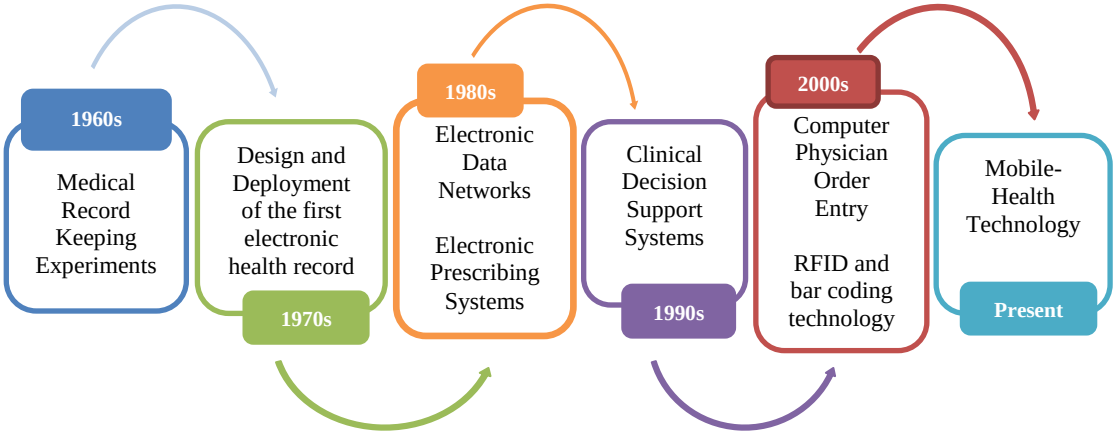



**Figure 2-1: Evolution of IT in Healthcare throughout the Decades**

The late 1960s and early 1970s saw the design and deployment of the first electronic health records (Kaplan, 1987; Goldschimdt, 2005; Heart et al., 2009). Bates et al., (2003) states that the motivation behind introducing Electronic Health Record (EHR) is that the human mind alone simply cannot process the volume of clinical data required for delivering healthcare services. By the mid-1970s, IT was extensively utilised in hospitals (Bates et al., 2003) to manage the complex and diverse work environment which existed at the time. The underlying objective behind the introduction of EHR was to improve productivity and performance by managing and organising health records.

In the 1980s, an increasing number of software vendors began to devote their products to the healthcare industry (Austin and Boxerman, 2003). Electronic data networks emerged, permitting information to be shared on a decentralised basis (Bernstein et al., 2007). More specifically, the 1980s witnessed the piloting of e-prescription technology (Åstrand et al., 2009) whereby electronic communication was established between the computer systems at a doctor's office in a medical clinic and those at a nearby pharmacy in Jönköping, Sweden.

During the 1990s, clinical decision support systems began to emerge in the marketplace to establish coordination of patient care (Austin and Boxerman 2003). Furthermore, Eysenbach (2001) argues that the rapid growth of the Internet played a role in healthcare by enhancing health consumers' awareness of health information and health-related products online (referred to "consumer e-health" by DeLuca and Enmark, 2000). Additionally system integration emerged whereby numerous hospitals and medical practices merged to form integrated healthcare networks (Teich, 1998).

According to Bernstein et al., (2007), IT became one of the principal driving forces behind improvements in the delivery of healthcare in the 2000s. This decade saw the introduction of Computerised Physician Order Entry (CPOE) systems to prevent medical errors (Kuperman and Gibson, 2003) and Radio Frequency Identification (RFID) to record inventory and bar coding to match patients to their medications (Bernstein et al., 2007). Integration of systems began to grow, more so than the 1990s, whereby data could be exchanged electronically between various healthcare stakeholders.

The rapid growth in mobile and wireless technologies in the first decade of the 21st century has given rise to a strong interest in implementing mobile commerce (m-commerce) in the hospital environment (Evans and Sarkar, 2004) as the application of mobile IT to healthcare provides a way for healthcare delivery to revolutionise itself (Wickramasinghe and Goldberg, 2005). Given the geographic dispersion of healthcare services many healthcare professionals realised that the capabilities offered through ubiquitous computing would support the provision and capture of

patient-related medical information at the point-of-care (Burley et al., 2005). The impetus towards mobile IT implementation has been driven by the disadvantages associated with working from traditional stationary desktop-based computers. Section 2.2.2 therefore focuses on the use of MHS in a healthcare domain.

### 2.2.2 Move towards Mobile Health Systems

Healthcare practitioners are now beginning to move from traditional desktop-based computer technologies towards mobile computing environments. Consequently, such environments have received immense attention from both academia and industry, in order to explore their promising opportunities, apparent limitations, and experienced implications for both theory and practice (Kjeldskov and Skov, 2007). Due to the chaotic nature associated with the delivery of healthcare services, the hospital environment appears well suited to the adoption of MHS. The underlying premise for this, according to Han et al., (2004), is that patient care in most environments is by its very nature a mobile experience. However, to understand what constitutes the term 'Mobile Health Systems' it necessitates revisiting the wider mobile IT literature to derive better insights into a suitable definition (Section 2.2.2.1). Once defined, attention is focused on the array of MHS available to healthcare practitioners (Section 2.2.2.2).

#### 2.2.2.1 Mobile IT: Definitions and Characteristics

Mobile IT facilitate transparent, integrated, convenient and adaptive communication and computing services to people (Kleinrock, 2001) through portable devices (Sørensen and Al-Taitoon, 2008) independently of the devices' locations (Lyytinen and Yoo, 2002). Mobile computing devices such as Personal Digital Assistants (PDA), smart mobile phones, and other portable computing devices hold much promise in terms of their organisational application (Scheepers and Scheepers, 2004) by introducing new flexibility in terms of when, where, and how these technologies can be applied (Varshney, 2003).

Although similar definitions exist in extant literature for what constitutes mobile IT, there is no single consensus on an agreed definition (Alsos et al., 2011). The

underlying premise for this, according to Basole (2004) and Ladd et al., (2011) is the fact that the term mobile, wireless, portable, and ubiquitous have all been used to describe the relative diversity of mobile technology. To add to this complexity, the term mobile IT has been used interchangeably with the term mobile computing, mobile information systems and mobile information and communication technologies. For example, Varshney (2003, page 155) described mobile information systems as *"systems involving mobile devices, users, wireless and mobile networks, mobile applications, databases and middleware."* Similarly, mobile information and communication technology is described as portable devices with associated wireless infrastructures (Sørensen and Al-Taitoon, 2008). Mobile computing is the concept of users carrying portable handheld devices that allow communication between people either in transit or from a remote location (Lyytinen and Yoo, 2002) with continuous access to networked services independent of their physical location (Grace et al., 2003) to execute their tasks everywhere (Hung et al., 2009). Juntumaa et al., (2009, p.5) define mobile technologies as technologies which enable the collection and maintenance of *"real time information about the variable production environment and to share this information on the on-demand basis to the employees going about in the distributed production environment."*

Based on the variety of definitions provided and the work of Vainino (2008), it is evident that 'mobile IT' have two main characteristics: (1) Devices and (2) Connectivity. Expanding on this, the 'device' characteristic refers to the portable IT hardware artefact which can be utilised independent of the user's location. On the other hand, the 'connectivity' characteristics refers not only to access to a network but also to the electronic storage, exchange, retrieval, search and communication of mobile content via an application run on the mobile device. One definition identified by the researcher which captures both characteristics clearly is presented by Jarvenpaa and Lang (2005, p. 8): *"Handheld IT artifacts that encompass hardware (devices), software (interface and applications), and communication."* Borrowing and modifying this definition, the term 'mobile IT' in this context refers to a:

> *"Handheld mobile device and application(s) run by the user on that device, independent of the user's location, for connectivity purposes."*

Section 2.2.2.2 subsequently examines the role of mobile IT in healthcare. Using the definitions of e-health and mobile IT outlined previously, this section defines MHS for the purpose of this study.

#### 2.2.2.2 Typology of Mobile Health Systems Used in Healthcare

The application of mobile IT within healthcare, referred to as mobile-health or m-Health (Istepanian et al., 2004), has revolutionised the delivery of healthcare services as mobile technologies offer the potential of retrieving and modifying patient-related information at the point-of-care (Burley et al., 2005). M-health refers to all portable computing devices used in a healthcare context (Lin and Vassar, 2004) to support public health and clinical care (Kahn et al., 2010). Applications of mobile IT in the healthcare domain can be recognised as both emerging and enabling technologies (Ammenwerth et al., 2003; Luo, 2008). As a result, numerous scholars propose the concept of Mobile Health Systems, or M-Health Systems, when they refer to mobile IT in a healthcare domain (c.f. Voskarides et al., 2002; Istepanian and Lacal, 2003; Jones et al., 2005; Kyriacou et al., 2007; Massey and Gao, 2010; Baumer et al., 2012). M-Health Systems (MHS) are created as a synergy of emerging mobile medical computing, multimedia technologies, and communication technologies (Istepanian et al, 2004).

Kahn et al., (2010) hypothesise that MHS are widely available and can play an integral role in healthcare at the regional, community, and individual levels. Hospitals have some history with MHS as they were the first significant institutional adopters of pagers, and many doctors have enthusiastically embraced mobile telephones and PDAs for their personal use (Hau, 2001; Vink, 2002). However, Pharow and Blobel (2008) highlight that MHS is not just the use of mobile phones for health-related purposes or the mobility of both patients and health professionals. Instead, the authors posit that a mobile environment incorporates self-organising systems and components along with mobile devices, tools, sensors (also known as ‘wearable computing’), and much more. Some currently active MHS, therefore, include mobile computers (e.g. laptops), tablets (e.g. iPad), mobile clinical assistant (i.e. rugged computers) and smartphones.

Ever since the introduction of the Apple Newton (The original MessagePad was launched at Macworld Boston in August 1993 [MacNeill 1998]) there have been medical applications for mobile computers (Tétard et al., 2006). Building on Porn and Patrick (2002), these applications include Electronic Health Records, E-prescription, Computerised Provider (or Physician) Order Entry (CPOE), Clinical Decision Support Systems (CDSS), and Picture Archiving and Communication Systems (PACS). Each application is described in Table 2-2. Noteworthy, some applications can be integrated together which may explain why some features/functionalities are repeated across applications in Table 2-2.

It is evident that mobile IT in a healthcare domain requires a portable device and applications run on that device to assist healthcare practitioners when delivering healthcare services. Building on this evidence, the definition of e-health in Section 2.2.1.1 (i.e. E-health refers to the use of information technology by healthcare practitioners which transmits, stores, searches, and retrieves digitised data electronically for clinical purposes) and the definition of mobile IT in Section 2.2.2.1 (i.e. Mobile IT refers to handheld mobile device and application(s) run by the user on that device, independent of the user's location, for connectivity purposes), the term MHS in this study refer to the:

*"Handheld mobile device and clinical application(s) run on the device by healthcare practitioners, in a medical domain, for communication and clinical purposes[3]."*

[3] Clinical purposes depict the connectivity characteristic of mobile IT which enable the electronic transmission, storage, search, and/or retrieval of digitised clinical/medical data.

**Table 2-2: Overview of Medical Applications**

| Application | Description | Features/Functionality | Authors |
|---|---|---|---|
| Electronic Health Record (EHR) | The digital collection of clinical accounts and diagnostic reports pertaining to an individual patient (Safran and Goldberg, 2000). | **Features:** Patient Management, Problem List, Medication List, Allergy List, Decision Support (e.g. Drug Interaction), Electronic Clinical Notes, Results Retrieval, Order Entry, Interoperability and Communication, Security and Administration, Transparency.<br><br>**Functions:** Record, Retrieve, Store, Search, Share, Select, Report, Alert, Diagnose, Remind, Suggest, Interpret, Predict, Critique, Assist, Integrate, Log-in, and Report. | Hassol et al., (2004); Bates (2005); Linder et al., (2007); Simon et al. (2008); Black et al., (2011). |
| Electronic (e-) Prescribing | Computer-based support for the creation, transmission, dispensing and monitoring of pharmacological therapies (Miller et al., 2005). | **Features:** Patient Data, Medication Selection, Medication Information (i.e. Drug Interactions and Allergy List), Prescribing Decision Support, Patient Information and Education, Clinical Notes, Monitoring and Recalls, Interoperability and Communication, Security and Administration, Transparency.<br><br>**Functions:** Record, Retrieve, Store, Search, Share, Select, Send, Report, Alert, Diagnose, Remind, Suggest, Interpret, Predict, Critique, Assist, Integrate, Log-in, Report, and Monitor. | Florentinus et al., (2006); Grossman et al., (2006); Fischer et al., (2008); Glintborg et al., (2008); Sweidan et al., (2010); Black et al., (2011). |
| Computer Provider (or Physician) Order Entry (CPOE) | Applications to order certain tests which can be scheduled and delivered to its required destination and acted upon (Porn and Patrick, 2002). | **Features:** Patient Data, Electronic Capture and Transmission of Order (i.e. order communication), Order Notification, Order Status, Order Prompting and Alerts/Prompts (e.g. allergy and/or drug interactions), Order Monitoring, Decision Support, Round Reports (summary of orders, diagnostic tests, patient data, etc.), Interoperability and Communication, Security and Administration, Transparency. | Kuperman and Gibson (2003); Ormond (2005); Campbell et al., (2006); Georgiou et al., (2007); Sittig et al., (2007); Black et al., (2011). |

| Application | Description | Features/Functionality | Authors |
|---|---|---|---|
| CPOE continued… | | **Functions:** Record, Retrieve, Store, Search, Share, Select, Send, Report, Alert, Diagnose, Remind, Suggest, Interpret, Predict, Critique, Assist, Integrate, Log-in, Report, and Monitor. | |
| Clinical Decision Support System (CDSS) | Provides healthcare practitioners with patient-specific assessments or recommendations to assist clinical decision making (Hunt et al., 1998; Miller et al., 2005). | **Features:** Alert/Recommendations Notifications, Clinical Guideline Support, Guidelines, Algorithms and Data Needed to Treat Patients, Evidence-Based Practice Synopses / Patient Oriented Evidence that Matters , Diagnostic Calculators, Clinical Prediction Rules, Interoperability and Communication, Security and Administration, Transparency, Monitoring and Control.<br><br>**Functions:** Record, Retrieve, Store, Search, Share, Select, Send, Report, Alert, Diagnose, Remind, Suggest, Interpret, Predict, Critique, Assist, Integrate, Log-in, Report, and Monitor. | Ramnarayan and Britto (2002); Johnston et al., (2004); Kawamoto et al., (2005); Mollon et al., (2009); Black et al., (2011). |
| Picture Archiving and Communication System (PACS) | The acquisition, transport, storage, reporting and viewing of images in a digitised format (Watkins, 1999). | **Features:** Patient Administration (e.g. scheduling appointments), Acquisition, Storage and Communication of Images, Image Display (contrast control), Multidimensional viewing/visualisation (3D/Video), Image Processing, PAC Status, Computer-assisted Diagnosis System, Interoperability, Security, and Transparency.<br><br>**Functions:** Record, Retrieve, Store, Search, Share, Select, Send, Report, Diagnose, Remind, Suggest, Interpret, Predict Critique, Assist, Alter, Integrate, Log-in, Report, Monitor, and Zoom. | Huang et al., (1997); Wu et al., (1999); El-Kwae et al., (2000); Im et al., (2010); Kalyanpur et al., (2010); Black et al., (2011). |

As stated in Section 2.2.1.2, organisations worldwide invest heavily in the implementation of technological innovations. The chapter now moves to explore the literature on the implementation of mobile technologies, presenting an insight into the various stages/phases of IT implementation.

## 2.3 MHS Implementation

The section argues that post-adoption use of MHS is under-investigated in extant literature. Section 2.3.1 commences with an examination of studies pertaining to success and failure of MHS in healthcare domains. This section reveals that more attention is required to understand MHS in post-adoptive scenarios, as a number of MHS initiatives fail following adoption. To understand post-adoptive scenarios, the researcher examines the wider IT implementation literature (Section 2.3.2). The Cooper and Zmud (1990) model of IT implementation is selected as a lens for this study as it overcomes weaknesses of existing models (e.g. lack of clarity, post-adoption considered as one phase of IT implementation, focus on new rather than existing technology use) and its foundations (i.e. definition of IT implementation) are found to be most consistent with the researcher's own interpretation.

Utilising the Cooper and Zmud (1990) model of IT implementation, the literature pertaining to mobile IT implementation is reviewed (Section 2.3.3). This section reveals that extant research predominantly focuses on the first five stages of Cooper and Zmud's (1990) six stage implementation model. The sixth phase, infusion, is under-investigated in extant literature and requires further examination. This concluding section argues that failure of MHS is the result of the declination of device usage after the adoption phase of implementation, thus highlighting the need to focus on the infusion stage of implementation.

### 2.3.1 MHS Implementation: Success and Failures

This section discusses some implementation success and failure studies on MHS. However, any discussion on success and failure first requires a definition for these two terms to be presented. Lyytinen and Hirschheim (1987) argue that infrequent,

inappropriate and ineffective long-term use of IS often contributes to failure. Therefore, failure in this study refers to the immediate abandonment of a new system or lack of usage post-adoption (Heeks, 2006) in a healthcare context. Contrary to this, success of an initiative refers to the adoption and sustained use of IS in a healthcare context (Hwabamungu and Williams, 2010).

The documented success of MHS is purported throughout both the IS and medical informatics fields. Such studies have focused on mobile technology applications from e-mail, voice, SMS (Heinzelmann et al., 2005), inventory management (Mitchell and Sullivan, 2001; Freudenheim, 2004; Bhattacherjee et al., 2007) to patient records (Dwivedi et al., 2007; Kirsch et al., 2007; Puentes et al., 2007). However, these studies primarily focus on the adoption of MHS and fall short of explaining the sustainability of MHS. Addressing this gap in the literature, Sultan and Mohan (2012) investigated what is necessary to ensure the sustainability of new mobile health initiatives in a healthcare domain and found that MHS should be used for extended periods of time after the technology is initially adopted.

Alternatively, there are instances whereby MHS have been abandoned or under-utilised by the users. According to Tierney and McDonald (1996) and Porta (2004), however, there exists a negative bias against publication of failures found in the medical informatics field. Hence, a limited number of publications exist claiming the failure of IT in healthcare. MHS have been increasingly incorporated into medical professionals' work practices. Initially, there is great enthusiasm and excitement amongst medical professionals associated with the introduction and adoption of new technological artefacts. This is evident throughout literature as a vast amount of research has primarily focused on the adoption of IT artefacts in healthcare organisations.

However, regardless of the documented potentials of MHS in healthcare some initiatives are still reported to fail once implemented. Lippert and Davis (2006) suggest that 50% of IT systems may be considered failures or fail to meet expectations. Failure to meet expectations is often depicted in existing literature through abandonment or lack of use (Heeks, 2006) of the technology recently

implemented. One such study, conducted in the Geneva University Hospital (Tschopp et al., 2002) with mobile handheld devices found that usage of the devices declined after its adoption within the hospital. The researchers show that data logs (i.e. records of users logging into the clinical system using the PDA) dropped from 900+ logins during the first three days of adoption and reached a plateau of less than 200 logins after fifty days. Investigating the impacts of a MHS deployed in a hospital setting, Tang and Carpendale (2008) observed their participants either completely abandoning or trying to avoid using the mobile technological tool post-adoption. Similarly, Standing and Standing (2008) found nurses abandoning the MHS when faced with certain barriers (i.e. when nurses were faced with difficulties in using the mobile technology, most tended to revert to previous methods rather than persevere with the new system). In all the presented studies, the MHS was either abandoned or under-utilised following adoption. Therefore, post-adoption use of MHS should be examined.

Despite substantial research on IT implementation in the IS field, the healthcare industry has historically been considered a technological laggard (Burke and Menachemi, 2004; Leu et al., 2012). The underlying premise behind this 'lag' is that information technologies are often under-utilised following adoption (Jasperson et al., 2005). It is therefore important to investigate post-adoptive use of any technological innovation to fully appreciate long term success of IT technologies (Stafford et al., 2010). To fully understand what is meant by post-adoption it is required to look at the overall implementation process. In light of this, Section 2.3.2 examines implementation stage models in the IS domain.

### 2.3.2 IT Implementation: Definition and Stage Models

Implementation, according to Orlandi (1987), refers to how technologies are used in practice and how that influences the effect of the technology. Kwon and Zmud, (1987, p.231) argue that implementation is *"an organizational effort to diffuse an appropriate information technology within a user community."* Prescott and Conger (1995) argue that some studies in the IS field embrace the concept of 'adoption' to

cover the entire process of implementation. However, it is evident from extant literature that there exist various stages/phases of IT implementation.

Authors differed as to how many stages are involved in IT implementation. Thompson (1969) viewed implementation efforts as consisting of a sequence of three processes (initiation, adoption, and implementation). Other authors of stage models concurred with Thompson, but they argued that this three stage model may have overlooked the importance of some pre-adoption and post-adoption evaluation processes. Table 2-3 demonstrates the relative significance of the various stages of three sample models.

Thompson (1969) and Pierce and Delbecq (1977) proposed a three phased innovation model which consists of three stages; Initiation, Adoption and Implementation. *Initiation* is the pressure to change, gathering and evaluation of information regarding the innovation. The second stage, *Adoption*, involves the decision to commit resources to the innovation whereas *Implementation* refers to development and installation activities to ensure that the expected benefits of innovation are achieved. According to these authors, post-adoption subsumes that of implementation. However, subsequent models provide a more detailed overview of post-adoption phases.

**Table 2-3: Various Phases of IT Implementation**
**(Amended from Dasgupta, 1997)**

| **Author** | **Phases** | | | | | |
|---|---|---|---|---|---|---|
| Thompson (1969); Pierce and Delbecq (1977) | Initiation | Adoption | Implementation | | | |
| McFarlan and McKenney (1982) | Technology Identification and Investment | | Experimentation, Learning and Adaptation | | Rationalisation and Management Control | Widespread Technology Transfer |
| Cooper and Zmud (1990) | Initiation | Adoption | Adaptation | Acceptance | Routinization | Infusion |
| *Overview:* | *Pre-Adoption* | *Adoption* | *Post-Adoption* | | | |

The Technological Identification and Investment stage proposed by McFarlan and McKeeney (1982) corresponds to both the Initiation and Adoption stages of Thompson (1969) and Pierce and Delbecq's (1977) model of IT implementation. The *Technological Identification and Investment* stage emphasises the exploration and evaluation of new technologies. User experiences, knowledge and familiarity with the new technology and the problems it can potentially solve are addressed in the *Experimentation, Learning, and Adaptation* stage. The *Rationalisation and Management Control* stage is exemplified by the pursuit for short term efficiencies, upgrading of user skills, and cost effective implementation. In the *Widespread Technology Transfer* stage, the benefits of new technology are disseminated to other units within the organisation. This model decomposes Thompson (1969) and Pierce and Delbecq (1977) post-adoption phase (i.e. implementation) into three distinct phases.

Finally, the Cooper and Zmud (1990) Technological Diffusion Model consists of six phases ranging from Initiation to Infusion. *Initiation* refers to the scanning of organisational opportunities and IT solutions. *Adoption* involves negotiations to achieve organisational backing for the implementation of an IT application. *Adaptation* includes the development, installation and maintenance of new technology, and the development of new organisational procedures. *Acceptance* is the stage at which organisational members are induced to commit to using the new IT. *Routinization* refers to the organisation's consideration of the new IT as a normal activity, and *Infusion* includes the integration of new IT with the organisation's system to support higher levels of organisational work.

The researcher employs the Cooper and Zmud (1990) model of IT implementation as the lens for examining post-adoption research as it firstly provides a more detailed overview of post-adoptive phases of implementation. This detailed overview is evident when compared with the work of Thompson (1969) and Pierce and Delbecq (1977) who perceive implementation as post-adoption. Such an approach is too generic in nature. Secondly, Cooper and Zmud (1990) provide clear and easy-to-interpret definitions of each phase which make it easier for examination purposes. Thirdly, although McFarlan and McKenney (1982) propose similar phases of post-

adoption in terms of their definitions, the researchers adopt a different view from Cooper and Zmud (1990). That is, McFarlan and McKenney (1982, p. 114) argue that examination of latter phases of IT implementation *"involves waves of new technologies, and companies must continually adopt different approaches to managing and assimilating them."* Contrary to this, Cooper and Zmud (1990) continue to focus on the same IT artefact in latter phases of IT implementation and seek to attain the full potentials offered by the technological tool. Fourth, the researcher's view of IT implementation coincides with the definition provided by Cooper and Zmud (1990). That is, *"an organizational effort directed toward the diffusion of appropriate information technology to support particular tasks within a specific work context"* (based on the work of Kwon and Zmud, 1987, pp.231).

Focusing on the Cooper and Zmud (1990) model, Section 2.3.3 analyses and reviews all phases of implementation, focusing on mobile IT artefacts.

### 2.3.3 Studies of Mobile Implementation in IS Research

A brief synopsis of the state-of-the-field in mobile IT implementation studies (see Table 2-4) is provided. Analysis of the literature pertaining to implementation of mobile IT reveals that extant research predominantly focuses on the first 5 stages. Stage 6; namely, infusion - remains one of the least studied facets of IT post adoption, not only in the mobile literature but also in the wider IS literature (Ng and Kim 2009; Tennant et al., 2011). Infusion is a distinctive feature in the Cooper and Zmud (1990) model, which reflects the extent to which an IT technology is fully embedded in one's work practices (Fadel, 2007), whether at an organisational or individual level.

**Table 2-4: Studies on Mobile Implementation at Various Stages in IS Research**

| Stage of IT Implementation | Definition (amended from Cooper and Zmud, 1990) | Literature on Mobile Technology Implementation |
|---|---|---|
| (1) Initiation | Scanning of organisational opportunities and IT solutions. | Zhou et al., (2003); Frolick and Chen (2004); Peffers and Tuunanen (2005); Wang et al., (2005); Batarliene and Baublys (2007); Devaraju et al., (2007); Hsieh (2007); Tiwari et al., (2007); Emmanouilidis et al., (2009); Dewan (2010). |
| (2) Adoption | Negotiations to achieve organisational backing for the implementation of IT. | Mallat et al., (2004); Scheepers et al., (2006); Liang et al., (2007); Standing and Standing (2008); Troshani and Hill (2009); Yap and Hii (2009); Gebauer et al., (2010); Wu et al., (2011). |
| (3) Adaptation | The development, installation and maintenance of new technology, and the development of new organisational procedures. | Jing et al., (1999); Ney et al., (2004); Schierholz et al., (2006); Sutherland and van den Heuvel (2006); Al-Dabbagh et al., (2010); Schmitz et al., (2010); Scornavacca and Al-Dabbagh (2011). |
| (4) Acceptance | Inducing members of organisations to commit to use the IT. | Dahlberg et al., (2003); Pérez et al., (2004); Han et al., (2005); Wu and Wang (2005); Snowden et al., (2006); López-Nicolás et al., (2008); Liu (2010); Luo et al., (2010), Hu et al., (2011); Zarmpou et al., (2012). |
| (5) Routinization | Continued use of various features offered by the IT. | Thong et al., (2006); Hung et al., (2007); Min and Shenghua (2007); Pihlström (2007), Chen et al., (2008); Chen (2010); Kim (2010); Lehrer et al., (2011); Kim and Oh (2011); Liang and Yeh (2011); Hung et al., (2012). |
| (6) Infusion | Realising the full potential of IT through comprehensive use. | White et al., (2005); Idowu et al., (2006); Oakley and Palvia (2012). |

It is evident that while a significant amount of extant literature focuses on initial technology adoption and acceptance, there remains a dearth of literature in the IS field focusing on the long term, post-adoptive utilisation and associated benefits of mobile IT. More specifically, the infusion of mobile IT is under-investigated. Combined with the scarcity of research focusing on MHS post-adoption (Section 2.3.1), a gap currently exists in the literature which examines the infusion of MHS.

Therefore, Section 2.4 discusses post-adoption, in terms of infusion, in order to address this gap in literature.

## 2.4 Understanding MHS Infusion

This section commences by distinguishing between the routinization and infusion phases. The rationale for doing so is that both phases of implementation are closely related and differentiating between the two phases reveals which stage of IT implementation users of IT artefacts can be situated in (Section 2.4.1). This section highlights that the infusion phase can be differentiated from the routinization phase by examining behaviours/characteristics of the subject using the IT artefacts. In doing so, Section 2.4.1 argues that routinization focuses primarily on the subject's use of various features that an IT artefact has to offer whereas, infusion focuses on the integration of IT artefacts as part of one's work practices which is used comprehensively.

Building from Section 2.4.1, a discussion surrounding the concept of IT infusion is presented (Section 2.4.2). This section argues that there exists a lack of consensus among scholars on an agreed definition and operationalisation of infusion. The researcher identifies that infusion subsumes elements of routinization and can be defined and operationalised at two levels. The first level primarily examines IT infusion as a dependent variable and focuses on the incorporation and use of the IT artefact in a comprehensive manner (Section 2.4.2.1). The second level focuses on the outcomes of incorporating and using the IT artefact comprehensively (Section 2.4.2.2). Next, commonalities across the two levels are revealed before a taxonomy is presented for future research in the infusion domain (Section 2.4.2.3). Leveraging this taxonomy, infusion is defined for the purpose of this study (Section 2.4.2.4).

Section 2.4.3 reviews various models of infusion. Numerous models exist focusing on IT infusion. However, the researcher identifies a number of limitations associated with IT infusion models and argues that existing models are unsuitable for investigating individual infusion of MHS. This section concludes by presenting the research objective underpinning this research.

### 2.4.1 Distinguishing Between the Routinization and Infusion Phases of IT Implementation

Saeed and Abdinnour-Helm (2011) argue that researchers can distinguish between the routinization and infusion phases of IT implementation, as per Cooper and Zmud (1990), by examining behaviours/characteristics of the subject. These authors argue that the routinization phase examines individuals' use of the various features offered by IT artefacts. Indicators used at this phase of IT implementation include feature use and extended use. Feature use is defined as using the technology's (i.e. MHS) features/functionality to complete any given task (adapted from Oakley and Palvia, 2012); whereas extended use refers to using more of the technology's features to support an individual's task (Saga and Zmud, 1994). Burns and Scapens (2008) argue that routines exist to purposefully *"guide participants towards acceptable ways to carry out their duties"* (p. 94). To ensure that tasks are performed certain features of an IT artefact must be utilised. Therefore, the routinization phase of implementation is only concerned with features of an IT artefact used by individuals.

On the other hand, Saeed and Abdinnour-Helm (2011) argue that infusion *"captures the extent to which users integrate the IS in their work"* (p. 6) and be captured using the indicator of integrative use. Integrative use refers to the extent to which *"users integrate the IS in their work"* (Saeed and Abdinnour-Helm, 2011, p. 7). Others scholars (e.g. Cooper and Zmud, 1990; Saga and Zmud, 1994; Wilson Green, 2003; Fadel, 2006; Grover et al., 2007) argue that infusion depicts the degree to which the IT artefact is embedded ("permanently adopted" – Meister and Compeau, 2002, p.24) within one's work system ("the processes that either an individual or organisation uses to fulfil their role" – adapted from Meister and Compeau, 2002, p.24) and used in a comprehensive and integrated manner (commonly referred to as "fullest potential").

Reviewing and analysing the definitions of infusion (Appendix 1 and Section 2.4.2), the researcher identifies that in order to ensure that the IT artefact is used to its fullest potential it is imperative that (i) users extensively use the features offered by the MHS, (ii) the IT is incorporated as part of their daily work practices and (iii)

exploration of the IT artefacts occurs. That is, infusion builds on the concept of routinization (i.e. users extensively use the features offered by the MHS) but also captures the extent to which users integrate the IS in their work practices and actively seek novel ways of using the IT in an effort to improve their daily work tasks. Figure 2-2 depicts the differences between the routinization and infusion phase of IT implementation.

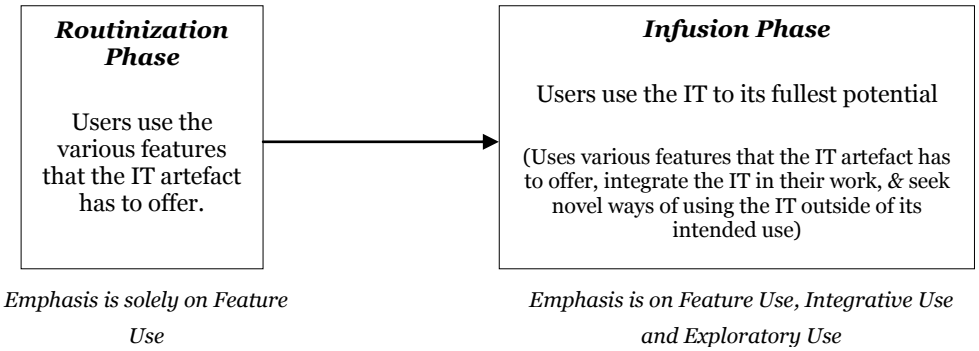



**Figure 2-2: Distinguishing Between Routinization and Infusion Phases**

Section 2.4.2 examines the concept of infusion in more depth. It provides some insights into how infusion is defined and operationalised in extant literature and proposes a taxonomy for examining IT infusion in future studies.

### 2.4.2 MHS Infusion: Definitions and Operationalisation

Having originated in the literature in the mid-1980s by Sullivan (1985) and Kwon and Zmud (1987) the concept of IT infusion has been studied by numerous authors at various levels of analysis in diverse academic disciplines. For example, teaching and educational studies (e.g. Collier et al., 2004; Rowley et al., 2005), aerospace studies (e.g. Cornford and Hicks, 2000), service sector (Wynekoop and Senn, 1992; Gharvai et al., 2005; Li, X. et al., 2009), retail sector (Zmud and Apple, 1992; Wu and Subramaniam, 2009) and manufacturing studies (Chang and Lung, 2002; Wang and Hsieh, 2006). Infusion is best recognised as the final stage in Cooper and Zmud's (1990) model of IT implementation in organisations and is considered to be one of the least studied facets of IT innovation in the literature (Jasperson et al., 2005; Zhu and Kraemer, 2005; Yu et al., 2009; Tennant et al., 2011; Oakley and Palvia, 2012). Yet, after two decades of research on the concept of infusion, there is a large variety

of definitions constituting the term and considerable uncertainty surrounding the operationalisation of infusion.

For these reasons, the purpose of this section is to provide a clear introduction to the concept of IT infusion by exploring definitions and operational indicators of infusion. From reviewing and synthesising the literature it is evident that infusion is defined at two levels; Incorporating and Using the IT Artefact in a Comprehensive Manner (Section 2.4.2.1); and (iii) Outcomes of Incorporating and Using IT Artefacts Comprehensively (Section 2.4.2.2). This section illustrates that infusion involves two related concepts: the level of IT incorporation and the impact of its use. Through critiquing and analysing extant literature the researcher recognises that keywords and the level of analysis, among other elements, is at the core of how infusion is defined and operationalised. As a result, a taxonomy of IT infusion is derived. This taxonomy is leveraged in order to define infusion for the purposes of this study (Section 2.4.2.3)

#### 2.4.2.1 Level 1: Infusion as Incorporating and Using the IT artefact in a Comprehensive Manner

Infusion can be defined based on the level of IT incorporation and the extent to which the IT artefact is used to its fullest potential (i.e. in a comprehensive and integrated manner). Examples of definitions depicting 'infusion as incorporating and using the IT artefact in a comprehensive manner' are presented in Table 2-5. Figure 2-3 illustrates how infusion is defined and operationalised at Level 1. Keywords used in describing infusion at this level often include 'integration', 'incorporation', 'deeply embedded' and 'integrated'. This highlights the integrative use of IT as part of one's work practices. These keywords also reflect the definition of infusion proposed by Saeed and Abdinnour-Helm (2011) outlined in Section 2.4.1.

Additional keywords for describing infusion at this level include 'full(est) potential' (categorised as 'product' by Cooper and Zmud, 1990, p. 124-125 and Wilson Green, 2003, p. 24) and 'comprehensive' (see Table 2-5). Although numerous authors utilise these two terms to describe infusion, little research has defined what is implied by

'full potential' and 'comprehensive'. Meister and Compeau (2002, p. 24) was one paper identified by the researcher that did define 'full potential'. They argue that 'full potential' relates to *"the usage of all possible and appropriate applications."* However, no research was identified which expands upon the term 'comprehensive' as it relates to IT infusion. Thus, to reduce any ambiguity, the researcher borrows and adapts the work of Meister and Compeau (2002) and proposes that the term 'full potential' subsumes 'comprehensive' and refers to the *"the usage of all possible and appropriate features and applications for both intended and non-intended purposes."* Building from this, 'non-intended purposes' reflect the active examination of new uses of the IT artefact outside of its intended use (commonly referred to as exploratory/emergent use).

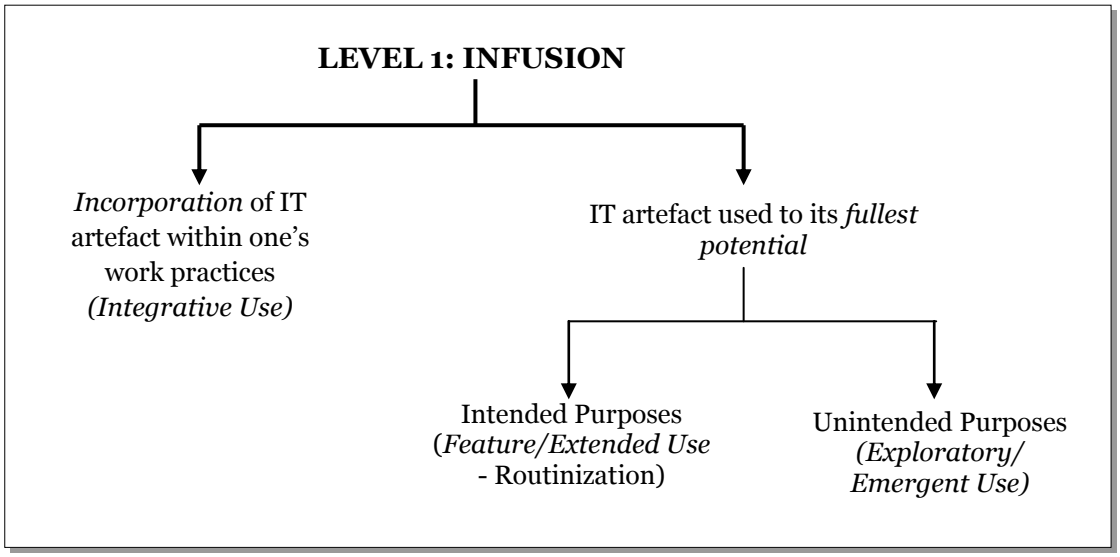



**Figure 2-3: Breakdown of Definition for Infusion at Level 1**

**Table 2-5: Infusion as Incorporating and Using the IT Artefact in a Comprehensive Manner**

| Infusion as Incorporating and Using the IT Artefact in a Comprehensive Manner | Author | Keywords |
|---|---|---|
| "A stage marked by the extent of the use of the innovation within the organization once the innovation has been adopted." | Ruppel and Harrington (1995, p.90) | Extent of Use |
| "The extent to which IT is operationalised as the number of correct functionality … utilised by subjects in performing an assigned task." | Bhattacherjee (1996, p.314) | Functionality |
| "Infusion includes the integration of new information technology with the organization's system to support higher levels of organizational work." | Dasgupta (1997, p.354) | Integration, Higher Levels |
| "Infusion occurs as IT applications become more deeply embedded with the organization's work processes and results when the IT application is used within the organization to its fullest potential." | Moorell (1999, p.1008) | Deeply embedded, work processes, fullest potential |
| "User's willingness and purpose to explore technology and identify its potential use." | Nambisan et al., (1999, p. 373) | Explore |
| "An individual's goal of finding novel uses of information technologies." | Ahuja and Thatcher, (2005, p. 435) | Novel |
| "Higher levels of work are achieved as the new system is used in an integrated and comprehensive manner." | Raisinghani and Ramsaroop (1999, p.38) | Integrated, Comprehensive |
| "Integration of technology with existing business processes." | Eder and Igbaria (2001, p. 234) | Integration, Business Process |
| "The degree to which an IS is fully integrated into an organization's or individual's work practices, and the degree to which the full potential of the IS is being exploited." | Fadel (2006, p. 278) | Integrated, Work Practices, Full Potential, Exploited |
| "IT infusion is the incorporation of information technology into the work structures that the technology supports." | Grover et al. (2007, p. 273) | Incorporation |
| "Infusion captures the extent to which an innovation's features and functionality are used in a complete and sophisticated manner in organizational work processes." | Kishore and McLean (2007, p. 5760) | Extent of Use, Feature Use |
| "Infusion refers to the process of embedding an IS application deeply and comprehensively in the work system." | Li et al., (2009, p.3) | Embedding, Deeply, Comprehensively, Work System |
| "The degree to which individual users employ the full range of features offered by the technology." | Fadel (2012) | Feature Use |

Infusion of IT artefacts therefore must integrate the IT within one's work system (i.e. integrative use) whereby the appropriate applications and features for both intended (feature use) and non-intended purposes (exploratory/emergent/extended use) are used (as depicted in Figure 2-3).

Examples of authors who use indicators outlined in Figure 2-2 include Saga and Zmud (1994), Abdinnour-Helm and Saeed (2006), Ng and Kim (2009) and Oakley and Palvia (2012). Saga and Zmud (1994) and Ng and Kim (2009) proposed three aspects of post-adoption use to characterise IT infusion which include integrative use, extended use, and emergent use.

Similarly, Oakley and Palvia (2012) utilise the same indicators to examine infusion. However, unlike the work of Saga and Zmud (1994) and Ng and Kim (2009) who define extended use as using more of the IT's features in order to accommodate a more comprehensive set of work tasks, Oakley and Palvia (2012) define it as *"the most basic use of mobile device features to complete any given task"* (p.3) which is more consistent with the concept of feature use outlined in the routinization phase. Similarly, Abdinnour-Helm and Saeed (2006) propose extended use, integrative use, and exploratory use. For a description of the indicators see Section 2.4.1.

Therefore, infusion defined at level 1 focuses on the level of incorporation and comprehensive use of the IT artefacts in one's work system. Building on the definition at this level, the second level at which infusion can be defined is that of 'infusion as outcomes of incorporating and using IT artefacts comprehensively' (level 2), which is subsequently described (Section 2.4.2.2).

#### 2.4.2.2 Level 2: Infusion as Outcomes of Incorporating and Using IT Artefacts Comprehensively

The second level at which infusion can be defined is that focusing on the outcomes of IT infusion; Infusion as outcomes of incorporating and using IT artefacts. That is, the degree to which embedding an IT artefact has penetrated a company in terms of importance, impact, or significance (Sullivan, 1985). It is evident from this definition

that infusion at this level builds on the definition presented at level 1 (i.e. Infusion as Incorporating and Using the IT Artefact in a Comprehensive Manner) but also encompasses the potential outcomes of same. Examples of definitions for describing infusion at level 2 are depicted in Table 2-6.

**Table 2-6: Infusion as Outcomes of Incorporating and Using the IT Artefact Comprehensively**

| Infusion as Outcomes of Incorporating and Using the IT Artefact Comprehensively | Author | Keywords |
|---|---|---|
| "The degree to which Information Technology (IT) has penetrated a company in terms of importance, impact, or significance." | Sullivan (1985, p.5) | Importance, Impact, Significance |
| "Increased organisational effectiveness … obtained by using IT application to its fullest potential." | Cooper and Zmud, (1990, pp. 124-125). | Effectiveness, Full Potential |
| "The extent to which an innovation is used completely and effectively and improves the organisation's performance." | Wynekoop and Senn (1992, p. 69) | Completely, Effectively, Performance |
| "The technology's potential to improve or enhance the capabilities of accomplishing tasks efficiently in order to achieve the objective of the organization's performance to gain net benefits." | Chang and Lung (2002, p.207) | Efficiently, Performance, Net Benefits. |
| "Increased organizational effectiveness is obtained by using the information technology application in a more comprehensive and integrated manner to support higher level aspects of organizational work." | Wilson Green (2003, p.24) | Effectiveness, comprehensive, integrative. |
| "Represents the extent to which an information system is used completely and effectively and improves the individual's performance." | Fadel (2006, p. 278) | Completely, Effectively, Performance |
| "IT utilised to its fullest extent to enhance productivity." | Sundaram et al., (2007, p.104) | Fullest Extent, Productivity. |

Operationalising infusion at level 2 is often achieved by using level 1 indicators and outcome indicators (e.g. performance, satisfaction, net benefits) to depict the level of IT incorporation and the impact of its use. Research at this level is under-developed in the infusion literature (Chapter 2). However, some studies have empirically examined infusion defined at level 2. For example, Chang and Lung (2002) examined organisational benefits from IT infusion. These authors argued that infusion must be first used comprehensively to improve or enhance the

accomplishment of tasks and ultimately, obtain organisational benefits. This clearly illustrates the various levels (i.e. Levels 1 and 2) required to investigate outcomes of IT infusion. Similarly, Sundaram et al., (2007) examined infusion (extent to which a salesperson fully uses the technology) and then its subsequent impact on productivity (IT-enabled administration performance, IT-enabled Salesperson performance). Here the researchers were able to highlight that the technology (i.e. Sales Force Automation) was used to its full potential and as a result, enhanced productivity of employees. Having identified the two levels at which IT infusion can be defined, Section 2.4.2.3 examines the common elements across the levels.

#### 2.4.2.3 Commonality Across the Two Levels of Infusion

Sections 2.4.2.1 and 2.4.2.2 highlight the two levels in which infusion can be defined. Noteworthy, however, these two levels share elements of commonality. The researcher identified keywords and indicators used at each of the two levels (Table 2-5 and Table 2-6). The researcher also identified that defining infusion often encompasses the unit/level of analysis for which the study is primarily targeted (Table 2-7).

**Table 2-7: Authors Defining Infusion with a Perspective of the Level of Analysis**

| | Example | Author(s) who refer to the level of analysis when defining infusion |
|---|---|---|
| Organisational | "Extent to which the full potential of the innovation has been embedded within and organisation's operational and managerial work system" – Zmud and Apple (1992, p. 148) | Cooper and Zmud (1990),Wynekoop and Senn (1992), Dasgupta (1997), Moorell (1999), Castner and Ferguson (2000), Jaakkola et al., (2001), Chang and Lung (2002), Wilson Green (2003), Idowu et al., (2006), Ramamurthy et al., (2008), Pongpattrachai et al., (2009), Wu and Subramaniam (2009), Yu et al., (2009) . |
| Individual | "Extent to which an information system is used completely and effectively and improves the individual's performance" – Fadel (2006, p.278) | Beaudry and Pinsonneault (1999), Meister and Compeau (2002), Ahuja and Thatcher (2005), Fadel (2006), Wang and Hsieh (2006), Wainwright and Waring (2007), Thatcher et al., (2011), Fadel (2012). |

Prior studies have primarily defined IT infusion in two segments: organisational and individual. Initially, when the concept of IT infusion emerged in IS literature it was

studied by many scholars (for example, Cooper and Zmud, 1990; Zmud and Apple, 1992) at the organisational level. It is argued (Fadel, 2006) however, that organisational infusion of any technological innovation can only be achieved as individuals infuse the technology into their own work practices. This is further reinforced by Sundaram et al., (2007) who argue that before organisations can optimise IS potential it should first optimise the potential of individual users. This rationale led to the modification of existing definitions of infusion in extant literature to reflect the individual user and not the organisation alone. Table 2-7 further illustrates researchers who defined infusion using the level of analysis under investigation (i.e. mentioned 'organisational' and/or 'individual' in the definition).

The infusion of an IT constitutes an important aspect of the overall assimilation process (Jasperson et al., 2005). Yet, Tennant et al., (2011) argues that the broad, abstract and complex nature of infusion provides few guidelines for developing consistent measures of infusion. Therefore, with various approaches to defining and operationalising infusion a taxonomy is put forward for future research in the infusion domain (see (Figure 2-4). As a result, the taxonomy presented (Figure 2-4) will be utilised when examining infusion in this research study.

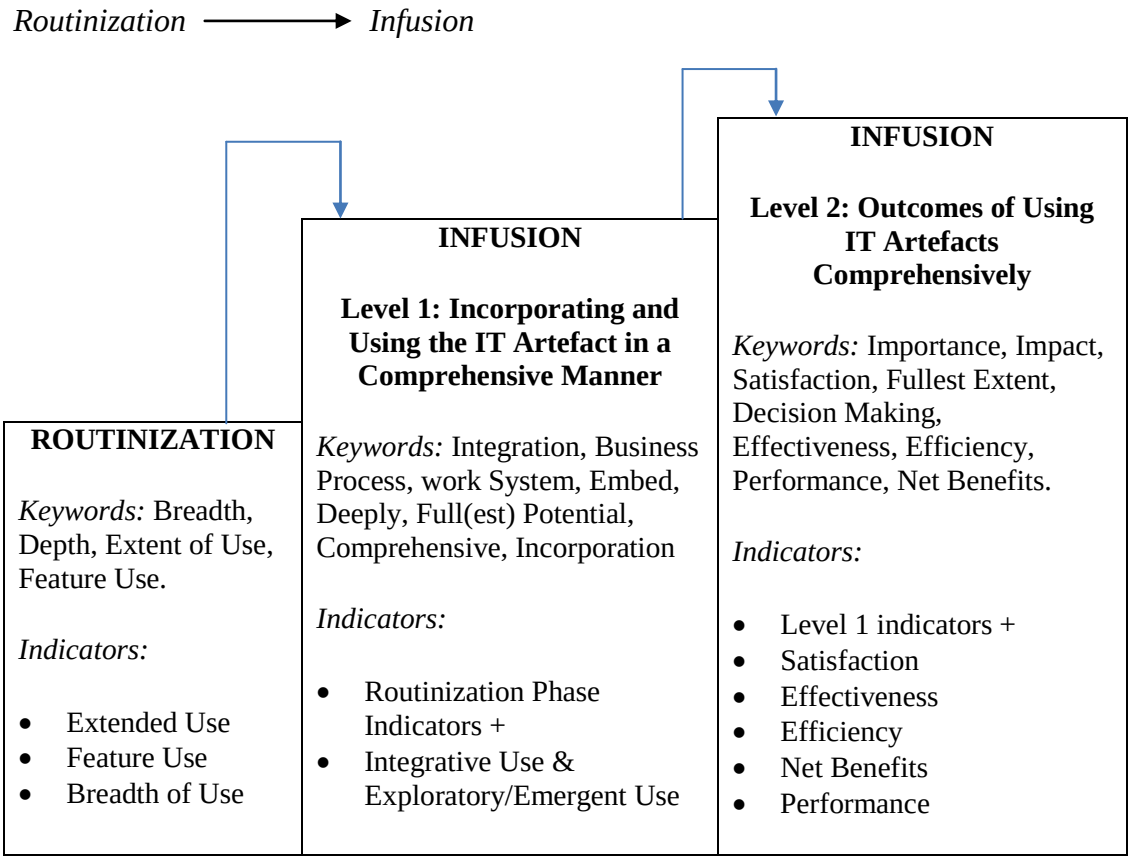



**Figure 2-4: Taxonomy for Examining IT Infusion**

By identifying keywords utilised in defining infusion, indicators for examining same, and the unit of analysis, researchers can now investigate infusion appropriately in the context of their study. In doing so, this will assist in maturing the future of infusion research. Leveraging the taxonomy depicted in Figure 2-4, Section 2.4.2.4 defines infusion for the purpose of this study.

#### 2.4.2.4 Defining Infusion for the Purpose of this Study

Building on the themes presented previously, infusion is defined for the purpose of this study at level 1. Thus, infusion in this research study is examined at the individual level of analysis and defined as:

> *"The extent to which individuals incorporate and use the IT artefact in a comprehensive manner (i.e. feature, integrative, exploratory use repectively)".*

This definition clearly uses keywords for appropriately defining level 1 (i.e. use). Moreover, the definition also highlights the unit/level of analysis under-investigation in this study (i.e. individual level). The indicators of infusion reflect the level for which infusion is defined and are outlined in more detail in Section 3.3.1.

### 2.4.3 Models for Explaining IT Infusion

In order to enhance studies on IT infusion many researchers turn to existing theories/models in the IS field to identify antecedents to infusion. Commonly cited authors include Jones et al. (2002), Wang and Hsieh (2006) and Hsieh and Wang (2007) whose theoretical foundations were based on Technology Acceptance Model, Theory of Reasoned Action, IS Continuance Model and Symbolic Adoption theory. Other theoretical models employed include Diffusion of Innovation (Ramamurthy et al., 2008), Psychological Empowerment Theory (Ng and Kim, 2009), Technology-Organisational-Environment framework (Wu and Subramaniam, 2009) and theories of adaptation and cognition (Fadel, 2006).

It is therefore evident that numerous models have been developed and utilised to examine IT infusion. The purpose of this section is to identify the limitations associated with infusion based models. From reviewing same, it is evident that some models have not been empirically examined. More studies focus on the organisational level of analysis and thus, propose organisational determinants for IT infusion. This section further reveals that a dearth of research exists examining the outcomes of IT infusion and the vast majority of IT infusion research primarily examines infusion of stationary desktop technology and limited studies have been investigated in the healthcare industry. These limitations are leveraged by the researcher in order to present the research objective of the study and argue for the need for a new model to examine MHS infusion.

#### 2.4.3.1 Reviewing Limitations of Existing IT Infusion Models

A number of models have been developed and/or utilised to examine IT infusion. However, from reviewing and synthesising models of IT infusion the researcher

identified a number of limitations. The first limitation of existing IT infusion models identified by the researcher is that a number of IT infusion based models have been developed but not empirically examined. Although these models provide rich insights into the infusion concept they have not yet been validated.

A review of the infusion literature reveals that infusion has primarily been studied at the level of the organisation, with less attention focused towards the individual level (Peijian and Lihua, 2007). The underlying rationale for the abundance of infusion research focusing on the organisational level of analysis could be due to the fact that infusion was initially defined focusing on the organisational level of analysis (c.f. Sullivan et al., 1985 and Cooper and Zmud, 1990). As a result, a vast array of organisational determinants for IT infusion has emerged. Ramamurthy et al., (2008), for example, examine the key organisational and innovation determinants that influence the infusion of IT within organisations and also examine if infusion leads to improved organisational outcomes. For example, Wu and Subramaniam (2009) propose determinants such as "Organizational Readiness", "Firm Size", "Transaction Volume", and "Compatibility" among others, which are primarily targeted at the organisational infusion of IT. Noteworthy, however, some determinants found to be important at an organisational level were found not to be important at an individual level. For example, unlike research conducted at the organisational level, Jones et al., (2002) found that compatibility with existing systems is insignificant when investigating infusion at an individual level.

Realising that the majority of research conducted on IT infusion focused on the organisational level scholars began focusing their attention on IT infusion at an individual level. Although understanding infusion at the organisational level is important, the researcher perceives that it is first necessary to understand individual infusion, as individual infusion is a prerequisite to organisational infusion (Sundaram et al., 2007). That is, individual level infusion is important as individuals are the primary users of the IS which underpins many organisations (Tennant et al., 2011). Yet, infusion research is primarily dominated by organisational-based studies.

Each model, independent of the level of analysis, provides insights into the infusion of IT artefacts. From reviewing same, the majority of models examine infusion as a dependent variable (Meister and Compeau, 2002). As a result, little is known on the outcomes of IT infusion (categorised as 'Process' by Cooper and Zmud, 1990, p. 124-125 and Wilson Green, 2003, p. 24 and 'Level 2' in Figure 2-4). Infusion studies which examine the organisational outcomes of infusion include Castner and Ferguson (2000), Chang and Lung (2002), and Ramamurthy et al., (2008). These authors argued that IT must be first used comprehensively to improve or enhance the accomplishment of tasks and ultimately, through infusion of IT, organisational benefits (such as Likelihood of software replacement – Castner and Ferguson, 2000; Organisational benefits – Chang and Lung, 2002; Organisational level outcomes in terms of benefits and stakeholder satisfaction – Ramamurthy et al., 2008) can be obtained. This clearly illustrates the various levels required to investigate outcomes of IT infusion.

The researcher, however, was able to identify an additional three papers (c.f. Beaudry and Pinsonneault, 1999; White et al., 2005; Sundaram et al., 2007) which examine the outcomes of infusing IT into one's work system. Sundaram et al., (2007) examined infusion (extent to which a salesperson fully uses the technology) and then its subsequent impact on productivity (IT-enabled administration performance and IT-enabled Salesperson performance). Here the researchers were able to highlight that the technology (i.e. Sales Force Automation) was used to its full potential and as a result, enhanced productivity of employees.

From the six papers (Table 2-8), only one study was examined in a healthcare domain; namely, White et al., (2005). Outside of these six papers, the majority of IT infusion studies have been conducted in industries such as manufacturing, services (e.g. utility, energy, insurance, stock-broking, and telecommunications) and education. Some models have been examined in the healthcare domain but some of these models have examined infusion at an organisational level (c.f. Ash and Goslin, 1997; Idowu et al., 2006; Wainwright and Waring, 2007). IT infusion at an individual level of analysis within the healthcare sector has also been investigated.

Shaw and Manwani (2011) examine electronic medical records. However, these authors investigate one aspect of infusion (i.e. feature usage) and fail to capture the entire concept of infusion as it is defined for the purpose of this study. Fadel (2012) examines infusion of an electronic medical system. This author, however, examines infusion of electronic medical systems from a stationary desktop perspective.

**Table 2-8: Dependent Variables Established from Infusion Literature**

| Dependent Variable | Authors |
|---|---|
| Individual Performance | Beaudry and Pinsonneault (1999)<br>*(Not empirically examined)* |
| Likelihood of Software Replacement | Castner and Ferguson (2000)<br>*(Organisational level)* |
| Organisational Benefits | Chang and Lung (2002)<br>*(Organisational level)* |
| Clinical and Educational Value | White et al., (2005)<br>*(Organisational and Individual level)* |
| IT-Enabled Performance<br>• IT-Enabled Administration Performance<br>• IT-Enabled Salesperson Performance | Sundaram et al., (2007)<br>*(Individual level)* |
| Organisational level outcomes<br>• Organisational benefits<br>• Stakeholder satisfaction | Ramamurthy et al., (2008)<br>*(Organisational level)* |

More research is required, however, to fully understand infusion in a healthcare context as this industry is often criticised for being relatively slow at adopting IT (Leu et al., 2012). Despite the wide support for the implementation of MHS, there lacks empirical evidence surrounding the benefits of IT in healthcare (Black et al., 2011). To truly establish the benefits of MHS it is argued (Zmud and Apple, 1992; Beaudry and Pinsonneault, 1999; Sousa and Goodhue, 2003; Fadel, 2006; Ramamurthy et al., 2008) that the IT artefact be fully embedded within an individual's work practices. Yet, a dearth of research exists which empirically establishes the benefits of infusing MHS in a healthcare domain.

Recent studies indicate that the use of mobile IT is growing, with research showing that companies are adopting mobile devices at a much higher rate than anticipated (O'Reilly et al., 2011). Individuals use mobile IT devices not only for hedonic but

also for utilitarian purposes (Kim and Zhang, 2010). Guo et al., (2010) argue that research on mobile technology remains under developed and offers potential opportunities for further research and practice. Therefore, the use of mobile IT by individuals in work domains is on the rise.

Organisations worldwide invest heavily in the implementation of technological innovations. The widespread availability of MHS in recent years has resulted in a growing industry marketplace estimated to be worth between $50 to $60 billion globally (McKinsy and GSMA, 2010). It is argued that the implementation of any e-health technology must *"live up to its fullest potential in real-world conditions and circumstance"* (van Limburg et al., 2011, p. e124). That is, MHS must corroborate the benefits proclaimed by vendors. To examine these potential benefits it is essential that the MHS be used comprehensively and fully embedded within a healthcare practitioners work practice. Failure to infuse the MHS may deliver only limited benefits to the end user. These limited benefits, according to Sousa and Goodhue (2003), may not compensate for what is usually a costly and difficult implementation process.

Since it originated in the 1980s, many studies on IT infusion focused on stationary desktop technologies and fall short of explaining the rapid diffusion of innovations such as mobile technologies. While the researcher recognises the value of existing infusion models they are limited when studying mobile IT as numerous differences exist between stationary and mobile IT artefacts. The unique characteristics of mobile artefacts, such as portability, reachability, accessibility, and localisation (Krotov and Junglas, 2006) help distinguish mobile IT from stationary IT. Tarasewich et al., (2002) argues that mobile IT extends beyond stationary IT by offering ubiquity, universality, unison and uniqueness.

In reviewing the literature, only three papers were identified which examine the infusion of mobile artefact (c.f. White et al., 2005; Idowu et al., 2006; Oakley and Palvia, 2012), two of which were examined in the healthcare domain. The first study (White et al., 2005) examines the technical aspects and regulatory compliance of

PDA infusion. Moreover, the authors describe the benefits and challenges met with the infusion of PDA technology. However, the authors examined the concept of PDA infusion by medical students in a classroom environment. Idowu et al., (2006) examined the degree and the extent of incorporation of IT in the Nigerian health sector and derived a mathematical model of IT infusion to understand the impact IT had on the healthcare delivery system in Nigerian teaching hospitals. Independent of these two studies and the work of Oakley and Palvia (2012), the majority of IT infusion research has examined stationary desktop technologies (see Appendix 1 for examples).

In summary, post-adoption research has overlooked the infusion phase of IT implementation. Reviewing and synthesising the infusion literature, the researcher establishes that empirical infusion studies are predominantly examined at an organisational level of analysis. Moreover, limited studies exist which focus on the outcomes of infusion. Only three papers were identified which examine mobile IT infusion, with the remainder primarily examining stationary desktop technologies. Building from this, little is known about infusion of mobile IT in healthcare domains by healthcare practitioners (Table 2-9). Based on gaps in the literature and limitations of existing infusion models, the objective of this research is subsequently outlined (Section 2.4.3.2).

**Table 2-9: Limitations of Existing IT Infusion Models**

| Overview of Models | Limitation | Authors who Develop/Examine Theory |
|---|---|---|
| 1. Model developed but not empirically examined. | The validity of the model and its components may be jeopardised. | Sullivan (1985); Dasgupta (1997); Beaudry and Pinsonneault (1999); Moorell (1999); Winston and Dologitte (1999); Raisinghani and Ramsaroop (1999); Fadel (2006); Shumarova (2006); Tennant et al., (2011). |
| 2. Model empirically examined primarily at organisational level of analysis. | Determinants found to be important at an organisational level have found not to be important at an individual level. | Sullivan (1985), Cooper and Zmud (1990),Wynekoop and Senn (1992), Zmud and Apple (1992), Ash and Goslin (1999); Dasgupta (1997), Patnayakuni and Rao (1998); Winston and Dologite (1999); Castner and Ferguson (2000), Fichman (2001); Eder and Igbaria (2001); Chang and Lung (2002), Sousa and Goodhue (2003); Wilson Green (2003), Gharvai et al., (2005); Wang (2005); Idowu et al., (2006), Wang and Hsieh (2006); Wainwright and Waring, (2007); Wang et al., (2007); Berger and Benyon-Davies (2008); Ramamurthy et al., (2008), Pongpattrachai et al., (2009), Wu and Subramaniam (2009), Yu et al., (2009), Senapathi and Srinvasan (2012). |
| 3. Model utilised/developed which focus on outcomes of IT infusion. | Little evidence is empirically presented which actually examines whether benefits can be obtained from IT Infusion. | Beaudry and Pinsonneault (1999); Castner and Ferguson (2000); White et al., (2005); Sundaram et al., (2007); Ramamurthy et al., (2008). |
| 4. Model utilised/developed examining mobile IT artefacts. | Mobile technologies are now becoming increasingly popular for performing work practices. However, the infusion of same is under-investigated. | White et al., (2005); Idowu et al., (2006); Oakley and Palvia, (2012). |
| 5. Model utilised/developed in the healthcare sector. | A small minority of research studies examine IT infusion in healthcare. More research is required to understand IT infusion in healthcare. | Ash and Goslin, (1997); White et al., (2005); Idowu et al., (2006); Wainwright and Waring, (2007); Shaw and Manwani (2011); Fadel (2012). |

#### 2.4.3.2 Research Objective

In order to bridge the existing gap in literature and answer calls for further research to advance academics' understanding of infusion by individuals, the objective of this research is to explore:

*The determinants and outcomes of MHS infusion by healthcare practitioners.*

This objective is warranted given the discussed limitations of existing models to explain and predict infusion of MHS at an individual (i.e. healthcare practitioner) level of analysis. A review of the literature demonstrated that a significant amount of extant literature focuses on initial technology adoption and acceptance, yet there remains a dearth of literature in the IS field focusing on the post-adoptive infusion of MHS. Describing the state-of-the-field in IS research, it is evident that the current state of literature is insufficient for understanding, explaining and predicting MHS infusion. Therefore, there is a need for developing a model to explore this phenomenon.

## 2.5 Chapter Conclusion

This chapter argues that while MHS hold much potential, the infusion of MHS is still in its infancy and has yet to achieve sufficient attention in the IS field. Therefore, this chapter has identified a gap in knowledge in relation to the determinants and outcomes of MHS infusion.

The chapter began by examining the role technology is playing in the reformation of healthcare organisations. MHS are now becoming commonplace in a healthcare practitioner's task of delivering healthcare services to patients at the point-of-care. While some healthcare practitioners have been pro-active in the adoption of IT it has been identified that such technological tools are often under-utilised post-adoption. If such technological tools are not infused within an individual's work practice, technology will ultimately fail, as individuals do not realise the full potential offered by the technological tools.

Although research has investigated the infusion of IT artefacts, only one study was identified which examines the infusion of mobile IT (Oakley and Palvia, 2012) and two studies which examine MHS in a healthcare domain (White et al., 2005; Idowu et al., 2006). As a relatively under-investigated phenomenon it is argued that a new model should be established to address this gap in literature. Subsequently, the following chapter derives a conceptual model to explain and predict MHS infusion. In developing this model for investigating MHS infusion by healthcare practitioners and the associated outcomes, a range of literature is reviewed. Such activities were performed in order to identify appropriate constructs with theoretical value for constructing a conceptual model to explore individual MHS infusion by healthcare practitioners. The constructs and the association between these will be discussed in detail in the following chapter (Chapter 3).

# CHAPTER 3: TOWARDS A RESEARCH MODEL OF MHS INFUSION

## 3.1 Introduction

The objective of this research is to explore the *determinants* and *outcomes* of MHS infusion by healthcare practitioners. The previous chapter concluded by arguing that a new timely, theoretically driven, conceptual model for explaining and predicting MHS infusion research is required. This chapter, therefore, describes the theoretical development of the conceptual research model that is used to guide this investigation. This chapter begins (Section 3.2) by outlining extant literature used for deriving a model of MHS infusion. Due to the immaturity of the MHS infusion domain (Chapter 2), the researcher first draws on IT infusion literature before examining other areas of IS research, such as mobile technology use in a healthcare domain and post-adoption use studies of IT usage. The rationale for selecting such material is also outlined in this section.

Section 3.3 comprises three components. The first component (Section 3.3.1) restates the definition of infusion as it relates to this study. That is, infusion refers to the extent to which individuals incorporate and use the IT artefact in a comprehensive manner (i.e. feature, integrative, exploratory use repectively). Building upon the taxonomy (Figure 2-4) derived from extant literature (Section 2.4.2.3); three indicators (i.e. feature, integrative and exploratory use) are documented for operationalising infusion. These indicators were selected as they examine the level in which the MHS is integrated and comprehensively used in healthcare practitioners' work practices[4].

The second component (Section 3.3.2) describes the independent variables of the model. This section focuses on three categories; namely, (i) User Characteristics, (ii) Task Characteristics, and (iii) Technology Characteristics. User Characteristics, in the context of this study, include MHS Self-Efficacy, Technology Trust and Habit. Task Characteristics comprise Task Demands and Task Significance while

[4] It is worth noting that outcome indicators are also examined. These are described in Section 3.3.3.

Technology Characteristics include Perceived Risk in Technology and Resource Availability. Each determinant, independent of the category of which it is included, is defined as it relates to this study. Moreover, all sections outline the relevance of each determinant to MHS infusion and highlight existing limitations. As a result, the initial steps towards theory building are depicted and a proposition is proposed. Only one proposition is selected due to the immaturity of the MHS infusion domain and the fact that the emphasis of this study is on identifying the main determinants of MHS infusion, using the categorisation of (1) user, (2) task and (3) technology characteristics as a guide to research. In doing so, the researcher does not aim to identify various categories which impact infusion but instead, identify individual determinants of MHS infusion by healthcare practitioners.

The third component (3.3.3) focuses on the dependent variables. The researcher argues that a dearth of research exists focusing on the outcomes of IT infusion. As a result, Section 3.3.3 outlines and describes potential outcomes of MHS infusion; namely, individual performance and knowledge creation. The researcher provides a rationale for their inclusion and argues that more empirical research is required to fully understand the outcomes of examining MHS infusion. Concluding this section is a diagram illustrating the potential outcomes of MHS infusion identified by the researcher and a second proposition is proposed. If additional propositions were derived for examining the outcomes of MHS infusion, then the researcher may be confined to examining only the outcomes outlined in this study. Due to the immaturity of the MHS infusion domain, having one proposition may facilitate the emergence of additional outcomes.

This chapter concludes (Section 3.4) by summarising the three categories (user, task, and technology characteristics) which may impact infusion. Furthermore, the two propositions are reiterated and a new conceptual model to investigate the research objective derived in Chapter 2 (Section 2.4.3.2) is presented.

## 3.2 Theory Building Approach

To derive a model for exploring MHS infusion, the researcher was required to examine other related areas of research as a dearth of research currently exists for MHS infusion. As a result, the researcher first draws on research pertaining to IT infusion, independent of technology used and level of analysis. Noteworthy, however, infusion is examined at an individual (i.e. healthcare practitioner) level of analysis in the context of this study. Therefore, infusion research focusing on the organisational level of analysis was used as a basis for finding (i) infusion research at the individual level of analysis and (ii) any core concepts deemed appropriate by the researcher (e.g. technology characteristics). An overview of some studies is depicted in Table 3-1 (a more exhaustive list is presented in Appendix 1).

The key findings from the IT infusion studies assisted the researcher in formulating a model of MHS infusion. For example, extant research in the wider IT infusion domain reveals that organisational determinants found to impact infusion do not apply at an individual level of analysis (see Jones et al., 2002). Similarly, the researcher was able to identify determinants which would impact mobile infusion (e.g. mobile self-efficacy – Oakley and Palvia, 2012) and obtain relevant literature to investigate and guide the inclusion of individual performance (Beaudry and Pinsonneault, 1999).

As the infusion phase of IT implementation is criticised for its lack of empirical research in extant literature (Tennant et al., 2011), the researcher drew on other related areas of research. These areas include mobile technology use in the healthcare domain, post-adoption studies of IT usage, and general IS material which was referenced in the infusion literature. Such research areas were examined based on a number of criteria related to this study. By applying a set of criteria, the researcher could delve deeper into the research domain.

**Table 3-1: Sample Overview of Infusion Based Studies Used for Developing a Model of MHS Infusion**

| Study | Context of Study | Model/Theory Developed/Use | Key Findings |
|---|---|---|---|
| Beaudry and Pinsonneault (1999) | *Level of Analysis:* Individual<br><br>*Methodology:* Theoretical | An Appropriation Model of IT Infusion (developed). | It conceptualises the IT infusion process as an appropriation process made of a series of reinforcing iterations between adaptation and usage. Also, argues that infusion can impact individual performance. |
| Jones et al., (2002) | *Level of Analysis:* Individual<br><br>*Technology:* Sales Force Automation (SFA) on desktop computers.<br><br>*Methodology:* Survey (85 respondents) | Determinants Leading to Infusion of Sales Force Automation (developed and empirically examined). | Findings of this research argue that theories such as Theory of Reasoned Action and Theory of Planned Behaviour fall short of predicting actual technology infusion. Unlike research conducted at the organisational level, Jones et al., (2002) found that compatibility with existing systems is insignificant when investigating infusion at an individual level. Moreover, these authors found that determinants impacting adoption of SFA did not necessarily impact the infusion of SFA (e.g. Perceived Usefulness, Compatibility). |
| Oakley and Palvia (2012) | *Level of Analysis:* Individual<br><br>*Technology:* Mobile Device<br><br>*Methodology:* Mixed Methods - Focus group and survey (111 respondents) | Mobile Device Infusion (developed and empirically examined). | Findings show that mobile self-efficacy and mobile emotional attachment have a positive effect on mobile device infusion. However, mobile self-efficacy has an overall greater impact on mobile device infusion as opposed to mobile emotional attachment. |

Firstly, mobile commerce research was selected to obtain a better understanding of the use of mobile technologies in the workplace. Such studies, however, were limited to the study of mobile technologies in a healthcare domain. Examples include, but are not limited to, Harkke (2006), Chatterjee et al., (2009), Junglas et al., (2009) and Hwabamungu and Williams (2010). Junglas et al., (2009) use a mixed-methods approach to examine technology (mobile trolleys in their study) acceptance

behaviour and identify individual characteristics that determine various types of perceived fit (e.g. Location Fit, Patient Interaction Fit, and User Comfort Fit). Subsequently, Junglas et al., (2009) examines the utilisation and the work performance impact from the various types of fit. This study was beneficial in developing a model of MHS infusion as it shows that healthcare practitioners' performance is impacted by mobile IT use in a healthcare domain. Although, Junglas et al., (2009) focus on the notion of 'fit', it identified key findings pertinent to the clinical domain. Similarly, the work of Hwabamungu and Williams (2010) is another example which was reviewed. These authors applied the theory of task-technology fit to examine mobile phone usage by medical staff in a clinic in South Africa. The pertinent findings of their study reveal that technology, task and people characteristics play an important role for mobile technology adoption. Such categorisation of characteristics can assist the researcher in shaping the theory for MHS infusion.

Secondly, the wider IS literature was selected based on a number of criteria as this would enable the researcher to gather appropriate material surrounding the objective of this research. The researcher examined post-adoption IS research at an individual-level of analysis. The rationale for focusing on post-adoption research is that IT infusion is a post-adoptive phase of implementation (see Table 2-3). Moreover, previous research has found that determinants impacting adoption do not necessarily impact infusion (c.f. Cooper and Zmud, 1990 and Jones et al., 2002). Examples of post-adoptive material covered by the researcher include, but are not limited to, Shaw and Manwani (2011) and Thatcher et al., (2011).

Shaw and Manwani (2011) examine the post-adoption of electronic medical records by building on the Post-Acceptance Model of IS Continuance (Bhattacherjee, 2001) and the Technology Acceptance Model (Davis, 1989). This study identifies that the benefits gained by the continued use of complex systems is established based upon the functionality of the technology deployed. This finding reveals the importance of feature use of medical applications in a post-adoptive scenario. Such findings help guide this study by establishing one indicator for which infusion should be examined. Thatcher et al., (2011) examine the role of trust in post-adoption in

exploring knowledge management systems. These authors show that trust in IT plays a central role in shaping behavioural beliefs, which leads to exploratory use of IT. This finding depicts the importance of investigating technology trust in post-adoptive scenarios.

Next, the wider IS literature was examined based on previous work in the infusion domain. That is, examining wider IS theories (e.g. Theory of Reasoned Action and Theory of Planned Behaviour) at an individual-level of analysis. The Theory of Planned Behaviour (TPB) is a popular, widely-used theory in predicting and studying human behaviour (Broadhead-Fearn and White, 2006). TPB (Ajzen, 1991) extends the Theory of Reasoned Action (Fishbein and Ajzen 1975), to account for conditions where individuals do not have complete control over their behaviour. As a result, such theories may influence how the MHS infusion theory is developed in the context of this study.

One of the most widely used theories in the IS field, namely the Technology Acceptance Model (TAM), has been used to explain how human beings behave when faced with new technology (Davis, 1989). The model proposes that the users' willingness to use or not to use new technology depends on two key constructs: perceived usefulness and perceived ease of use. The researcher acknowledges the contributions that TAM has made to IS research. However, these constructs have been reported to have more of an influence on the adoption phase of implementation[5] as opposed to the post-adoption phase of infusion (Saeed and Abdinnour-Helm, 2008). As a result, the researcher perceives that these two constructs are not appropriate for the context of this research study.

This section presented a high level overview of the range of material underpinning the theoretical development of a model of MHS infusion. Building from this section, a model for exploring this phenomenon is outlined and built in Section 3.3. This section provides a more detailed approach to the theory building process.

[5] See Table 2-3 for an overview of the different phases associated with IT implementation.

## 3.3 Theoretical Development Constructs

The objective of this research is to explore the *determinants* and *outcomes* of MHS infusion by healthcare practitioners. Little is known on this phenomenon and thus, a model for examination is derived to provide more insights into this domain. It commences by restating the definition of infusion as it applies to this study (Section 3.3.1). Using the taxonomy (Figure 2-4) developed previously this section argues that infusion of MHS is operationalised using three indicators (i.e. feature, integrative and exploratory use). Each indicator is ultimately described to provide clarity and reduce any ambiguity as the concept of infusion has been defined and operationalised inconsistently in the literature (Section 3.3.1).

Next, the emphasis is placed on identifying determinants which impact infusion of MHS (Section 3.3.2). Three categories (user, task and technology) with seven determinants are identified from extant literature. These seven determinants include MHS Self-Efficacy, Technology Trust, Habit, Task Demands, Task Significance, Perceived Risk in Technology and Resource Availability. This section describes each determinant in the context of this research study. However, the researcher outlines that the applicability of these determinants to MHS infusion is open to question due to limitations in extant literature. However, the seven determinants illustrate that user, task and technology characteristics affect the infusion of MHS. Section 3.3.2 concludes with a summary of the determinants and a visual depiction of same. Moreover, one proposition is proposed for examination, for which a rationale is presented.

Building from this, the dependent variables are presented (Section 3.3.3). These include individual performance and knowledge creation. These outcomes were selected based on extant literature in both the IS and medical informatics domain. It presents an overview of existing models which examine IS utilisation and its impact on end users and reveals the importance of evaluating the impact IT may have on healthcare practitioners' work. Moreover, it argues that knowledge changes rapidly in a healthcare domain but yet, little is known about the ability of MHS infusion to assist healthcare practitioners with such exacting requirements (i.e. knowledge

creation). As a result, both individual performance and knowledge creation is described in the context of this study. Section 3.3.3 concludes with a summary of the healthcare practitioner related outcomes of MHS infusion and includes a visual depiction of same. Moreover, one proposition is proposed for examination, for which a rationale is presented.

### 3.3.1 Theoretical Development: Infusion

Although the concept of infusion was previously discussed in detail in Section 2.4, this section focuses on the concept of infusion as it relates to this research study. Infusion is defined for the purpose of this study as *"the extent to which individuals incorporate and use the IT artefact in a comprehensive manner (i.e. feature, integrative, exploratory use repectively")* (Section 2.4.2.4). To ensure that infusion is examined appropriately (i.e. investigating the comprehensive and integrative use of MHS) the taxonomy developed in Section 2.4.2.3 is used. Three reflective indicators[6] (Figure 3-1) are described in this section; namely feature use (Section 3.3.1.1), integrative use (Section 3.3.1.2) and exploratory use (Section 3.3.1.3). A definition of each indicator is presented and examples are illustrated as a means for interpreting the indicator utilised in this study.

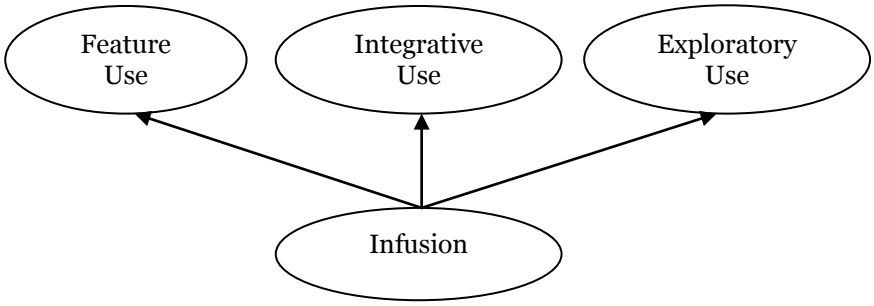



**Figure 3-1: Conceptualisation of Infusion in this Study**

[6] For additional information pertaining to the use of reflective constructs please see Chapter 4, Section 4.6.2.1.

#### 3.3.1.1 Feature Use

The terms features and functionality are used interchangeably and are defined as *"specific technological capabilities for, and potential constraints on, users"* (Weiling and Jingwen, 2007, p. 3852). As a result, the notion of features and functionality will be referred to as features. Similar concepts of feature use exists in the IS literature including extended use (Saga and Zmud, 1994; Fadel, 2006; Wang and Hsieh, 2006), feature usage (Shaw and Manwani, 2011) and deep structure usage (Burton-Jones and Straub, 2006). Noteworthy, however, is that a user's behaviour can range from stagnation in utilising IS features to total integration of the IS in his/her work domain (Agarwal, 2000; Jain and Kanungo, 2006). Feature use is defined in the context of this study as:

> *"The degree to which healthcare practitioners use the technology's (i.e. MHS) features/functionality to complete any given task" (adapted from Oakley and Palvia, 2012).*

Using the EHR features/functions outlined in Table 2-2, for example, feature use occurs when the healthcare practitioner documents and maintains the primary source of patient demographic information (i.e. patient management feature) or selects a new medication from a predefined list which automatically updates the patient file (i.e. medication list feature). Feature use occurs when healthcare practitioners utilise any of the medical application features to complete any given task (i.e. deliver healthcare services to patients at the point-of-care).

#### 3.3.1.2 Integrative Use

Users exploit mobile technologies through a process of evaluation that results either in rejection, adoption, adaptation or integration of the technology into their daily activities (Carroll et al., 2003). The concept of integrated use has received limited attention in the IS academic community (Tennant et al., 2011). Integrative use refers to the use of IS (such as MHS) within individual users' work practices (Saeed and Abdinnour-Helm, 2008). Here, integrative use refers to:

*"The degree to which healthcare practitioners organise their work tasks to fulfil their role using the MHS" (adapted from Meister and Compeau, 2002; Saga and Zmud, 1994).*

MHS containing electronic pharmacopoeias (i.e. drug information), medical calculations, guideline information and administrative tasks have been identified as the most useful resources by physicians, nurses and other clinical staff (Honeybourne et al., 2006). Integrative use of MHS can facilitate an assortment of information that directly contributes to how patients are provided with healthcare services (Idowu et al., 2006). MHS offer healthcare practitioners the potential for flexible and mobile access to patient information quickly, efficiently and securely and/or disease management systems from any location at any point in time (Ooi et al., 2005; Chen et al., 2012). By integrating MHS into one's daily work practices healthcare practitioners can access the health status of a patient at the point-of-care (Demiris et al., 2008). Having access to this information, a healthcare professional can organise their daily tasks based on the content stored in MHS (Kossman and Scheudenhelm, 2008). For example, some MHS have automated alert warning systems, which identify that the health status of a patient has deteriorated. As a result, the healthcare practitioner will prioritise this patient (Kossman and Scheudenhelm, 2008). Thus, the content stored in MHS allows health care professionals to organise their tasks.

#### 3.3.1.3 Exploratory Use

It is important to focus on users' exploratory use of IT artefacts to advance IS literature about the dynamics of IT use (Ciborra, 2002; Ferneley and Sobreperez, 2006). According to Sousa and Goodhue (2003) individual users of IT artefacts frequently take advantage of only the most basic capabilities of a system. Exploratory usage captures active examination of new uses of the IS post implementation by supporting users to move beyond routine use of the system (Saeed and Abdinnour-Helm, 2008) by 'doing new things' with the mobile artefact. Others have described exploratory use as the user's willingness and purpose to find new ways of applying IT to work tasks (Wang and Hsieh, 2006; Saeed and Abdinnour-Helm, 2008; Wang et al., 2008). Similar concepts to exploratory use in

the IS literature include emergent use (Agarwal, 2000; Saga and Zmud, 1994; Wang and Hsieh, 2006), innovative use (Wang et al., 2008), individual feature extension (Jasperson et al., 2005), trying to innovative with IT (Ahuja and Thatcher, 2005) and trying new features (Sun, 2012). Each concept promotes the active examination of new uses of IS. Here, exploratory use is defined as:

> *"The degree to which healthcare practitioners actively seeks novel uses of the MHS within their work environment" (adapted from Saeed and Abdinnour-Helm, 2006).*

That is, exploratory use involves individual users of mobile artefacts discovering new information or new features/functionalities through a different set of actions from the ones they normally perform on a routine basis.

According to Sun (2012) an individual user usually utilises a large number of known and unknown features of IS to accomplish tasks. In post-adoptive scenarios, people may employ different features to cope with changing work requirements. Therefore, as a user gains more experience with an IS, they can continue to use additional features after the IS has been adopted (Jasperson et al., 2005). Individual users who have a propensity to spend more time on a system will *"learn new ways of exploiting the system's capabilities or become more adept at "discovering" more efficient ways of using systems outside of their original use"* (Jain and Kanungo, 2006, p.5). It is argued (Burton-Jones and Straub, 2006) that users must explore an IT artefact if they are to discover the features that match their work needs. However, such exploratory behaviours involve doing new things and can be associated with some degree of risk and uncertainty for individuals (Thatcher et al., 2011). Exploration of the system could result in unintended and harmful consequences for the individual (i.e. medical professional) as well as the patient. Such adverse consequences in healthcare could prove fatal.

Therefore, in the context of this research study, infusion is operationalised by examining feature use, integrative use and exploratory use of MHS by healthcare practitioners. Having identified the core component of the conceptual model derived

for this research, Section 3.3.2 discusses the determinants which impact MHS infusion.

### 3.3.2 Theoretical Development: Independent Constructs

This section describes three categories; namely, (i) user, (ii) task, and (iii) technology. As a result, three components of this section examine various determinants which fall under each category. That is, MHS Self-Efficacy, Technology Trust, and Habit are discussed and categorised as user characteristics in Section 3.3.2.1. The researcher argues that limited studies exist focusing on the impact these three determinants have on MHS infusion. Next, task characteristics are described which focus on task demands and task significance (Section 3.3.2.2). The researcher documents that the way tasks are performed can impact the infusion of MHS. Moreover, it is revealed that tasks performed in a healthcare domain are significant in nature as a patient's life may be severely impacted. However, to date, limited studies examine the impact of these two determinants (i.e. Task Demand and Task Significance) have on MHS infusion. Finally, Section 3.3.2.3 describes the determinants categorised as technology characteristics; namely, Perceived Risk in Technology and Resource Availability. This section argues that the negative effect when using IT may discourage healthcare practitioners from infusing MHS (i.e. Perceived Risk in Technology). Yet, a lack of empirical evidence exists investigating this association. Moreover, the researcher identifies that the technological resources are imperative for infusion however, the majority of existing infusion research primarily focuses on resources such as time and finance and fall short of explaining technological resources. Concluding this section is a summary of the determinants, a visual depiction of same, and the development of one proposition (Section 3.3.2.4). The researcher argues that one proposition is warranted given the lack of empirical studies pertaining to MHS infusion.

#### 3.3.2.1 User Characteristics

User characteristics, in the context of this study, refer to the user's attributes (e.g. self-perception, behaviour) when interacting with MHS. A number of determinants

emerged within this category including MHS Self-Efficacy, Technology Trust and, Habit. Each determinant will be described in the following paragraphs.

*MHS Self-Efficacy*

IS researchers, according to Lewis et al., (2003 p. 663), have found that self-efficacy tailored to an IT artefact is an important determinant of a variety of user perceptions of technology. As a result, self-efficacy has received considerable empirical support in a vast array of papers spanning both pre-and post-adoption research studies. Focusing on the latter, self-efficacy has widely been reported as a determinant which impacts individual infusion of IT artefacts (Beaudry and Pinsonneault, 1999; Vannatta et al., 2001; Pongpattrachai et al., 2009; Craig et al., 2010) and mobile artefacts (c.f. Oakley and Palvia, 2012).

In the IS literature, self-efficacy has been conceptualised at both the general computing behaviour level and at the specific computer application level (Marakas et al., 1998). Therefore, the concept of MHS self-efficacy is tailored for the context of this study and refers to:

> *"The degree to which an individual's perceives his or her ability to use MHS in the accomplishment of a task" (adapted from Compeau and Higgins, 1995).*

Shaw and Manwani (2011) found that physicians with high self-efficacy had greater potential to extensively utilise the vast array of features offered by a technology. Moreover, it is argued (Bandura, 1997; Stajkovic and Luthons, 1988; Vannatta et al., 2001; Pongpattrachai et al., 2009) that individuals with high self-efficacy tend to perform well when conducting a variety of tasks using IT. In contrast, low self-efficacy individuals tend to avoid tasks and situations that they believe exceed their capabilities. Pierce et al., (2003) found that feelings of self-efficacy encourage individuals to explore and manipulate the environment within which they work and to feel a sense of empowerment. Similarly, Lippert and Forman (2005) reasons that individuals with low self-efficacy or low computer proficiency maybe more likely to avoid experimentation due to the concern that a mistake will occur. This suggests

that skill levels of individuals may impact the degree of exploration which may occur. Overall, limited research examines the relationship between MHS self-efficacy and MHS infusion in the healthcare domain by healthcare practitioners. As a result, MHS self-efficacy will be one component of user characteristics examined in this study.

*Technology Trust*

Throughout extant literature there exist numerous definitions for trust. Rousseau et al., (1998) define trust as an individual's willingness to depend on another party because of the characteristics of the other party. Similarly, Gefen et al., (2003) describes trust as the degree to which people believe a firm is dependable in protecting customers' personal information.

Although a rich literature base exists focusing on trust in people within the IS field, comparatively little research focuses on the IT artefact and trust in the infusion domain. In recent years, many researchers have realised the importance of examining trust for IT use (for example, McKnight, 2005; Vance et al., 2008; Gefen et al., 2008; Kim and Benbasat, 2009; Koo and Wati, 2010; Thatcher at al., 2011). Research focused on the IT artefact and trust has found that technology, as an object of trust, influences one's adoption of that artefact (Wang and Benbasat, 2005).

In a post-adoptive infusion scenario, users' of IT artefacts can anticipate how that particular artefact will respond under different conditions (Saga and Zmud, 1994). As a result of this experience, individuals' can ascertain whether or not they trust the technology. The terms "Trust in IT artefacts" (c.f. McKnight et al., 2011; Thatcher et al., 2011) and "Technology Trust" (c.f. Cassell and Bickmore, 2000; Ratnasingam et al., 2002; Lippert and Davis, 2006) are often used interchangeable in extant literature. The concept of trust in an IT artefact can be extended to any technology; however, in the context of this study, it is limited to trust in MHS which is infused within healthcare practitioners' work practices. Borrowing and adapting the definition provided by McKnight et al., (2011) technology trust is defined here as:

*"The degree to which an individual perceives that the MHS is capable of facilitating tasks based on expectations of reliability and functionality."*

Users' work can be highly dependent on the reliability of the IT tools, and the tools' failure to maintain adequate functionality under all circumstances can lead to fatal outcomes (Brewster, 2010). If content (i.e. patient-related data/information) stored in electronic formats is considered bad quality or missing, or has many different sources which can contain contradictory information (Miettinen and Korhonen, 2008), then this often leads to confusion among healthcare professionals. As a result, trust in the IS may decrease, which can lead to a diminished use of such systems (Strong et al., 1997, Brewster, 2010) following implementation. However, at present, there exists no empirical research which examines the association between technology trust and MHS infusion in a healthcare context. As a result, the second component of user characteristics examined in this study is that of technology trust.

*Habit*

The concept of habit has long been examined in the IS field. In post-adoptive scenarios, research has focused on habits as an antecedent and/or determinant of continued use (Jasperson et al., 2005; Lankton, 2010) and habit formulation in post-adoption scenarios (Vaghefi et al, 2010), to name but a few. More specifically the impact of habit on infusion has been explored in extant infusion literature (Mäkinen and Jaakkola, 2000; Meister and Compeau, 2002; Ng and Kim, 2009) and found to have a significant effect on infusion.

The concept of habit has often been conceptualised through two perspectives. The first perspective conceptualises habit as a past behaviour, often measured in terms of frequency of behaviour (c.f. Bergeron et al., 1995; Gefen, 2003). The second perspective conceptualises habitual behaviour as automatic and subconscious (Kim and Malhotra, 2005; Limayem et al., 2007). In this study, habit refers to:

*"The extent to which an individual tends to use MHS automatically (adapted from Limayen and Hirt, 2003) often inferred from past experiences" (Bergeron et al., 1995).*

As depicted in the Cooper and Zmud (1990) implementation model the routinization phase precedes the infusion phase. Limayem and Hirt (2003) found that habit plays an important role in explaining usage behaviour. Subsequently, Limayem et al., (2007) found that habitual routines are often established during the routinization phase which can either facilitate or hinder infusion (Zmud and Apple, 1992). The underlying premise for Cooper and Zmud's (1990) argument is that individuals who have made it customary to habitually utilise the MHS in a restrictive manner, become less receptive to novel uses of the technology and thus, maintain a level of current usage through established ways (i.e. do not exceed the routinization phase). This can hinder the infusion process. Contrary to this, individuals who possess habitual routines which exceed their current usage (for example, make it customary to discover new features/functionality) can facilitate infusion of IT artefacts. Therefore, habits formulated in pre-infusion phases (i.e. adaptation, acceptance and routinization) are often maintained during the infusion phase (Ng and Kim, 2009). While habit has been examined in the wider IT infusion (i.e. IT infusion of stationary desktop computer at various levels of analysis) literature, no empirical research exist examining habits of healthcare practitioners and the association of same with MHS infusion. As a result, habit is the final component of user characteristics examined in this study.

#### 3.3.2.2 Task Characteristics

Task characteristics refer to the nature of the task(s) users perform (adapted from Trice and Treacy, 1988). When IT artefacts are embedded within an individual's work practice then it must facilitate the accomplishment of tasks (Kim et al., 2012). Building on this, task demands and task significance are selected for examination purposes within this study. Selecting these two determinants reflect the importance of conducting tasks in a healthcare domain.

*Task Demands*

Task demands refers to the procedures an individual is required to perform. Depending on the nature of the work, there will be specific task demands that must be met. Tasks performed in the healthcare environments are very demanding and any mistake may have very serious consequences (Hellgren et al., 2008). Moreover, in complex environments such as health care, it is argued (Walker and Carayon, 2008, p. 469) that *"many team members work together to achieve a goal, carrying out high-risk tasks and processes under uncertainty and time pressure."*

It is argued that users rely on the information accessible through an IS in effectively performing their tasks (Saeed and Abdinnour-Helm, 2008). Therefore, Kim et al., (2008) posit that mobile content (i.e. patient-related data/information) must be fit for use and free from defects for a specific user in a specific context. Content held in electronic repositories and delivered in a reliable and timely manner is essential to the health and well-being of patients, the wider population, and to the management of health care organisations (Long and Seko, 2002). As an information intensive industry, healthcare practitioners use various information regarding patient history, symptoms, functions and lifestyle; information about diseases, diagnostic aids, drugs, and treatment methods (Kane and Luz, 2009), which are all required to arrive at a diagnosis. Access to information is a prerequisite for evidence-based practice and the coordination of care (Moen, 2003) whereby healthcare practitioners are recommended to obtain clinical information by searching, reading and critically appraising the medical literature (Fontelo et al., 2004).

Therefore, research argues that the way tasks are performed can impact the usage of a system (Saeed and Abdinnour-Helm, 2008). However, limited studies exist focusing on task demands and its impact on MHS infusion. As a result, task demands are the first component of task characteristics examined in this study.

*Task Significance*

Task significance refers to the degree to which the task is meaningful and important (Hackman and Oldham, 1976). In healthcare, task significance plays an important

role in the delivery of healthcare services to patients. It is argued that an abundance of information presented on the screen of technological tools can keep a healthcare practitioner from finding the right information (Eady et al., 2008) at the right time, in the right format relating to the correct patient (El Morr and Supercaze, 2010). Moreover, deficient or insufficient data retrieved via IT can lead to serious consequences because the available information has a direct effect on the patient (Parker and Coiera, 2000). This is indicated by IPAC (2009) who published a report illustrating that over 98,000 people died in US hospitals in 2009 due to preventable medical errors. Previous studies examining medical errors have found that such errors result from poor quality data in medical records and databases (Mettler et al., 2008). Such flawed content quality in healthcare environments can lead to many negative outcomes, including the improper administration of drug treatment to patients, dose error (e.g. overdose, under-dose, missed dose), frequency errors (e.g. too many or too few medical interventions), drug interactions, illegible orders, known allergy to drug not being disclosed, preparation error, and delays in treatment (Bates et al., 1999). In an industry such as healthcare, poor content quality, accessed via IT, can literally be the difference between life and death (Byrd et al., 2011). From a clinical point of view, a pertinent question is whether systems can actually help medical professionals answer questions relating to patient care (Hersh and Hickam, 1998) at the point–of-care. Therefore, it is imperative that healthcare practitioners receive timely and accurate patient-related content through the MHS when delivering healthcare services (perform tasks), especially in time-critical situations.

Eady et al., (2008) proposes that tasks performed in a healthcare domain are significant in nature as they can severely impact on patient outcomes. Due to this, task significance may impact infusion of MHS. If healthcare practitioners perceive that using MHS could hinder them from performing a significant task then they may not embed the technological tool within their daily work practices. However, there exists a lack of empirical evidence examining the impact task significance has on MHS infusion and IT infusion in general. As a result, task significance is the second component of task characteristics examined in this study.

#### 3.3.2.3 Technology Characteristics

Technology characteristics refer to specific features, functionality, or usability of a technology that can affect its usage by target users (Agarwal and Venkatesh, 2002). Mobile IT facilitate transparent, integrated, convenient, adaptive, real-time communication and computing services to people (Kleinrock, 2001) independently of the devices' locations. However, Koppel (2005) argues that poor graphical user interface design and bad process design of MHS result in unnecessary medical errors. As a result, MHS which present poor results are often neglected and as a result the users do not effectively integrate these mobile technologies into their work practices. Furthermore, unlike stationary information systems, mobile devices rely heavily on battery performance as batteries are the largest single source of energy in a portable device (Smit and Havinga, 2000). MHS are limited based on their battery performance (Hummel and Hlavacs, 2003). Therefore, numerous authors (Pierre, 2001; Gebauer et al., 2010) argue that battery constraints will limit the capabilities of MHS.

*Perceived Risk in Technology*

The first technology characteristic, in the context of this study, is perceived risk in technology. Different types of perceived risk exist in the IS literature base. Risk perceptions associated with IT artefacts can be described as the perceived possibility of loss or harm which a user believes makes it is unsafe to use a technology (Rousseau et al, 1998; McKnight, D.H. et al., 2002). This definition of risk reveals that negative consequences of IT artefact utilisation are feasible (Grazioli and Jarvenpaa, 2000; McKnight, D.H. et al., 2002) along with a subjective belief of the potential of suffering loss in the pursuit of a desired outcome (Brewster, 2010). Borrowing and adapting these definitions, perceived risk in technology is defined here as:

*"The degree to which an individual perceives that the MHS is unsafe to use as part of their daily work practices.*

The presence of risk highlights that negative consequences of using the technology are possible (McKnight, D.H. et al., 2002; Alter and Sherer, 2004). Since risk perception is context dependent (Conchar et al., 2004), the individual risk dimensions forming the overall risk may vary from one case to another. According to Croll and Croll (2007) and Baker et al., (2011), two highly citied dimensions of risk perceptions in a healthcare context from IT use include that of privacy and safety.

The increasing dependency being placed on electronic devices in healthcare environments presents concerns of privacy, security and harm to patients. Privacy is an area of high sensitivity in healthcare (Croll and Croll, 2007) that is viewed as a key governing principle of the patient–physician relationship (Appari and Johnson, 2010). However, as personal health information is digitised, transmitted and mined for effective care provision, new threats to patients' privacy emerge (Mercuri, 2004). Clinical data is privileged information and should be accessed based on a need to know basis (Croll, 2011; Fernando and Dawson, 2009). This is evident as it is reported that medical data disclosures are one of the highest reported breaches in a healthcare domain (Hasan and Yurcik, 2006). Improper access/unauthorised access can result in breaching of patient confidentiality (Parks et al., 2011) in healthcare domains. As a result of patient data disclosure, Neubauer and Heurix (2011) argue that patients can be harassed, discriminated against, be under threat of economic harm or be denied service from insurance or employers. Such a risk is possible as, due to their compact size, mobile devices can be lost or stolen (Gururajan, 2006). This is evident as laptop or computer loss is said to be accountable for half of the ten biggest health care security breaches in 2006 (Report on Patient Privacy, 2006). Unauthorised access to patient data may result in tampering of data or medical identity theft (Naumovich, and Memon, 2003). It is of critical importance, therefore, to safeguard medical data integrity as unacceptable modification of patient data may result in misdiagnosis (Kundu and Das, 2010). Therefore, according to Croll and Croll (2007) and Baker et al., (2011) risks associated with technology can have negative effects when using IT technologies. This negative effect in healthcare can be detrimental to both the user of the technology and the patient receiving care. Thus, if individuals perceive risk associated with the MHS then they may not infuse the technology. However, a lack of empirical evidence exists between perceived risk

in technology and all infusion-related research. As a result, perceived risk in technology is one component of task characteristics examined in this study.

*Resource Availability*

Resource availability is found in the literature to play an important role during the implementation process of IT in organisations (Rahrovani and Pinsonneault, 2012), even more so in post-adoptive scenarios (Gallagher et al., 2012). In healthcare, Mackinnon and Wasserman (2009) found that technical, human and financial resources are critical for the successful implementation of integrated electronic medical records.

In general, the concept of resource availability is often examined under the term 'facilitating conditions'. Facilitating conditions refer to individual's perceptions of the availability of technological and/or organisational resources that can overcome barriers to system usage (Venkatesh et al., 2008). Moreover, facilitating conditions often reflect the environment in which the technology is implemented.

From a review of the infusion literature, it has been argued that resources such as time and finance, for example, are imperative for IT infusion (Cowan et al., 2004). Yet, such studies fall short of examining the physical technological artefact itself. As a result, resource availability in this context primarily focuses on technological itself (referred to as 'Technology Facilitating Conditions' by Lau et al, 2001). Borrowing and adapting Lau et al., (2001) definition, resource availability is defined as follows:

*"The perceived disposal of MHS, at any given time, required by healthcare practitioners to facilitate infusion."*

Resource availability could be considered as environmental determinant. However, as inadequate technological resources impede the usage of such systems it is considered a technological characteristic as per the definition provided at the start of Section 3.3.2.3. Research argues that technological resources are required for system use (Venkatesh et al., 2008). In healthcare environments, MHS may be in constant use thus, there may not be sufficient numbers of technological resources for

healthcare practitioners to infuse the technology. Limited empirical research exists, however, examining the association between resource availability (i.e. MHS availability) and infusion. As a result, technological resource availability is another component of technology characteristics examined in this study.

#### 3.3.2.4 Summary of Characteristics

This section presents a summary of the three categories (3.2.1.1); namely, (i) User, (ii) Task and, (iii) Technology Characteristics. As shown in Table 3-2, a review of the literature reveals seven determinants which are believed to impact infusion of IT artefacts. However, as shown in Table 3-2, the applicability of these determinants is open to question due to the acknowledged limitations of the particular studies. They nevertheless illustrate that three categories affect infusion of MHS by healthcare practitioners. These three categories include user, task and technology characteristics.

**Table 3-2: Determinants Impacting MHS Infusion: Relevance and Limitations**

| Determinant | Relevance to MHS infusion | Limitation |
|---|---|---|
| **User Characteristics** | | |
| Self-Efficacy | Research argues that users may avoid tasks and situations (i.e. not incorporate IT into their work-practices) which they believe exceed their capabilities (Oakley and Palvia, 2012). | Limited studies exist focusing on MHS self-efficacy and its impact on infusion by medical staff in a healthcare domain. |
| Technology Trust | Research argues that users may be reluctant to use some IT technologies because they may fear it will not perform reliably or possess insufficient functionality for users to perform tasks. If it is not used then it cannot be infused (Saga and Zmud, 1994; Thatcher et al., 2011). | Majority of research only deals with trust relating to the individual and not the technology. Lack of empirical research on the association between technology trust and MHS infusion. |

| Determinant | Relevance to MHS infusion | Limitation |
|---|---|---|
| Habit | Research argues that habit can impact the infusion of an IT artefact (Mäkinen and Jaakkola, 2000; Meister and Compeau, 2002; Ng and Kim, 2009). | Limited studies exist focusing on habit and its impact on MHS infusion. |
| **Task Characteristics** | | |
| Task Demands | Research argues that the way tasks are performed can impact the usage of a system (Saeed and Abdinnour-Helm, 2008). | Limited studies exist focusing on task demands and their impact on MHS infusion. |
| Task Significance | Research argues that tasks performed in a healthcare domain are significant in nature as they can severely impact on patient outcomes (Eady et al., 2008). Content, perceived as poor quality, retrieved via MHS may discourage users from infusing MHS within their daily work practices. | Lack of empirical evidence examining the impact task significance has on MHS infusion and IT infusion in general. |
| **Technology Characteristics** | | |
| Perceived Risk in Technology | Research argues that perceived risk in technology can have a negative effect when using IT (Croll and Croll, 2007; Baker et al., 2011). Such negative outcomes may discourage healthcare practitioners from infusing MHS. | Lack of empirical evidence on the association between perceived risk in technology and MHS infusion. |
| Resource Availability | Research argues that technological resources are required for system usage (Venkatesh et al., 2008). Without sufficient resources (i.e. MHS) available to healthcare practitioners' infusion of same may be hindered. | Existing research primarily focuses on resources such as time, finance, IT support, etc. However, little empirical research examines the impact technological resources have on MHS infusion by healthcare practitioners. |

Figure 3-2 represents a diagrammatic depiction of the independent constructs and their association with infusion. Based on the evidence presented through Section 3.3.2, one proposition is proposed. Of note, is that the researcher perceived that one proposition was warranted, as determinants impacting MHS infusion literature are currently under-investigated in extant literature. The emphasis of this section is to identify the main determinants of MHS infusion, using the categorisation of (1) user, (2) task and (3) technology characteristics as a guide to research. The researcher does not aim to identify various categories which impact infusion but instead, focus on the individual determinants. As a result, the interrelationships between categories/determinants are outside the scope of this study (unless evidence emerges from the qualitative analysis). As a result, the first proposition is presented:

**Proposition 1:** *Infusion of MHS by healthcare practitioners is affected by user, task, and technology determinants.*

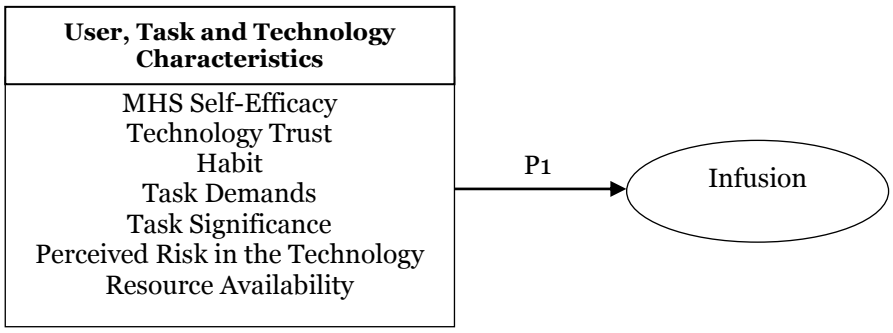



**Figure 3-2: Influencing Determinants Impacting Infusion**

### 3.3.3 Theoretical Development: Dependent Constructs

Building from previous sections, this section reviews potential outcomes of infusing MHS within a healthcare practitioner's daily work practices. As described in Sections 2.4.2.2 and 2.4.3.1 (see Table 2-8), there exists a dearth of research which empirically examines the outcomes of infusion. Therefore, Section 3.3.3.1 begins by discussing individual performance and argues that there exists limited research focusing on the association between infusion and individual performance in terms of effectiveness, efficiency and knowledge creation. This section proposes that MHS usage by healthcare practitioners have resulted in improvements in clinical care and workflow efficiency. Moreover, this section argues that knowledge changes rapidly

in healthcare domains thus, healthcare practitioners should create knowledge to adhere to evidence-based medical practices. Concluding this section a summary of outcomes is presented along with a visual depiction of the initial stages of the model's development (Section 3.3.3.2).

#### 3.3.3.1 Individual Performance

Torkzadeh and Doll (1999, p. 328) advocate that "*it is difficult to imagine how information technology can be assessed without evaluating the impact it may have on the individual's work."* Consequently, a number of models/theories for studying IS utilisation and the impact on end users were developed and employed in the IS domain. The most commonly used models/theories are Technology Acceptance Model (TAM – Davis, 1989), DeLone and McLean model (D&M – DeLone and McLean, 1992; 2003), Task-Technology Fit (TTF – Goodhue and Thompson, 1995) and, a Unified Theory of Acceptance and Use of Technology (UTAUT – Venkatesh et al, 2003). Therefore, the impact of IS on user performance is well documented in wider IS literature, as depicted by the work of Abugabah et al., (2009).

In the wider adoption literature researchers have found that mobile technologies impact performance of mobile workers and promote efficiency (Abraham, 2004; Basole 2004; Rossi et al., 2007; Lee et al., 2007; Hsiao and Chen, 2012). Indeed, these papers provide theoretical contributions but do not inform their audiences on the affect mobile technologies have on individual performance in post-adoptive scenarios. Beaudry and Pinsonneault (1999) propose that IT infusion is an important determinant leading to improved individual performance. Yet, Tennant et al., (2011) reason that a critical link between infusion and performance is omitted from extant IS literature.

A review of the infusion literature reveals an argument for the association between infusion and performance at a theoretical level. Researchers who employ the view of infusion at level 2 of the taxonomy developed in this study (see Figure 2-4) argue that the extent to which expected outcomes are realised is dependent upon the IT being used in a comprehensive and integrated manner (i.e. to its fullest potential) to support higher levels of one's work practices. Moreover, Kwon and Zmud (1987, p.

232) postulates that performance is largely reflected on the view of strong and weak use (this can be conceptualised in the context of this study as infusion or not). While mainstream infusion theorists have focused on organisational performance (for example, Tanoglu and Basoglu, 2006; Ramamurthy et al 2008), individual performance impacts have gone relatively unnoticed.

Yet, despite the theoretical arguments, there is a dearth of empirical research which examines the individual performance impacts from infusing IT artefacts within one's work practices. The underlying premise behind limited studies focusing on the association between infusion and individual performance may stem from the fact that the majority of extant literature in this domain examines infusion as the main dependent variable (see Appendix 1). Nevertheless, Sundaram et al., (2008) empirically examined the association between IT infusion and individual performance. In their paper (p. 104), IT-enabled administrative performance ("a measure of the extent to which the technology affects the quality of the salesperson's call planning and time and expense management") and IT-enabled sales performance ("the extent to which the technology affects the quality of the salesperson's ability to produce key sales results") and how they are impacted by infusing Sales Force Automation IT were examined. The authors found that infusion positively impacts both aspects of performance, thus overall sales performance was enhanced.

Due to the limited empirical research examining this relationship, this study seeks to address this gap in literature. Individual performance reflects individual outcomes of IT usage. For example, using IT has been reported to impact effectiveness, efficiency (Goodhue and Thompson, 1995) and knowledge creation (Alavi and Leidner, 2001; Davenport et al., 2008). Building from the previous paragraph, individual performance is defined in this study as:

*"The degree to which a healthcare practitioner effectively and efficiently delivers health care services and creates knowledge through the use of MHS."*

To provide more clarity and to reduce ambiguity, this definition is decomposed further; Effectiveness, in this context, refers to the degree to which a given activity

or program undertaken by medical professionals (i.e. utilising MHS) improves clinical care whereas efficiency refers to the degree to which a given activity or program undertaken by medical professional (i.e. utilising MHS) leads to a more efficient workflow. Knowledge creation is defined as the capability to improve continuously, and apply expertise by expanding the existing knowledge base (Nonaka et al. 2000) of individuals, through MHS, in a particular context. The three indicators of individual performance (Effectiveness, Efficiency, and Knowledge Creation) are subsequently discussed.

*Effectiveness*

Effectiveness, in this context, refers to the degree to which a given activity of a program undertaken by medical professionals (i.e. utilising MHS) improves clinical care. In terms of effectiveness, mobile technology usage by healthcare practitioners has been reported to improve the quality of patient care by facilitating decision support and medication safety in terms of prescribing and dispensing (Progmet et al., 2009).

MHS are often integrated with Clinical Decision Support Systems which assist healthcare practitioners when making decisions during the delivery of healthcare services to patients (Berner and Lande, 2007). Decision support at the point-of-care provides healthcare practitioners with evidence-based information with the aim of improving the quality of care patients receive (Berner, 2009). For instance, Lee et al., (2009) examined decision support via a handheld mobile device (PDA) and found that the integration of a decision support feature assisted nurses in terms of delivering healthcare services to patients. More specifically, these authors identified that mobile decision support increased diagnoses and decreased missed diagnoses of patients requiring obesity-related care.

A number of authors have also examined the impact of MHS on medication prescribing and dispensing by healthcare practitioners (Grasso et al., 2002; Shannon et al., 2006; Rothschild et al 2006). The common theme across the findings of these studies is that medication errors can be minimised with the introduction of IT as medication errors are primarily caused by illegible handwriting (Rodriguez-Vera et

al., 2002). A misread prescription or a transcription error in a pharmacy can lead to the wrong drug being dispensed to the patient and the pharmacist the subject of a malpractice case (Middleton, 2000). Furthermore, drug interactions, duplicative therapies and patient drug allergies are common medication errors caused by handwritten prescribing (Shannon et al., 2006). Prgomet et al., (2009) argue that using handheld devices during clinical practice assist healthcare practitioners on how medications can be prescribed and dispensed, thus improving the quality of care patients receive.

Sintchenko et al. (2005) argue that MHS containing decision-making tools and summaries of evidence-based medicine may reduce patients' length of stay in hospitals. Other authors have examined the quality of patient care, and how it is impacted by the use of IT, based on patient's experience and satisfaction (c.f. Gittell et al., 2000; McKnight, L.K. et al., 2002; Hsu et al., 2005; Dykes et al., 2007). Moreover, it is argued that handheld devices have given physicians the ability to use reference materials at the point-of-care (Nesbitt, 2002).

It is evident from this section that the use of MHS can improve clinical care delivered to patients. The following section describes how the use of MHS has been reported in extant literature to improve healthcare practitioners' workflow.

*Efficiency*

Efficiency, in the context of this study, refers to the degree to which a given activity or program undertaken by a medical professional (i.e. utilising MHS) leads to a more efficient workflow. Extant research has examined the efficiency achieved by healthcare practitioners from the use of MHS. For example, Junglas et al., (2009) found that the use of MHS facilitated the interaction between nurses and their patients. That is, the MHS was used as a tool to engage patients by showing the patient a scan recently taken and/or visually depicting the effectiveness of a particular medication regimen, for example.

Rudkin et al., (2006) examine time spent delivering healthcare services to patients by comparing paper based resources with an electronic resource; namely, a PDA. These

authors found that healthcare services were delivered faster to patients when delivered with an electronic resource compared to the paper based approach, thus saving time. The underlying rationale for this finding is that information was readily available to the healthcare practitioners.

Using the MHS within a healthcare practitioner's work practice ensures that information is mobilised and can be used at any time, independent of location within the hospital. In doing so, Nambisan et al., (1999) proposes that the use of mobile IT and instant access to information has an impact on the work processes of some users, enhancing use of time and decreasing unnecessary trips to a computer terminal. Operational efficiency is important to study, primarily in healthcare, as organisational tasks/medical procedures (e.g., lab tests and imaging) have to be planned and prepared, appointments with different service providers be scheduled, samples or the patients themselves be transported, visits of healthcare practitioners from other departments be arranged, and reports be written, transmitted, and evaluated (Lenz and Reichert, 2007). Such work tasks can be achieved more efficiently through integrative use of MHS.

Due to the variation of tasks performed by some clinicians, there is the potential for errors and unwanted effects occur. In terms of unwanted effects (Lenz and Reichert, 2007) posit that patients may have to wait, because resources (e.g., physicians, rooms, technical equipment) are not available (e.g., due to bad planning). Consequently, time loss is inevitable on both the patients and clinicians' behalf as appointments have to be re-scheduled, hospital stays are often longer than required, and costs or even invasiveness of patient treatment are unnecessary high. Infusing the MHS within a healthcare practitioners work practice reduces the possibilities of such events occurring.

*Knowledge Creation*

Generating numerous debates, the definition of knowledge has been of interest to many scholars as knowledge is seen as a versatile concept with multi-layered meanings (Nonaka, 1994). From a review of the literature Alavi and Leidner (2001) found several perspectives of knowledge including (1) knowledge vis-à-vis data and

information, (2) a state of mind, (3) an object, (4) a process, (5) a condition of having access to information, or (6) a capability (see Table 3-3).

Knowledge has been differentiated into two main modes: explicit and tacit (Nonaka, 1994). The first, explicit knowledge is defined by Grant (1996) and Berman et al., (2002) as knowledge that is based on facts and theories that can be codified, replicated, and transmitted to others easily in formal and systematic language (Polanyi, 1962; Grant, 1996; Berman et al., 2002). The second, tacit knowledge, is knowledge which is largely embodied or personal knowledge (Nonaka, 1994; Lam, 2000). That is, the implicit knowledge that people have developed (Allard, 2003, p. 269) which often evolves after experience (Abeson and Taku, 2006).

**Table 3-3: Perspectives on Knowledge (Source: Alavi and Leidner, 2001, p.111)**

| Knowledge Perspective | Description |
|---|---|
| 1. Knowledge vis-à-vis data and information | *Data* is raw numbers and facts (Maglitta, 1996) with no meaningful form which is derived from transactions (Davenport and Prusak, 1998). When this data is processed and is meaningful to the recipient it becomes *information* (Davenport and Prusak, 1998). Finally, when information is made "actionable" it becomes *knowledge* (Maglitta, 1996), which requires an understanding of the context, insights into the relationships within a system, the ability to identify leverage points and weaknesses, and to understand future implications of actions taken to resolve problems (Bennet and Bennet, 2003). |
| 2. State of mind | Knowledge is the state of knowing and understanding. |
| 3. Object | Knowledge is an object to be stored and manipulated. |
| 4. Process | Knowledge is a process of applying expertise. |
| 5. Access to information | Knowledge is a condition of access to information. |
| 6. Capability | Knowledge is the potential to influence action. |

El Morr and Supercaze (2010) argue that knowledge created by one healthcare practitioner is of utmost importance to the community of healthcare practitioners in order to deliver quality of care. Knowledge, therefore, is of extreme importance to healthcare as the health care industry is increasingly becoming a knowledge-based community that depends critically on knowledge management activities to improve the quality of care (Hsia et al., 2006).

Knowledge creation at an individual level must involve the ability to deal with new situations, events, information and contexts (Von Krogh et al., 2000, p. 19). According to Mitchell and Boyle (2010), there is a lack of evidence as to an agreed definition of knowledge creation. This lack of consensus has often led to the creators of knowledge being unaware of the different ways in which knowledge is created and as a result, Persson and Stirna (2006) posit that valuable knowledge may be lost. Therefore, knowledge creation is defined as:

> *"The capability to improve continuously, and apply expertise by expanding the existing knowledge base (Nonaka et al. 2000) of individuals, through MHS, in a particular context."*

Infusing the MHS may promote healthcare practitioners to actively seek medical literature. Providing access to medical literature increases the extent to which knowledge will be sought and incorporated into patient care decisions (Sackett et al. 1996), an approach often referred to as evidence-based medicine or evidence-based practice. This approach to delivering healthcare services aims to apply the best available evidence gained from the scientific method to clinical decision making. Medical knowledge is of critical importance to patient care delivery (Jones et al., 2008). According to Lenz et al., (2007) the reason for this is that the patient treatment process can be improved by providing medical knowledge. However, medical knowledge changes rapidly (Ebell, 2009) therefore, it is important that medical professionals constantly create knowledge to ensure that patient safety is not compromised. Sufficient medical knowledge may help prevent doctors from misdiagnosing an illness or prescribing medications that cause adverse drug events (Weingart et al., 2009) resulting in potential problems (Kim, S. et al, 2010). Infusing the MHS within a healthcare practitioner's work practice will enable the user to have constant access to such information, independent of time and location. Moreover, users who are engaged in exploratory behaviour are seeking new ways of utilising the MHS to conduct their work. When people introduce new ways of doing things then knowledge is said to be created (Hasting, 2010). However, limited studies exist which examine the association between IT infusion and knowledge creation.

### 3.3.3.2 Summary of Dependent Variables

Figure 3-3 represents a diagrammatic vision of the dependent constructs and its association with infusion. Based on the evidence presented through Section 3.3.3, a second proposition is presented. The researcher perceived that one proposition was warranted as outcomes of MHS infusion literature are currently under-investigated. Moreover, the emphasis in this section is to explore the outcomes which are derived from MHS infusion and as a result, the interrelationships between individual performance indicators are outside the scope of this study (unless evidence emerges from the qualitative analysis conducted in this study). If three propositions were derived for examining the outcomes of MHS infusion, then the possibility of additional outcomes may not arise. Based on the evidence presented through Section 3.3.3, the second proposition is therefore presented:

**Proposition 2:** *The infusion of MHS impacts various healthcare practitioner related outcomes.*

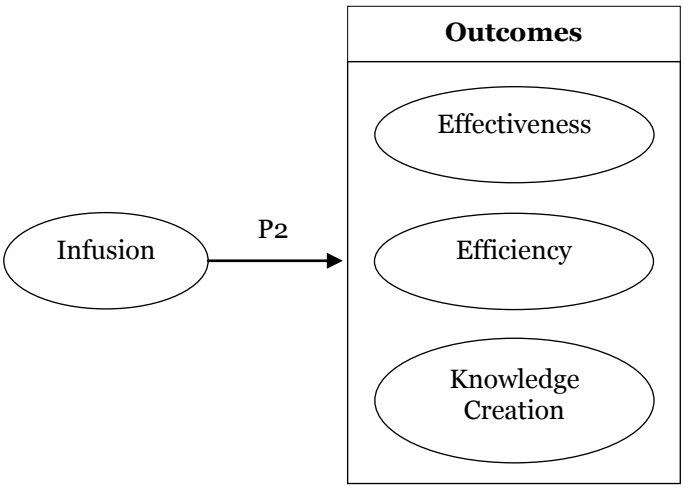



**Figure 3-3: Dependent Variables in this Study**

## 3.4 Chapter Conclusion

This chapter presents the theory building approach for exploring MHS infusion by healthcare practitioners. User, task and technology characteristics were established which impact the infusion of MHS by healthcare practitioners. Moreover, it examined potential outcomes from incorporating MHS within a healthcare

practitioners work practice. Two propositions were established in this chapter including:

**Proposition 1:** *Infusion of MHS by healthcare practitioners is affected by user, task, and technology determinants.*

**Proposition 2:** *The infusion of MHS impacts various healthcare practitioner related outcomes.*

Figure 3-4 depicts the conceptual model with independent and dependent constructs and the propositions highlighted above. In order to enhance understanding of MHS infusion, a mixed-method research approach is required. Such an approach will (i) facilitate refinement of the two propositions and the conceptual model and the derivation of hypotheses via a case study and (ii) test the hypotheses and model via a survey to (iii) derive at a model of MHS infusion by healthcare practitioners. In the next chapter (4), the methodology employed in this research is outlined and discussed.

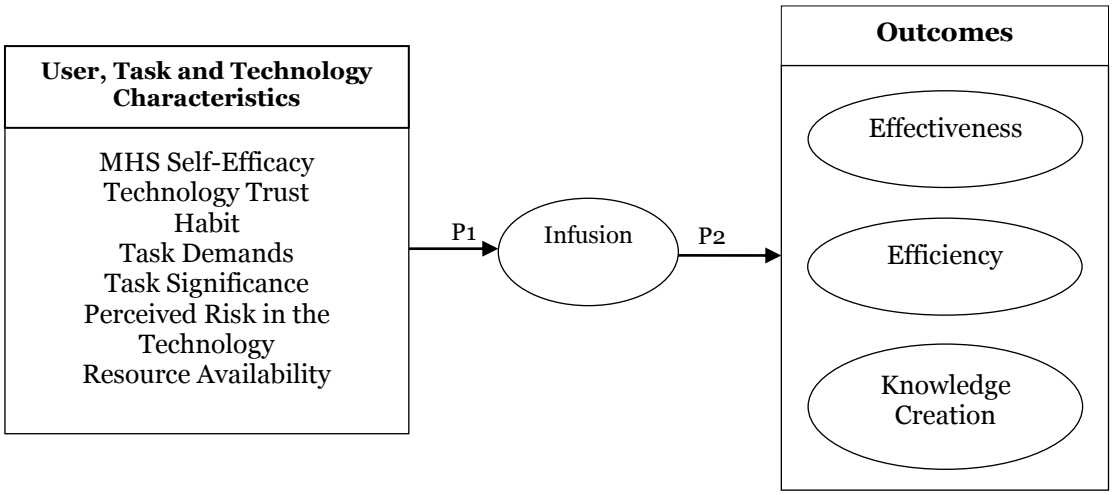



**Figure 3-4: Conceptual Model for MHS Infusion from Theory**

# CHAPTER 4: METHODOLOGY

## 4.1 Introduction

This chapter details the research design and presents the research strategy for this study. It begins by restating the research objective and the associated research questions (Section 4.2). The chapter depicts principles of IS research with a discussion on the epistemological, ontological and methodological stances guiding IS research by focusing on the various philosophical paradigms (Section 4.3). Due to the exploratory nature of this research and the assumptions of the researcher, the scientific inquiry of post-positivism is employed in this study.

In applying a post-positivist approach the researcher reviewed various methods in which to conduct this study and focuses on the selection of an appropriate research strategy (Section 4.4). An exploratory sequential mixed methods approach is favourable given the research objective and research questions presented (Section 4.2) and the epistemological stance of the researcher (Section 4.3). As the intent of this research is to explore the determinants and outcomes of infusing MHS within healthcare practitioners daily work practices, case study methods are presented as a suitable method in which to investigate the research objective (Section 4.4.3).

The chapter continues by describing the implementation of the research strategy in two sections. As this study adopts a two phased sequential mixed method approach, initial discussions focus on the first qualitative phase (Section 4.5) choosing University Hospitals Birmingham, NHS Foundation Trust (UK) in which to conduct the initial phase of this study. Applying case study techniques, data collection consisted of interviews. Additionally, this section provides an overview of the research site, criteria for participants and data collection period, before addressing the manner in which data is analysed and validated.

Next, the chapter focuses on the implementation of the second quantitative phase (Section 4.6) selecting the Ottawa Hospital in Canada in which to gather data. An online survey was considered to be the most appropriate data collection method. This section first provides an overview of the survey design, pre-test, site-selection, and

data collection, before addressing the manner in which data is analysed and validated.

Concluding this chapter, Section 4.7 summarises the two-phased sequential mixed methodological approach adopted in this study. Figure 4-1 depicts the overall research strategy employed in this study.

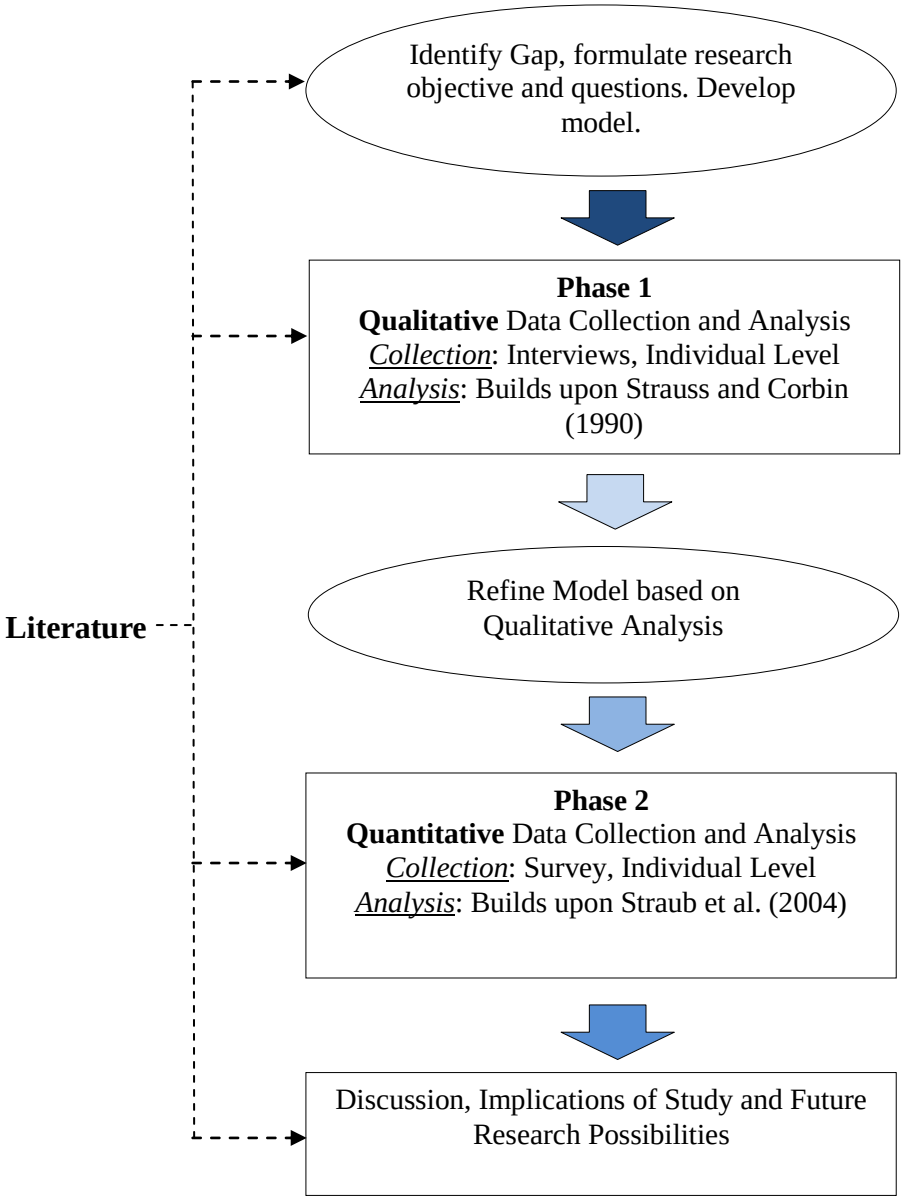



**Figure 4-1: Overview of Research Design and Strategy**

## 4.2 Research Objective and Research Questions

The identification of a suitable research objective is the most critical step involved in undertaking a research study and must be well-defined, clear of any ambiguity, concise and accurate (Jenkins, 1985). Based on the review of the literature conducted in Chapter 2, the **objective** of this research is to explore:

*The determinants and outcomes of MHS infusion by healthcare practitioners.*

In operationalising the research objective, four research questions were formulated:

- **Research Question 1:** What are the determinants of Mobile Health Systems infusion?
- **Research Question 2:** What are the outcomes of Mobile Health Systems infusion by healthcare practitioners?
- **Research Question 3:** To what degree do these determinants impact upon Mobile Health System infusion?
- **Research Question 4:** To what degree does Mobile Health System infusion impact upon healthcare practitioner outcomes?

These research questions are exploratory in nature. Such an approach is warranted due to the dearth of empirical research investigating MHS infusion. Overall, the research objective and questions lend themselves towards a theory building approach. In the next section, this study is positioned within the research paradigm debate and identifies the epistemological stance adopted by the researcher within this study.

## 4.3 Philosophical Position Underpinning this Research

This section reviews existing literature pertaining to various paradigms underpinning IS research (Section 4.3.1). The ontological, epistemological and methodological issues in IS research are addressed. The philosophy of science allows research to be viewed in a particular way by following approaches such as positivism (Section 4.3.1.1), constructivism/interpretivism (Section 4.3.1.2), critical theory (Section

4.3.1.3) and post-positivism (4.3.1.4). Concluding this section is a discussion on the scientific inquiry of post-positivism underpinning this research (Section 4.3.2), justifying it as a suitable philosophical stance upon which to study the research objective. The post-positivist paradigm was found to be most consistent with the researcher's own philosophical stance.

### 4.3.1 The Paradigm Debate in Information Systems Research

The philosophy of science offers a rich variety of views pertaining to human knowledge and action. However, Guba and Lincoln (1994) argue that four paradigm structures exist and guide scientific inquiry; namely, Positivism, Constructivism/ Interpretivism, Critical Theory, and Post-Positivism (see Table 4-1[7]). A paradigm can be defined as *"a set of lenses for the researcher"* (Burke, 2007, pg. 479) permitting the researcher to connect and share a particular set of core beliefs or basic assumptions, values and methods that guide the investigation (Kuhn, 1970; Guba and Lincoln, 1994). Each paradigm encompasses three attributes; namely (1) ontology, (2) epistemology and (3) methodology. The following depicts the fundamental questions, as per Guba and Lincoln (1994, pg. 108), underpinning each paradigmatic attribute;

- *Ontology*: What is the form and nature of reality?
- *Epistemology*: What is the relationship between the knower and what is known? How do we know what we know? What counts as knowledge?
- *Methodology*: How can the inquirer (would-be knower) go about finding out whatever he or she believes can be known.

As aforementioned, there exist numerous philosophical paradigms at the disposal of the researcher. These paradigms as well as their adoption within the IS field are discussed in the subsections below (Sections 4.3.1.1 to 4.3.1.4). Subsequently, the reasons why the post-positivist paradigm was found to be most appropriate to the researcher's pre-disposition are discussed (Section 4.3.2).

[7] The position of the paradigms in Table 4-1 has been modified in this study for the purpose of flow.

**Table 4-1: Basic Assumptions of Alternative Inquiry Paradigms (Modified from Guba and Lincoln, 1994, p.109)**

| Item | Positivism | Interpretivist | Critical Theory et al. | Post-positivism |
|---|---|---|---|---|
| **Ontological** | Naïve realism – 'real' reality but apprehendable. | Realivism – local and specific constructed realities. | Historical realism – virtual reality shaped by social, political, cultural, economic, ethnic, and gender values, crystallized over time. | Critical realism – 'real' reality but only imperfectly and probilistically apprehendable. |
| **Epistemological** | Dualist/ objectivist; findings true. | Transactional/ subjectivist; created findings. | Transactional/ subjectivist; value-mediated findings. | Modified dualist/ objectivist; critical tradition/ community 'findings probably true. |
| **Methodological** | Experimental/ manipulative verification of hypotheses; chiefly quantitative methods. | Hermeneutical/ dialectical. | Dialogic/ dialectical. | Modified experimental/ manipulative; critical multiplism; falsification of hypotheses; may include qualitative methods. |

#### 4.3.1.1 Positivist Approach

Under the positivist paradigm researchers adopt a realist ontology that embraces the *"belief that external world consists of pre-existing hard tangible structures which exist independently of an individual's cognition"* (Fitzgerald and Howcraft, 1998a, pg. 323). This implies that there only exists one true reality. To capture and accurately represent this one true reality, it is argued that the researcher must remain objective (Crotty, 1998; Hammersley, 2000). The researcher and the phenomena under investigation are expected to be independent whereby the researcher remains impartial. Any reduction in independence threatens the validity of the research. To

achieve this objectivity the positivist school of thought employs general theories which are used to generate propositions that are operationalised as hypotheses and subjected to empirical testing (Guba and Lincoln, 1994). The key to the positivist methodology is the use of repeatability, reductionism and reliability/refutability (Checkland, 1981; Pather and Remenyi, 2004), where every statement is either logically true or empirically testable (Landry and Banville, 1992). Therefore, the focus of the positivist researcher is on validity and control of the research procedures (Orlikowski and Baroudi, 1991).

Assessing different theoretical perspectives in major IS journals, Orlikowski and Baroudi (1991) identify that the positivist paradigm of inquiry was previously the dominant paradigm of choice for most U.S. scholars when undertaking IS research. Consequently, much has been learned about the development and utilisation of IS through the positivist stream of research (Jarvenpaa, 1988). The values of neutrality, measurement, rigor, and quantitative observation of events can be accounted as strengths of positivist research (Nissen, 1985; Kaplan and Duchon, 1988). However, since it originated in the 1920's, positivism has been criticised from many positions (Hjørland, 2005). Moreover, many IS researchers (cf. McFarlan et al., 1984; Weick 1984; Mumford et al., 1985; Land, 1987; Orlikowski and Baroudi 1991; Galliers, 1992; Hirschheim, 1992; Walsham, 1993; Myers, 1995) ascertain that the positivist school of thought limits IS research. According to Orlikowski and Baroudi (1991, pg. 12) *"the design and use of information technology in organisations, in particular, is intrinsically embedded in social contexts, marked by time, locale, politics, and culture."* Neglecting the exploration of these influences may reveal an incomplete picture of IS research.

By the end of the 1900s it became apparent that there were other ways of studying organisations and individuals than that of the dominant positivist inquiry, which lead the early years of social science research (Pather and Remenyi, 2004). Such approaches are subsequently discussed.

#### 4.3.1.2 Constructivism/Interpretivism Approach

Despite the dominance of the positivist stance within traditional IS, scholars began addressing how alternative paradigms such as "constructivism" and "interpretivism" could be employed to convince readers as to their validity towards the growth of scientific knowledge (e.g. Walsham, 1995; Klein and Myers, 1999). Unlike positivism, the constructivist school of thought adopts a relativist ontology that incorporates the *"belief that multiple realities exist as subjective constructions of the mind [whereby] socially-transmitted terms direct how reality is perceived and this will vary across different languages and cultures*" (Fitzgerald and Howcraft, 1998a, pg.325). This implies that reality is constructed and relative. Researchers embracing this paradigm contend that only through the subjective interpretation of and intervention in reality can that reality be fully understood (Klein and Myers, 1999). The constructivist/interpretivist approach therefore attempts to understand phenomena through the meaning that people assign to them (Boland, 1985; Orlikowski and Baroudi, 1991; Deetz, 1996). In other words, this approach favours subjective descriptions and understanding over the explanation and prediction goals associated with positivist research (Nissen, 1985).

The subjectivity employed by a constructivist delivers an understanding of social phenomena within context via an inductive process (Collis and Husse, 2009). Applying the same ontological belief of relativism and epistemological stance of subjectivity, the constructivist researcher is often referred to as an interpretivist, primarily in the IS field (cf. Walsham, 1993; Walsham, 1995; Checkland and Holwell, 1998). A hermeneutical dialectic methodology is primarily adopted by researchers in the constructivist/interpretivist paradigm (Guba and Lincoln, 1994). This approach elicits and refines constructions through interaction between, and among, the researcher(s) and respondent(s) and is interpreted through conventional hermeneutical techniques (Guba and Lincoln, 1994).

Many IS scholars (Walsham, 1993; Myers, 1995; Walsham, 1995; Myers and Avison, 1997; Shanks, 1997) stress that the constructivist/interpretivist school of thought is apt for studying IS. When applied to IS research, the interpretive approach provides greater depth to the research (Greene, 1994). However, interpretivism has

been criticised as it *"focuses on particularities and neglects the general"* (Hackley, 2007 pg. 104). In other words, interpretivist IS research does not explain the unintended consequences of actions, which cannot be explained by reference to the participants and which are often a significant element in shaping social reality (Orlikowski and Baroudi, 1991). An alternative inquiry paradigm, critical theory, can be employed by scholars in the IS field. This is subsequently discussed in Section 4.3.1.3.

#### 4.3.1.3 Critical Theory Approach

Under the critical theory paradigm, researchers adopt an ontological view that assumes that there is a 'reality' that is apprehendable. This is a reality created and shaped by social, political, cultural, economic, ethnic and gender-based forces that have been formed over time (Guba and Lincoln, 1994). This implies that critical theorists focus on a single reality, influenced over time by social changes. Critical theorists inherit *"modified transactional or subjectivist epistemology"* (Guba and Lincoln, 1994, pg. 109) whereby the researcher cannot separate themselves from what they know, thus influencing inquiry.

Methodological approaches employed by critical theorists tend to rely on dialogic methods (i.e. conversation and reflection) used to challenge assumptions. The aim of the dialogue between the investigator and the subjects of the inquiry is to *"excavate those forms of historical and subjugated knowledge that point to experiences of suffering, conflict and collective struggle [and]…to link the notion of historical understanding to elements of critique and hope"* (Giroux, 1988, p. 213). Therefore the overall aim of this paradigmatic inquiry is to critique, transform, and emancipate the social reality under investigation (cf. Orlikowski and Baroudi, 1991; Alvesson and Willmott, 1992; Hirschheim and Klein, 1994; Klein and Myers, 1999; Macey, 2000; Probert, 2004; Myers and Klein, 2011).

When applied to IS research, critical theory was argued to have a modest impact on the domain (Lyttinen, 1992). However since this was proclaimed, scholars in the IS community have applied this paradigm to their research (cf. Forester, 1992;

Ngwenyama and Lee 1997; Kanungo, 2004; Kincheloe and McLaren, 2005; McGrath, 2005).

The final paradigm proposed by Guba and Lincoln (1994) and employed by some IS scholars is that of post-positivism, which is discussed in Section 4.3.1.4.

#### 4.3.1.4 Post-Positivism

The many differences between positivist and interpretive research have given rise to much debate (Fitzgerald and Howcroft, 1998b). The apparent conflicts between positivist and interpretive inquiries can be resolved by adopting what Hirschheim (1985) calls a post-positivism paradigm. According to Vasquez (1995) and Klein (2004), post-positivism employs the ontological position of critical realism moving beyond the naïve realism embraced by the traditional positivist researcher. Critical realism refers to the belief that reality can be understood only *"imperfectly and probabilistically*" (Lincoln and Guba, 2000, pg. 168). This implies that any observations/findings are recognised by the researchers own feelings/perception and therefore cannot be taken as a precise view of reality, but only the researcher's perception of it (Teddlie and Tashakkori, 2009). In other words, critical realism is the belief that social phenomena exist in the objective world, and that there are some "*lawful reasonably stable relationships*" among them (Miles and Huberman, 1994, p. 429).

The post-positivist stance advocates methodological pluralism - the assertion that there is no one correct method of science but, instead, many methods (Wildemuth, 1993). Numerous IS scholars have embraced the post-positivist paradigm (Smith, 2006; Bygstad, 2008; Mutch, 2010, Carlsson, 2012). Chen and Hirschheim (2004) acknowledge that pluralism helps build upon the body of knowledge by allowing alternative approaches to research, and that continuous commitment to such pluralism is imperative for the future of the IS discipline. It is this pluralism which reinforces the use of post-positivism in IS research.

Having addressed numerous paradigms in the IS literature the subsequent section focuses on the paradigm employed in this research study (Section 4.3.2).

### 4.3.2 Scientific Inquiry Employed in this Study

As outlined previously, various paradigms of inquiry exist. Building on this, an argument is proposed for using the paradigm of choice within this study.

The mixed approach of post-positivism is the scientific inquiry employed in this study. The assumptions of the post-positivist paradigm were found to be most consistent with the researcher's own philosophical assumptions. The researcher embraces the post-positivist paradigm due to the limitations associated with other paradigms.

Firstly, the researcher does not agree with the positivist stance of investigating 'just the facts', devoid of context. In IS research, for example, Chesney (2008) found that the context in which an information system is utilised affects the determinants of the user's acceptance of same. The importance of exploring context is also argued by Orlikowski and Baroudi (1991). Moreover, Dey (1993, p.33) argues that *"contexts are important as a means of situating action, and of grasping its wider social and historical import*." This research explores MHS infusion in a healthcare context, a context argued to be different from others studied in the IS field (Chiasson and Davidson, 2004).

Secondly, the researcher does not agree with the paradigms of constructivism/interpretivism and critical theory, principally because both paradigms maintain that realities are subjective (cf. Guba and Lincoln, 1994). As a result, such paradigms may restrict the establishment of determinants and outcomes of MHS infusion due to the researchers existing knowledge on the topic. These reasons provide a sound basis for justifying the application of post-positivist epistemological stance to this research.

The stance of post-positivist critical realism is further justified due to the theoretical objective and research questions established in Chapter 2. The objective of this research study aims to address an under-investigated area of extant literature through a theory building approach. Employing the post-positivism critical realism stance enables the researcher to drill down from a theory to hypotheses to data, which leads to a theory either being supported or contradicted (Creswell and Plano-Clark, 2007).

Essentially, post-positivist critical realism promotes induction and deduction to continuously refine a researcher's understanding of phenomena under examination.

Having outlined the epistemological stance adopted by the researcher, Section 4.4 describes the research approach that was adopted within this study, in order to develop a theory for explaining and predicting MHS infusion.

## 4.4 Overview of Research Strategy

The section outlines the various research designs available to researchers embracing a post-positivist epistemology stance to research. First, a research design is selected (Section 4.4.1) by reviewing quantitative, qualitative and mixed-method research. An exploratory sequential mixed methods approach is selected as the research design of choice (Section 4.4.2) and is considered favourable given the research objective and research questions presented in Section 4.2. This section continues by discussing a research method; namely, case studies (Section 4.4.3). The requirements of the study and the suitability of the case study for empirical data gathering are presented.

### 4.4.1 Research Design Approach

The research strategy determines how empirical data are collected and analysed (Yin, 1994), and builds a general plan for the research regarding how it preceeds in order to fulfil its purpose (Saunders et al., 2000). In formulating a research strategy it is important to acknowledge that different modes of research allow researchers to understand different phenomena and for different reasons (Deetz, 1996). The methodology chosen depends on what one is trying to do rather than a commitment to a particular paradigm (Cavaye, 1996). Thus, the methodology employed must match the particular phenomenon of interest (ibid).

#### 4.4.1.1 Qualitative and Quantitative Research

Qualitative research is defined as any kind of research that produces findings not arrived at by means of statistical procedures (Strauss and Corbin, 1990) but obtained through the use of interviews, documents and participant observation data to understand and explain social phenomena (Myers and Avison, 1997). The intent of

qualitative research, therefore, is to understand a particular social situation, event, role, group, or interaction (Locke et al., 1987) in an effort to obtain a holistic overview of the context under investigation (Miles and Huberman, 1994, pg. 5-7). General examples of qualitative research strategies include action research, ethnographic studies and case study (Marshall and Rossman, 1989). The main strength of qualitative research is that it gives rich and detailed data that provide insights into peoples' behaviour and views of reality (Myers and Avison, 1997).

Unlike qualitative research which is concerned with words, pictures, descriptions and narratives, quantitative research is based on numbers, counts and measures of constructs used to represent the characteristics of an event or activity (Hair et al., 1998). Quantitative research, therefore, may be expressed as the techniques associated with the gathering, analysis, interpretation, and presentation of numeric information (Teddlie and Tashakkori, 2009). Moreover, the intent of quantitative research is to establish, confirm and/or validate the phenomenon under investigation (Leedy and Ormrod, 2005). This is often achieved through research instruments such as surveys, secondary data sources or archival data, objectives measures or test, and interviews (Straub et al., 2005). One of the strengths of quantitative research is that quantitative approaches are well formulated and clear criteria exist for conducting quantitative research (Kaplan and Maxwell, 1994). In particular, statistical analysis of quantitative data establishes reliability and generalisability of the data (Straub et al., 2005).

Both qualitative and quantitative approaches however have their own inherent limitations (cf. Myers and Avison, 1997 [qualitative]; Straub et al., 2005 [quantitative]). Neither qualitative nor quantitative research in isolation is considered appropriate in the context of this study. First, this study seeks to address the research objective – to explore the *determinants* and *outcomes* of infusing MHS within healthcare practitioners daily work practices. In order to achieve this objective, a post-positivist theory building approach was adopted. This involves first building a conceptual model from extant research and subsequently, refining this model. The application of quantitative research is better suited to theory testing and not theory building as the researcher might miss phenomena occurring because of the focus on theory/hypothesis testing rather than on theory or hypothesis generation (Marshall

and Rossman, 1989; Sutton and Staw, 1995; Cavaye, 1996; Darke et al. 1998; Gregor, 2006; Marshall and Rossman, 2010). Therefore, some determinants impacting healthcare practitioners' infusion of MHS and subsequent outcomes may be omitted. As a result, quantitative research in isolation is not considered appropriate for this study. Second, nor does the researcher believe that a qualitative approach is appropriate as qualitative research methods may be less reliable than quantitative methods due to their (traditionally) subjective nature (Roshan and Deeptee, 2009). Hence, a mixed methods approach, encompassing both qualitative and quantitative methods is considered apt for this study (Section 4.4.1.2) and is further justified in Section 4.4.1.3.

#### 4.4.1.2 Mixed Method Research

Researchers in the social sciences have been combining methods for some time, but the literature on mixed methods has only recently attained a critical mass (Creswell and Plano-Clark, 2007). By definition, mixed methods is a procedure for collecting, analysing, and "mixing" or integrating both qualitative and quantitative data at some stage of the research process within a single study for the purpose of gaining a better understanding of the research problem (Tashakkori and Teddlie, 2003; Creswell, 2005) in either parallel or sequential phases. As a result, the weaknesses of a single approach are minimised through the complementary utilisation of other methods (McDougall et al., 2007).

The rationale for mixing both types of data within one study is grounded in the fact that individually neither quantitative nor qualitative methods are sufficient to encapsulate the trends and details of a situation (Ivankova et al., 2006). Therefore, when used in combination, qualitative and quantitative methods complement each other and allow for a more rigorous analysis, taking advantage of the strengths of each (Greene et al., 1989; Tashakkori and Teddlie, 2003). As a result, this approach is considered appropriate for this study. The rationale for adopting this approach is expanded upon in Section 4.4.1.3.

#### 4.4.1.3 Justification for a Mixed Method Approach

Teddlie and Tashakkori (2003) identify three reasons that mixed-method research may be superior to single-approach designs which underpin the rationale for employing a mixed-method approach in this study:

*(1) Mixed-method research can answer research questions that other methodologies cannot.* One dimension on which quantitative and qualitative research is said to vary is the type of question posed by the researcher (Creswell, 1998; Carson et al., 2001; Sayre, 2001; Yin, 2003). Four research questions were previously presented (Section 4.2) to explore the research objective for this study. Research questions 1 and 2 ('what are') can be answered qualitatively (Creswell, 1998) whereas the research questions 3 and 4 ('to what degree') can be answered quantitatively (Carson et al., 2001). Neither qualitative nor quantitative research in isolation would be suitable in answering all four research questions (see Section 4.4.1.1). A mixed-method approach overcomes this limitation by permitting answers to all four research questions.

*(2) Mixed-method research provides better (stronger) inferences.* Mixed methods provide a wide array of data sources to assist in understanding complex phenomena. They enable multiple inferences that complement one another. That implies that one research method is utilised to inform the other allowing better conclusions to be drawn. As previously mentioned, a post-positivist theory building approach was adopted in the study. This involves first building a conceptual model from extant research and subsequently, refining this model. Refinement of the model can be achieved by applying quantitative statistics to an initial qualitative approach (Greene et al., 1989).

*(3) Mixed-methods provide the opportunity for presenting a greater diversity of views.* A mixed-method approach facilitates a stronger integration of data and results enabling each research method to confirm contradict and/or enrich the results of existing research (De Silva, 2011). Very little is known in existing literature pertaining to individual infusion of MHS (Chapter 2 and 3). Adopting a mixed-

method approach to this phenomenon will enrich understanding of MHS infusion by individuals in the IS field.

Further strengths of mixed-methods approaches can be found in existing literature (c.f. Ivankova et al., 2006; Creswell and Plano-Clark, 2007; McDougall et al., 2007). The above reasons provide a sound basis for justifying the application of the mixed-method approach to this research. Section 4.4.2 now depicts the mixed method research design employed in this study.

### 4.4.2 Mixed Method Research Design

Having identified the appropriateness of using a mixed method research approach (Section 4.4.1.3) this section provides additional insights into the mixed method research design employed in this study. It describes the differences between concurrent and sequential mixed method research approaches and advocates why a sequential approach is apt for this research study (Section 4.4.2.1).

Mixed methods research originates from the mixing of qualitative and quantitative methods. An important consideration in using a mixed methods approach, therefore, is the way in which the qualitative and quantitative methods are combined (Brannen, 1992). The qualitative and quantitative strands of research under the mixed method 'umbrella' can be conducted in concurrent or sequential phases (Teddlie and Tashakkori, 2009). In concurrent mixed methods research design (also known as parallel or simultaneous designs), the qualitative and quantitative components of the study occur in a parallel manner, either simultaneously (starting and ending at approximately the same time) or with some time lapse (i.e. slight delay in the implementation of both qualitative and quantitative components of research). Both components of research are planned and implemented to answer related aspects of the same basic research question(s). Alternatively, a researcher can adopt a sequential mixed method research design. This research design involves the qualitative and quantitative components of the study occurring chronologically in order (Creswell and Plano-Clark, 2007). The data collection techniques of one component emerge from or are dependent on the previous component. The research

questions for the two components of research (qualitative and quantitative) are related to one another.

A sequential mixed methods approach was selected as the research design of choice and was used to examine both the determinants which impact MHS infusion by healthcare practitioners and the relationship between such infusion and various healthcare practitioner related outcomes. This research design is warranted given the research objective and research questions outlined previously (Section 4.2). The following (Section 4.4.2.1) describes what constitutes the sequential mixed method research approach employed in this research.

#### 4.4.2.1 Sequential Mixed Methods: The Adopted Research Approach

For this research investigation an exploratory sequential mixed methods design is adopted. This research design consists of two distinct phases; qualitative followed by quantitative (see Figure 4-2). It is evident from Figure 4-2 that the two phases are connected to each other through the testing of the refined model and propositions.

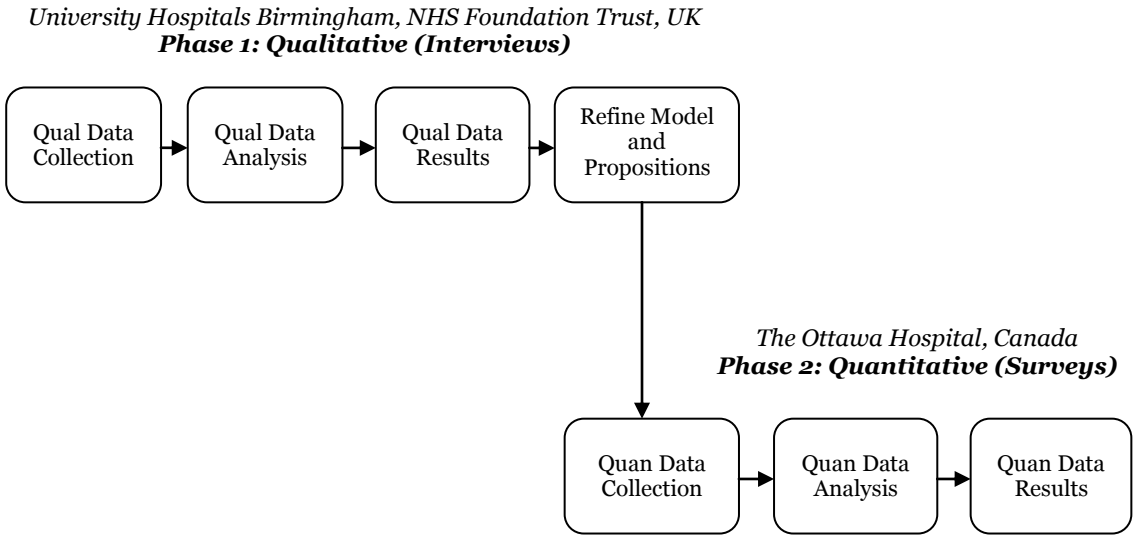



**Figure 4-2: Sequential Mixed Methodological Approach in this Study**

The underlying rationale for (i) selecting a sequential over concurrent approach and (ii) collecting qualitative data prior to quantitative data is determined by the research questions. The initial part of this research study is the identification of determinants

and outcomes of MHS infusion by individuals. Therefore, it is necessary to seek depth and delve deep into the determinants and outcomes associated with this phenomenon. Obtaining such richness and depth is necessary to ensure the relevance of this study. To fully understand infusion elements and answer research questions 1 and 2, qualitative data is most appropriate. Such an approach will enable the refinement of the *a-priori* model (Greene et al., 1989). As a result, the researcher believed that conducting qualitative research in the first phase of this study was most appropriate. Findings obtained from the qualitative phase allow for the refinement of the model and propositions established from literature into hypotheses for further testing. These developments connect the initial qualitative phase to the subsequent quantitative component of the study. The researcher considered the quantitative approach to be more appropriate for hypothesis testing as it would provide numeric data which would help answer research question 3 and 4.

Creswell (1994, page 212) argues that the exploratory sequential mixed methods design is *"the procedure of choice when a researcher needs to develop an instrument because existing instruments are inadequate or not available."* As a result, this methodology best suits this study due to the immaturity of the MHS infusion domain (Chapter 2 and 3). According to Creswell and Plano-Clark (2007) this is achieved by using a three-phase approach; (i) the researcher first gathers qualitative data and analyses it (Chapter 5), and (ii) uses the analysis to develop an instrument (Chapter 5) that is (iii) subsequently administered to a sample population (Chapter 6). Having identified the research strategy the next step is to identify the research method to perform the strategy (Section 4.4.3).

### 4.4.3 Research Method: Case Study

The value of research output is dependent on the method employed (Jenkins, 1985). This research consists of two distinct phases; a qualitative phase chronologically followed by a quantitative phase. Independent of the research mode (qualitative, quantitative or mixed) the case study approach is one of the most commonly used research methods in the IS field. The case study approach aims to obtain an in-depth understanding of the phenomenon and its context (Cavage, 1996). Case studies enable researchers to investigate a pre-defined phenomenon without explicit control

or manipulation of any variables (Yin, 1994; Cavage, 1996; Darke et al., 1998). Marshall and Rossman (1989) argue that a case study is a valid research method when a phenomenon is under-investigated and the focus of the researcher is on "discovery" and/or "theory building." Therefore, a case study was considered appropriate for this research study. This is further depicted in Table 4-2 which describes the requirements of the study and the suitability of the case study for empirical data gathering.

**Table 4-2: Case Study Characteristics and Requirements for this Study**

| Case Study Characteristics | Requirements of this Study |
|---|---|
| Facilitates in-depth exploration of the phenomenon under investigation (Marshall and Rossman, 1989; Darke et al., 1998) and the analysis of a wide range of variables (Galliers, 1992). | Exploration of determinants and outcomes of MHS infusion. |
| A conceptual model may be used to help shape the design of a theory building case study (cf. Benbasat et al., 1987; Eisenhardt, 1989; Wheeler, 2002; Yin, 2003) and provides firmer empirical grounding for the emergent theory (cf. Eisenhardt, 1989; Whetten, 1989; Yin, 2003). | Post-positive perspective (conceptual model developed from extant literature prior to entering the field). |
| Case Study useful for exploring areas where existing knowledge is limited (Benbasat et al., 1987; Marshall and Rossman, 1989; Yin, 1994; Cavaye, 1996; Darke et al., 1998). | Extant literature on MHS infusion is still in its infancy. |

The case study method therefore, provides an opportunity to address the research objective and questions. As the case study is deemed suitable for this research study, the next task facing the researcher is to decide on whether a single case or multiple case study approach is most suitable. The number of cases to be studied depends on the objective under investigation (Darke et al., 1998). A single case study is *"appropriate when it represents a critical case, where it is an extreme or unique case, or where it is revelatory case"* (Yin, 1994, pg. 39-42). Conversely, multiple case designs are desired because they allow cross-case analysis and comparison, whereby the investigation of a particular phenomenon in diverse settings can occur (Darke et al., 1998).

Adopting a single case study approach for each phase of this research study permits the researcher to investigate a phenomenon in-depth; thus, providing rich descriptions and understanding (Walsham, 1995). The rationale for utilising a single case study approach is that it represents an extreme or unique case (Yin, 1994). Two case studies are employed in this study, which are discussed in more detail in Sections 4.5 and 4.6:

(1) The first case study (qualitative phase) helps in refining the conceptual model/propositions and,

(2) The second case study (quantitative phase) examines hypotheses generated from the first case study.

## 4.5 Implementation of the Research Strategy: Phase 1 (Qualitative)

This section details the implementation of the first qualitative phase. Initial discussions focus on the first qualitative phase (Section 4.5.1) selecting University Hospitals Birmingham, NHS Foundation Trust (UK) in which to conduct the initial phase of this study. Applying case study techniques, data collection consisted of semi-structured interviews with various healthcare practitioners using MHS. Additionally, this section provides an overview of the research site, criteria for participants, and data collection period, before addressing the manner in which data is analysed (Section 4.5.2) and validated (Section 4.5.2.4).

### 4.5.1 Data Collection

This section details the data collection process for the initial qualitative phase. More specifically, it addresses the research site (Section 4.5.1.1), the ethical approval process (Section 4.5.1.2), the concept of reciprocity (Section 4.5.1.3), criteria for selecting participants (Section 4.5.1.4), data sources (Section 4.5.1.5), and finally the treatment of data (Section 4.5.1.6).

#### 4.5.1.1 Research Site – University Hospitals Birmingham, NHS, UK.

Successfully completing case study research within the IS field requires the selection of site(s) that are relevant to the area under investigation. Marshall and Rossman (1989, pg. 54) argue that the ideal site is one where (1) entry is possible; (2) there is a high probability that a rich mix of many of the processes, people, programs, interactions, and/or structures that may be part of the research question are present; (3) the research can devise an appropriate role to maintain continuity of presence for as long as necessary; and (4) data quality and credibility of the study are assured by avoiding poor sampling decision. Building on this, the following paragraph provides the context for the first case study:

*Overview of Hospital:* The first case study occurs in a West Midlands hospital in the National Health Service (NHS), United Kingdom; namely, University Hospitals Birmingham, NHS Foundation Trust (UHBFT). UHBFT is one of the most consistently high performing trusts in the NHS and has been rated "excellent" for financial management and quality of clinical and non-clinical services by the Healthcare Commission. The Trust employs approximately 6,900 staff and provides adult services to more than half a million patients every year, from single outpatient appointments to heart transplants. Furthermore, UHBFT first began using 'tablet technology' some ten years ago and currently has over 500 tablets in operation within the Trust. This is an exemplary case as researchers (Burke and Menachemi, 2004; Leu et al., 2012) argue that hospitals are slow to implement IT. The NHS case was chosen as it represents a critical case with regards to understanding determinants and outcomes of MHS infusion by healthcare practitioners.

Initially, communication was made with Dr. Jamie Coleman, Senior Lecturer in Clinical Pharmacology and IT clinical lead, requesting the possibility of establishing a case study in the UHBFT. Dr. Coleman is renowned for his research on patient safety and in particular electronic prescribing for which he is nationally recognised in the UK. He leads a multi-method applied health research team investigating IT and safety funded by the National Institute for Health Research (NIHR), Collaborations in Applied Health Research and Social Care (CLAHRC) scheme.

Building from this, a brief synopsis of the MHS in operation within the hospital is presented.

*Overview of MHS:* PICS (Prescribing and Information Communication System) is a rule-based clinical decision support system deployed on Intel Motion C5 devices. PICS has a number of features/functionalities including electronic prescribing and medication capabilities that incorporates management facilities, laboratory and radiology ordering, observations charting, results and discharge summaries[8]. Screenshots of these features/functionalities are presented in Appendix 2.

*Post-Adoption (Infusion):* As this research investigates the infusion phase of MHS implementation, it is imperative that the case study selected is indeed in the post-adoption phase of infusion. Aforementioned, UHBFT has been using the MHS for more than ten years, whereby the technological tool is fully integrated within healthcare practitioners daily work practices. Moreover, UHBFT continually strives to find novel uses of the MHS outside of its intended use. For example, UHBFT were integrating the camera technology to assist healthcare practitioners when delivering healthcare services to patients. Healthcare practitioners also have access to an open training domain whereby they are free to roam the technology's features and suggest improvements to the MHS. This illustrates that this case study moves beyond routine use of the MHS by extending their use of the technology outside of the intended use (i.e. infusion).

Once Dr. Coleman granted the establishment of a case study within UHBFT, additional steps were necessary prior to conducting the qualitative research onsite. These steps are described in the Section 4.5.1.2.

#### 4.5.1.2 Ethical Approval

The Research Governance Framework in the United Kingdom regulates any research performed within any NHS organisations (in this study, on-site in UHBFT). This framework declares that for non-NHS staff to conduct any research in the NHS

[8] Source of information: http://www.cse-healthcare.com/Products/PICS.html

requires the successful completion and approval of an Honorary Contract[9]. Complying with regulatory frameworks, a research passport was completed and submitted to the relevant parties within UHBFT. Notification of successful approval was received on the 12th October 2011 together with a letter of access for research.

#### 4.5.1.3 Reciprocity

Some researchers (Creswell, 1998; Hammell et al., 2000) assert that there should be reciprocity in what participants give and what they receive from participation in a research project. According to Creswell (1998), the term reciprocity is defined as something that is returned to participants of a study in exchange for the information collected from them. The researcher was indebted to participants for sharing their experiences, which allowed the researcher to explore the research objective. In doing so, the researcher offered to share the chapters five and six from the study with interested participants.

#### 4.5.1.4 Criteria for Selecting Participants

The unit of analysis is the main analytical level of the case to be studied (Yin, 1994) and must be sufficient for breadth and depth of data to be collected to allow the research objective to be achieved (Darke et al., 1998). For this research investigation, the unit of analysis proposed is the individual level of analysis to understand individual healthcare practitioners' perspectives on MHS infusion.

Having identified the unit of analysis it is noteworthy to highlight the process of sampling. The researcher applied criterion sampling, a specific type of purposeful sampling whereby the subjects for this study had to meet the predetermined criterion of importance stipulated by the researcher (Patton, 2001). According to Patton (2001), criterion sampling is useful for identifying and understanding perceptions that are information-rich and which provide for the emergence of themes from the data. Therefore, it is considered as a strong approach that assures the quality of the research. Any healthcare professionals (for example, consultant, non-consultant

[9] For more information of Research Passports in the NHS: http://www.birmingham.ac.uk/partners/rcs/centre-academic-staff/governance/overview-nhs-reqs.aspx#ResearchPassport

hospital doctor, doctors, nurses, pharmacists, dieticians, etc.) who met the following three criteria were selected for the data gathering process;

Participant is using -

1. Any handheld MHS (e.g. tablet, mobile clinical assistants, PDA, smartphone) during clinical practice,
2. For six or more months and,
3. As part of their daily clinical practice (e.g. looking up patient records, health status, electronic prescribing).
   - i.e. Data communication over voice communication.

#### 4.5.1.5 Data Sources: Collection Techniques

Case study research has no specific methods of data collection or of analysis which are unique to it as a method of enquiry (Bassey, 2000; Stake, 2003; Yin, 2003). Drawing on in-depth semi-structured interviews with healthcare practitioners meeting the three criteria previously outlined (Section 4.5.1.4), necessary data was collected for the initial phase of this two phased sequential mixed methodology approach. Data was gathered over a one month period in November 2011.

Interviews

Interviews are considered one of the most important sources of information in qualitative research (Yin, 1994; Stake, 1995; Tellis, 1997) for collecting data and seeking to describe the meanings of central themes in the world of study (Kvale, 1996). For this investigation, an interview is where researchers interact and communicate with the respondent (Hair et al., 2007). It is important to note that many researchers have attempted to categorise interviews (Yin, 2003) ranging from being unstructured to highly structured.

For this phase of the investigation the interview was guided by the preliminary conceptual model derived from literature (see Chapter 3). Therefore, a semi-structured interview was utilised, thus allowing the researcher free to exercise her own initiative in following up an interviewee's answer to a question (Remenyi and

Williams, 1995). This ability to re-focus and explore issues which organically arose during interviews overcomes the restrictive element associated with structured interviews (Trauth and O' Connor, 1981). A semi-structured interview protocol (see Appendix 3) was developed and pre-tested internally with colleagues within UCC. It was provided to the research supervisors and fellow PhD candidates prior to entering the field and a number of recommended changes in terms of question sequences and wording were implemented.

A combination of focused (based on the preliminary model derived from the literature) and open-ended questions were included in the interview guide. The researcher commenced the interview by asking broad questions concerning the interviewees' occupation and how they utilise MHS as part of their daily work practices. Subsequently, more specific and targeted questions about MHS infusion were explored. This approach (i.e. use of focused and open-ended questions) has been advocated in the literature (c.f. Bouchard, 1976) and permitted the researcher to re-focus during the interview process as advocated by Trauth and O' Connor (1981).

**Table 4-3: Overview of On-Site Interviews Conducted**

| Occupation | Number Interviewed | Date | Total Contact Time |
|---|---|---|---|
| Doctor | 3 | November 2011 | 180 minutes |
| | | November 2011 | |
| Clinical Pharmacologist | 1 | November 2011 | 65 minutes |
| Nurse | 3 | November 2011 | 190 minutes |
| Pharmacist | 2 | November 2011 | 130 minutes |
| Dietician | 1 | November 2011 | 65 minutes |
| **Total** | **10** | | **10.5 hours (630 minutes)** |

The different categorisations of individuals that work in UK hospital environments include consultants, non-consultant hospital doctors, nurses, pharmacists and others. Therefore, the target population were selected according to the inclusion criteria previously described (Section 4.5.1.4). This resulted in over ten hours of interviews, conducted onsite, with a broad spectrum of healthcare practitioners ranging from clinical lead in pharmacology, nurses, dieticians to pharmacists interviewed (see Table 4-3).

#### 4.5.1.6 Treatment of the Collected Data

Interviews were recorded using an Olympus WS-650S Dictation Machine and transcribed with the consent of the interviewee. This was undertaken in order to ensure accurate information gathering and to facilitate improved data analysis. Prior to recording the interviews each participant was informed that any response provided would be kept confidential and at no time would their actual identity be revealed. Noteworthy, however, interviewees may feel inhibited by the presence of the dictation machine therefore, a combination of digital recording and note taking were utilised as advocated by Walsham (1995). From the ten healthcare practitioners interviewed one interviewee indicated that s/he did not want to be recorded. When asked, the researcher duly obliged, as this enabled her to obtain a greater insight into MHS infusion. With the consent of this individual, notes and direct quotations were noted throughout the process of interviewing. Once the data was gathered, the recorded interviews were transcribed and electronically stored by the researcher.

### 4.5.2 Data Analysis

This section describes the analytical process undertaken in the study. The analytical process employed in this thesis adopts the coding process advocated by Strauss and Corbin (1990); namely, open coding (Section 4.5.2.1), axial coding (Section 4.5.2.2) and selective coding (Section 4.5.2.3).

Qualitative data analysis is a process of viewing, synthesising and interpreting data to describe and explain the phenomena or social world being studied (Fossey et al., 2002). Gliner and Morgan (2000, p. 9) propose that qualitative data analysis refers to the *"various methods for coding, categorising and assigning meaning to data*." Creswell (1994) contends that there is no correct approach of conducting qualitative data analysis. The issue of most concern in mixed methods is *"ensuring that the qualitative data is not poorly designed, badly collected, and shallowly analysed"* (Grbich, 2007, p. 203). It is at this stage of the research investigation that, the contextual and data richness of the study should be presented, and a clear chain of evidence should be established (Benbasat et al., 1987).

As the core feature of qualitative data analysis (Creswell and Plano-Clark, 2007, page 132), data coding facilitates the organisation, retrieval, interpretation of data the formation of conclusions on the basis of that interpretation (Lockyer, 2004). Strauss and Corbin (1990) present a comprehensive approach for managing, analysing and interpreting qualitative data which draws on grounded theory and analytic induction. They recommend that three coding steps or procedures (open coding, axial coding and selective coding) be used in the process of analysing qualitative data.

In conducting data analysis in the context of this study, the Strauss and Corbin (1990) approach (i.e. open, axial and selective coding techniques) was considered appropriate for a number of reasons. It is worth noting that this research study is not conceptualised as Grounded Theory as it establishes core concepts in this study and derives an *a-priori* model from literature for examination.

The rationale for employing Strauss and Corbin (1990) techniques is that it allows for the flexibility of interpretivism with the rigor of positivism (Sarkar et al., 2000), which is favourable for a research study engaged in theory building. That is, it enables the researcher to draw on existing theoretical knowledge (Strauss and Corbin, 1990) without imposing a theory (Urquhart, 2001) when engaged in the data (Glaser and Strauss, 1967).

The researcher utilised the coding techniques; namely, open, axial and selective coding, advocated by Strauss and Corbin (1990). These coding techniques were employed in the analysis phase of this study and are described in the subsections below (Section 4.5.2.1 to Section 4.5.2.3).

#### 4.5.2.1 Open Coding

Open coding refers to *"the analytic process through which concepts are identified and their properties and dimensions are discovered in the data"* (Strauss and Corbin, 1990, p. 101). This analytical process involves the data being examined 'word-by-word', 'line-by-line' to ascertain the main ideas. Through comparative analysis across interviews and with regards to similarities and differences, the researcher then grouped codes together and formed, where applicable, more abstract categories or themes. Furthermore, each interviewee (I) was assigned a number (1, 2,

3, etc.) in order to allow the researcher to trace a specific code to a specific interviewee. An example of codes from the data, pertaining to patient content is outlined in Table 4-4.

**Table 4-4: Sample Open Coding Used During Data Analysis**

| # | Transcription | Open Codes |
|---|---|---|
| I:4 | *"I don't know the reality of how quick it would be to access the PICS whereas you could scan the notes to see the resuscitation card."* | Timeliness, Accessibility |
| I:7 | *"Keeping up to date with additions and deletions of patient data."* | Content in MHS is sufficiently up-to-date for the task at hand (Timeliness) |
| I:8 | *"As long as it has being updated I could see which bed number they are in."* | |
| I:3 | "*Oh it [patient data] is updated all the time."* | |
| I:6 | *"Access is important", "role based access."* | Access mobile content (Accessibility) |
| I:1 | *"There are essential parts of the PICS system which requires mobile access for medication administration prescription."* | |

The subsequent task undertaken by the researcher was to develop concepts based on these codes. An example of this is presented in Table 4-5, based on the codes presented in Table 4-4. It is important to note that this is only a snippet of the overall coding process.

**Table 4-5: Codes to Concepts**

| Code | Concept |
|---|---|
| Timeliness | Urgency (pressing) when using MHS when delivering healthcare services to patients at the point-of-care. |
| Accessibility | Retrieval of data when required when delivering healthcare services. |
| Up-to-date | Real-time data/Information accessed via MHS when delivering healthcare services to patients at the point-of-care. |

Through comparative analysis across interviews and with regards to commonality, the researcher grouped codes together and formed, where applicable, more abstract categories or themes. This is depicted in Table 4-6.

**Table 4-6: Concepts to Category**

| Concepts | Commonality | Category |
|---|---|---|
| • Urgency when using MHS when delivering healthcare services to patients at the point-of-care.<br>• Retrieval of Data when required. | • Time<br>• Urgency | Time-Criticality |

#### 4.5.2.2 Axial Coding

After open coding, the next step in analysing qualitative material is axial coding (cf. Strauss and Corbin, 1990; Charmaz, 2000). The data now has to be analysed to establish if relationships between categories and other (sub) categories exist. Thus, theory emerges from the linking of categories, and investigating the connections between concepts (Allan, 2003). Axial coding involves two tasks which further develop categories (Strauss and Corbin, 1990): (i) connecting categories in terms of a sequence of relationships, and (ii) validating relationships.

The first task (i.e. connecting categories in terms of a sequence of relationships) was established by examining the context or conditions in which a category is influenced (i.e. where, when and why does infusion take place?). Next, the emphasis was placed on the sequencing of actions and interactions under these conditions, whether deliberate and/or unintended (i.e. how does infusion occur?). Furthermore, intended and unintended consequences or outcomes were examined (i.e. what happens as a result of actions/failure of actions in the infusion process). Conducting these steps, as per Strauss and Corbin (1990, p.128-133), helped the researcher delve deeper and gain more insight into how the concepts identified in open coding are related. The continuous interplay between open and axial coding enabled the researcher to create additional properties and dimensions which were not previously identified in initial stages of open coding. Moreover, it assisted the researcher in identifying concepts which were categories (i.e. those which had a direct impact on MHS infusion) and which were subcategories (i.e. which had an indirect relationship with MHS infusion).

The second step in axial coding is the validation of relationships. According to Strauss and Corbin (1990) researchers must *"validate his or her interpretations through constantly comparing one piece of data to another"* (1990, p. 137). This required the researcher to return to the data and conduct further validation of relationships across all healthcare practitioners interviewed.

To aid in the process of axial coding, memos and diagrams illustrating the coding process was utilised as advocated by Urquahart (2001). Memos can take several

forms including code notes, theoretical notes, operational notes and sub-varieties of these (Strauss and Corbin, 1990). Memos *"may relate to any aspect of the data"* (Dey, 1993, p.93) whether *"a sentence, a paragraph or a few pages"* (Glaser, 1978, pp. 83). Memos, therefore, refer to *"the theorizing write up of ideas about codes and relationships as they strike the analyst while coding"* (Urquahart, 2001, pg. 120). Figure 3-4 illustrates an excerpt from a memo written by the researcher during the study.

*At a glance, it appears that willingness to use MHS is dependent upon (1) the context in which the MHS is used (i.e. emergency and non-emergency situations), (2) which is influenced by elements such based on system/content quality. Overall, this impacts infusion. Why? Focusing on urgent situations, some practitioners think that the paper based approach was quicker as you could scan the notes. Others believe that the patient's safety could be jeopardised having to wait for the MHS to boot up and log in (note: that is, if they are required to locate a MHS and do not have one readily available to them). Why impact infusion? Data suggests that if the patient's safety could be harmed by using the MHS then practitioners are slow to use them. Dealing with urgent situations is part of a healthcare practitioners daily work practices. Therefore, staff must be willing to use MHS in urgent situations to ensure that it is infused within their daily work practices.*

**Figure 4-3**: **Excerpt from Memo**

Strauss (1987) and Urquhart (2001) argue that the use of diagrams is an invaluable technique to depict relationships between categories/subcategories and as a method of describing ideas to others. An example of an illustrative diagram is presented in Figure 4-4.

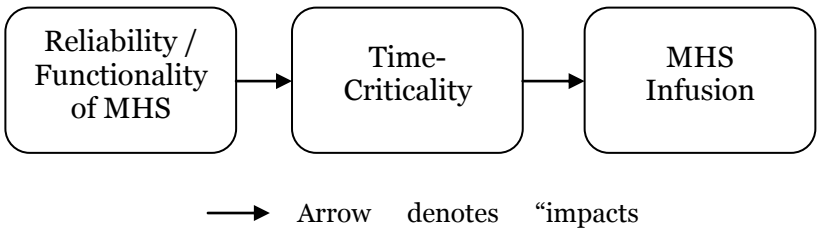



**Figure 4-4: Illustrative Diagram Based on Previous Coding Examples**

#### 4.5.2.3 Selective Coding

Selective coding is the process of building a "story." Essentially, this technique involves the identification of the core category, relating it to all other categories, and validating the relationships and elaborating the categories that require further refinement and development (Strauss and Corbin, 1990; Sarker et al., 2000). This entailed reviewing categories/subcategories for internal consistency, validating the statements of relationship between categories and sub-categories and expanding upon categories/subcategories that required further refinement. Depicted in Figure 4-5 is an example of the selective coding process. This presents more detail than Figure 4-4 (i.e. additional relationships and relationship influences), illustrating the refinement process undertaken by the researcher. Ultimately, this process continued until all categories/sub-categories were well established.

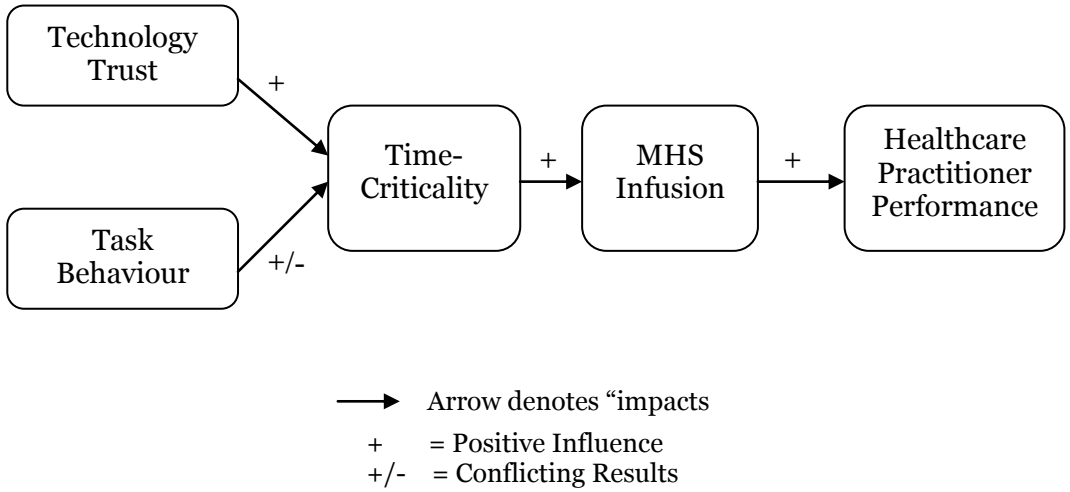



**Figure 4-5: Example of Selective Coding**

Undertaking selective coding enabled the researcher to further probe established relationships towards a *"process of integrating and refining the theory"* (Strauss and Corbin, 1990, p. 143). Through this process, new constructs and several new relationships between constructs emerged which enabled the researcher to refine the initial model derived from the literature (Chapter 3).

#### 4.5.2.4 Validation of Qualitative Analysis

The purpose of this section is to present the validation techniques employed by the researcher to ensure the research's legitimacy. The validation techniques proposed by Yin (1994) were implemented in this phase of the research investigation. Yin (1984) recommends that researchers continually validate the quality of their case study design. Validity relates to both the representativeness of the data as well as the 'truthfulness' of the researcher's interpretation of the data (Schultze, 2000). To ensure validity and reliability in this research, clearly defined methodological guidelines were followed. They include construct validity, internal validity, external validity and reliability (cf. Lee, 1989; Yin 2003). Yin (1984) argues that these tests should be applied throughout the case study process: during design, data collection, data analysis and reporting. Following these recommendations will *"increase the quality of the case study tremendously, and overcome traditional criticisms of the weakness of case study research"* (Yin, 1998, p. 242). The actions performed in this research study towards validity and reliability is depicted in Table 4-7. After applying the four validity tests to this case study, the first research phase was validated based on the assessment presented in Table 4-7.

**Table 4-7: Evaluation Criteria Adopted in this Study (Amended from Yin, 1998)**

| Test | Description | Action Taken in this Research | Phase |
|---|---|---|---|
| **Construct Validity** | *"The extent to which the measure reflects the intended construct" (Dooley, 2001, page 342) or "establishing correct operational measures for the concepts being studied" (Yin, 1984, page 36).* | A-priori theoretical/ conceptual approach to validity was adopted. | Research Design |
| | | Establish Chain of Evidence: Interview data was both digitally recorded (in real time) and transcribe; multiple evidence sources were entered into excel. | Data Collection, Data Analysis |
| **Internal validity** | *"The extent to which its design and the data it yields allow the researcher to draw accurate conclusions about the cause-and-effect and other relationships within the data" (Leedy and Ormrod, 2005, page 97).* | Rigorous coding techniques - Patterns identified within the data and some causal links identified (explanation building). | Data Analysis |

| Test | Description | Action Taken in this Research | Phase |
|---|---|---|---|
| **Reliability** | *"The operations of the study can be repeated with the same results" (Yin, 1984, pg. 36).* | Case Study Protocol: Semi-structured interview guide based on conceptual model derived from literature. | Research Design/ Data Collection |
| | | Developed Case Study Database, as per Yin (2003), consisting of digitally recorded interviews, transcripts, codes, memos, etc. | Data Collection |
| **External validity** | *"Establishing the domain to which a study's findings can be generalised" (Yin, 1984, pg. 36).* | Findings from the first case study are further examined in the second phase. | Research Design |

## 4.6 Implementation of the Research Strategy: Phase 2 (Quantitative)

This section details the implementation of the quantitative phase conducted in the Ottawa Hospital, Canada (phase two of the sequential mixed methods approach). Applying case study techniques, data collection consisted of a web survey. Additionally, this section provides an overview of the research site, survey design and data collection period (Section 4.6.1), before addressing the manner in which data is analysed and validated (Section 4.6.2).

### 4.6.1 Data Collection

This section details the data collection process for the second quantitative phase. More specifically, it addresses the research site (Section 4.6.1.1), the ethical approval process (Section 4.6.1.2), data sources (Section 4.6.1.3), combating bias in web surveys (Section 4.6.1.4), the administration of the survey (Section 4.6.1.5), follow-up procedures (Section 4.6.1.6), and finally the treatment of data (Section 4.6.1.7).

#### 4.6.1.1 Research Site – The Ottawa Hospital, Canada

*Overview of Hospital:* Consisting of 1,190 beds, the Ottawa Hospital (Canada) provides patient-centred health services with an emphasis on tertiary-level and speciality care, primarily for residents of Eastern Ontario. The Ottawa Hospital is an academic health care leader that supports advancing environmental innovations.

Each year it continues to bring forward new technologies that not only target the delivery of healthcare services but also improve the environmental foot print for their organisation and community.

In 2010, the Ottawa Hospital launched a pilot program to roll out a mobile Electronic Medical Record (EMR) application on tablet devices over a large medical community. At time of data collection, the Ottawa Hospital had 3,000 iPads whereby certain healthcare practitioners can access a mobile EMR. It is one of the first hospitals in Canada to introduce iPads for use during the delivery of healthcare services, thus making this case study unique.

Initially, communication was made with Mr. Dale Potter, Chief Information Officer of the Ottawa Hospital, requesting the possibility of establishing a case study in the hospital. Subsequent to this email, a telephone conversation was arranged between the researcher and Mr. Potter and it transpired March 27th 2012 at 09.45 EST. Mr. Potter granted the establishment of a case study within the Ottawa Hospital and the researcher was put in contact with Ms. Robin Morey, the Ottawa Hospital Coordinator of Information Services, and Ms. Kelly Doxtater, Executive Assistant to Dr. Jeffrey Turnbull, Chief of Staff/Médecin-Chef, the Ottawa Hospital.

*Overview of System:* EMR is an Electronic Medical Record run on iPads and used during clinical practice. It has a number of features/functionalities including dashboards of all patients, patient and medication list which incorporate clinical notes, lab results, orders, reports, observation charts and alerts.

*Post-Adoption (Infusion):* Aforementioned, the Ottawa Hospital has been using the MHS for a number of years, whereby the technological tool is fully integrated within healthcare practitioners daily work practices. Moreover, the Ottawa Hospital continually strives to find novel uses of the MHS outside of its intended use. For example, healthcare practitioners have access to a dashboard depicting their performance when delivering healthcare services to patients at the point-of-care. As a result, healthcare practitioners often run ad-hoc reports based on the data, which is not mandated by the Ottawa Hospital. This illustrates that this case study moves

beyond routine use of the MHS by extending their use of the technology outside of the intended use (i.e. infusion).

Once initial access was achieved, ethical approval was sought by the researcher. This procedure is subsequently described in Section 4.6.1.2.

#### 4.6.1.2 Ethical Approval

Conducting research within any healthcare organisations (in this study, the Ottawa Hospital) requires ethical approval. Ms. Robin Morey, the Ottawa Hospital Coordinator of Information Services, on my behalf, investigated whether ethics approval was required to complete the survey. On April 18th 2012 notification was received from Ms. Robin Morey that ethical approval was not required as (1) the researcher would not be on-site and (2) no patient data would be used during the case study process. Having received approval the next step undertaken by the researcher was the selection of participants and sources of data.

#### 4.6.1.3 Data Sources: Collection Techniques

Building on the sources of data collection in the qualitative phase, participants were selected based on the same criteria sampling for quantitative data collection. The criteria for selecting participants for the second quantitative phase of this research strategy is the same as those described in the first qualitative phase. Please see Section 4.5.1.4 for the list of criteria.

Drawing on web surveys with healthcare practitioners who met the three criteria established previously (Section 4.5.1.4), data was collected for the second phase of this two phased sequential mixed methodology approach. Fowler (1993) and Pinsonneault and Kraemar (1993) both define survey research as surveys with the following characteristics: (1) the purpose of the survey is to produce statistics which requires standardised information about the subjects being studied, (2) collection of information via structured and/or predefined questions, and (3) data collection via sampling techniques but which can be generalised to the whole population. Therefore, survey research is *"conducted to advance scientific knowledge"* (Pinsonneault and Kraemar, 1993, pg. 77). A survey was the preferred type of

quantitative data collection procedure as it allows for proposition/hypotheses testing and is considered a good technique for gathering base-line data for informing future research (Babbie, 2001). More specifically, surveys are favourable for answering research question 3 and 4 (Section 4.2) of this study ('to what degree'). Data was gathered over a four month period from April 2012 to July 2012.

Electronic Survey

Survey research is used to describe "*the characteristics, behaviour or opinions of a particular population"* (Salant and Dillman, 1994, pg. 10) and is realised by gathering and statistically analysing numeric data. Web surveys are becoming common (Evans and Mathur, 2005) and results from web surveys can be the same as postal/mail survey content results (Andrews, 2003), with advantages of speedy distribution, low administration cost, convenience, and response times (Taylor, 2000). A comprehensive list of the advantages associated with online surveys can be found in existing IS research (c.f. Evans and Mathur, 2005). However, the use of online surveys is not without problems. Such problems include respondent's lack of online proficiency, privacy and security issues and misconceptions that the legitimate survey is junk mail (Evans and Mathur, 2005). Yet, despite the drawbacks associated with the use of web surveys, the researcher believed that the tool was the appropriate method required to gather data to answer the remaining two research questions (research question 3 and 4, please see Section 4.2).

Survey Design

Existing tools for creating online web surveys (for example, SurveyMonkey, Qualtrex, SurveyGizmo and many more) can be utilised to accommodate data entry and minimise mistakes. After completing a trial using the three online survey tools - SurveyMonkey, Qualtrex and SurveyGizmo – SurveyGizmo, which offers a wide range of features for creating, deploying and analysing of online surveys, was selected.

**Table 4-8: Initial Survey Design**

| # | Name of Section | Number of Statements | Captured via: |
|---|---|---|---|
| 1 | Introduction | N/A | N/A |
| 2 | Respondent Information | N/A | Structured Approach |
| 3 | Nature of Work | 11 | 5-point Likert Scale |
| 4 | Nature of Mobile Health System | 11 | 5-point Likert Scale |
| 5 | User Characteristics | 15 | 5-point Likert Scale |
| 6 | Mobile Health System Improvements | 11 | Rating Scale |
| 7 | Infusion of Mobile Health Systems | 12 | 5-point Likert Scale |
| 8 | Individual Performance and Learning | 14 | 5-point Likert Scale |
| 9 | Closing | N/A | N/A |

The design of the original survey began late January 2012. Items used in the survey were compiled from existing literature and guided by the qualitative findings. Initially, the online survey consisted of 9 sections with a total of 75 statements. Each section is outlined in Table 4-8 and was presented to the respondents on separate webpages. The first section presented an overview of the research while the second section gathered relevant data pertaining to the respondent's profile. The third, fourth, and fifth sections captured responses based on task, technology and user characteristics respectively. The sixth section was only presented to the user, based on branching logic at the end of section five. This section asked respondents to rank a series of MHS features/functionalities for which they perceived was necessary for improving the MHS. Section seven captured responses based on feature, integrative, and exploratory use of MHS (i.e. infusion) while section eight focused on the outcomes of MHS infusion. Finally, section nine acknowledged the time and effort of those who completed the survey, informing the respondent that their contributions were greatly welcomed and valued. Furthermore, my contact details were provided to allow respondents to contact me regarding the survey results.

Responses were captured vis-à-vis a structured approach and 5-point Likert Scale (Section 2-7). Respondents were asked to rate each statement on a Likert Scale with responses ranging from "Strongly Disagree (1)" to "Strongly Agree (5)." Measures utilised in this study (see Section 6.4.1) were adapted from researchers who

commonly used a 5-point Likert scale. Thus, to maintain an element of consistency a 5-point Likert scale was chosen in this study.

Pre-test

According to Fowler (1993, pg. 100) the underlying premise for conducting a pre-test of the survey research instrument is to *"find out how the data collection protocols and the survey instrument work under realistic conditions."* Following the generation of an initial iteration of the instrument as per Hair et al., (2006) the survey pre-test was deployed in March 2012. The instrument was pre-tested with medical 'experts' (people who work in healthcare environments and others who actively use MHS as part of their daily work lives) and academic 'experts' (people who have previously created surveys as part of their research activities) in order to assess the semantic content of all the constructs' items.

The majority of subjects who participated in the pre-test believed that the survey was *"too long"* and *"repetitive."* On average, it took participants 14 minutes to fully complete the survey. Participants believed that the repetitiveness was extreme and should be reduced without damaging the reliability of the instrument.

One particular respondent, skilled in research methods, offered recommendations for improving the semantics of the survey; *"Just one note, the term consultant (the way you mean it) is confusing to US based physicians as that means something different here in our system. In your system that means you are at the end of training and are certified in your area, as opposed to the US where that means that you provide consultation to other physicians, rather than direct patient visits (we don't have GP's like the UK). The terms we use that I would suggest you change your terms to:*

- *Consultant/Attending Physician*
- *Non Consultant Hospital Doctor/ resident or fellow"*

Respondents from the pre-test further highlighted that they were forced to rank improvement to the Mobile Health Systems, even if they did not believe that improvements were necessary. It was suggested that some branching logic be used to ensure that this does not impact the results.

Based on the recommendations obtained during the pre-test phase, the survey instrument was refined prior to launching the survey. All amendments to the survey are indicated in Table 4-9 as *italicised*. The final survey consisted of 9 sections with a total of 64 statements. Furthermore, all 64 statements were shortened to make it easier and quicker for the participant to complete.

**Table 4-9: Final Survey Design**

| # | Name of Section | Number of Statements | Captured via: |
|---|---|---|---|
| 1 | Introduction | N/A | N/A |
| 2 | Respondent Information | N/A | Structured Approach |
| 3 | Nature of Work | *9* | 5-point Likert Scale |
| 4 | Nature of Mobile Health System | *9* | 5-point Likert Scale |
| 5 | User Characteristics | *12* | 5-point Likert Scale |
| | *User Characteristics - Improvements* | *N/A* | *Pre-defined Answers & branching logic* |
| 6 | Mobile Health System Improvements | 11 | Rating Scale |
| 7 | Infusion of Mobile Health Systems | *9* | 5-point Likert Scale |
| 8 | Individual Performance *(spilt over 2 pages)* | 14 | 5-point Likert Scale |
| 9 | Closing | N/A | N/A |

With the necessary amendments in place, some experts were asked to pre-test the finalised version and were timed for the session. It took participants approximately eight minutes to complete the revised survey, a reduction of six minutes from the initial fourteen recorded.

#### 4.6.1.4 Combating Bias in Web Survey

When considering surveys as a quantitative data collection approach it is imperative to consider the expected quality of the collected data, estimated costs, predicted nonresponse rates, expected level of measure errors, and length of the data collection period (Lyberg and Kasprzyk, 1991). However, the use of surveys is considered one of the most important forms of measurement in research (Fowler, 1993). It is critical therefore that a survey be designed carefully (Foo and Hepworth, 2000) in an effort to reduce/eliminate any bias (Podsakoff et al., 2003; Reio, 2010; Vicente and Reis, 2010). The two major types of bias associated with web surveys are common method variance bias (Podsakoff et al., 2003; Richardson et al., 2009) and non-

response bias (Vicente and Reis, 2010). Each type of bias is discussed further in the subsequent sections.

*Common Method Variance* (CMV) refers to variance attributable to measurement method rather than to the construct or constructs supposedly represented by the measures (Podsakoff et al., 2003). Therefore, it is a systematic method error due to use of a single rater or single source (Reio, 2010), i.e. Likert scales. It is imperative to address any CMV bias because, as a measurement error, method biases can threaten the validity of the conclusions pertaining to the relationships between measures (cf. Bagozzi and Yi, 1991; Nunnally, 1978; Spector, 1987; Burton-Jones, 2009).

To overcome the concern of CMV bias in the web survey, the researcher first included several reverse-scored items in the principal constructs to reduce single rating problems (Lindell and Whitney, 2001). Second, CMV was assessed during data analysis using Harman's one-factor test (Podsakoff and Organ, 1986). In this test, all the principal constructs were entered into a principal components determinant analysis. The basic assumption of this technique, according to Podsakoff et al., (2003), is that if a single factor emerges from the unrotated extraction analysis or one general factor accounts for the majority of the covariance among the measures then a substantial amount of CMV is present. CMV was investigated using IBM Statistical Solutions, Version 20.0.

*Non-response bias* refers to the likelihood that respondents who did not return a completed questionnaire/survey would have responded to the questionnaire/survey items differently from those who did not respond (Bosnjak and Tuten, 2001). Vicente and Reis (2010) argue that non-response bias can be overcome by following key design practices when creating web surveys. As a result, the researcher incorporated these practices when designing the web survey (depicted in Table 4-10).

**Table 4-10: Approaches Taken to Mitigate Non-Response Bias**

| Design Practices (Vicente and Reis, 2010, pg. 262-264) | Approach undertaken by the researcher |
|---|---|
| Screen designs tend to yield a lower item nonresponse rate than scroll designs. | Screen Designs were used. |
| Surveys with lengthy questionnaires tend to have lower overall completion rates mainly because the increased burden of long questionnaires tends to increase dropout rates. | The survey was designed to be fully completed within 8 minutes (this was achieved after pre-testing, initially 14 minutes). |
| The respondents' perception of the burden is more important than the burden itself and may result in a higher dropout rate. | A progress bar was included in the web survey to give the respondent some feedback as to the point of the questionnaire where he or she stands. |
| Illustration enhancements of the questionnaires can make the questionnaire more attractive and pleasant thus contributing to higher completion rates. But visual enhancements can also cause premature abandon of the survey if the questionnaire becomes difficult to navigate or download due to software or hardware compatibility problems. | The survey inherited three different visual presentation techniques (1) Visual language, (2) symbolic language and (3) numerical language.<br><br>*Visual Language:* Font (Calibri), font size (11), borders and tables were used. *Symbolic Language:* Arrows were used for guidance purposes. *Numerical Language:* All questions were numbered in the survey. |
| The radio button format instead of drop-down boxes or text entry for closed-ended questions seems to work in favour of lower item nonresponse. | The majority of closed-ended questions were in radio button format. |

Moreover, in order to assess the possibility of non-response bias a comparison of responses was conducted between early and late respondents (Armstong and Overton, 1977). Because late-respondents, or those that respond after several attempts, are theorised to have some similarities with non-respondents, researchers can compare scores on key metrics (i.e. infusion in this study) from both the early respondents and the late respondents. This process involves conducting a two-sample (independent groups) t-test to compare early with late respondents whereby the means of the two populations are examined. Any differences in the means could be considered an estimate of non-response bias (c.f. Zaheer et al., 1998). As data was gathered over a four month period (April to July) early respondents were those who completed the survey in April and May whereas late respondents were those who

collected data during June to July. Testing for non-response bias was undertaken using IBM Statistical Solutions, Version 20.

#### 4.6.1.5 Survey Administration

Various healthcare professionals (primarily MDs) were initially contacted via email by Ms. Robin Morey, the Ottawa Hospital Coordinator of Information Services, on the researcher's behalf. This email message endorsed the research and encouraged healthcare practitioners (attending physicians and residents/fellows) to respond and fully complete the survey. All responses were kept completely anonymous and could be accessed by the participants at the following web address:

- http://edu.surveygizmo.com/s3/828292/phdresearch.[10]

#### 4.6.1.6 Follow-Up Procedure and Sample Size for Survey

Three e-mail reminders were sent by Ms. Robin Morey to remind healthcare practitioners to complete the survey. There was no face-to-face contact between the researcher and the subjects at any time during the second phase of this research strategy.

A total of 157 responses were obtained from various healthcare practitioners via the administration on an online survey. After excluding 56 incomplete responses 101 surveys were usable for data analysis. To ensure that the sample size was appropriate to reject the null hypotheses G*Power analysis (using G*Power version 3.1.2) was conducted. The t-tests statistical test "Means: Difference from constant (one sample case)" was used post-hoc to determine the power (tails: two; effect size: 0.5; α err prob: 0.05; total sample size: 101). An alternative approach for estimating sample size is suggested by Chin (1998) where the sample size is equal to the larger of (i) ten times the number of indicators on the most formative construct, or (ii) ten times the largest number of antecedent constructs leading to a dependent latent variable.

[10] The survey was closed end of July, 2012.

According to power analysis and Chin's guideline, the sample size of 101 in this research study was suitable for testing the research model.

#### 4.6.1.7 Treatment of the Data

Surveys were entered and stored in a database online using SurveyGizmo. To ensure that no data was lost, each response was downloaded as a .PDF file and saved in a number of locations. Results were exported as a .CSV file. Data was then analysed for completeness, recoded and correlated to inform the Structural Equations Modelling (SEM) analysis as use of a complete data set is essential when performing any SEM analysis (Kline, 2005).

### 4.6.2 Quantitative Data Analysis and Validation

This section depicts the data analysis and validation procedures employed by the researcher. It first discusses the model and its associated reflective measures (Section 4.6.2.1). Next, the emphasis is focused on the evaluation of the measurement model (Section 4.6.2.2) followed by the structural model (Section 4.6.2.3). Moreover, the inclusion of control variables in the context of this research study is established (Section 4.6.2.4).

This study employed the *Partial Least Square [PLS]* (Structural Equation Modelling [SEM]) approach which utilises component-based estimation. Such an approach is apt given that it allows simultaneous exploration of both the measurement and the structural models (Vinzi et al., 2010). The measurement (outer) model portrays the relationships between a construct and its associated variables (measurement items) whereas the structural (inner) model represents direct and indirect unobservable relationships among constructs (Chatelin et al., 2002; Tenehaus et al., 2005; Diamantopoulos and Siguaw, 2006). The PLS approach was utilised as it allows testing of a model with a relatively small sample size (n=101 in this research study). As a robust technique, PLS is often utilised to predict endogenous latent variables and to test relationships between latent variables.

All statistical analysis of the quantitative results was conducted with the help of SmartPLS (Version 2.0.M3). SmartPLS, developed by a team from the School of

Business, University of Hamburg, is a software application that enables the user to perform path modelling with latent variables using the partial least squares method (Ringle et al., 2005).

#### 4.6.2.1 Reflective Measures

The conceptual model examined during this phase of the research study is measured reflectively. According to Hair et al., (2010, page 753), researchers are still examining which measures should be used (i.e. formative or reflective). However, Bollen and Ting (2000) and Jarvis et al., (2003) argue that it is important that the researcher focuses on the true nature of the construct(s) being studied. Using the findings from the qualitative phase of this study the researcher paid careful attention to guidelines presented in the literature (Jarvis et al., 2003) when designing the measures for the conceptual model and thus, emphasis was placed on the constructs itself. The constructs are viewed as the cause and the measures/indicators its manifestation (Jarvis et al., 2003; Petter et al., 2007), resulting in reflective constructs. Reflective item indicators do not define the construct but instead, are manifestations of the construct. That is, reflective indicators represent the same phenomenon (the reflective construct) and thus should be highly correlated (Jarvis et. al, 2003; Andreev et al., 2009). Therefore, if the construct was altered, changes are also observed in all measurement items simultaneously. Moreover, reflective measures are interchangeable and dropping one of the measures does not change the meaning of the construct. By adhering to the guidelines presented by Jarvis et al., (2003) the researcher presented a conceptual model with reflective measures for quantitative data and analysis.

#### 4.6.2.2 Measurement Model Evaluation

As the model has constructs with reflective indicators, appropriate steps were undertaken in terms of analysing the data as different analytical approaches are taken for formative and reflective constructs (MacKenzie et al., 2011). Aforementioned, the measurement (outer) model represents the relationships between a construct and its associated measurement items (Chatelin et al., 2002; Tenehaus et al., 2005; Diamantopoulos and Siguaw, 2006). The measurement model was assessed in order

to demonstrate that the measures used in the analysis are valid and adequately reflect the underlying theoretical constructs. This was achieved in three steps by accessing (i) content validity, (ii) reliability and, (iii) construct validity. In simple terms, reliability means that an instrument will consistency measure something whereas validity means that it will measure what it is intended to measure (Boudreau et al., 2001).

*(i) Content validation* focuses on representation (Straub, 1989) ensuring that the items capture the full meaning of the construct (Cronbach, 1971). For this study, the concepts are derived from literature and guided by the qualitative findings thus, making the construct valid.

Measurement reliability refers to *"the proportion of variance attributable to the true score of the latent variable"* (DeVellis, 1991, page. 24). That is, how much variance is accounted for via the construct and/or measurement error? The reliability of construct measurement (referred to internal consistency reliability and indicator reliability) can be evaluated by examining the composite reliability, cronbach alpha's, average variance extracted, and communality.

*Composite Reliability (CR)* refers to a measure of the internal consistency of indicators to the construct, depicting the degree to which they indicate the corresponding latent construct (Hair et al., 1998). That implies, how well a construct is measured by its assigned indicators. CR should be greater than the acceptable level of 0.6 (cut off point for exploratory purposes as depicted by Chin, 1998). Similarly, *Cronbach Alpha* measures the internal consistency of a test of scale and should be equal to or exceed 0.7 (Cronbach, 1971).

*Average Variance Extracted (AVE)* measures the amount of variance captured by the indicators in relation to the amount of variance due to measurement error (Fornell and Larcker, 1981). That implies, the amount of variance of indicators captured by the construct compared to the total amount of variance, including the measurement error (variance of variables due to errors in data collection or measurement). AVE should be equal to or exceed 0.5 (Chin, 1998, p.321). AVE less than 0.5 explain more variance is due to error variance than to indicator variance.

*Communality* refers to the total amount of variance an original value shares with all other variables included in the analysis and should also be equal to or exceed the 0.5 threshold (Chin, 1998).

*(ii) Individual Reliability* examines determinant loadings by specifying which part of an indicators' variance can be explained by the underlying latent variable (Chin, 1998; Lewis et al., 2005). It is evident throughout literature that various threshold criterion exist for individual reliability with various authors (Stevens, 1992; Hair et al., 1998; Field, 2005; Tabachnick and Fidell, 2007) acknowledging and using various threshold values. For example, a common threshold criterion is that more than 50% of an indicators' variance should be explained by the latent construct (i.e. 0.707). This threshold value (0.707 or higher) can be observed in Chin (1998), Gefen et al., (2000), and Henseler et al., (2009). Alternatively, it is argued (Sidorova et al., 2008) that threshold values of 0.4 and 0.5 can be utilised in research. Examples of research using these threshold values include Barki et al., (1993), Tan and Teo, (2000), and Duarte and Raposo, (2010). The work of Treiblmaier and Filzmoser (2010) highlights such discrepancies in IS research. As a result, there is an element of inconsistency, to some degree, of what constitutes the genuine threshold. For this research study, the threshold cut-off value for individual reliability is 0.707.

*(iii) Convergent validity and discriminant validity* are components of a larger scientific measurement concept known as construct validity (Straub et al., 2004). Simply stated, construct validity is an 'operational issue' (Straub et al., 1989). Convergent validity is depicted when each measurement item correlates strongly with its assumed theoretical construct, while discriminant validity is depicted when each measurement item correlates weakly with all other constructs except for the one to which it is theoretically associated (Gefen and Straub, 2005). In other words, construct validity reflects the degree to which items measure the construct they intent to (convergent) and only this one (divergent) ensuring the constructs are not subject to bias.

Convergent validity is assessed by examining Composite Reliability and Average Variance Extracted. Discriminant validity can be assessed using two approaches (Chin, 2010, p.671): comparing the squared root of the average variance extracted of

a construct to construct correlations or comparing the average variance extracted with the squared correlations among constructs. In this study, discriminant validity was assessed following the Fornell and Larcker (1981) approach whereby the AVE of a determinant must be larger than the squared correlation of this determinant with any other determinant. If the AVE for each construct is greater than its shared variance with any other construct, discriminant validity is supported. Noteworthy, however, the Fornell/Larcker criterion has to be assessed manually as it is not automatically calculated by the applied software SmartPLS. When all criteria are fulfilled, the measurement model can be regarded as valid, which is a necessary condition for a valid assessment of the structural model.

Moreover, the online survey was prepared in such a way that it is easy to interpret and complete. Any subjective values that the researcher had were omitted or removed from the survey. Furthermore, any ambiguity was eliminated by pre-testing the survey with a panel of experts.

Table 4-11 presents an overview of the different criteria applied in this research study to assess the validity of a measurements model.

**Table 4-11: Evaluation Criteria: Measurement Model**

| Scope | Criteria | Threshold |
|---|---|---|
| Composite Reliability | Determinant Loads | ≥ 0.6 (exploratory research) |
| Convergent Validity | Composite Reliability | ≥ 0.6 (exploratory research)<br>≥ 0.7 (advanced research) |
| | Average Variance Extracted | ≥ 0.5 |
| Discriminant Validity | Fornell/Larcker | AVE of a determinant must be larger than the squared correlation of this determinant with any other determinant. |
| | Cross loadings | The correlation of each indicator with its associated construct must be larger than its correlation with any other construct. |

#### 4.6.2.3 Structural Model Evaluation

Once a valid estimation of the constructs is confirmed, the structural model can be assessed according to certain evaluation criteria. Structural model evaluation is the

assessment of the predictive or causal relationship between constructs in the model (Ringle et al., 2005). Various evaluation criteria can be applied to assess the structural model including level of explained variance ($R^2$), effect size ($f^2$), predictive relevance ($Q^2$), and path coefficients (β) and hypotheses testing.

To assess the statistical significance of the model, the PLS Algorithm in SmartPLS was run to calculate the $R^2$ for the model. The *coefficient of determination* $R^2$ represents the proportion of the total variance of an endogenous variable that is explained by its related latent variables (Martinez-Ruiz and Aluja-Banet, 2009). $R^2$ values of 0.67, 0.33 or 0.19 are described by Chin (1998, page 323) as "substantial", "moderate" or "weak" respectively. The researcher applies Chin's (1998) recommendation as a guideline for evaluating $R^2$ values in the present study.

*Effect sizes* were determined by a method identified by Cohen (1988, p.410) and adopted by Schroer and Hertel (2009) in PLS path models. In this method, effect sizes of single predictors are obtained by comparing the explained amount of variance when a predictor is either included or not included in the model, that is, $f^2 = (R^2_{incl} - R^2_{excl})/ (1 - R^2_{incl})$. This assessment is performed in two stages within this study. In the first stage the effect size technique was used to investigate the impact of each determinant on infusion whereas in the second stage, the effect size technique was used to investigate the impact of infusion on individual level outcomes. This study employs Cohen's guidance (1988) for evaluating effect size ($f^2$) of 0.02, 0.15, and 0.35 which signify small, medium, and large effects, respectively.

The *predictive relevance* of the structural model was also assessed in this thesis. To evaluate the predictive relevance of the structural model, Stone and Geisser's $Q^2$ test was employed (Stone, 1974; Geisser, 1975). To achieve this, the blindfolding procedure incorporated in SmartPLS package was used. The blindfolding procedure is designed to remove some data and then estimate them as missing values. Based on that, the blindfolding procedure produce general cross-validating metrics $Q^2$, that is $Q2 = (Q2\text{incl} - Q2\text{excl})/ (1 - Q2\text{incl})$. The cross-validated redundancy measure, derived from the blinding procedure, can be a reliable measure of the predictive relevance of the theoretical/structural model investigated (Fornell and Cha, 1994; Chin 1998). A cross-validated redundancy approach estimates both the structural

model and the measurement models for data prediction. In this approach, the scores of the endogenous latent variables are estimated using the scores of the exogenous latent variables (Chin, 1998). Chin (1998) stated that positive $Q^2$ greater than zero provides evidence that the model is considered to have predictive validity. Conversely, negative $Q^2$ reflects absence of predictive relevance. The researcher applies Chin's (1998) recommendation as a guideline for evaluating $Q^2$ values in the present study.

*Path Coefficient and Hypotheses Testing:* PLS path coefficients are assessed using absolute value, significance and sign. Values close to 1 (or -1) imply a strong influence of a latent variable on their causal successor, whereas values close to 0 indicate weak influence. Values above 0.2 (or below -0.2) can be regarded as substantial (Chin 1998). Analysis of the structural model allows us to accept or reject each hypothesis as well as understand the actual contribution that an independent variable makes in explaining the variance in a dependent variable (Vinzi et al., 2010). The hypotheses derived from the qualitative findings were tested (i.e. examining strength and significance) by employing the bootstrapping re-sampling technique to calculate the corresponding t-values for each path, in order to assess the significance of path estimates. Since larger numbers of resamples lead to more reasonable estimates of standard error (Tenenhaus et al., 2005) the bootstrapping procedure was undertaken with 1000 samples to produce stable results.

Table 4-12 presents an overview of the different criteria applied in this research study to assess the structural model.

**Table 4-12: Evaluation Criteria: Structural Model**

| Criterion | Description | Recommended Thresholds | |
|---|---|---|---|
| Level of explained variance ($R^2$) | Proportion of the total variance of an endogenous variable that is explained by its related latent variables. | $R^2 \geq 0.67$<br>$0.33 \leq R^2 < 0.67$<br>$0.19 \leq R^2 < 0.33$ | Substantial<br>Moderate<br>Weak |
| Effect size ($f^2$) | Effect sizes of single predictors are obtained by comparing the explained amount of variance when a predictor is either included or not included in the model | $f^2 \geq 0.35$<br>$0.15 \leq f^2 < 0.35$<br>$0.02 \leq f^2 < 0.15$ | Large<br>Medium<br>Small |
| Predictive relevance ($Q^2$), | Capability of the model to predict. | $Q^2 > 0$ | Predictive relevance confirmed |
| Path coefficients (β) and hypotheses testing. | Reflects a hypothesis. Should be assessed with regard to absolute value, significance, and sign. | Path coefficients > 0.2<br>Sufficient significance (e.g. $p < 0.05$)<br>Sign in accordance with hypothesis | |

### 4.6.2.4 Analysing Control Variables in PLS: Multi-Group Analysis

PLS does not facilitate for the examination of control variables (Chin, 2010). In order to assess variations in survey responses, using PLS, multi-group analysis must be performed (Chin, 2001). To encompass the multi-group analysis, the parametric approach proposed by Chin (2001) was used. Statistically significant differences between the path coefficients of the sub-samples were measured by performing a *t*-test with pooled standard errors. The equation which will be applied in this study is as follows:

$$t = \frac{\text{Path}_{sample_1} - \text{Path}_{sample_2}}{\left[\sqrt{\frac{(m-1)^2}{(m+n-2)} * S.E.^{2}{}_{sample1} + \frac{(n-1)^2}{(m+n-2)} * S.E.^{2}{}_{sample2}}\right] * \left[\sqrt{\frac{1}{m} + \frac{1}{n}}\right]}$$

Where *m* represents the acquainted group sample, *n* shows the unacquainted group sample, $(m + n - 2)$ symbolises the degrees of freedom, and *S.E.* is the standard error of the path in the structural model.

In order to analyse if the infusion process diverge between people, the length of time (i.e. timeframe) healthcare practitioners are using the MHS were assessed. The

rationale for conducting multi-group analysis was to ascertain whether the timeframe might influence the model results. Infusion is documented in the literature as occurring at different timeframes (ranging from 6 months to 9 years, see Appendix 1). As a result, it is imperative to examine timeframe as it may affect the outcome of the survey.

## 4.7 Chapter Conclusion

This chapter details how the research investigation was conducted and justifies the appropriateness of the approach in the context of the research objective and research questions. It was established in Chapter 2 and 3 that a theory building approach is warranted to establish better insights into MHS infusion by healthcare practitioners. As a result, this chapter revealed a research strategy which would ensure this activity (i.e. theory building) would be realised. This chapter, therefore, presents a sequential mixed methods approach and describes, in detail, both phases of data collection and analysis. The first qualitative phase (conducted in University Hospitals Birmingham, NHS Foundation Trust, in the UK) ensures that the researcher obtains rich data to refine the *a-priori* model and propositions into testable hypotheses (findings presented in Chapter 5). The second quantitative phase (conducted in the Ottawa Hospital in Canada) enables the researcher to test the hypotheses and corroborate the model (findings presented in Chapter 6). This approach was essential towards the theory building process and to gain richer insights into the infusion of MHS by healthcare practitioners. Having identified the methodology employed by the researcher in this study, the following chapters (5 and 6) present the findings from each phase of the mixed method research approach.

# CHAPTER 5: RESEARCH MODEL DEVELOPMENT: FINDINGS OF THE QUALITATIVE STUDY

## 5.1 Introduction

Having identified the gap in literature (Chapter 2 and 3) and the methodological approach underpinning this study (Chapter 4) this chapter presents the findings of the qualitative case study conducted in University Hospitals Birmingham, National Health Services (NHS) Foundation Trust in the United Kingdom. This chapter addresses research questions 1 and 2.

Section 5.2 answers the first research question (What are the *determinants* of MHS infusion?). Initially, the objective is reiterated and a synopsis of the term infusion and its characteristics are presented. Building on extant literature this section continues by identifying six determinants which directly impact (Availability, MHS Self-Efficacy, Time-Criticality and Habit) and indirectly impact (Technology Trust and Task Behaviour) infusion of MHS by various healthcare practitioners. As a result, this section is decomposed into a number of components including Availability (Section 5.2.1), MHS Self-Efficacy (Section 5.2.2), Time-Criticality (Section 5.2.3), Habit (Section 5.2.4), Technology Trust (Section 5.2.5) and Task Behaviour (Section 5.2.6). Moreover, findings reveal that Perceived Risk of Technology does not impact infusion (Section 5.2.7). A summary of the determinants impacting individual infusion of MHS is then presented (Section 5.2.8). The findings presented in this Section (5.2) provide for a more detailed overview on the model presented in Chapter 3 (Section 3.3).

Section 5.3 addresses the second research question (What are the outcomes of Mobile Health Systems infusion by healthcare practitioners?). This section presents the findings pertaining to MHS infusion and its impact on individual performance indicators (Section 5.3.1), which include Effectiveness (Section 5.3.1.1), Efficiency (Section 5.3.1.2) and Knowledge Creation (Section 5.3.1.3). Analysis reveals improvements in preventive care, decision making and reductions in medical errors as a result of MHS infusion. It further reveals that knowledge was not directly created by MHS; however, the concept of learning emerged from discussions on

knowledge creation. A summary of individual-level outcomes is presented in Section 5.3.2.

Concluding this chapter is a summary of the qualitative findings (Section 5.4). It is evident from this summation that the initial model presented in Chapter 3 (Section 3.3) was too broad for explaining MHS infusion by healthcare practitioners. Both indirect and direct relationships (eight relationships in total) are identified in this chapter which impact MHS infusion by healthcare practitioners. Furthermore, the outcomes of the initial model are modified by removing knowledge creation and including the concept of learning. As a number of relationships emerged from the qualitative findings, the researcher is enabled to refine the two propositions established in Chapter 3 into nine testable hypotheses. Consequently, a revised model is proposed based on the findings presented in this chapter.

## 5.2 Determinants of MHS Infusion by Healthcare Practitioners

The purpose of this section is to explore the first research question: "What are the determinants of MHS infusion?" This research question helps identify the determinants which impact infusion of MHS by individuals in a healthcare context. An understanding of the determinants impacting individual infusion of MHS is important as it can provide an explanation of what will occur in the future if certain prerequisites hold. Therefore by answering the first research question, individuals infusing MHS into their daily work practices can identify determinants which facilitate or hinder that process.

To reiterate, the objective of this research is to explore the *determinants* and *outcomes* of infusing MHS within healthcare practitioners daily work practices. MHS infusion is defined in this study as *"individual outcomes obtained by using the MHS in a more comprehensive and integrated manner (i.e. to its fullest potential) to support healthcare practitioner with their work tasks"* (Section 2.4.1.2). Three indicators of infusion were identified in extant literature (Chapter 3); namely, feature use, integrative use and exploratory use. First, feature use refers to "the most basic use of MHS features to complete any given task" (adapted from Oakley and Palvia, 2012). Examples of basic features include electronic prescribing, patient

management and electronic observation. Second, integrative use refers "to the organisation of work tasks that healthcare practitioners undertake to fulfil their role using the MHS" (adapted from Meister and Compeau, 2002; Saga and Zmud, 1994). Examples of integrative use include prioritising which patients are to be seen first. This is based on the content accessed through MHS and sequencing tasks for delivering healthcare services at the point-of-care. Third, exploratory use captures active examination of new uses of the MHS by enabling individual users to find novel uses of the IS within their work environment (adapted from Saeed and Abdinnour-Helm, 2008). Examples of exploratory use include exploring the training domain and non-mandatory features of MHS.

Analysis of the qualitative data revealed a number of determinants which impact healthcare practitioner infusion of MHS. This section, consequently, is decomposed into various components including Availability (Section 5.2.1), MHS Self-Efficacy (Section 5.2.2), Time-Criticality (Section 5.2.3), Habit (Section 5.2.4), Technology Trust (Section 5.2.5) and Task Behaviour (Section 5.2.6). Perceived Risk in Technology is also discussed (Section 5.2.7) before a summary (Section 5.2.8) surrounding the first research question concludes this section.

### 5.2.1 Availability of MHS

Analysis reveals that availability of MHS directly impacts infusion. A chain of evidence, in the form of quotations, between availability and infusion is presented in Table 5-1. To facilitate the demand for MHS, University Hospitals Birmingham, NHS Foundation Trust was saturated with considerable amounts of MHS (approximately 500 as per June, 2011 and increasing annually), which was actively in use by approximately 3,500 (clinical pharmacologist) at the time of data collection. Supplying the organisation with MHS was perceived to make the MHS readily available to the end user. This statement is depicted by a clinical pharmacologist who stated *"we saturated this organisation with vast amounts of MHS so that there should never be a queue to use a computer [MHS]."* Yet, despite the number of MHS implemented in the hospital, healthcare staff perceived that the availability of MHS at their disposal was limited. The rationale behind the perceived

**Table 5-1: Chain of Evidence between Availability and Infusion**

| Availability | | |
|---|---|---|
| | **General Comments** | **Outcomes – Impact on Individual Infusion** |
| **Number of Users** | **Clinical Pharmacologist:** "MHS are costly pieces of equipment and it is currently not feasible to provide every staff member with their own dedicated tablet."<br>**Nurse (1):** "I sometimes am required to leave the patient's bedside to find an available computer to work with."<br>**Nurse (2):** "In our ICU every single bed, and we have 100, within this organisation has a MHS per patient… so one is always available to staff."<br>**Nurse (3):** "I have to walk ten minutes to locate a stationary computer to work with... obviously; I am away from the patient, this is not ideal."<br>**Doctor (2):** "There is thousands of staff working within this Trust and although there are vast amounts of IT in the hospital the majority of staff are required to share these resources." | **Pharmacist (1):** "I have access to MHS all the time so I open it up and roam around on it [MHS]."<br>**Doctor (3):** "Practitioners who don't use MHS at the patient's bedside are not taking advantages of what the MHS has to offer."<br>**Nurse (2):** "I cannot explore this [MHS] because the MHS are in constant use by staff."<br>**Doctor (1):** "Looking around the MHS would be easier if they were not used consistently by staff."<br>**Dietician:** "When available, MHS provides all the necessary features to enables staff to deliver patient care at the bedside."<br>**Clinical Pharmacologist:** "The features of MHS are simply not used when staff resorts to other technologies." |
| **Alternative Methods for data recording** | **Clinical Pharmacologist:** "We know that some users write the observations on a piece of paper and go in later and sit down with a PC desktop and write them down."<br>**Doctor (1):** "Having the ability to do everything at the bedside without having to go and find a static PC or write a paper note."<br>**Nurse (2):** "It would work if the computer was at the end of the bed or it they had their own. So sometimes what they [medical staff] do is write it on bits of paper with the intention at a later stage of inputting the data." | **Doctor (3):** "Sometimes practitioners tend to write on pieces of paper. As a result, I do not have all the necessary information in front of me to organise which patients need to be seen to."<br>**Nurse (3):** "When finished with the fluid balance checks I have to return to find an available computer to enter the data scribbled down on paper."<br>**Dietician:** "Prioritising which patients are to be examined is only possible when staff have all the information relating to the patient." |

limitation of MHS stemmed from the amount of users required to utilise MHS at the point-of-care. With the exception of the Intensive Care Unit (ICU) whereby each of the one hundred beds had dedicated MHS assigned to them, the remaining four hundred were required to be shared on various wards among numerous staff. At time of data collection (i.e. November, 2011), 41 out of the 61 (67%) of wards had at least one healthcare practitioner log into PICS using the MHS. A snapshot of tablets used in wards, in November 2011, is presented in Appendix 4. One nurse reported that *"in the ICU it's a 1:1 ratio [number of healthcare staff to MHS] and on the wards it is 16:1 in some shifts."* Fifteen MHS were assigned to most wards within the hospital, however, this number of MHS was considered to be insufficient (as indicated by three nurses, one dietician, and two doctors – with appeals for the introduction of additional MHS – *"if anything we need more [MHS] in the Trust"* (nurse). The rationale for this argument, according to one nurse, is that *"they [MHS] are in constant use and you struggle to find one that is available"* to perform necessary tasks.

Sharing the MHS among various staff members reduced the available time for individuals to **explore** the MHS as they were in constant use. Analysis revealed that users who had a propensity to spend more time on MHS learned new ways of exploiting the system's capabilities and became more adept at discovering more efficient ways of using systems outside of their original use. This was primarily evident between staff that had access to dedicated MHS (pharmacist) when compared to those required to share MHS (i.e. nurses). The pharmacist was found to explore the MHS more when compared with nurses. Also noteworthy is the rationale behind sharing the MHS which stemmed from the cost of the portable device. In this case, MHS were purchased at approximately £2,000 each, thus reflecting the large investment required to purchase the technological tools. Although cost was imperative, it was established that the purchase of MHS is the responsibility of the organisation and not the individual user in this case study.

In addition, as a result of sharing MHS, healthcare practitioners could not deliver healthcare services at the point-of-care using the MHS. This viewpoint is depicted by one dietician who stated that *"there are only a finite number within the trust so if*

*you don't get hold of one easily then you cannot prescribe the supplements correctly."* In some situations, healthcare practitioners were required to leave the patient at the point-of-care to find a stationary desktop. As a result, healthcare practitioners were not using all the **features** of MHS available to them (for example, electronic prescribing at the point-of-care). In addition to this, acquiring IT is critical for delivering healthcare services to patients at the point-of-care as all patient data is stored and accessed electronically. When healthcare staff did not have MHS at their disposal they were sometimes required to walk *"ten minutes"* (nurse) to find an available desktop. This ultimately impacted how the tasks were organised (**integrative use**) as there would be a delay in conducting such tasks. For example, the healthcare practitioner may have organised to see ten patients before lunch, however, each time s/he visits a patient it is then necessary to find a desktop on each occasion. As a result, approximately one hour of his/her time is wasted (ten minutes by ten patients). As a result, that healthcare practitioner may only deliver healthcare services to only eight from the intended ten patients. Although tasks would ultimately be organised when IT was at the disposal of the end user, such a delay would have a knock on impact across the entire hospital.

Secondly, the absence (i.e. non-availability) of MHS when required resulted in staff seeking alternative methods for recording data. In this case study, a small minority of healthcare practitioners admitted to writing down patient information on pieces of paper and inputting this data at a later stage. As it is mandatory to input patient information into PICS, this resulted in the recording of duplicate information (both on softcopy and hardcopy) which ultimately influenced the subsequent sequence of steps in delivering healthcare services to patients (i.e. **integrative use**). For example, one nurse indicated that she would record, on paper, fluid balances for various patients and input them once all her patients were reviewed. However, that nurse could not administer any other fluid to the first patient until the notes written on pieces of paper were compared with the electronically documented notes. Similarly, one doctor expressed that he could not prescribe drugs because some other members of staff had not recorded the information into the system. Although staff initially conducted their tasks by writing down patient details on pieces of paper they were

required to input this information in the MHS at a later stage. As a result, staff would utilise the **features** offered by MHS. Analysis further revealed that the individuals who often wrote on pieces of paper duplicated their work and often did not have time to **explore** the system. Similar views pertaining to time-consumption of exploring MHS were expressed by a doctor who stated that he would not explore the system because most of the time he was *"under a lot of time pressure."*

Analysis revealed that availability of MHS impacts feature use, integrative use and exploratory use of MHS. Therefore it is hypothesised (and illustrated in Figure 5-1) that:

- *H1: Availability of MHS positively impacts the infusion of MHS by healthcare practitioners*

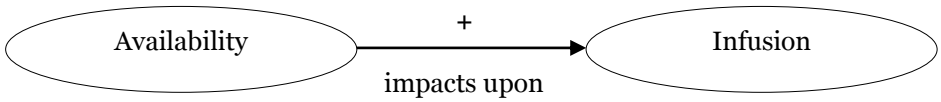



**Figure 5-1: Availability Impacts upon Individual Infusion of MHS**

### 5.2.2 MHS Self-Efficacy

Another determinant to impact MHS infusion is that of MHS self-efficacy. MHS self-efficacy refers to the degree to which an individual perceives his or her ability to use MHS in the accomplishment of a task (adapted from Compeau and Higgins, 1995). A chain of evidence, in the form of quotations, between MHS self-efficacy and infusion is presented in Table 5-2.

Analysis revealed that the more self-efficacious individuals are with the MHS, the more confident they are with infusing the tool. For instance, individuals who were self-assured about their capabilities to use MHS were found to **explore** the MHS more when compared with people who were apprehensive. This was primarily evident in the case of one pharmacist and one nurse. The pharmacist was confident in his ability to use the MHS stating "*I am a bit of a geek"* and *"I am confident to look around the MHS"* whereas the nurse indicated that s/he does *"not feel fully*

*content in my ability to work with the MHS … [and] only uses what [features] I know."* One nurse explained that exploration of MHS *"depends on your proficiency with IT and how you want to interact with it."* This viewpoint was evident throughout the analysis whereby the individuals who did not explore MHS entertained serious doubts about their capabilities of exploring the MHS and refrained from doing so (i.e. exploratory use). For example, the nurse used in the comparison example earlier stated s/he was *"hesitant"* to even consider exploring the MHS.

**Table 5-2: Chain of Evidence between MHS Self-Efficacy and Infusion**

| **MHS Self-Efficacy** | | |
|---|---|---|
| | **General Comments** | **Outcomes – Impact on Individual Infusion** |
| **Confidence** | **Pharmacist (1):** "I am a bit of a geek."<br>**Doctor (1):** "I have the necessary skills to use MHS."<br>**Nurse (3):** "I am not content in my ability to work with the MHS."<br>**Doctor (3):** "When I am unsure of a particular aspect of the MHS I normally ask someone to help me."<br>**Dietician:** "I am capable of using MHS on my own initiative."<br>**Nurse (2):** "You only get training on it [MHS] when you start in the hospital." | **Nurse (1):** "You need the appropriate skill set to explore this [MHS], otherwise people will not be enticed to investigate it."<br>**Doctor (2):** "My computer skills enable me to use certain features of the MHS."<br>**Nurse (3):** "I do not have the computer skills to even know where to start."<br>**Pharmacist (2):** "Reviewing patient data through this [MHS] allows me to proficiently coordinate which patients I need to see and when."<br>**Nurse (2):** "Dependent upon your proficiency with IT and how you interact with it." |

Similarly, various individuals (clinical pharmacologist, doctors, pharmacist and dietician) specified that they are confident in their ability to organise tasks (**integrative use**) based on the content accessed through MHS. This is exemplified by a clinical pharmacologist who stated that *"reviewing patient data through this [MHS] allows me to proficiently coordinate which patients I need to see and when."* This was further exemplified during demonstrations of the MHS by a pharmacist and a nurse whereby both individuals demonstrated how they organise their tasks. Conversely, one doctor indicated that *"when I am unsure of a particular aspect of the MHS I normally ask someone to help me."*

Moreover, PICS not only facilitates electronic prescribing but also ordering, results, medicine administration, discharge letters, clinic letters, referral management, handover, patient list management and electronic patient observation system. Healthcare practitioners who perceived that they possessed the ability to use MHS in the accomplishment of a task were confident when using various **features** of PICS.

In summary, highly self-efficacious healthcare practitioners were found to infuse MHS within their daily work practices. However, those who did not perceive that they had the ability to perform tasks using MHS often refrained from infusing the MHS. Based on this evidence, it is hypothesised (and illustrated in Figure 5-2) that:

- *H2: MHS self-efficacy impacts upon healthcare practitioners' infusion of MHS*

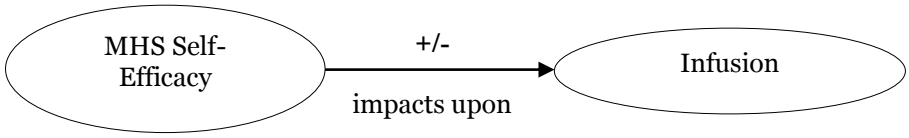



**Figure 5-2: MHS Self-Efficacy Impacts upon Individual Infusion of MHS**

### 5.2.3 Time-Criticality

Time-Criticality represents the importance with which a task needs to be performed (Zhang et al., 2011). The concept of time-criticality evolved from both task demands and task significance. Time-criticality refers to the willingness to use MHS in time-critical situations. A chain of evidence, in the form of quotations, between time-criticality and infusion is presented in Table 5-3.

**Table 5-3: Chain of Evidence between Time-Criticality and Infusion**

| Time Criticality | | |
|---|---|---|
| | **General Comments** | **Outcomes – Impact on Individual Infusion** |
| **Urgency of the patient's problem – Timeliness of accessing content** | **All practitioners:** "Presented with warning notifications."<br>**Nurse (2):** "If someone's observations are getting very abnormal then what will happen is it will set off the bleep of the critical care outreach team."<br>**Clinical Pharmacologist**: "Patient safety is essential." | **Doctor (2):** "Warning notifications are issued to highlight some actions are required for patient care. Every staff member must acknowledge and ensure certain steps are undertaken. So I often use MHS in urgent cases."<br>**Nurse (1):** "Warning notifications via MHS can help me prioritise which patients I attend to first."<br>**Doctor (1):** "Tasks are organised based on the patients' health status."<br>**Nurse (3):** "We sometimes have to drop everything and attend to patients who require attention. Using this [MHS] in these cases enables me to get the relevant information I need."<br>**Nurse (3):** "I do not play around on this [MHS] when a task needs our immediate attention. I will attend to it." |
| **Ability to use existing content** | **Pharmacist (1):** "Staff has access to a real time drug database."<br>**Dietician:** "MHS has all the information we require." | **Nurse (1):** "I explore the drug database when I need to find an answer asap."<br>**Nurse (3):** "We [healthcare practitioners] have our observations on it, blood pressures/pulses everything is on here... we can decide on the appropriate action to take when required."<br>**Pharmacist (2):** "Certain features of MHS are used to ensure a solution to the problem can be identified in cases which require a patient to be treated quickly." |

Analysis revealed that time criticality impacts individual infusion of MHS because the decision to pursue content from MHS is contingent on the urgency of the patient's problem. If a patient requires immediate attention it is therefore imperative that healthcare practitioners can obtain relevant patient content in a timely manner. In this case study, warning notifications/alerts were issued by PICS to healthcare practitioners when a task needed to be performed urgently. For example, the system created various alerts relating to potential prescribing errors which were classified into three groups; drug-allergy interactions, drug-drug interactions, drug-range inspection. Each alert was classified using a hierarchical approach decomposed into low-level, middle-level and high-level alerts. Low-level alerts require healthcare practitioners to tick a box indicating that the alert has been considered whereas users must apply a password before continuing when issued with intermediate (i.e. middle-level) alerts. The most imperative alert healthcare professionals must abide by is defined as high-level. If this is presented to the user, s/he is not permitted to continue. This inevitably has an impact on how healthcare practitioners organise and prioritise which patients are to be seen and treated promptly (**integrative use**). This is exemplified in a comment from a nurse who stated *"I may have to drop what I am doing and attend to a patient when warning messages appears"* (nurse).

As all patient content is stored electronically, healthcare practitioners were found to utilise the **features** offered by MHS. In some situations, warning notifications depict additional features to the healthcare practitioners which they previously may have been unaware of – *"I was not sure such a feature existed until it popped up on screen"* (pharmacist).

Due to time-pressure, however, **exploratory use** conducted by healthcare practitioners was limited when a task was required to be performed promptly. Treating patients promptly is of the utmost importance and healthcare practitioners (doctors and nurses) argued that time is better spent on identifying, diagnosing and treating patients and not on discovering novel uses of the MHS within their work environment. This is exemplified in the following comments: *"Spending the time appropriately so that the patient receives all our attention"* (nurse) and *"I do not*

*play around on this [MHS] when a task needs our immediate attention. I will attend to it."* Therefore, limited exploration of MHS occurs in a time-critical situation.

Analysis furthered revealed that healthcare practitioners use the MHS only with the expectation that an answer to the issue(s) exists. That means that the content received by healthcare practitioners can assist with decision making in a time-critical situation. Firstly, healthcare practitioners were required to navigate through various features of the MHS in order to uncover relevant content. As previously described, the MHS in this case study dispatched various notifications informing healthcare practitioners of potential problems associated with patients. Incorporated within the MHS (PICS) is a Clinical Decision Support System (CDSS). The CDSS assist healthcare practitioners with decision making tasks, such as determining the diagnosis and/or treatment of a patient. Moreover, the CDSS in this case was also based on the rules established within the British National Formulary (BNF[11]) which are updated frequently (clinical pharmacologist). The CDSS embedded within the MHS assist healthcare practitioners in selecting appropriate medication (type of drug and administration of drug) for patients and when integrated with patients' records, it assesses for any potential adverse drug events. This is illustrated by a pharmacist stating there are approximately *"3000 drugs in PICS at the moment with a large amount of clinical support and lab checks attached to that."* This point is further reinforced by a nurse stating *"when you select certain drug(s) it checks to see the patient's information to make sure it does not interact with the patient."* When prescribing to a patient a dropdown list of drugs is available to the healthcare practitioner. Having these features, according to doctors, nurses and pharmacists interviewed, improves decision making as the appropriate drugs relating to the patients' conditions are readily available to the healthcare practitioner. Therefore, **feature use** of MHS was often performed in urgent situations.

[11] British National Formulary (BNF): Third party software which is compiled with the advice of clinical experts which provide up-to-date guidance on prescribing, dispensing and administering medicines.

Secondly, the NHS hospital in this case study electronically stored vast amounts of content pertaining to patient care. However, in urgent situations healthcare practitioners were presented with relevant information ensuring timely access to patient content. Most healthcare practitioners perceived that they could locate the necessary content from the MHS as the *"MHS has all the information we require"* (dietician). Similar views were expressed by pharmacists, clinical pharmacologist, doctors and dietician. As a result, healthcare practitioners could organise their tasks quickly (**integrative use**) and address the needs of the patient.

Although healthcare practitioners admitted that they did not explore the MHS when tasks required immediate attention, healthcare practitioners were found to marginally **explore** the help functionality (e.g. BNF in this case) for assistance in a time-critical situation. Healthcare practitioners delivering safer healthcare services to patients was a result of exploring and following clinical guidance depicted in the MHS. Overall, exploratory use was limited in time-critical scenarios.

Based on the evidence presented in this section, it is hypothesised (and illustrated in) Figure 5-3 that:

- *H3*: *The ability of MHS to support healthcare practitioners with decision making in urgent situations positively impacts the infusion of MHS.*

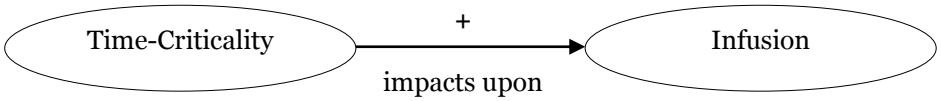



**Figure 5-3: Time-Criticality Impacts upon Individual Infusion of MHS**

### 5.2.4 Habit

Habit refers to the extent to which an individual tends to use MHS automatically (adapted from Limayen and Hirt, 2003) typically inferred from past experiences (Bergeron et al., 1995). A chain of evidence, in the form of quotations, between habit and infusion is presented in Table 5-4.

**Table 5-4: Chain of Evidence between Habit and Infusion**

| Habit | | |
|---|---|---|
| | **General Comments** | **Outcomes – Impact on Individual Infusion** |
| **Length of Time** | **Clinical Pharmacologist:** "I am working in the Trust for a number of years… I to use the same features all the time."<br>**Doctor (3):** "I am here as long as the system itself and have used it the same way since the first day I was introduced to it."<br>**Dietician:** "Since starting here I pick this [MHS] up automatically when I start my shift"<br>**Nurse (2):** "I have used MHS for some time now." | **Clinical Pharmacologist:** "If they know one particular way of getting and doing something… they will continue to use it in the same way."<br>**Pharmacist (1):** "I have always explored the system and will continue to do so"<br>**Doctor (1):** "It is easy to organise your tasks when you have been using this [MHS] for a long time" |
| **Frequency of Use** | **Nurse (2):** "I say I would use this [MHS] more than anyone else in the hospital."<br>**Nurse (3):** "I always use MHS when working with patients."<br>**Doctor (2):** "I use MHS regularly." | **Nurse (3):** "I normally use the same features so I do not need to know about the other features on the MHS."<br>**Doctor (2):** "If you want to do something that is routine you will just sign in and go. You won't stop and have a look at what is going on." |

The longer the length of time healthcare practitioners interact with the MHS, the more experiences they acquire. These experiences often reflect how healthcare practitioners embed MHS within their daily work practices. Healthcare practitioners, in this case study, acknowledged that they have become accustomed to the current MHS set up and can indicate which features are to be used for certain tasks (**feature use**). This is exemplified in comments such as *"I use the same features all the time"* (clinical pharmacologist) and *"I am here as long as the system itself and have used it the same way since the first day I was introduced to it"* (doctor). Some individuals therefore using MHS for a long period of time use the same features consistently and become less receptive to new features and stay with the current usage through established ways. This can hinder the infusion process.

Moreover, analysis revealed that healthcare practitioners utilising the MHS for an extended time period could establish work-flow linkages within their work process

**(integrative use)**. For example, PICS could be used to record data and the data is utilised later for analysis and reporting. This is exemplified in a comment from a doctor who stated that *"it is easy to organise your tasks when you have been using this [MHS] for a long time."* Therefore, analysis reveals that habit impacts feature use of MHS, because prior experiences with MHS help form inculcated responses that healthcare staff bring towards MHS usage.

Analysis further revealed that some healthcare practitioners who were utilising the MHS for a long period of time tended to **explore** the system. Working with MHS for a long period of time often results in the discovery of issues relating to the delivery of healthcare services vis-à-vis MHS (e.g. the way patient observations are entered into the MHS). As a result, some healthcare practitioners explored the system to see if this could be addressed. However, not all healthcare practitioners who used the MHS for long periods of time explored the system. These individuals argued that such changes were not of concern to the staff. This is exemplified in the comment from a nurse who argued that "*they [MHS] are not a priority for the nurses; they are flying around all day."*

Furthermore, frequency of use reflects the effects of habit on individual infusion of MHS. The more frequent individuals interact with the MHS, the more experience those individuals acquire. This acquired experience leads to the automatic infusion of MHS within their daily work practice. For instance, two pharmacists and one clinical pharmacologist who made it customary to explore the MHS frequently (via the training domain, third party software [BNF] and Help Feature) could locate various features of the MHS which assisted them when delivering healthcare services.

The training domain, for example, was an exact replica of the main, live application and did not have any features disabled, thus allowing staff free to roam all available features of the PICS (*"here we have the facility to play around"* – pharmacist). In addition to exploration of the training domain other members of the medical team were found to explore the help feature. The help feature offered in PICS was not a mandatory feature for staff to utilise when delivering healthcare services but was always available to the end user. This feature, for example, enabled users to explore

the BNF. According to doctors, nurses and pharmacists, exploring these domains is beneficial as they can discover new ways to conduct their tasks and locate features/functionality which were previously unknown to the user. Moreover, by exploring these domains, staff could request recommendations to the in-house development team for adapting and improving the current set-up.

Nonetheless, outside of the areas highlighted previously (i.e. training domain, third party software and help feature) analysis revealed that **exploratory use** of the MHS was regulated, to some extent, in the NHS case study. That is, the live mainstream application (PICS) on the MHS is 'locked down' and when healthcare staff log into the system they have certain right privileges (as delineated by a clinical pharmacologist). Locking down MHS in this context refers to limited access to application and feature use of the mobile artefact whereby some aspects of the MHS were disabled and hidden from the user (for example, certain features/functionality on PICS were disabled based on the occupation held by the user). This was undertaken by the management team to ensure privacy and security controls were adhered to at all times. Moreover, exploring the MHS was perceived as a time-consuming activity. In some situations, healthcare practitioners were reluctant to explore the MHS due to the ill-effects their actions may have on the delivery of healthcare services to patients at the point-of-care. This is depicted in a comment from a pharmacist who stated that *"we don't want to explore on this [main systems] and mess with patient's data."*

Analysis therefore revealed that individuals who regularly used MHS became familiar with the wide scope of **features** available to them *("if you want to do something that is routine you will just sign and go. You won't stop and have a look at what is going on"* - doctor). Similarly, it was established in the analysis that individuals who frequently use the same features become less aware of additional features. Conversely, healthcare practitioners were able to configure their work linkages among a set of work tasks (**integrative use**). The more frequent the user interacted with the MHS, the more the healthcare practitioner became accustomed to the current set-up, the easier it was for them to organise their tasks.

In summary, the habitual routines of healthcare practitioners were found to both hinder and facilitate the process of infusion in this case study. Based on the evidence presented in this section, it is hypothesised (and illustrated in Figure 5-4) that:

- *H4: Habits formed by healthcare practitioners' impacts the infusion of MHS by healthcare practitioners.*

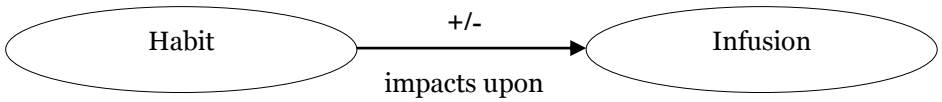



**Figure 5-4: Habit Impacts upon Individual Infusion of MHS**

### 5.2.5 Technology Trust

Sections 5.2.1 to 5.2.4 examined the direct relationships of various determinants (i.e. Availability, MHS Self-Efficacy, Time-Criticality and Habit) with MHS infusion. This section addresses one of the indirect determinants (Technology Trust) and its association with MHS infusion. Technology Trust refers to the degree to which healthcare practitioners perceive that the MHS is capable of facilitating tasks based on expectations of **reliability** and **functionality** (adapted from McKnight et al., 2011).

Firstly, technology trust was found to impact MHS self-efficacy. A chain of evidence, in terms of quotations, between technology trust and MHS self-efficacy is presented in Table 5-5. Analysis revealed that some healthcare practitioners depend on the MHS operating **reliably** and not undermining their efforts through unpredictable behaviour. This was primarily evident when healthcare staff experienced malfunctions with the MHS (e.g. technical error messages, system freezes, etc.) and were not capable of delivering healthcare services to patients without the assistance of fellow colleagues.

**Table 5-5: Chain of Evidence between Technology Trust and Self-Efficacy**

| Technology Trust | |
|---|---|
| | **Outcomes – Impact on MHS Self-Efficacy** |
| **Reliability** | **Nurse (3):** "When this breaks down [unreliable] I ring technical support as I do not know how to fix it."<br>**Doctor (2):** "When this [MHS] acts normal (so doesn't flash up technical errors or automatically switch off) I believe I am able to use the MHS… however, I am not an IT person so when this [MHS] does not perform reliably I tend to abandon it and locate one that is working."<br>**Dietician:** "I have no problem when it comes to using it [MHS] as, one, I believe that the data is reliable."<br>**Pharmacist (2):** "I would say I have the ability to perform tasks using the MHS primarily when it [MHS] is working smoothly." |
| **Functionality** | **Doctor (2):** "I have the ability to retrieve patient data because I know the features exist in the MHS for this to occur"<br>**Pharmacist (1):** "I am self-assured in my abilities to complete a given task because I know the features required to complete the task are on the MHS when I require them"<br>**Pharmacist (2):** "I logged into this morning and found they had made changes to the way things are entered into the system. I was unsure of how to continue so I had to find someone else to help me through the process."<br>**Nurse (3):** "When certain features are guaranteed to be on the system I feel comfortable working with it. However, if new features/ functionalities are introduced I sometimes feel uncertain in using the MHS"<br>**Clinical Pharmacologist:** "When I log into the system I have access to a number of key features. These key features are used daily and overtime I have gained confidence in using these features." |

This is exemplified in a comment by a nurse who stated that *"when this [MHS] breaks down I ring technical support as I do not know how to fix it."* Contrary to this, however, is when the MHS was behaving reliably the majority of staff felt confident in their abilities to perform tasks using MHS. For example, one doctor stated *"when this [MHS] acts normal (so doesn't flash up technical errors or automatically switch off) I believe I am able to use the MHS."* A similar view was expressed by a pharmacist who stated *"I have the ability to perform tasks using the MHS primarily when it [MHS] is working smoothly."* Additionally, it is imperative that the MHS provides reliable information pertinent to the delivery of healthcare services to patients. In this case study, careful consideration was given to each aspect of the system to ensure that information was *"recorded in the same way across practices"* (clinical pharmacologist). Staff (i.e. doctors, nurse, pharmacists and

clinical pharmacologist) acknowledged that, for the majority of the time, the information was reliable and this enabled them to perform their tasks using MHS.

Furthermore, individuals gain self-assurance about their ability to conduct their work when the MHS has the necessary features and functions. When executing daily tasks, healthcare practitioners believed they had the necessary skills to accomplish these tasks. The underlying rationale for their self-assurance stemmed from the awareness that the necessary features and functions exist within the MHS. This viewpoint was expressed by a number of individuals including a doctor who stated "*I have the ability to retrieve patient data because I know the features exist in the MHS for this to occur"* and a pharmacist *"I am self-assured in my abilities to complete a given task because I know the features required to complete the task are on the MHS when I require them."*

Likewise, healthcare practitioners were found to surmount any challenges when delivering healthcare services because they perceived that the MHS had the necessary **functionality** to assist them. However, when faced with tasks whereby features/functionality have been changed and/or removed within the MHS, some individual's retreated to disarray. This was exemplified in the following comment by a pharmacist; "*I logged in this morning and found they had made changes to the way things are entered into the system. I was unsure of how to continue so I had to find someone else to help me through the process."* Again, practitioners acknowledged instances when they were unsure of how the task should be performed due to changes in the MHS (i.e. features/functionality) and pursued help to overcome this obstacle.

In summary, when the MHS is perceived as being reliable and has the necessary functionality for healthcare practitioners to perform their tasks (i.e. MHS is perceived as trustworthy) then practitioners feel confident in their ability to deliver healthcare services using the MHS. However, concerns with malfunctions and changing features (i.e. mistrust of MHS) affect the self-efficacy of some healthcare practitioners. Therefore, it is hypothesised (and illustrated in Figure 5-5) that:

- *H5: Healthcare practitioners' trust in the MHS technology positively impacts MHS self-efficacy.*

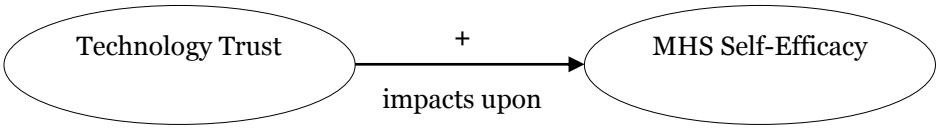



**Figure 5-5: Technology Trust Impacts MHS Self-Efficacy**

Secondly, technology trust was also found to impact time-criticality (i.e. willingness to use the MHS in urgent situations). A chain of evidence, in terms of quotations, between technology trust and time-criticality is presented in Table 5-6. Critical tasks (i.e. tasks which need to be performed urgently) are often performed at the point-of-care. It is clinically imperative therefore that the MHS does not malfunction (i.e. operate **reliably**) for the simple reason that all patient data, in the context of this study, is electronically stored and healthcare practitioners cannot deliver services without access to this data. For the majority of the time the MHS was found to operate as expected with very low unplanned downtime. A clinical pharmacologist stated that the system was reliable with *"less than 0.7% of downtime running PICS over the last 8 years."* This guarantees that patient data can be accessed at the point-of-care, assuming healthcare practitioners have necessary permission.

Nevertheless, analysis revealed that MHS are susceptible to some malfunctions with reports of poor battery performance and instantaneous log off. This was found to hinder individuals' willingness to use MHS as some healthcare practitioners acknowledged resorting to COWS (Computer-On-Wheels, also known as windsurfers in the context of this study) in urgent situations. This is exemplified in a comment by a nurse who stated *"in certain situations[12], I grab a windsurfer… they [windsurfer], I think, are more reliable."* A similar viewpoint regarding perceptions of MHS reliability in urgent situations was expressed by a pharmacist; *"it [MHS] takes time to boot up if they are switched off… when needed on demand it is*

[12] This comment arose when describing patient care at crucial times.

*important that you get one which is switched on."* One nurse in particular believes that the use of MHS in urgent situations impedes the delivery of healthcare services to patients - *"I cannot look at the end of the bed and see instantly what the normal blood pressure is. I have to leave the patient, go to find a computer that works, somewhere on the whole of this enormous ward to actually wait for it to warm up, log in and all that hassle – taking me away from the patient who has collapsed – before I know that this is something normal for the patient or whether it is alarming."* This nurse continued by stating that *"the only way to accurately do this [deliver healthcare services to patients] is on bits of paper – old fashioned paper charts."*

**Table 5-6: Chain of Evidence between Technology Trust and Time-Criticality**

| **Technology Trust** | |
|---|---|
| | **Outcomes – Impact on Time-Criticality** |
| **Reliability** | **Pharmacist (2):** "It takes time to boot up if they are switched off… when needed on demand it is important that you get one which is switched one."<br>**Nurse (1):** "In certain situations, I grab a windsurfer… they [windsurfer], I think, are more reliable."<br>**Nurse (3):** "I think I would rather use bits of paper as I think it [MHS] hinders nursing care and I think it makes things less accurate and reliable."<br>**Nurse (3):** "I cannot look at the end of the bed and see instantly what the normal blood pressure is. I have to leave the patient, go to find a computer that works, somewhere on the whole of this enormous ward to actually wait for it to warm up, log in and all that hassle – taking me away from the patient who has collapsed – before I know that this is something normal for the patient or whether it is alarming." |
| **Functionality** | **Doctor (3):** "This facilitates for speedy search queries which are beneficial to staff when patients require attention."<br>**Dietician:** "This is really good because it is quite easy to find all the different things that you need to find on demand."<br>**Nurse (2):** "If a patient is for resuscitation they have a heart next to the name but if they are not for resuscitation they will have a line. If you work in a busy area and you don't know your resuscitation status for your patient and that patient went into arrest I don't know the reality of how quick it would be to access the MHS whereas you could scan the notes to see the resuscitation card."<br>**Pharmacist (2):** "A keyboard is available with the windsurfer, which is a lot quicker to enter information that tapping. I prefer using the windsurfer when I want to get to type patient data quickly." |

In addition to this, large volumes of patient data is recorded and utilised on a daily basis. According to various healthcare practitioners (pharmacists, nurses and doctors) delivering healthcare services to patients in swift and comprehensive manner necessitates speedy access to patient information. It was therefore imperative that the MHS encompasses the necessary **functions/features** to facilitate this (i.e. speedy access to patient data). The search functionality within PICS was found appropriate as staff could seek medical data relevant only to the patient who required immediate attention – *"I can easily search for patient details when required"* (doctor). This improved decision making and ensured that the task of delivering healthcare services was conducted without delay.

Conversely, some functionality was reported (primarily by nurses) to barricade the timeliness in delivering healthcare services. Authorisation in PICS requires password entry and is grounded on role-based access standards that take into account an individual's job function and the relevant content required to deliver healthcare services. In some scenarios, it was reported *"that there are quite a few people in the hospital which seem not to have access to the PICS. So they will do the observations, write them on a bit of paper and they will then ask someone else to enter them into the system"* (nurse). Therefore, these individuals cannot use the MHS in urgent situations as they are required to locate someone else to log into the system. Access to the MHS was deemed a key issue as it was perceived by some individuals (primarily nurses) to obstruct the delivery of healthcare services in urgent situations. The underlying rationale for their argument stemmed from the fact that practitioners were required to log into the system which required some time. Inevitably, this would delay the patient treatment process.

Moreover, data retrieval and input via the MHS was achieved using a digital stylus (pen technology). It was reported by a number of staff (clinical pharmacologist, nurses, doctors and pharmacists) that these pens are often removed from the MHS thus, making the MHS redundant to use in urgent situations. Issues pertaining to the use of the digital pen also revealed that staff resorted to the use of COWS. This is exemplified in a comment by a pharmacist who stated that *"a keyboard is available with the windsurfer, which is a lot quicker to enter in information than tapping. I*

*prefer using the windsurfer when I want to get or type in patient data quickly."* Similarly, a nurse expressed that *"it's quicker for most people to type than it is tap using the stylus. A keyboard does appear but it is not so much the size but it is the fact that you have to do the individual taps."* This nurse continued by stating that this approach is time consuming and would rather use COWS or stationary desktops *"especially when I need to access patient data straightaway."*

In summary, healthcare practitioners who perceived that the MHS was untrustworthy in terms of reliability and functionality often resorted to the use of COWS or stationary desktops in urgent situations. Therefore, it is hypothesised (and depicted in Figure 5-6) that:

- *H6: Healthcare practitioners' trust in the MHS technology positively impacts upon their willingness to use MHS in urgent situations.*

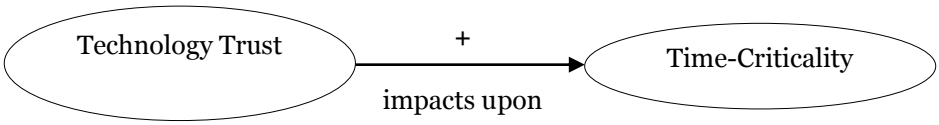



**Figure 5-6: Technology Trust Impacts upon Time-Criticality**

### 5.2.6 Task Behaviour

Building from Section 5.2.5, this section examines the second indirect determinant of MHS infusion (task behaviour). Task behaviour refers to the activities that **team members** perform using MHS to carry out a task (adapted from Chung and Guinan (1994) and derived from discussions pertaining to task demands from the initial case study.

First, analysis revealed that task behaviour impacts time-criticality (i.e. willingness to use MHS in urgent situations). A chain of evidence, in the form of quotations, between task behaviour and time-criticality is depicted in Table 5-7. In a situation where tasks have to performed promptly (often undertaken at the point-of-care) it is imperative that any data entered into the system is complete and up-to-date. In a minority of situations, however, it was reported that this was not always the case. For

example, one nurse stated that she would utilise the MHS in urgent situations when *"all the information is on the PICS... However, I have seen one or two members of staff putting patient data on pieces of paper. In critical situations, for example, I need this information. Instead of attending to the patient I have to find that member of staff to give me that information. I would not use it [MHS] then as I retrieve the information verbally."*

**Table 5-7: Chain of Evidence between Task Behaviour and Time-Criticality**

| **Task Behaviour** | |
|---|---|
| | **Outcomes – Impact on Time-Criticality** |
| **Group tasks/ teamwork** | **Clinical Pharmacologist:** "PICS has been developed to minimise partiality in the data. Therefore, all healthcare practitioners who interact with a patient should provide complete and comprehensive documentation on that patient. Because of this, I would use it [MHS] in all situations."<br>**Nurse (1):** "If all the information is on the PICS I will use it. However, I have seen one or two members of staff putting patient data on pieces of paper. In critical situations, for example, I need this information. Instead of attending to the patient I have to find that member of staff to give me that information so I don't use it [MHS] then"<br>**Nurse (3):** "So they will do the observations, write them on a bit of paper and they will then ask someone else to enter them into the system. For the whole lot of that time that bit of paper is in their pocket.… in the meantime the consultant does his ward round and says why is there nothing written on this chart."<br>**Nurse (3):** "All the information is on the PICS... However, I have seen one or two members of staff putting patient data on pieces of paper. In critical situations, for example, I need this information. Instead of attending to the patient I have to find that member of staff to give me that information. I would not use it [MHS] then as I retrieve the information verbally."<br>**Doctor (3):** "In urgent cases, I am happy to use it [MHS] because I am confident that it has all the data pertaining to the patient on it. Not only my notes but documentation from other members of staff." |

For the majority of the time, however, staff acknowledged that they would utilise the MHS in urgent situations as they perceived that the documentary practices of fellow colleagues was sufficient for them to deliver healthcare services. This is exemplified in a comment from a doctor who stated "*in urgent cases, I am happy to use it [MHS] because I am confident that it has all the data pertaining to the patient on it - not only my notes but documentation from other members of staff."* A similar viewpoint

was expressed by a clinical pharmacologist; *"PICS has been developed to minimise partiality in the data. Therefore, all healthcare practitioners who interact with a patient should provide complete and comprehensive documentation on that patient. Because of this, I would use it [MHS] in all situations."*

In summary, analysis revealed that MHS are often not used in urgent situations when healthcare practitioners retrieve the information verbally often as a result of poor documentary practices. However, communicating verbally was found to occur occasionally. Therefore, it is hypothesised (and illustrated in Figure 5-7) that:

- *H7: The documentary practices performed by team members when delivering healthcare services impacts fellow healthcare practitioners use of MHS in urgent situations.*

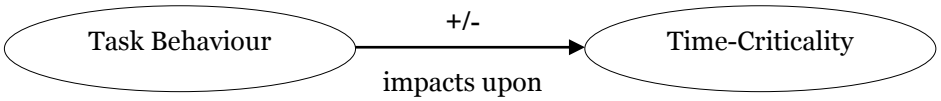



**Figure 5-7: Task Behaviour Impacts upon Time-Criticality**

Secondly, analysis further revealed that working as part of a team when delivering healthcare services to patients influences healthcare practitioners MHS behaviour (i.e. habits). A chain of evidence, in the form of quotations, between task behaviour and habit is presented in Table 5-8.

It was reported by some healthcare practitioners (doctor, nurse and dietician) that their current usage of the MHS was established based on guidance by fellow team colleagues. This is exemplified by a dietician who stated that *"initially, I was confused about how to use it [MHS]. Getting assistance from my colleagues back then enabled me to take what they showed me and use it routinely to this day."* In some situations, simply observing how others utilise the MHS influenced individual MHS behaviour. This is expressed by a nurse who stated *"I found that working with other staff members that I have picked up, overtime, how they use it [MHS] and automatically adopted the same approach."* A similar viewpoint is revealed by a doctor; *"When I first started working with the consultant a few months ago, I noticed*

*how he was using the MHS. Since then, I took it upon myself to use it in the same way."* In contrast not all MHS habitual routines were derived from working as part of a team. Some habits were formed via training programmes – *"I have a tendency to use the same features all the time because that is how I was trained"* (pharmacist) and *"I received training years back when I first started working in the Trust. That is how I came to know and use the MHS to this day"* (nurse). Additionally, analysis revealed that habits were also established based on an individual's own interaction with the MHS. This comment is exemplified by a pharmacist (different from previously) who stated that "*we taught ourselves on this… we never had any training. So I tend to use it based on my own experience working with it."*

**Table 5-8: Chain of Evidence between Task Behaviour and Habit**

| **Task Behaviour** | |
|---|---|
| | **Outcomes - Impact on Habit** |
| **Group tasks/ teamwork** | **Dietician:** "Initially, I was confused about how to use it [MHS]. Getting assistance from my colleagues back then enabled me to take what they showed me and use it routinely to this day."<br>**Nurse (2):** "I found that working with other staff members that I have picked up, overtime, how they use it [MHS] and automatically adopted the same approach."<br>**Doctor (3):** When I first started working with the consultant a few months ago, I noticed how he was using the MHS. Since then, I took it upon myself to use it in the same way."<br>**Pharmacist (1):** "I have a tendency to use the same features all the time because that is how I was trained."<br>**Nurse (1):** "I received training years back when I first started working in the Trust. That is how I came to know and use the MHS to this day."<br>**Pharmacist (2):** "We taught ourselves on this… we never had any training. So I tend to use it based on my own experience working with it." |

In summary, analysis revealed that habits can be influenced by various events. In a healthcare context, a number of healthcare practitioners often deliver healthcare services in collaboration. Consequently, it was determined that task behaviours of others in the team can influence one's habits. Therefore, it is hypothesised (and illustrated in Figure 5-8) that:

- *H8: Working as part of a team when delivering healthcare services to patients influences healthcare practitioners MHS behaviour.*

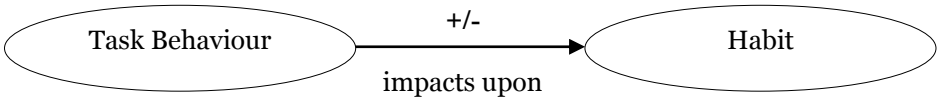



**Figure 5-8: Task Behaviour Impacts upon Habit**

### 5.2.7 Perceived Risk in Technology

Analysis pertaining to perceived risk in technology yielded no significant impact on individual infusion of MHS. Many people (doctors, nurses and pharmacists) acknowledged that some risks exist in the system when **initially implemented** as *"risks are inherent within any system"* (pharmacist). However, due to the maturity and stability of the current MHS, many healthcare practitioners consider it safe and did not perceive any technology risk associated with MHS infusion (e.g. issues with security and patient data confidentiality). To such an extent that one pharmacy technician would still consider infusing the technology if some risk exists: "*I don't think that should stop us going through and pushing on with technology."* The rationale underpinning this realisation was the fact that healthcare practitioners never experienced any technical difficulty/issues with the MHS in a post-adoptive scenario. Moreover, perceived risk of technology was not a concern to healthcare practitioners because backup strategies were in place which ensured that the delivery of healthcare services to patients would not be disturbed. Additionally, PICS was customised based on the job function of the healthcare practitioner. This further ensured that privacy of patient data and security were maintained. As a result, insufficient evidence was established to associate perceived risk with MHS infusion and thus is not further investigated.

### 5.2.8 Summary of Determinants

Section 5.2 answers the first research question by detailing the determinants of MHS infusion by healthcare practitioners. The determinants presented here are among the first to be analysed in terms of MHS infusion at the individual level (healthcare practitioners) of analysis in a healthcare domain. These determinants include Availability, MHS Self-Efficacy, Time-Criticality, and Habit which were found to

directly impact infusion. However, analysis further revealed two additional, indirect determinants; namely, Technology Trust and Task Behaviour. As a result of these findings, proposition 1 (*Infusion of MHS by healthcare practitioners is affected by user, task, and technology determinants*) is refined by specifying eight hypotheses:

- H1: Availability of MHS positively impacts the infusion of MHS by healthcare practitioners.
- H2: MHS self-efficacy impacts upon healthcare practitioners' infusion of MHS
- H3: The ability of MHS to support healthcare practitioners with decision making in urgent situations positively impacts the infusion of MHS.
- H4: Habits formed by healthcare practitioners' impacts the infusion of MHS by healthcare practitioners.
- H5: Healthcare practitioners' trust in the MHS technology positively impacts MHS self-efficacy.
- H6: Healthcare practitioners' trust in the MHS technology positively impacts upon their willingness to use MHS in urgent situations.
- H7: The documentary practices performed by team members when delivering healthcare services impacts fellow healthcare practitioners use of MHS in urgent situations.
- H8: Working as part of a team when delivering healthcare services to patients influences healthcare practitioners MHS behaviour.

A preliminary model of MHS infusion is therefore presented (Figure 5-9) which represents a model for explaining the infusion of MHS included in this study. It illustrates the determinants and hypotheses which impact individual infusion of MHS. While this section reveals the determinants which impact infusion, however, it does not explore the outcomes of infusion. This aspect of the study is explored in the Section 5.3.

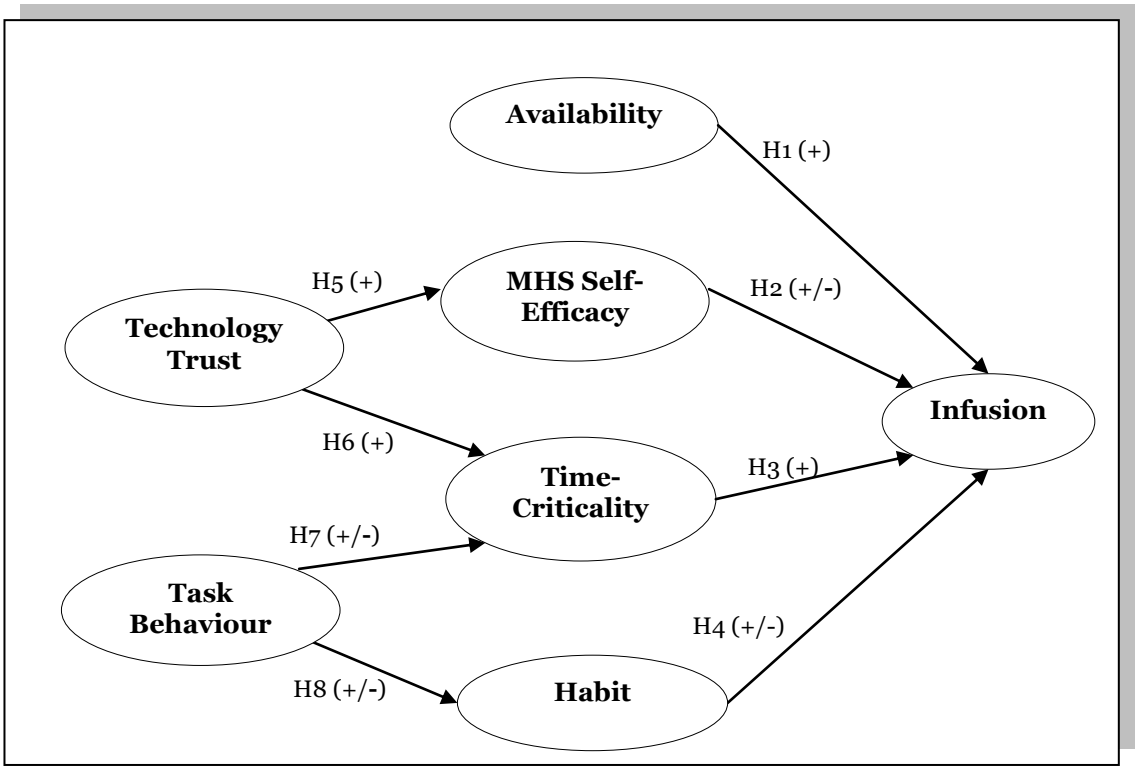



**Figure 5-9: Preliminary Model of MHS Infusion**

## 5.3 Outcomes of Individual Infusion of MHS

Section 5.2 focused on the determinants which impact individual infusion. Section 5.3 presents an analysis surrounding the second research question ("What are the outcomes of Mobile Health Systems infusion by healthcare practitioners?") This research question yields some insight into individual level outcomes of infusing MHS. The question remains as to whether practitioners' performance significantly improves as a result of infusing MHS into healthcare practitioners' work practices. Understanding these outcomes is imperative as healthcare practitioners may be reluctant to infuse MHS if no anticipated benefits are achieved. This section analyses the findings related to Effectiveness (Section 5.3.1.1), Efficiency (Section 5.3.1.2) and Knowledge Creation (Section 5.3.1.3). A summation is presented (Section 5.3.2) highlighting the main outcomes realised by healthcare practitioners from infusing MHS into their daily work practices.

### 5.3.1 Examination of Individual Performance

This section describes the impact MHS infusion has on individual performance. Individual performance is defined in this study as the degree to which a healthcare practitioner effectively and efficiently delivers health care services and creates knowledge through the use of MHS. To appreciate individual performance, it is assessed through Effectiveness (Section 5.3.1.1), Efficiency (Section 5.3.1.2 ) and Knowledge Creation (Section 5.3.1.3). Effectiveness refers to the degree to which a given activity or program (i.e. infusing MHS) undertaken by healthcare practitioner improves clinical care. Efficiency refers to the degree to which a given activity or program (i.e. infusing MHS) undertaken by healthcare practitioners lead to a more efficient workflow. Knowledge Creation refers to the capability to improve continuously, and apply expertise by expanding the existing knowledge base (Nonaka et al. 2000) of individuals through MHS, in a particular context" (see Section 3.3.3.1 for further information regarding individual performance).

#### 5.3.1.1 Effectiveness

In relation to effectiveness (defined in Section 5.3.1) individual healthcare practitioners' highlight the importance of particular aspects from MHS infusion including decreasing error rates, increasing the quality of patient care, improving the diagnosis and treatment of patients and assisting in disease monitoring and management within the hospital.

In this case study, warning notification/alarms were issued to healthcare practitioners (described earlier in Section 5.2.3) to improve the delivery of healthcare services to patients. Due to the presence of this alert scheme and acting accordingly (integrative use) many individuals (nine healthcare practitioners) perceived that error rates were reduced as a result. A clinical pharmacologist conducting internal research within the hospital found that on average, *"probably several thousand hard stopped warnings occur every year*." If healthcare practitioners address these notifications many interviewees believed that, as a result, there would be a reduction in medical errors. One nurse in particular was very enthusiastic stating *"definitely, definitely,*

*definitely"* to a reduction in medical errors from MHS infusion. It was advised by a pharmacist, however, that *"IT electronic systems do reduce errors but this is not the panacea – it doesn't eradicate errors."*

When responding to the warning alerts, healthcare practitioners can either acknowledge the clinical implications of the decision to proceed or disregard the message (feature use). All operations undertaken on the MHS by the healthcare practitioners are electronically recorded, ensuring accountability. In addition to the prescribing alerts highlighted previously, the MHS prompts healthcare practitioners of non-standard laboratory results (discussed by doctors, nurses and pharmacists). Examples of non-standard laboratory results include increased cholesterol and low haemoglobin. These notifications are presented at two levels (warning and alerts). Warning notifications inform the healthcare practitioner of patient results which are considered irregular but has no immediate threat to the patient. These warnings are presented to the individual user when they log onto the MHS. Instances whereby the patients are in immediate danger, grounded on anomalies in laboratory results, doctors are immediately notified via an interruptive alert which must be acknowledged. As a result, this improves the diagnosis and treatment of patients (reflected by doctors, nurses and pharmacists). Additionally, the use of MHS improves the quality of patient care as it enables healthcare practitioners to access patient-content independent of their location. This viewpoint is presented by a doctor who stated that the MHS *"certainly enables me to have much greater surveillance on my patients compared to drug charts on the end of the bed."*

Assistance in terms of disease monitoring and managing was evident within the hospital. For example, if there was a patient/ward/hospital outbreak of Methicillin-resistant Staphylococcus Aureus (MRSA) the medical team is notified (as indicated by a pharmacist and one nurse). S/he continues by stating that, firstly, in terms of managing the disease effected patients are *"prescribed treatment for MRSA"* (pharmacist). Secondly, healthcare practitioners must undertake infection control and monitor the situation (integrative use). The viewpoint of monitoring and managing disease through MHS was evident in the Intensive Care Unit whereby patients were continuously monitored to ensure vital signs remained stable. Any deterioration

would result in notification sent to staff to act accordingly. Because all patients' vital signs (for example, temperature, heart/pulse rate, respiratory rate, blood pressure, pain assessment and level of consciousness) were electronically recorded healthcare practitioners (doctors, nurses, pharmacists) utilised this information to indicate the health or ill health of patients, independent of their location within the hospital. This viewpoint is depicted in the following comment by one nurse who stated "*we [healthcare personnel] have our observations on it, blood pressures/pulses; everything is on here which is great so anyone can assess them."* A different nurse highlighted how they use vital sign indicators for risk management assessment. In some situations exploring the BNF assisted in delivering appropriate healthcare services to patients (exploratory use). It is inevitable that clinical care is improved through infusion of MHS.

In summary, this section presented the improvements to preventive care by medical personnel. Evidence emerged illustrating that infusion of MHS showed a reduction in medical errors which improved the diagnosis and treatment of patients. Furthermore, disease monitoring and management was unveiled thereby increasing the quality of patient care. Not only did the analysis find clinical care of patients was improved but also, through infusion of MHS, healthcare practitioners workflow was enhanced. This is further discussed in the subsequent Section (5.3.1.2).

#### 5.3.1.2 Efficiency

In relation to efficiency (defined in Section 5.3.1) individual healthcare practitioners acknowledged the importance of particular aspects relating to workflow as a result of infusing MHS. For example, time saving, ease in providing healthcare services, enhancements in clinical documentation, decision making and improvements when following clinical guidelines protocols.

Firstly, healthcare practitioners' highlight that their decision making was improved as a result of infusing MHS. The underlying rationale for this is that the clinical information required in decision making is readily available to the healthcare practitioner at the patient's point-of-care (described in Section 5.2.3). This is

exemplified in the following comment by a pharmacist who specified that "*you can get the maximum amount of information you need to make decisions at the bedside because you have a whole raft of information available to you - so I think it helps me to make better decision quicker."* This viewpoint is reinforced by three nurses and two doctors who acknowledged that having patients' data readily available is essential in the decision making process.

By having access to this content healthcare practitioner can configure their work tasks which save time (i.e. integrative use). Time saving was found throughout the delivery of healthcare services. Firstly, as previously revealed, having the CDSS functionality, in addition to relevant patient data, at the point-of-care assist healthcare practitioners in the decision making process. As a result, various healthcare practitioners (doctors, nurses and pharmacists) do not have to spend a lot of time researching before making a decision. This is depicted in the following comment by one nurse who expressed that in a previous hospital s/he worked in s/he was required to *"undertake more research because I did not have all the information readily available to me at the bed-side."*

Secondly, all patient data is initially inputted into the system when admitted to hospital (feature use). The admission process cannot be completed without first inputting the electronic data of the patient. This data can then be accessed throughout the patient's stay thus, saving time required to locate appropriate files. The viewpoint of time saving is expressed by a pharmacist who stated *"we [healthcare practitioners] do not have to waste time locating patient files, which could be stored off-site, because everything is readily available on this [MHS]."* Time saving in this respect is also strengthened by the arguments made by a dietician who stated *"we don't have to wait before we find the entire medical notes… we can look at all the information here. So yes, it saves time significantly."*

Thirdly, time saving is also achieved through the infusion of MHS at the point-of-care. This point is clearly stated by a dietician indicating that "*it obviously saves a huge amount of time because we can use them whenever and wherever*." Moreover, one nurse indicated that nurses can save time by accessing readily available

information at the point of care *"rather than running down to a stationary desktop computer."* As a result, the time saved is used to deliver healthcare services to more patients according to a dietician and a pharmacist. According to the pharmacist s/he *"can see more people quicker because I can make quicker and more efficient decisions. Obviously if that information isn't available if you have a paper based system then you still have to do a bit of digging around."* However, it is important to note that the MHS was criticised for the poor response time of booting up as expressed by numerous interviewees. Various doctors and nurses indicated that *"it [MHS] takes a good few minutes to boot up*" which impedes on their workflow.

Aforementioned, healthcare practitioners are notified when potential problems exist when delivering healthcare services to patients. In addition to this, tests, drug administration and vital sign checks are scheduled and completed on time due to prompts notified to the individual user once they log in. This is exemplified in a comment by a nurse who stated that "*you start your drug ward which is a scheduled time on PICS. You start your observations which again are scheduled at a time on PICS."* These reminders are an efficient way to ensure that routine clinical care is carried out on time.

Additionally, MHS infusion facilitates for clinical data to be captured at the point-of-care. This data is captured in various formats (for example, text, drop-down lists, check boxes and radio buttons) and varies among healthcare practitioners. For instance, nurses may document fluid balances, doctors may document observations, dieticians may document risk scores and pharmacists may document the reasons for not administering a drug on time. One nurse stated that *"there is an option of being quite detailed in annotating and putting notes on there [MHS]. This is really good from a patient care point of view and from a safety point of view. It also enables me to see when the last time a drug was administered which on a paper chart you couldn't see. So that is much safer."* Moreover, clinical documentation overcomes any issues associated with illegibility. This viewpoint is expressed by a nurse stating *"we [nurses] are not relying on doctors' hand writing for drugs."*

From infusing MHS healthcare practitioners perceived that they followed clinical guidelines more rigidly. This is depicted in instances whereby nurses are required to record patients' pain scores. In this situation, the nurse indicated that, at the point-of-care, the MHS *"provides charts to help rating some aspects of patients' data. So it shows me what scores to give it and I could put a comment in as well."* A different nurse indicated that all the necessary steps have to be undertaken to deliver healthcare services. For example, *"if we (staff with privileges) have to prescribe something they are required to do the stages."* These stages ensure that clinical guideline protocols are obeyed as workarounds are not achievable – *"You can't do shortcuts with it"* (nurse), *"we can't attempt workarounds"* (pharmacist) and *"it is not possible to complete workarounds"* (doctor).

It is evident from the previous sections that an association between infusion and individual performance exists. This is primarily evident through the use of prompt notifications warnings/alerts which are required to be addressed by healthcare practitioners. Furthermore, scheduling of clinical activities ensures that healthcare services are delivered on-time and when required. By organising tasks based on content accessed through MHS, time is saved and decision making is improved. The link between exploratory use and efficiency was not fully established. A paradox exists in terms of time saving as staff members found exploratory use of MHS, a time consuming activity, which could have been spent on patient care. However, by exploring the MHS, some healthcare practitioners were able to save time in terms of locating certain features. In summary, this section presented the improvements to healthcare practitioners' workflow as a result of MHS infusion.

#### 5.3.1.3 Knowledge Creation

Exploring knowledge creation through individual infusion of MHS was one key finding from the data analysis. Initially when PICS was programmed, locally developed knowledge was incorporated within the system (clinical pharmacologist). However, analysis revealed inconsistencies with interviewees' impressions of knowledge creation. From the ten people interviewed, two believed that knowledge was created (one nurse and one dietician), four believed that it was not created (two

pharmacists, one doctor and one nurse) and the remaining four (one nurse, one clinical pharmacologist, two doctors) were undecided. However, two common threads emerged from the analysis associated with knowledge creation. First, a number of interviewees confused knowledge with information and second, individuals associated knowledge with learning.

One interviewee (dietician) believed that s/he *"creates knowledge"* directly from MHS. However when asked to expand on this, the interviewee started to discuss the information regarding patients which is often recorded. For example, s/he stated that *"particularly with my burn patients – we got all there admission details, percentage of burn, where it is."* Similarly, the other person who perceived that knowledge could be created via MHS (i.e. nurse) stated that s/he creates knowledge by looking at the BNF. This person was found to associate knowledge with learning. One pharmacist stated that *"I don't know whether we can create knowledge but we can present knowledge to people."* However, in this situation information (as opposed to knowledge) is presented on screen.

One nurse believed that healthcare practitioners should not rely on the system stating it would be difficult to assess *"whether people's knowledge increases because messages come up all the time or do they become reliant on a system which stops them from thinking outside the box."* Therefore, it was perceived that information can be accessed via MHS but does not directly result in knowledge creation among healthcare practitioners. It was acknowledged, however, that knowledge can be created by healthcare practitioners independent of using MHS. This is depicted by a pharmacy technician who mentioned *"if people have a thirst for knowledge or a quest for knowledge then I think they will find it. They will go and read a book. I am not sure if they would get it entirely from the PICS system."*

MHS presents information to healthcare practitioners. This information can then be adopted by the user whereby s/he can apply their experiences within a specific context to create knowledge. Therefore, MHS does not create knowledge directly but facilitates for knowledge creation. This is depicted by one doctor who stated that *"I use patient data from this [MHS] to help evaluate a patient's condition."* Similarly,

one nurse expressed that the MHS assists users to *"critically analyse things*" but *"users should not just rely on it fully"* and apply *"their own expertise."*

Moreover, when describing knowledge many interviewees referred to the concept of learning. Accessing medical reference resources through MHS assist healthcare practitioners in learning more about delivering healthcare services to patients. This is exemplified in a comment by a nurse who stated that the BNF (via exploratory use) can aid him/her in *"learning ten types of ace-inhibitors for example."* One doctor revealed *"I can learn about new drug-drug/allergy interactions that I was not previously aware of"* (feature use). This is further strengthened by a nurse who states that she *"can learn about new drug interactions that I hadn't known about recently."* A second nurse stated "*there is having the knowledge as in being able to memorise things."* Additionally, the use of warning/alert notifications promotes learning as revealed by one nurse who stated *"I learn how to deliver patient care from absorbing what warnings appear on it [MHS]"* (integrative use). It is evident from these comments that learning is an outcome of individual infusion.

Thus, MHS are a convenient source of information or means of communication that assist healthcare practitioners with medical learning rather than directly create knowledge. For this reason, analysis revealed no association was found between infusion and knowledge creation. However, an association between infusion and learning[13] emerged from the analysis.

Based on the evidence presented in Section 5.3.1, it is hypothesised that:

- *H9: Infusion of MHS positively impacts healthcare practitioners' performance in terms of clinical care, workflow and learning.*

[13] Individual Performance now also incorporates the concept of learning.

### 5.3.2 Summary of Outcomes of Individual Infusion of MHS

Section 5.3 answers the second research question by detailing the outcomes of infusing MHS at an individual level of analysis. Analysis first revealed that effectiveness (focuses on clinical care delivered to patients) and efficiency (focuses on healthcare practitioners' workflow) was improved as a result of incorporating MHS into healthcare practitioners' daily work practices. Furthermore, analysis reveals that knowledge is not directly created by MHS however; it promotes individual learning. Figure 5-10 depicts the outcomes found in this case study from MHS infusion. As a result of these findings, proposition 2 (*The infusion of MHS impacts various healthcare practitioner related outcomes*) is refined to:

- *H9: Infusion of MHS positively impacts healthcare practitioners' performance in terms of clinical care, workflow and learning.*

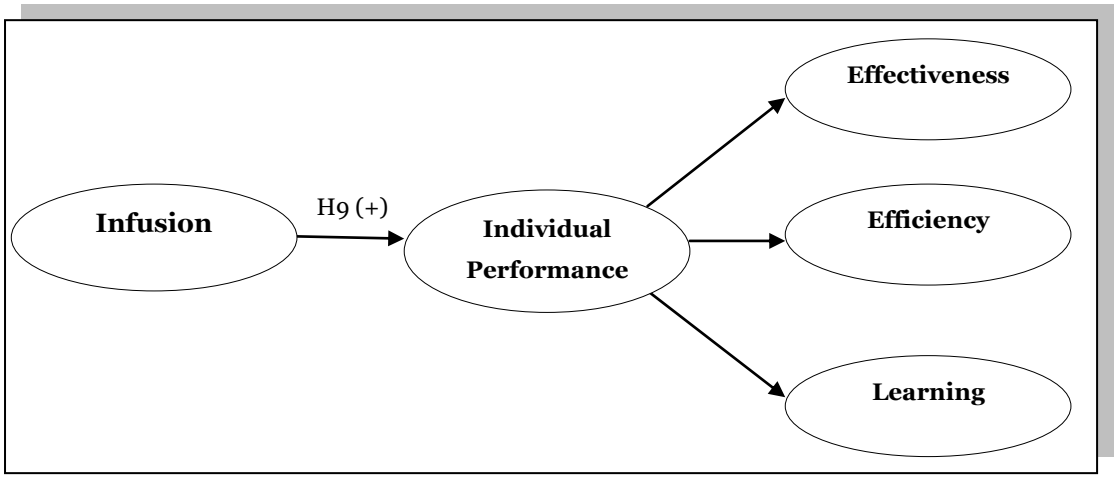



**Figure 5-10: Outcomes of MHS Infusion**

## 5.4 Conclusion: Revised Model of Individual Infusion of MHS

This chapter presents the qualitative findings from interviewees conducted with healthcare practitioners at University Hospitals Birmingham, NHS Foundation Trust. It sets out to answer two research questions: (1) What are the determinants which impact healthcare practitioner infusion of Mobile Health Systems (MHS)? (2) What are the outcomes of infusing MHS into an individual's work practices? This chapter

addresses the gap in extant literature pertaining to healthcare practitioner infusion of MHS through investigation of a preliminary conceptual model derived in Chapter 3.

This section presents a summary of the findings presented earlier and discusses its implications for the conceptual model derived from extant literature. Although individual infusion has recently received attention in the literature little is known pertaining to the infusion of mobile artefacts, primarily in a healthcare domain. Addressing this gap in literature, analysis first revealed that infusion did occur by individual healthcare practitioners (Sections 5.2 and 5.3). Next, the emphasis was placed on answering the first research question (outlined earlier). Six determinants were found which directly (four determinants) and indirectly (two determinants) impact individual infusion of MHS (Section 5.2). These determinants include Availability, MHS Self-Efficacy, Time-Criticality, Habit (direct impact), Technology Trust and Task Behaviour (indirect impact).

Section 5.3 set out to answer the second research question, whereby analysis detailed individual level outcomes of MHS infusion. Little evidence exists which explores such outcomes (described in Chapter 2, Section 2.4.2.3). Analysis provides empirical evidence of the impact which infusion of MHS has on practitioners' performance. Performance, in terms of effectiveness, efficiency and learning, was found to improve as a result of infusing MHS. Conversely, knowledge creation was not found to be created directly by MHS.

Based on the analysis presented in this chapter, it is evident that the model derived in chapter 3 is too generic for explaining MHS infusion at an individual level of analysis. As a result, Figure 5-11 presents a revised model of Individual Mobile Health Infusion for further investigation. The findings from this investigation is further examined and tested quantitatively, of which the results are presented in the following chapter (Chapter 6).

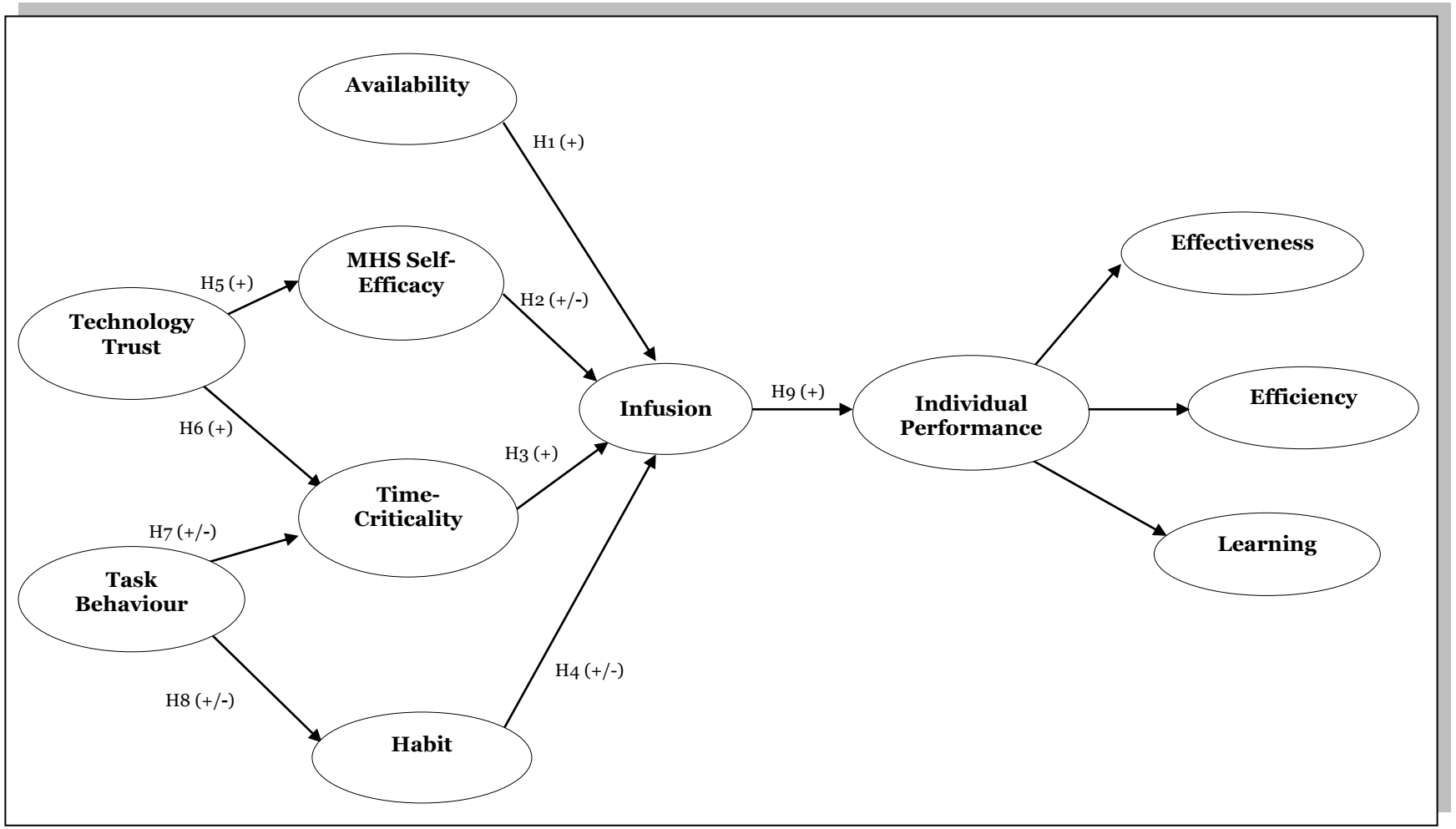



**Figure 5-11: Revised Model of MHS Infusion (Qualitative)**

# CHAPTER 6: RESEARCH MODEL VALIDATION: FINDINGS OF THE QUANTITATIVE STUDY

## 6.1 Introduction

This chapter presents the survey findings from this study conducted in the Ottawa Hospital, Canada. This chapter presents the results of the survey surrounding two research questions: (3) to what degree does the determinants impact individual infusion of MHS? And (4) to what degree does individual infusion of MHS impact outcomes? This chapter builds on the results (i.e. refined model and hypotheses) presented in Chapter 5. Section 6.2 presents the revised model and the nine hypotheses.

Section 6.3 presents an overview of the survey administration and highlights that common method variance and non-response bias is not a threat to the survey results (Section 6.3.1). Moreover, G*Power analysis indicates that the sample size (n = 101) is sufficient for the survey findings as it reveals a power value close to one (Section 6.3.3) thus, allowing the researcher to reject the null hypotheses. The final component (Section 6.3.4) outlines the respondents' profiles.

Section 6.4 evaluates the revised model of MHS infusion (derived from the qualitative findings) and identifies that the model is robust as it meets several reliability and validity test. In this section both the measurement model (Section 6.4.1) and structural model (Section 6.4.2) are evaluated. Furthermore, the potential influence of timeframe is assessed in Section 6.4.3. A summary of the quantitative findings is presented in Section 6.5.

## 6.2 Individual MHS Model and Hypotheses

As a two-phased sequential mixed methods study, this chapter builds on the findings presented in the previous chapter. Just to reiterate, the objective of this research is to explore the *determinants* and *outcomes* of MHS infusion by healthcare practitioners. Concluding Chapter 5 (Section 5.4) is a revised model for exploring MHS infusion

at an individual level of analysis (Figure 6-1) with nine hypotheses. The nine hypotheses are as follows and will be examined later in this chapter:

- H1: Availability of MHS positively impacts the infusion of MHS by healthcare practitioners.
- H2: MHS self-efficacy impacts upon healthcare practitioners' infusion of MHS
- H3: The ability of MHS to support healthcare practitioners with decision making in urgent situations positively impacts the infusion of MHS.
- H4: Habits formed by healthcare practitioners' impacts the infusion of MHS by healthcare practitioners.
- H5: Healthcare practitioners' trust in the MHS technology positively impacts MHS self-efficacy.
- H6: Healthcare practitioners' trust in the MHS technology positively impacts upon their willingness to use MHS in urgent situations.
- H7: The documentary practices performed by team members when delivering healthcare services impacts fellow healthcare practitioners use of MHS in urgent situations.
- H8: Working as part of a team when delivering healthcare services to patients influences healthcare practitioners MHS behaviour.
- H9: Infusion of MHS positively impacts healthcare practitioners' performance in terms of clinical care, workflow and learning.

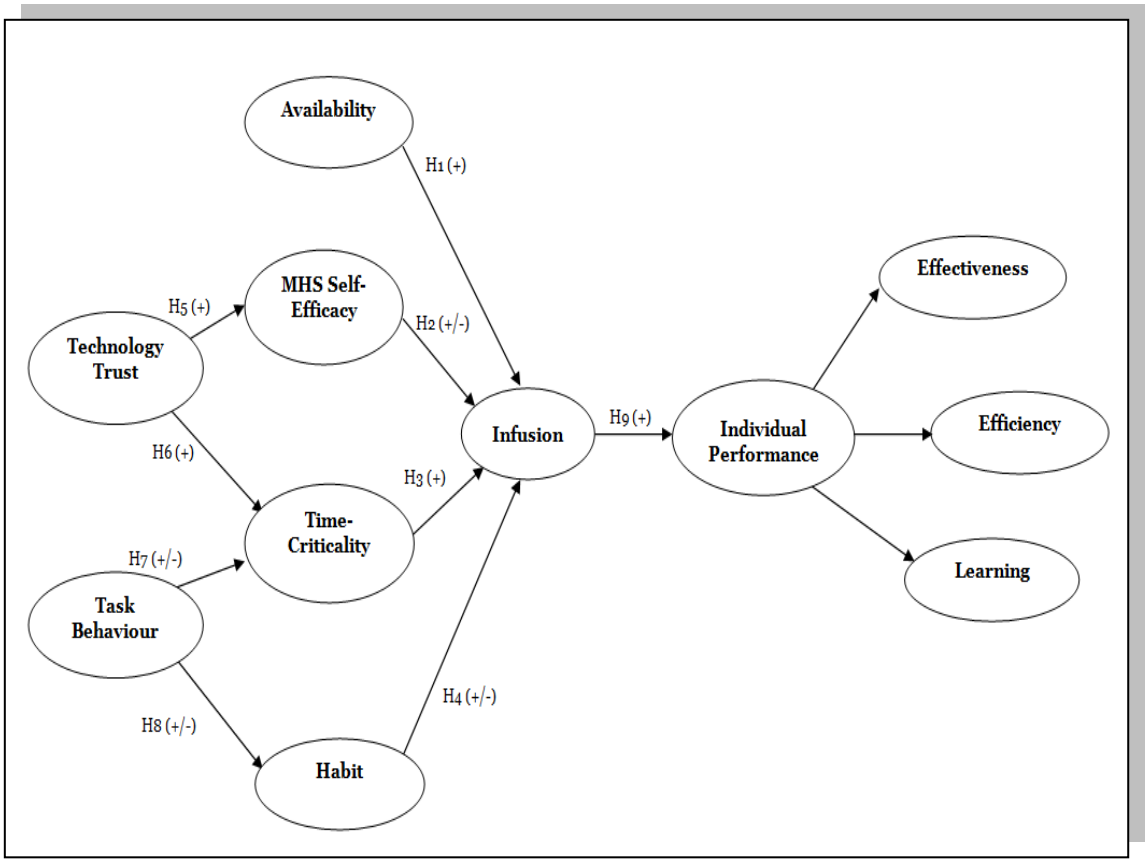



**Figure 6-1: Conceptual Model from Qualitative Findings**

## 6.3 Survey Administration: Overview

In Section 6.3, the response rate for the study is depicted (Section 6.3.1). The next section describes the results from examining bias in the survey data collection method (Section 6.3.2). It is established that the survey instrument used in this research is free from nonresponse bias and common method bias. Moreover, G*Power analysis was conducted (Section 6.3.3) and reveals that the sample size of 101 survey is appropriate for rejecting the null hypothesis. Finally, respondents' profiles are presented (Section 6.3.4).

### 6.3.1 Response Rate

Response rate refers to the ratio of number of people who answered the survey divided by the number of people in the sample (Fowler, 2002). A total of 157 responses were obtained from various healthcare practitioners via the administration of an online survey (871 physicians in total), yielding a response rate of 18%.

### 6.3.2 Bias in Web Surveys

Nonresponse bias and common method variance bias were examined in this research study. Firstly, non-response bias was overcome by incorporating key guideline practices when designing the web survey (depicted in Section 4.6.1.4). Moreover, a two-sample (independent groups) t-test was used to compare early with late respondents whereby the means of the two populations were examined. For nonresponse bias not to be an issue, it is required that the means of both the early and late respondents are not substantially different (see Section 4.6.1.4 for more details). Table 6-1 presents the results from conducting a two sample t-test. It is evident from Table 6-1 that the means across the early and late respondents do not differ substantially for infusion. Hence, the researcher believes the threat to internal validity of the results is limited.

**Table 6-1: Results from Two Sample T-Test (Non-Response Bias)**

| Group Statistics | | | |
|---|---|---|---|
| | **Early Or Late[14]** | **N** | **Mean** |
| **Feature Use** | (Early) April & May | 46 | 7.6087 |
| | (Late) June & July | 55 | 7.3636 |
| **Integrative Use** | (Early) April & May | 46 | 7.2826 |
| | (Late) June & July | 55 | 7.1273 |
| **Exploratory Use** | (Early) April & May | 46 | 6.5870 |
| | (Late) June & July | 55 | 6.2000 |

Next, Common Method Variance (CMV) bias was examined. To reduce the potential of CMV the instrument was first designed using several reverse-scored items in the principal constructs to reduce single rating problems. Second, a one-factor Harman test was performed to examine for CMV. The basic assumption of this technique, according to Podsakoff et al., (2003), is that if a single factor emerges from the

[14] Data was gathered over a five month period from April 2012 to July 2012.

unrotated extraction analysis or one general factor accounts for the majority of the covariance among the measures then a substantial amount of CMV is present. The results of a Harman's one-factor (or single-determinant) test showed that fourteen factors were present and the most covariance explained by one factor is 32%. Covariance equal to or exceeding 50% indicates the presence of CMV (Podsakoff et al., 2003). Based on this, CMV in this study is not a likely contaminant of the results. For a more descriptive overview of CMV please refer to Chapter 4, Section 4.6.1.4.

### 6.3.3 G*Power Analysis

G*Power version 3.1.2 was used to conduct power analysis and to establish whether the sample size was appropriate to reject the null hypotheses (i.e. the determinants do not have an impact on infusion and subsequent individual level outcomes). Power values close to one can indicate if the null hypothesis can be rejected or not. In this research study G*Power analysis revealed a power of 0.9987202, thus this study rejects the null hypothesis. The results indicate that a sample size of 101 is more than sufficient to explain medium population effects, as per Cohen (1988). For additional information pertaining to G*Power analysis please see Chapter 4, Section 4.6.1.6.

### 6.3.4 Respondent Profiles

After excluding 56 incomplete responses from the 157 received, 101 surveys were usable for data analysis. Table 6-2 presents the demographic characteristics of the survey sample. Overall, the demographic data gathered via the survey indicates that the respondents are representative of the intended target population by meeting the three criteria outlined in Chapter 4 (Section 4.5.1.4).

**Table 6-2: Demographic Characteristics of the Survey Sample (n=101)**

| | Value | Count | Percent |
|---|---|---|---|
| **Age Group** | 18 – 25 years | 2 | 2% |
| | 26 – 40 years | 57 | 56.4% |
| | 41 – 55 years | 25 | 24.8% |
| | 56 – 65 years | 14 | 13.9% |
| | > 65 years | 3 | 3% |
| **Gender** | Male | 59 | 58.4% |
| | Female | 42 | 41.6% |
| **Occupation** | Attending Physician | 54 | 53.5% |
| | Resident/Fellow | 47 | 46.5% |
| **Timeframe** | 6 months – 8 months | 23 | 22.8% |
| | 9 months – 11 months | 10 | 9.9% |
| | 1 year | 41 | 40.6% |
| | 1-3 years | 20 | 19.8% |
| | 3+ years | 7 | 6.9% |

Building from this section, Section 6.4 evaluates the model. This is pertinent to ensure that the model is robust and valid. Furthermore, it presents the findings from the testing of nine hypotheses (outlined in Section 6.2).

## 6.4 Individual Mobile Health Infusion: Model Evaluation

This section assesses the model in terms of its measure (Section 6.4.1) and structure (Section 6.4.2). The measurement (outer) model portrays the relationships between a construct and its associated variables (measurement items) whereas the structural (inner) model represents direct and indirect unobservable relationships among constructs (Chatelin et al., 2002; Tenehaus et al., 2005; Diamantopoulos and Siguaw, 2006). Analysis reveals that the model passes several validity and reliability tests and that the majority of path relationships identified in the model (via hypothesis creation) produce significant results. The researcher also performs multi-group analysis for any potential influence on MHS infusion (Section 6.4.3).

### 6.4.1 Measurement Model Evaluation

The first criterion of assessing the measurement model is reliability and the second is validity. However, prior to evaluating the model, the questions used for survey data collection are presented.

Technology Trust, Task Behaviour, Availability, MHS Self-Efficacy, Time-Criticality, Habit, Infusion, Effectiveness, Efficiency and Learning were measured using a range of reflective items adapted from extant literature and the case study findings (Table 6-3). Each construct in the model has a number of items for measurement purposes, which were all pre-tested to ensure their reliability and validity. All statements were measured on a five-point Likert scale (1=strongly disagree, 5=strongly agree), which is consistent with existing sources from which these items were selected.

**Table 6-3: Questions Used for Survey Data Collection**

| Construct | Item | Item Description | Adapted from: |
|---|---|---|---|
| Availability | Avail1 | I have no difficulty findings a MHS to use when required. | Taylor and Todd (1995) |
| | Avail2 | When providing healthcare services, availability of MHS is not a problem. | |
| | Avail3 | There are sufficient amounts of MHS for me to use in the department in which I am predominantly located. | |
| MHS Self-Efficacy | SE1 | I have the necessary skills for using MHS. | Ng and Kim (2009) |
| | SE2 | I am self-assured about my capabilities to use the MHS. | |
| | SE3 | I am confident in my ability to use the MHS. | |
| Time - Criticality | TC1 | In emergency situations, I use MHS to access patient information. | Gebauer et al., (2007), Gebauer and Tang (2008) |
| | TC2 | In urgent situations, I use MHS to help me make clinical decisions. | |
| | TC3 | Timeliness, in terms of accessing relevant patient information through MHS, is a critical element in urgent situations. | |
| Habit | Hab1 | The use of MHS has become a habit for me. | Limayem and Hirt (2003) |
| | Hab2 | Using the MHS has become automatic to me. | Limayem et al., (2007) |
| | Hab3 | The use of the MHS has become a routine practice when providing healthcare services. | |
| *Technology Trust: Reliability, Functionality(Second-Order Construct)* | | | |
| Reliability | TTRel1 | The MHS is very reliable. | McKnight et al., (2011) |
| | TTRel2 | The MHS is extremely dependable. | |
| | TTRel3 | The MHS does not malfunction for me. | |
| Functionality | TTFun1 | The MHS has the functionality I need. | |
| | TTFun2 | The MHS has the features I require. | |
| | TTFun3 | The MHS has the ability to do what I want it to do. | |

| Construct | Item | Item Description | Adapted from: |
|---|---|---|---|
| Task Behaviour | TB1 | I process information from many sources through MHS. | Gebauer et al., (2007) |
| | TB2 | MHS enable me to share patient information with other healthcare professionals. | |
| | TB3 | I require accurate information through MHS from other healthcare professionals. | Pearce and Gregersen (1991) |
| *Infusion: Feature Use, Integrative Use, Exploratory Use (Second-Order Construct)* | | | |
| Feature Use | InfFeat1 | I use all of the capabilities offered through MHS. | Ramamurthy et al., (2008), Jones et al., (2002) |
| | InfFeat2 | I use most of the available features on the MHS. | |
| | InfFeat3 | I only use a limited amount of the available features offered through MHS. | |
| Integrative Use | InfInt1 | I use the data accessed through MHS to support me when delivering healthcare services. | Ng and Kim (2010) |
| | InfInt2 | I use the data accessed through MHS to organise which patients I meet first. | |
| | InfInt3 | I use the data accessed through MHS to coordinate the delivery of healthcare services. | |
| Exploratory Use | InfExp1 | I explore the features of MHS (e.g. exploring medical reference resources). | Saeed and Abdinnour-Helm (2008) |
| | InfExp2 | I often search for new medical/clinical information through MHS (outside of the primary application). | Agarwal and Karahanna (2000) |
| | InfExp3 | I use the MHS in novel ways. | Hsieh and Wang (2007) |
| *Individual Performance: Effectiveness, Efficiency, Learning (Second-Order Construct)* | | | |
| Effectiveness | Effect1 | In my experience using MHS increases the quality of patient care. | Junglas et al., (2009) |
| | Effect2 | Using the MHS helps improve the diagnosis of patients. | Pinnock et al., (2006); Katz and Rice (2009) |
| | Effect3 | Using the MHS helps improve the treatment of patients. | |
| | Effect4 | Using the MHS helps improve the monitoring and management of disease within the hospital. | |
| Efficiency | Effic1 | Using MHS saves me time when delivering healthcare services as information is readily available. | Torkzadeh and Doll (1999) |
| | Effic2 | Using the MHS makes it easier to provide healthcare services. | Junglas et al., (2009) |
| | Effic3 | In my experience using MHS encourages me to follow clinical guidelines/protocol. | DesRoches et al., (2008) |
| | Effic4 | The MHS supports me in interacting with patients when they request more information. | Junglas et al., (2009) |

| Construct | Item | Item Description | Adapted from: |
|---|---|---|---|
| Learning | Learn1 | Accessing medical reference resources through MHS help me learn more about delivering healthcare services to patients | Torkzadeh et al., (2011) |
| | Learn2 | Intervention alerts (e.g. drug-drug, drug-allergy interactions) when using MHS help me learn more about delivering healthcare services to patients. | |
| | Learn3 | MHS are a convenient source of information or means of communication that assist me with medical learning. | |

The complete set of measures were presented to and discussed with experienced academics to ensure completeness and clarity prior to survey distribution (Chapter 4). Now, the test pertaining to the reliability and validity of these constructs measurements are subsequently presented.

**Reliability:** In this study, reliability of construct measurements was evaluated by examining the Average Variance Extracted (AVE) and Composite Reliability (CR). For a description of these techniques please see Section 4.6.2.2. All constructs exhibited AVE and CR greater than the acceptable level of 0.6 (Table 6-4).

**Table 6-4: Internal Consistency Reliability Test**

| | AVE | Composite Reliability |
|---|---|---|
| **Availability** | 0.683043 | 0.865896 |
| **Effectiveness** | 0.677176 | 0.893287 |
| **Efficiency** | 0.704462 | 0.877246 |
| **Exploratory Use** | 0.685940 | 0.867575 |
| **Feature Use** | 0.669045 | 0.857895 |
| **Functionality** | 0.762646 | 0.905905 |
| **Habit** | 0.831412 | 0.936686 |
| **Infusion*** | 0.664969 | 0.856085 |
| **Integrative Use** | 0.609556 | 0.823586 |
| **Learning** | 0.689059 | 0.868670 |
| **Performance*** | 0.730723 | 0.856089 |
| **Reliability** | 0.799689 | 0.922894 |
| **Self-Efficacy** | 0.835959 | 0.938574 |
| **Task Behaviour** | 1.0000 | 1.0000 |
| **Tech. Trust*** | 0.677311 | 0.90271385 |
| **Time-Criticality** | 0.677300 | 0.862856 |

* Denotes that manual calculations were performed.

SmartPLS does not accurately calculate the AVE and CR for second-order constructs. Therefore, in order to calculate AVE and CR for second-order constructs (marked with * in Table 6-4), the recommended manual calculations as suggested by Fornell and Larcker (1981), Tenenhaus et al., (2005), and Hair et al., (2010) were followed and depicted in Table 6-5.

**Table 6-5: AVE and CR for Second-Order Constructs**

| Second-Order Construct (SOC) | First-Order Constructs (FOC) | Path Coefficients from SOC to FOC | Communalities of FOC (Path coefficient)$^2$ | Variance of Error (1-communalities) |
|---|---|---|---|---|
| ***Infusion*** | Feature Use | 0.779 | 0.606841 (60%) | 1 - 0.605284 = 0.393159 |
| | Integrative Use | 0.821 | 0.674041 (67%) | 1 – 0.674041 = 0.325959 |
| | Exploratory Use | 0.845 | 0.714025 (72%) | 1 - 0. 714025 = 0.285975 |
| **AVE:** | (0.606841+ 0.674041 + 0. 714025)/3 = 0.664969 = 67% | | | |
| **CR:** | (0.779+0.821+0.845))^2/[(0.779+0.821+0.845)^2+(0.393159+0.325959+ 0.285975)] = *0.856085* | | | |
| ***Technology Trust*** | Reliability | 0.913 | 0.833569 (83%) | 1 - 0.833569 = 0.166431 |
| | Functionality | 0.901 | 0.811801 (81%) | 1 - 0.188199 = 0.188199 |
| **AVE:** | (0. 833569 +0. 811801)/2 = *0.822685* = 82% | | | |
| **CR:** | (0. 913+ 0. 901)^2/[(0. 913+ 0. 901)^2 + (0. 166431+ 0. 188199)] = *0.90271385* | | | |
| ***Individual Performance*** | Effectiveness | 0.946 | 0.894916 (89%) | 1 - 0.894916 = 0.105084 |
| | Efficiency | 0.842 | 0.708964 (71%) | 1 - 0.708964 = 0.291036 |
| | Learning | 0.767 | 0.588289 (59%) | 1 – 0. 588289 = 0.411711 |
| **AVE:** | (0. 894916 + 0. 708964 + 0. 588289)/3 = 0.730723 = 73% | | | |
| **CR:** | (0. 894916 + 0. 708964 + 0. 588289)^2/(0. 894916 + 0. 708964 + 0. 588289)^2 + (0.105084 + 0.291036 + 0.411711) = *0.856089* | | | |

***Individual Reliability*** (λ) of the indicators relies on the expectation that loadings of manifest variables should not be less than 0.707. Table 6-6 depicts that the majority of the indicators are higher than the 0.707 threshold (with the lowest value depicted at λ= 0.737). However, the following items fell below the 0.707 threshold; TB1 (λ = 0.673), TB2 (λ = 0.703), Effic3 (λ = 0.648) and will be removed from the model.

**Table 6-6: Loading of Manifest Variables**

| Latent Variable | Item | Loading Value (λ) |
|---|---|---|
| Technology Trust*[15] | Reliability | 0.913 |
| | Functionality | 0.901 |
| Reliability | TTRel1 | 0.901 |
| | TTRel2 | 0.917 |
| | TTRel3 | 0.864 |
| Functionality | TTFun1 | 0.877 |
| | TTFun2 | 0.908 |
| | TTFun3 | 0.833 |
| Task Behaviour | TB3 | 1.000 |
| Availability | Avail1 | 0.848 |
| | Avail2 | 0.846 |
| | Avail3 | 0.785 |
| Self-Efficacy | SE1 | 0.889 |
| | SE2 | 0.942 |
| | SE3 | 0.911 |
| Time-Criticality | TC1 | 0.856 |
| | TC2 | 0.816 |
| | TC3 | 0.798 |
| Habit | Hab1 | 0.912 |
| | Hab2 | 0.918 |
| | Hab3 | 0.905 |
| Infusion* | Feature Use | 0.779 |
| | Integrative Use | 0.821 |
| | Exploratory Use | 0.845 |
| Feature Use | InfFeat1 | 0.769 |
| | InfFeat2 | 0.894 |
| | InfFeat3 | 0.785 |
| Integrative Use | InfInt1 | 0.737 |
| | InfInt2 | 0.761 |
| | InfInt3 | 0.841 |
| Exploratory Use | InfExp1 | 0.816 |
| | InfExp2 | 0.829 |
| | InfExp3 | 0.839 |
| Individual Performance * | Effectiveness | 0.946 |
| | Efficiency | 0.840 |
| | Learning | 0.767 |
| Effectiveness | Effect1 | 0.800 |
| | Effect2 | 0.848 |
| | Effect3 | 0.871 |
| | Effect4 | 0.769 |

[15] * denotes second-order construct. Individual Reliability is assessed by examining the path coefficients between the second order latent variable to its first order latent variable (Fornell and Larcker, 1981; Terenhaus et al., 2005).

| Latent Variable | Item | Loading Value (λ) |
|---|---|---|
| Efficiency | Effic1 | 0.840 |
| | Effic2 | 0.864 |
| | Effic4 | 0.812 |
| Learning | Learn1 | 0.899 |
| | Learn2 | 0.754 |
| | Learn3 | 0.830 |

**Validity:** The second criterion to be examined is that of validity. Latent variable cross loadings were used to assess convergent validity and discriminant validity. Table 6-5 highlights that AVE exceeds 0.5, which indicates sufficient convergent validity (each latent variable explains more than 50% of their indicator variance on average). Discriminant validity refers to the extent to which a construct is different from other constructs in the model (described in Section 4.6.2.2). In order to achieve discriminant validity, the average variance extracted of a construct must be higher than the squared correlation of this construct with any other construct in the model.

Table 6-7 shows all constructs have sufficient discriminant validity. However, high correlations exist between second-order constructs and their associated first-order constructs. These include (a) Performance and Effectiveness (0.895) and Efficiency (0.705) (b) Infusion and Exploratory Use (0.714), Integrative Use (0.6067) and Integrative Use (0674) and, (c) Technology Trust and Functionality (0.812) and Reliability (0.833). These high correlations were expected due to the reflective nature of the second-order constructs.

Next, the loadings and cross-loadings of indicators were assessed (Table 6-7). No indicator variable should have a higher correlation with another latent variable than with its own latent variable, or the model is incorrectly specified. In general, indicator variables loaded higher on their respective construct than indicator variables intended for other constructs. Similar to the construct-cross loadings, the second-order constructs exhibited high variance with the indicator variables within their associated first-order construct. The results of these tests show that manifest variables (indicators) presented in the research model are reliable and valid.

**Table 6-7: Cross Construct Matrix**

| | AV | EU | EFFE | EFFI | FU | FUNC | HAB | IU | INF | LEAR | PERF | REL | SE | TC | TB | TT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **AV** | **0.683** | | | | | | | | | | | | | | | |
| **EU** | 0.1633 | **0.686** | | | | | | | | | | | | | | |
| **EFFE** | 0.1144 | 0.316 | **0.677** | | | | | | | | | | | | | |
| **EFFI** | 0.2417 | 0.292 | 0.465 | **0.704** | | | | | | | | | | | | |
| **FU** | 0.2232 | 0.216 | 0.195 | 0.233 | **0.669** | | | | | | | | | | | |
| **FUNC** | 0.2546 | 0.133 | 0.255 | 0.298 | 0.1412 | **0.763** | | | | | | | | | | |
| **HAB** | 0.2322 | 0.33 | 0.373 | 0.521 | 0.2176 | 0.349 | **0.831** | | | | | | | | | |
| **IU** | 0.1905 | 0.312 | 0.387 | 0.347 | 0.2217 | 0.307 | 0.232 | **0.61** | | | | | | | | |
| **INF** | 0.2892 | 0.714 | 0.442 | 0.436 | 0.6067 | 0.276 | 0.393 | 0.674 | **0.665** | | | | | | | |
| **LEARN** | 0.0826 | 0.401 | 0.446 | 0.229 | 0.0951 | 0.097 | 0.415 | 0.254 | 0.3586 | **0.689** | | | | | | |
| **PERF** | 0.1688 | 0.416 | 0.895 | 0.705 | 0.2305 | 0.297 | 0.474 | 0.452 | 0.5429 | 0.589 | **0.731** | | | | | |
| **REL** | 0.2326 | 0.077 | 0.156 | 0.163 | 0.0728 | 0.417 | 0.277 | 0.15 | 0.1463 | 0.072 | 0.17 | **0.8** | | | | |
| **SE** | 0.2827 | 0.238 | 0.125 | 0.174 | 0.228 | 0.198 | 0.287 | 0.14 | 0.3051 | 0.076 | 0.161 | 0.243 | **0.836** | | | |
| **TC** | 0.0195 | 0.212 | 0.184 | 0.162 | 0.1049 | 0.084 | 0.196 | 0.123 | 0.2188 | 0.127 | 0.206 | 0.061 | 0.0292 | **0.677** | | |
| **TB** | 0.0317 | 0.119 | 0.091 | 0.135 | 0.0065 | 0.035 | 0.18 | 0.062 | 0.0818 | 0.069 | 0.126 | 0.071 | 0.0791 | 0.319 | **1** | |
| **TT** | 0.2954 | 0.125 | 0.244 | 0.272 | 0.1259 | 0.812 | 0.38 | 0.267 | 0.2493 | 0.101 | 0.276 | 0.833 | 0.2702 | 0.088 | 0.064 | **0.677** |

AV=Availability, EU = Exploratory Use, EFFE=Effectiveness, EFFI=Efficiency, FU=Feature Use, FUNC=Functionality, HAB=Habit, IU=Integrative Use, INF= Infusion, LEARN=Learning, PERF = Performance, REL=Reliability, SE= MHS Self-Efficacy, TC=Time-Criticality, TB=Task Behaviour, TT=Technology Trust

**Table 6-8: Item Cross Loading**

| | AV | EFFE | EFFI | HAB | EU | FU | IU | LEAR | SE | TB | TC | FUNC | REL | INF* | PERF* | TT* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Avail1** | **0.848** | 0.369 | 0.514 | 0.501 | 0.431 | 0.354 | 0.371 | 0.278 | 0.45 | 0.231 | 0.234 | 0.44 | 0.332 | 0.477 | 0.438 | 0.423 |
| **Avail2** | **0.846** | 0.291 | 0.402 | 0.333 | 0.322 | 0.391 | 0.404 | 0.3209 | 0.502 | 0.123 | 0.079 | 0.46 | 0.51 | 0.458 | 0.358 | 0.535 |
| **Avail3** | **0.785** | 0.161 | 0.284 | 0.353 | 0.233 | 0.436 | 0.3 | 0.0934 | 0.357 | 0.074 | 0.016 | 0.342 | 0.353 | 0.393 | 0.201 | 0.384 |
| **Effect1** | 0.279 | **0.8** | 0.637 | 0.627 | 0.576 | 0.372 | 0.475 | 0.6381 | 0.312 | 0.351 | 0.373 | 0.429 | 0.361 | 0.587 | 0.809 | 0.434 |
| **Effect2** | 0.332 | **0.848** | 0.5 | 0.492 | 0.511 | 0.36 | 0.538 | 0.585 | 0.233 | 0.223 | 0.322 | 0.388 | 0.33 | 0.576 | 0.783 | 0.394 |
| **Effect3** | 0.233 | **0.871** | 0.589 | 0.488 | 0.427 | 0.406 | 0.472 | 0.508 | 0.369 | 0.304 | 0.392 | 0.398 | 0.327 | 0.532 | 0.801 | 0.398 |
| **Effect4** | 0.271 | **0.769** | 0.511 | 0.391 | 0.323 | 0.312 | 0.571 | 0.4567 | 0.242 | 0.098 | 0.321 | 0.451 | 0.279 | 0.488 | 0.714 | 0.4 |
| **Effic1** | 0.537 | 0.506 | **0.84** | 0.699 | 0.458 | 0.448 | 0.532 | 0.388 | 0.358 | 0.367 | 0.399 | 0.514 | 0.382 | 0.588 | 0.674 | 0.492 |
| **Effic2** | 0.433 | 0.585 | **0.864** | 0.575 | 0.332 | 0.41 | 0.548 | 0.3899 | 0.379 | 0.309 | 0.283 | 0.506 | 0.442 | 0.523 | 0.715 | 0.522 |
| **Effic4** | 0.277 | 0.62 | **0.812** | 0.548 | 0.569 | 0.359 | 0.405 | 0.4248 | 0.313 | 0.253 | 0.336 | 0.359 | 0.196 | 0.552 | 0.722 | 0.304 |
| **Hab1** | 0.455 | 0.546 | 0.673 | **0.912** | 0.479 | 0.417 | 0.409 | 0.375 | 0.406 | 0.363 | 0.457 | 0.53 | 0.488 | 0.536 | 0.627 | 0.562 |
| **Hab2** | 0.412 | 0.531 | 0.636 | **0.918** | 0.533 | 0.455 | 0.451 | 0.3731 | 0.565 | 0.405 | 0.366 | 0.578 | 0.547 | 0.592 | 0.606 | 0.621 |
| **Hab3** | 0.454 | 0.593 | 0.666 | **0.905** | 0.555 | 0.403 | 0.455 | 0.3856 | 0.488 | 0.39 | 0.392 | 0.507 | 0.404 | 0.583 | 0.65 | 0.502 |
| **InfExp1** | 0.454 | 0.423 | 0.47 | 0.529 | **0.816** | 0.421 | 0.523 | 0.559 | 0.445 | 0.29 | 0.36 | 0.395 | 0.346 | 0.734 | 0.527 | 0.409 |
| **InfExp2** | 0.246 | 0.519 | 0.411 | 0.477 | **0.829** | 0.396 | 0.432 | 0.517 | 0.295 | 0.244 | 0.423 | 0.219 | 0.109 | 0.69 | 0.548 | 0.18 |
| **InfExp3** | 0.295 | 0.458 | 0.46 | 0.415 | **0.839** | 0.332 | 0.426 | 0.4943 | 0.471 | 0.324 | 0.361 | 0.285 | 0.225 | 0.671 | 0.528 | 0.281 |
| **InfFeat1** | 0.412 | 0.341 | 0.399 | 0.344 | 0.3 | **0.769** | 0.359 | 0.1537 | 0.399 | 0.047 | 0.164 | 0.352 | 0.308 | 0.574 | 0.357 | 0.363 |
| **InfFeat2** | 0.452 | 0.457 | 0.443 | 0.427 | 0.504 | **0.894** | 0.489 | 0.3859 | 0.413 | 0.088 | 0.338 | 0.334 | 0.236 | 0.762 | 0.495 | 0.313 |
| **InfFeat3** | 0.279 | 0.26 | 0.333 | 0.368 | 0.3 | **0.785** | 0.278 | 0.1762 | 0.361 | 0.057 | 0.276 | 0.231 | 0.114 | 0.547 | 0.299 | 0.189 |
| **InfInt1** | 0.572 | 0.467 | 0.57 | 0.479 | 0.47 | 0.36 | **0.737** | 0.3602 | 0.469 | 0.405 | 0.263 | 0.473 | 0.485 | 0.643 | 0.534 | 0.529 |
| **InfInt2** | 0.159 | 0.501 | 0.358 | 0.287 | 0.448 | 0.358 | **0.761** | 0.4318 | 0.146 | 0.033 | 0.259 | 0.339 | 0.129 | 0.629 | 0.511 | 0.254 |
| **InfInt3** | 0.287 | 0.488 | 0.448 | 0.358 | 0.389 | 0.384 | **0.841** | 0.3889 | 0.258 | 0.144 | 0.297 | 0.482 | 0.288 | 0.649 | 0.528 | 0.422 |
| **Learn1** | 0.259 | 0.647 | 0.429 | 0.433 | 0.684 | 0.311 | 0.483 | **0.8992** | 0.345 | 0.296 | 0.321 | 0.296 | 0.211 | 0.614 | 0.732 | 0.278 |
| **Learn2** | 0.005 | 0.456 | 0.23 | 0.15 | 0.25 | 0.093 | 0.351 | **0.7545** | -0.02 | 0.042 | 0.178 | 0.178 | 0.124 | 0.283 | 0.529 | 0.165 |

| | AV | EFFE | EFFI | HAB | EU | FU | IU | LEAR | SE | TB | TC | FUNC | REL | INF* | PERF* | TT* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Learn3** | 0.416 | 0.54 | 0.508 | 0.41 | 0.585 | 0.334 | 0.409 | **0.8302** | 0.307 | 0.28 | 0.373 | 0.29 | 0.322 | 0.551 | 0.63 | 0.338 |
| **SE1** | 0.53 | 0.291 | 0.388 | 0.514 | 0.461 | 0.409 | 0.249 | 0.2779 | **0.889** | 0.32 | 0.163 | 0.36 | 0.407 | 0.465 | 0.359 | 0.425 |
| **SE2** | 0.501 | 0.366 | 0.401 | 0.508 | 0.467 | 0.497 | 0.411 | 0.2371 | **0.942** | 0.226 | 0.138 | 0.462 | 0.514 | 0.564 | 0.391 | 0.541 |
| **SE3** | 0.428 | 0.304 | 0.353 | 0.449 | 0.41 | 0.393 | 0.352 | 0.2462 | **0.911** | 0.236 | 0.172 | 0.389 | 0.421 | 0.476 | 0.347 | 0.448 |
| **TB3** | 0.178 | 0.302 | 0.368 | 0.424 | 0.345 | 0.081 | 0.25 | 0.2632 | 0.281 | **1** | 0.565 | 0.186 | 0.266 | 0.286 | 0.355 | 0.252 |
| **TC1** | 0.159 | 0.34 | 0.281 | 0.349 | 0.34 | 0.276 | 0.279 | 0.2711 | 0.133 | 0.414 | **0.855** | 0.253 | 0.256 | 0.367 | 0.341 | 0.282 |
| **TC2** | 0.034 | 0.428 | 0.342 | 0.352 | 0.365 | 0.321 | 0.387 | 0.3558 | 0.118 | 0.335 | **0.816** | 0.22 | 0.151 | 0.438 | 0.432 | 0.205 |
| **TC3** | 0.142 | 0.302 | 0.364 | 0.384 | 0.42 | 0.213 | 0.217 | 0.2615 | 0.165 | 0.606 | **0.798** | 0.239 | 0.201 | 0.356 | 0.352 | 0.243 |
| **TTFun1** | 0.489 | 0.445 | 0.472 | 0.554 | 0.357 | 0.313 | 0.508 | 0.2765 | 0.434 | 0.19 | 0.241 | **0.877** | 0.644 | 0.48 | 0.478 | 0.834 |
| **TTFun2** | 0.41 | 0.462 | 0.465 | 0.518 | 0.283 | 0.381 | 0.526 | 0.2808 | 0.397 | 0.18 | 0.233 | **0.908** | 0.555 | 0.48 | 0.489 | 0.8 |
| **TTFun3** | 0.42 | 0.415 | 0.498 | 0.472 | 0.315 | 0.287 | 0.41 | 0.2596 | 0.328 | 0.111 | 0.288 | **0.833** | 0.484 | 0.413 | 0.459 | 0.721 |
| **TTRel1** | 0.409 | 0.293 | 0.361 | 0.494 | 0.219 | 0.24 | 0.305 | 0.2371 | 0.463 | 0.187 | 0.183 | 0.555 | **0.901** | 0.313 | 0.338 | 0.809 |
| **TTRel2** | 0.451 | 0.384 | 0.399 | 0.554 | 0.334 | 0.285 | 0.412 | 0.2431 | 0.548 | 0.355 | 0.321 | 0.606 | **0.917** | 0.423 | 0.394 | 0.847 |
| **TTRel3** | 0.434 | 0.383 | 0.321 | 0.358 | 0.186 | 0.196 | 0.318 | 0.2373 | 0.304 | 0.166 | 0.156 | 0.571 | **0.864** | 0.285 | 0.373 | 0.792 |

The results depicted in this section illustrates that the model and its components are robust in terms of reliability and validity. Having established and evaluated the measurement model, the researcher focuses her attention on the evaluation of the structural model, which is presented in Section 6.4.2.

### 6.4.2 Structural Model Evaluation

Structural model evaluation is the assessment of the predictive or causal relationship between constructs in the model. This section assesses the structural model (Section 6.4.2.1) and examines the hypotheses (Section 6.4.2.2).

#### 6.4.2.1 Assessment of Structural Model

A PLS structural model is mainly evaluated by the coefficient of determination ($R^2$) of endogenous variables, effect size techniques, and predictive relevance (estimated using the Stone-Geisser's $Q^2$ test). Please see Section 4.6.2.3 for a description on all three techniques.

Firstly, to assess the statistical significance of the model, the PLS Algorithm in SmartPLS was run to calculate the $R^2$ for the model. The constructs Availability, MHS Self-Efficacy, Time-Criticality, Habit, Technology Trust and Task Behaviour were predictive of Infusion with $R^2$ of 0.556. The central criterion for evaluating the structural model is the level of explained variance of the dependent construct Individual Performance, for which the $R^2$ was 0.543. $R^2$ values of 0.67, 0.33 or 0.19 are described by Chin (1998, page 323) as “substantial”, “moderate” or “weak” respectively. Applying this criterion, all the relationships in the conceptual model are considered moderate.

Second, effect sizes were determined by comparing the explained amount of variance when a predictor is either included or not included in the model, that is, $f^2 = (R^2\text{incl} - R^2\text{excl})/ (1 - R^2\text{incl})$. According to Cohen (1988), $f^2$ values of 0.02, 0.15, and 0.35 signify small, medium, and large effects, respectively. The results of the

effect size investigation show that infusion has a small effect on individual performance (with $f^2$ equals 0.074).

**Table 6-9: Effect Size Test on Individual Performance**

| Construct | *R2incl* | *R2excl* | *f2* | Effect |
|---|---|---|---|---|
| **Infusion** | 0.556 | 0.523 | 0.074 | Small |

Thirdly, the predictive relevance of the structural model was assessed. That is, how well the observed values are reproduced by the model and its parameter estimates. Based on this, the blindfolding procedure was used to produce general cross-validating metrics $Q^2$, that is $Q^2 = (Q^2\text{incl} - Q^2\text{excl})/ (1 - Q^2\text{incl})$. Chin (1998) stated that positive $Q^2$ greater than zero provides evidence that the model is argued to have predictive validity. Conversely, negative $Q^2$ reflects absence of predictive relevance. Table 6-10 shows that all values of $Q^2$ exceeded zero, thus the predictive validity of the model was established.

**Table 6-10: Blindfolding Test for Predictive Relevance**

| Total | ∑SO | ∑SE | $Q^2$ |
|---|---|---|---|
| **Exploratory Use** | 306.000000 | 171.309536 | 0.440165 |
| **Effectiveness** | 408.000000 | 154.890407 | 0.620367 |
| **Efficiency** | 306.000000 | 153.980775 | 0.496795 |
| **Feature Use** | 306.000000 | 184.964810 | 0.395540 |
| **Functionality** | 306.000000 | 115.771909 | 0.621660 |
| **Habit** | 306.000000 | 263.720659 | 0.138168 |
| **Integrative Use** | 306.000000 | 188.094295 | 0.385313 |
| **Infusion** | 918.000000 | 706.752435 | 0.230117 |
| **Learning** | 306.000000 | 179.957275 | 0.411904 |
| **Performance** | 918.000000 | 668.684354 | 0.271586 |
| **Reliability** | 306.000000 | 94.808507 | 0.690168 |
| **Self -Efficacy** | 306.000000 | 238.002070 | 0.222215 |
| **Time-Criticality** | 306.000000 | 236.458819 | 0.227259 |

#### 6.4.2.2 Predictive Power: Hypotheses Testing

The model derived from the qualitative findings presented a total of nine hypotheses that focused on the determinants which impact individual infusion of MHS and subsequent outcomes. Each structural path in the research model (Figure 6-1)

represents a hypothesis. The hypotheses were tested (i.e. examining strength and significance) by employing the bootstrapping re-sampling technique to calculate the corresponding t-values for each path, in order to assess the significance of path estimates. The bootstrapping procedure was undertaken using 101 cases with 1000 samples to produce stable results. The results are shown in Table 6-11.

Figure 6-2 presents the graphical output for the structural model evaluation. This figure portrays the path coefficients and their associated significance levels, t-values (in blue font), and $R^2$ values.

**Table 6-11: Path Coefficients and Significance Levels**

| | Association | T Statistics | Significant (1-tailed) | Significant (2-tailed) |
|---|---|---|---|---|
| + | Availability -> Infusion | 2.717612 | p<0.005 × × | ---- |
| +- | Self-Efficacy -> Infusion | 2.383598 | ---- | p < 0.05* |
| + | Time-Criticality -> Infusion | 4.261993 | p<0.0005 × × × | ---- |
| +- | Habit -> Infusion | 2.484910 | ---- | p < 0.01** |
| + | Tech. Trust -> Self-Efficacy | 5.845051 | p<0.0005 × × × | ---- |
| + | Tech. Trust -> Time-Criticality | 1.841006 | NS | ---- |
| +- | Task Behaviour -> Time-Criticality | 5.340515 | ---- | p < 0.001*** |
| +- | Task Behaviour -> Habit | 3.545709 | ---- | p < 0.001*** |
| + | Infusion -> Performance | 14.27402 | p<0.0005 × × × | ---- |
| | Overview: | | p<0.005 × ×<br>p<0.0005 × × × | t> 1.96 @ p<0.05*<br>t> 2.576 @ p<0.01**<br>t> 3.29 @ p<0.001*** |

The results from testing the hypotheses are further presented below:

*H1 (Availability of MHS positively impacts the infusion of MHS by healthcare practitioners) is accepted.* Results show that a positive association exists between availability of MHS and infusion (AV → INF, $\beta = 0.251$, $p<0.005$). This means the higher the number of MHS available to the end user, the greater occurrence of MHS infusion.

*H2 (MHS self-efficacy impacts upon healthcare practitioners' infusion of MHS) is accepted.* A positive, direct relationship was established between MHS self-efficacy and infusion (SE → INF, $\beta = 0.233$, $p<0.05$). This result shows that the more self-

efficacious healthcare practitioners are, the more confident they are with infusing MHS, thereby improving infusion.

*H3 (The ability of MHS to support healthcare practitioners with decision making in urgent situations positively impacts the infusion of MHS) is accepted.* As postulated, a positive, direct relationship was established (TC → INF, $\beta = 0.279$, $p<0.0005$). This result shows that the higher the number of healthcare practitioners' willing to use MHS in urgent situations, the greater occurrence of MHS infusion.

*H4 (Habits formed by healthcare practitioners' impacts the infusion of MHS by healthcare practitioners) is accepted.* Results show that a positive association exists between the direct relationships of habit and infusion (HAB → INF, $\beta = 0.258$, $p<0.01$). This result shows that when habit increases there is a subsequent increase in the infusion of MHS.

*H5 (Healthcare practitioners' trust in the MHS technology positively impacts MHS self-efficacy) is accepted.* The association between technology trust and MHS self-efficacy was tested and found significant (TT → SE, $\beta = 0.520$, $p<0.0005$). This means that where there are greater levels of trust in the MHS, self-efficacy of healthcare practitioners improves.

*H6 (Healthcare practitioners' trust in the MHS technology positively impacts upon their willingness to use MHS in urgent situations) is <u>not</u> accepted.* While technology trust was found to be significantly associated with self-efficacy (H5), the study did not support the relationship between technology trust and time-criticality (TT → TC, $\beta = 0.165$).

*H7 (The documentary practices performed by team members when delivering healthcare services impacts fellow healthcare practitioners use of MHS in urgent situations) is accepted.* The direct relationship between task behaviour and time-criticality was also tested and found significant (TB → TC, $\beta = 0.523$, $p<0.001$). This result denotes that the documentary practices performed by team member impacts fellow healthcare practitioners use of MHS in urgent situations. That is, using the MHS when performing tasks in time-critical situations improves when

fellow team members electronically document patient data in a complete and comprehensive manner via the MHS.

*H8 (Working as part of a team when delivering healthcare services to patients influences healthcare practitioners MHS behaviour) is accepted.* The relationship between task behaviour and habit was found to be positive and significant (TB → HAB, $\beta = 0.424$, $p<0.001$). This shows that habitual routines are seen to increase with higher instances of task behaviour.

After testing the hypotheses surrounding the determinants of MHS infusion (research question 3[16]), additional tests were performed to answer research question 4[17]. In doing so, the tests were performed focusing on hypotheses pertaining to individual performance.

*H9 (Infusion of MHS positively impacts healthcare practitioners' performance in terms of clinical care, workflow and learning) is accepted.* Results show that a positive association exists between the direct relationships of infusion and individual performance (INF → PERF, $\beta = 0.737$, $p<0.0005$). This result shows that as infusion increases, individual performance improves (i.e. improvements in delivering clinical care to patients, workflow and learning).

It is also important to examine external determinants which may influence the findings presented thus far. Therefore, Section 6.4.3 presents the findings from examining timeframe in the context of this research study.

[16] Research Question 3: To what extent do determinants impact individual infusion of MHS?

[17] Research Question 4: To what extent does individual infusion of MHS impact outcomes?

**Table 6-12: Summary of Hypothesis Testing**

| Hypotheses | Accepted |
|---|---|
| H1: Availability of MHS positively impacts the infusion of MHS by healthcare practitioners | ✓ |
| H2: MHS self-efficacy impacts upon healthcare practitioners' infusion of MHS. | ✓ |
| H3: The ability of MHS to support healthcare practitioners with decision making in urgent situations positively impacts the infusion of MHS. | ✓ |
| H4: Habits formed by healthcare practitioners' impacts the infusion of MHS by healthcare practitioners. | ✓ |
| H5: Healthcare practitioners' trust in the MHS technology positively impacts MHS self-efficacy. | ✓ |
| H6: Healthcare practitioners' trust in the MHS technology positively impacts upon their willingness to use MHS in urgent situations | **x** |
| H7: The documentary practices performed by team members when delivering healthcare services impacts fellow healthcare practitioners use of MHS in urgent situations. | ✓ |
| H8: Working as part of a team when delivering healthcare services to patients influences healthcare practitioners MHS behaviour. | ✓ |
| H9: Infusion of MHS positively impacts healthcare practitioners' performance in terms of clinical care, workflow and learning. | ✓ |

(* p<0.01, **p<0.05; *** p <0.001 – Significant using *two*-tailed test)
(ˣˣ p<0.005; ˣˣˣ p <0.0005 – Significant using *one*-tailed test)

Positive Relationship

Hypotheses not supported

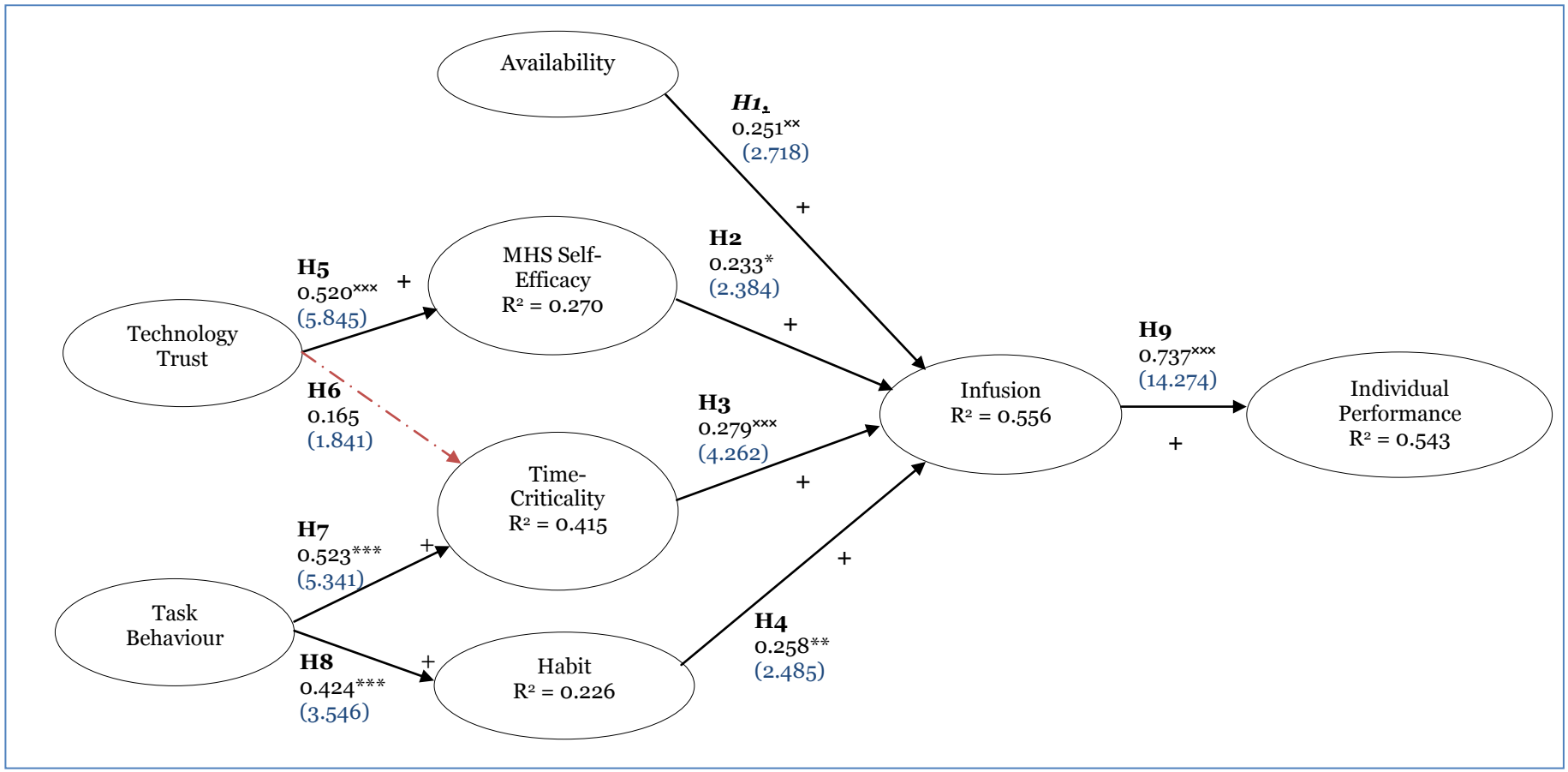



**Figure 6-2: Structural Model Evaluation**

### 6.4.3 Multi-Group Analysis: Timeframe

In order to analyse if the infusion process diverge between people using MHS during their daily work practices over different time periods (i.e. timeframe), two subsamples were used: one for healthcare practitioners who were using the MHS for one year or less, called 'group one' (74 participants) and the other for those individuals who were using the MHS for more than one year, called 'group two' (27 participants). The inclusion of timeframe in this research study and a description of multi-group analysis are described in Section 4.6.2.4.

Statistically significant differences between the path coefficients of the sub-samples were measured by performing a *t*-test with pooled standard errors. The empirical results of the structural path' analysis for each group is presented in Table 6-13. From the analysis performed one relationship (TT -> TC) was found to differ across both groups investigated (t= -1.995, p<0.05). However, this did not impact the overall MHS infusion process by healthcare practitioners.

**Table 6-13: Multi-Group Analysis**

| Influence | Regression Weight | Standard Error | T-Statistic |
|---|---|---|---|
| **TT -> SE** | **Group1:** 0.480 | **Group1:** 0.116212 | 0.3189 |
| | **Group2:** 0.411 | **Group2:** 0.170804 | |
| **TT -> TC** | **Group1:** 0.083 | **Group1:** 0.103248 | -1.995* |
| | **Group2:** 0.456 | **Group2:** 0.131342 | |
| **TB -> TC** | **Group1:** 0.516 | **Group1:** 0.109745 | -0.2369 |
| | **Group2:** 0.563 | **Group2:** 0.138429 | |
| **TB ->HAB** | **Group1:** 0.435 | **Group1:** 0.141524 | 0.1615 |
| | **Group2:** 0.391 | **Group2:** 0.239213 | |
| **AV -> INF** | **Group1:** 0.213 | **Group1:** 0.112394 | -0.4034 |
| | **Group2:** 0.300 | **Group2:** 0.187451 | |
| **SE -> INF** | **Group1:** 0.246 | **Group1:** 0.137116 | -0.3891 |
| | **Group2:** 0.345 | **Group2:** 0.198267 | |
| **TC -> INF** | **Group1:** 0.264 | **Group1:** 0.079051 | -0.1132 |
| | **Group2:** 0.288 | **Group2:** 0.195860 | |
| **HAB -> INF** | **Group1:** 0.303 | **Group1:** 0.115676 | 0.7058 |
| | **Group2:** 0.136 | **Group2:** 0.238184 | |
| **INF -> PERF** | **Group1:** 0.732 | **Group1:** 0.064731 | -0.4133 |
| | **Group2:** 0.782 | **Group2:** 0.096715 | |

* significant at p<0.05

## 6.5 Chapter Summary

The main objective of this study is to explore the determinants and outcomes of MHS infusion. In order to address this objective two research questions are investigated, building on the findings from Chapter 5. These two research questions include (a) To what degree do the determinants impact individual infusion of MHS? And (b) To what degree does individual infusion of MHS impact outcomes?

Research question 3 set out to investigate "To what degree does the determinants (based on the findings from the qualitative case study) impact individual infusion of MHS"? Collectively, Availability, MHS Self-Efficacy, Time-Criticality, Habit, Technology Trust and Task Behaviour contribute to the individual infusion of MHS in a healthcare domain. All the relationships between these determinants and infusion were found to be positive. This signifies that the greater presence of these determinants establishes greater infusion of MHS. Time-criticality was a significant contributor to directly influence infusion. Indirectly, task behaviour also plays a critical role in the infusion process. The weakest association (in terms of significance) in the model was found between technology trust and time-criticality. Based on research question 3, eight hypotheses were established (from Chapter 5) and tested. One (H5) from these eight hypotheses was rejected since the relationship was found insignificant due to the sample size of 101 in this study. The remaining seven hypotheses (H1, H2, H3, H4, H6, H7 and H8) were accepted (Figure 6-3).

Research question 4 (To what degree does individual infusion of MHS impact outcomes?) was explored by examining the degree individual infusion of MHS impacts individual outcomes. The statistical analysis of the survey data revealed that infusion of MHS by individual practitioners was found to positively impact individual performance (Effectiveness, Efficiency, Learning respectively).

To account for possible confounds, multi-group analysis was performed between people using MHS during their daily work practices over different time periods (i.e. timeframe). During this analysis, healthcare practitioners who were using the MHS for longer than two years were found to be more willing to use MHS in urgent

situations as opposed to healthcare practitioners using the MHS for one year or less. However, this finding did not influence the infusion process overall.

Overall, eight hypotheses from nine were supported (refer to Table 6-12) in the revised model derived from the findings presented in chapter 5. From this chapter, the model is validated (see Figure 6-8). These findings present some interesting points for discussion. To this end, the next chapter (7) will discuss the findings from both case study and survey before focusing on the implications of this research and major contributions in terms of theory and practice.

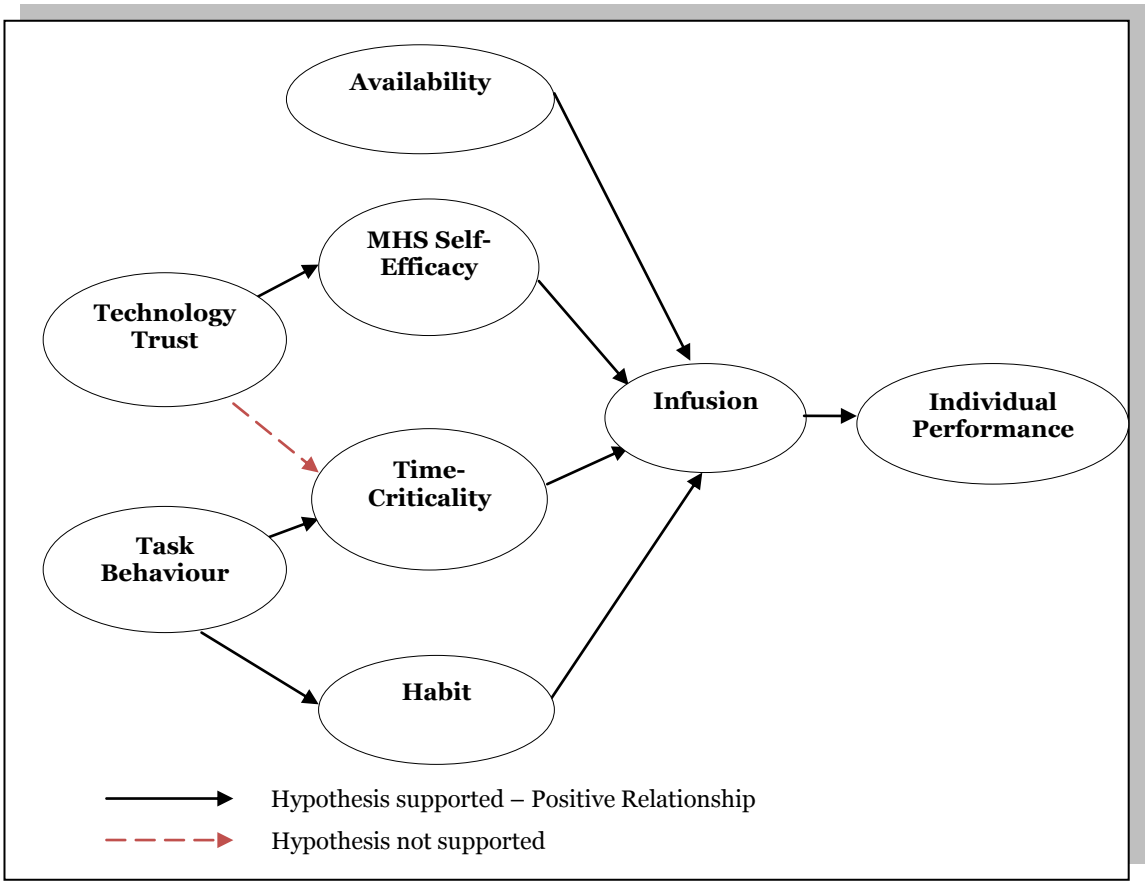



**Figure 6-3: Final Version of MHS Infusion Model**

# CHAPTER 7: DISCUSSION AND CONCLUSIONS

## 7.1 Introduction

This chapter draws on previous chapters to discuss the study's findings, highlight the contributions of this study to extant theory and practice, and presents the conclusions of this study. Chapter 5 answered research questions 1 (What are the *determinants* of Mobile Health System infusion?) and 3 (What are the *outcomes* of the infusion of Mobile Health Systems by healthcare practitioners?). Chapter 6, on the other hand, answered research question 2 (To what degree do the *determinants* impact Mobile Health System infusion?) and 4 (To what degree does Mobile Health System infusion impact upon healthcare practitioner outcomes?).

Building from this, Section 7.2 analyses and discusses the study's findings in relation to extant literature. Section 7.2.1 focuses on the *determinants of MHS infusion* (findings pertaining to research questions 1 and 3). The study's findings revealed six determinants (Availability, MHS Self-Efficacy, Time-Criticality, Habit, Technology Trust, and Task Behaviour) which impact MHS infusion. The study established that 56% of infusion was explained by these six determinants. From the six determinants, two emerged from the qualitative case study; namely, Time-Criticality and Task Behaviour. Time-Criticality was identified to be the single most contributing factor to directly impact infusion while the weakest association (in terms of significance) in the model was found between Technology Trust and Time-Criticality. Furthermore, the qualitative case study revealed that Perceived Risk in Technology does not impact MHS infusion. Therefore, the objective of Section 7.2.1 is to analyse, discuss and interpret the study's findings pertaining to each determinant in relation to extant theory.

Section 7.2.2 focuses on the *outcomes of MHS infusion* (findings pertaining to research question 2 and 4). This study revealed three healthcare practitioner related outcomes of MHS infusion, which include Effectiveness, Efficiency and Learning. MHS infusion was found to be positively associated with all three outcomes. The qualitative case study revealed that MHS infusion does not result in knowledge creation by healthcare practitioners. Therefore, the objective of Section 7.2.2 is to

analyse, discuss and interpret each outcome from the study's findings in relation to extant theory.

Section 7.3 first presents the contributions of the study to theory. More specifically, it reveals the contributions of the study's findings to both MHS infusion research (Section 7.3.1.1) and IS research (Section 7.3.1.2). This section continues by presenting the contributions to practice (Section 7.3.2).

Subsequently, the chapter considers the implications for current theory and practice and provides recommendations for future research in these areas (Section 7.4). Finally, the limitations of this research are presented in Section 7.5 and concluding this chapter is a brief summation of the research study (Section 7.6).

## 7.2 Research Findings

This section analyses the study's findings whereby the determinants and outcomes of MHS infusion are discussed in relation to extant literature. Section 7.2.1 describes the study's findings pertaining to the left side of the conceptual model (Figure 7-1); namely, *determinants*. This section discusses each determinant and how it relates to extant literature; the findings of this study in terms of each determinant (qualitative findings) and the degree (quantitative findings) to which it impacts MHS infusion; and presents a discussion of the study's finding in relation to each determinant. It describes how six determinants impact MHS infusion: (i) directly (Availability, MHS Self-Efficacy, Time-Criticality, and Habit) and (ii) indirectly (Technology Trust and Task Behaviour). Furthermore, this section discusses how and why Perceived Risk in Technology does not impact MHS infusion by healthcare practitioners.

Building from the previous section, Section 7.2.2 focuses on the right side of the conceptual model (Figure 7-2); namely, *outcomes*. This section discusses three outcomes (Effectiveness, Efficiency, and Learning) and how they relate to extant literature; the findings of this study in terms of each outcome (qualitative findings) and the degree (quantitative findings) to which MHS infusion impacts same; and

presents a discussion of the study's finding in relation to each outcome. It describes (i) the impact MHS infusion has on the workflow of tasks performed by healthcare practitioners and (ii) how the infusion of MHS improves (a) healthcare practitioners' effectiveness in terms of clinical care and (b) individual learning in a medical domain. This section concludes with a discussion of how and why Knowledge Creation is not an outcome from MHS infusion in the context of this study.

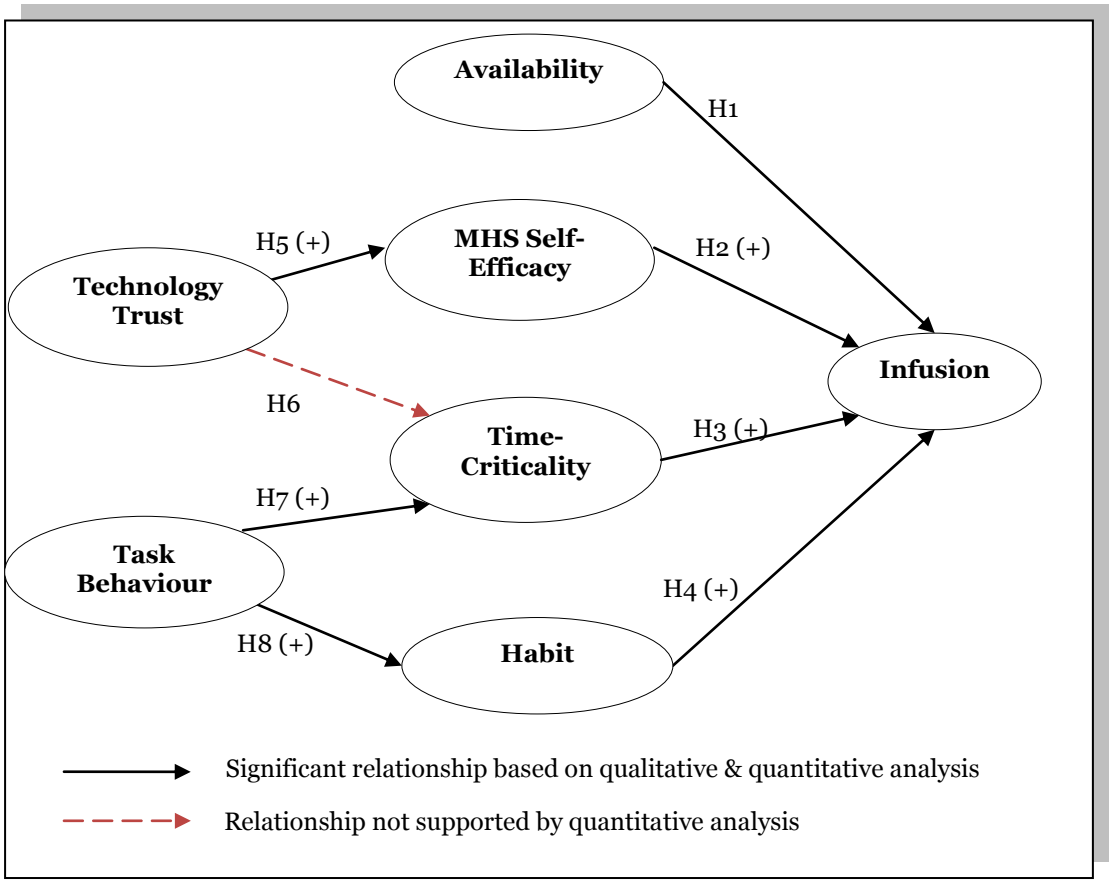



**Figure 7-1: Determinants Impacting MHS Infusion by Healthcare Practitioners**

### 7.2.1 Discussion of Findings Pertaining to Determinants of Infusion

Six determinants were identified in this study which impact MHS infusion by healthcare practitioners. From these determinants, four emerged from literature (Availability, MHS Self-Efficacy, Technology Trust, and Habit) while the remaining two determinants (Time-Criticality and Task Behaviour) emerged from the qualitative findings. This study identified four direct and two indirect determinants

of MHS infusion respectively (depicted by the black arrows in Figure 7-1). The study's qualitative findings also reveal that Perceived Risk in Technology does not impact infusion.

All six determinants of MHS infusion and their associated relationships (depicted in Figure 7-1) and Perceived Risk in Technology is analysed and discussed as they relate to extant literature and a discussion of the study's findings is also presented (Sections 7.2.1.1 - 7.2.1.7, inclusive).

#### 7.2.1.1 Availability and its Association with Infusion and Other Determinants

Extant research in both the MHS infusion literature (White et al., 2005) and the wider IS literature (Pongpattrachai et al., 2009) noted that the availability of resources is imperative for IT infusion. These studies, however, primarily examine the availability of resources such as time and finance. Therefore, this study adds to current infusion based research by examining technology resource availability. It also lends empirical support to studies which documented the necessity of having sufficient resources for using IT (c.f. Gallagher et al., 2012; Rahrovani and Pinsonneault, 2012).

Availability, in the context of this study, was established from literature and found to directly impact MHS infusion (H1, Figure 7-1). Moreover, this relationship was found to be positive thus, corroborating the findings from the qualitative case study. The positive relationship between availability and MHS infusion means that the higher the number of MHS available to the end user, the greater the occurrence of MHS infusion.

To interpret this finding, the researcher draws on literature pertaining to facilitating conditions. Triandis (1980) argues that the availability of resources is essential for individuals to engage in a behaviour. The absence of sufficient resources represents barriers to usage (Taylor and Todd, 1995). Due to expenditure reasons, healthcare practitioners are often required to share IT (Daniel and Sabin, 2002). In such situations there is insufficient time to infuse the IT artefact as they are always in

use/demand by other healthcare practitioners, yet users require time to exploit the systems capabilities and/or become more adept at discovering new uses of the systems outside of their intended use. In this study, the Ottawa Hospital in Canada was saturated with vast amounts of MHS (3,000+ MHS, at time of writing). Therefore, staff had access to available MHS on-demand, which facilitated the infusion process. In essence, this finding means that for MHS infusion to occur there is a need for sufficient technological resources to be available. As a result, the healthcare organisation may have to invest significantly in the implementation of MHS.

#### 7.2.1.2 MHS Self-Efficacy and its Association with Infusion

Extant research confirms that self-efficacy plays an important role for IT usage in the wider IS literature (c.f. Beaudry and Pinnsonneault, 1999, 1977; Compeau and Higgins, 1995; Igbaria and Iivari, 1997; Vannatta et al., 2001; Saeed and Abdinnour-Helm, 2008; Pongpattrachai et al., 2009; Karsten et al., 2012). This study, therefore, confirms extant IS research which argues that self-efficacy impacts individuals' use of IT in the accomplishment of tasks.

MHS self-efficacy, in the context of this study, was established from literature and found to directly impact MHS infusion (H2, Figure 7-1). The positive relationship corroborates and enhances the findings from the case study. It supports the qualitative case study findings, in relation to healthcare practitioners who were confident in their ability to use MHS during clinical practice and subsequently were found to infuse the MHS. Likewise, it enhances the findings from the qualitative case study by depicting the association/direction of the relationship (i.e. positive). The quantitative findings also revealed that MHS self-efficacy is one of the weakest determinants which directly impact MHS infusion. This implies that other determinants are more influential on MHS infusion.

Research argues that the more self-efficacious individuals are with the MHS, the more confident they are in their ability to accomplish tasks with hardware and/or software (Compeau and Higgins, 1995). The positive association between MHS self-

efficacy and MHS infusion implies that the more self-efficacious healthcare practitioners are, the more confident they are with infusing MHS, thereby improving infusion. Therefore, when MHS self-efficacy increases, there is a subsequent increase in MHS infusion by healthcare practitioners. In the context of this study, users have utilised the IT artefact for a number of months. During this time, users can acquire knowledge of the features/functionality of MHS and procedural knowledge (i.e. how to use the MHS for performing clinical activities via the MHS). Having such knowledge may establish confidence in users for performing tasks with the MHS. Therefore, this research shows that individual's perceptions of his or her ability to use MHS in the accomplishment of a task influences the infusion of MHS.

#### 7.2.1.3 Time-Criticality and its Association with Infusion

The concept of urgency has been examined in the wider IS literature in relation to IT adoption and use (c.f. Gebauer, 2008; Junglas et al., 2009; Yuan et al., 2010; Zhang et al., 2011) but has yet to appear in the MHS infusion domain. This study confirms current studies in the wider IS domain (ibid) by highlighting the importance of examining the context in which the technology is used (i.e. urgent situations, in this study) at the infusion phase of implementation. Moreover, it enhances extant MHS infusion research by examining a determinant previously undocumented in this domain.

Time-criticality, in the context of this study, was established from the qualitative analysis (H3, Figure 7-1) and refers to the willingness of healthcare practitioners to use MHS in urgent situations. This study found that time-criticality directly impacts MHS infusion, of which the relationship was positive. This relationship confirms the findings from the qualitative case study. That is, healthcare practitioners who were willing to use MHS in urgent situations were found to infuse the MHS within their daily work routine. Moreover, the quantitative findings identified that time-criticality had the strongest direct association with MHS infusion from all the determinants identified in the study (Section 6.4.2.2).

The positive association between time-criticality and MHS infusion means that the greater the willingness of healthcare practitioners to use the MHS in urgent situations, the greater the subsequent increase in the infusion of the technology. In a time-sensitive environment such as healthcare, it is imperative that healthcare practitioners deliver efficient and timely healthcare services to patients at the point-of-care. Healthcare practitioners can leverage the mobility associated with MHS by exploiting its time and efficiency utilities at any time and place. However, if utilising the MHS hinders the delivery of patient care then healthcare practitioners will refrain from using it in urgent situations. In such scenarios, the MHS will not be embedded within a healthcare practitioner's daily work practices and ultimately will not be infused. Therefore, healthcare practitioners must first be willing to use the MHS in urgent situations before infusion of same can be achieved.

#### 7.2.1.4 Habit and its Association with Infusion

Habit is a determinant which frequently arises in wider IS literature with regards to IT usage (c.f. Jasperson, 2005; Lin and Wang, 2006; Limayem et al., 2007; Vaghefi et al., 2010; Zhou, 2011; Kim et al., 2012). However, it has not been empirically examined in MHS infusion research to date. This study, therefore, confirms research by Mäkinen and Jaakkola (2000) and Meister and Compeau (2002) which found that habit directly impacts IT infusion (mobile phones by individuals and medical records system for education purposes by medical students, respectively). Moreover, it enhances extant MHS infusion research by examining a determinant previously undocumented in this domain.

Habit, in the context of this study, was established from literature and found to directly impact MHS infusion (H4, Figure 7-1). Moreover, habit was found to have a positive relationship with MHS infusion. The positive relationship corroborates and augments the findings from the qualitative case study. It supports the qualitative case study findings in relation to healthcare practitioners who made it customary to explore the MHS. Moreover, it enhances the findings from the case study by depicting the association/direction of the relationship (i.e. positive).

This positive, direct relationship between habit and MHS infusion can be interpreted as follows: when habitual routines of healthcare practitioners increase, there is a subsequent increase in the infusion of MHS. An explanation for this finding is that when system usage becomes repetitive and routinised, habitual routines for system usage will emerge (Ng and Kim, 2009). This often is established in the phase preceding infusion (i.e. routinization, as per Cooper and Zmud, 1990) and continued into the infusion phase. However, stagnating at current usage can hinder the infusion process. Therefore, to ensure that habit positively impacts infusion, healthcare practitioners are required to employ 'good' habitual routines from early phases of IT implementation. That is, healthcare practitioners may have formed habits in the routinization phase which facilitated the infusion process in the context of this study.

#### 7.2.1.5 Technology Trust and its Association with Other Determinants

Technology trust has been examined in depth in the wider IS literature (c.f. McKnight, 2005; Vance et al., 2008; Gefen et al., 2008; Kim and Benbasat, 2009; Koo and Wati, 2010; Thatcher at al., 2011). More specifically, Craig et al., (2010) argues that technology trust impacts self-efficacy. This study confirms Craig et al., (2010) by showing that technology trust has an impact on self-efficacy.

Technology trust, in the context of this study, was established from literature and found to indirectly impact MHS infusion (H5, Figure 7-1). Firstly, a positive relationship between technology trust and MHS Self-Efficacy was found in this study. The positive relationship corroborates the findings from the qualitative case study in which it was hypothesised that healthcare practitioners' trust in the MHS technology positively impacts MHS self-efficacy. Secondly, this study reveals a weak association between technology trust and time-criticality (H6, Figure 7-1). This relationship diverges from the qualitative case study findings as qualitative evidence showed that healthcare practitioners who were found to trust the MHS were willing to use it in urgent situations. Moreover, the qualitative case study revealed that healthcare practitioners who mistrust the MHS refrained from using it in urgent situations. Yet, discrepancies exist between the qualitative and quantitative results

regarding the relationship between technology trust and time-criticality (i.e. H6, Figure 7-1, is unsupported).

The positive relationship between technology trust and MHS self-efficacy shows that greater levels of trust in the MHS result in subsequent improvements in self-efficacy of healthcare practitioners. An explanation for this is as follows: according to Saga and Zmud (1994) users' of IT artefacts in post-adoptive scenarios can anticipate how that particular artefact will respond under different conditions. Therefore, when individuals trust the IT artefact they are aware of how the IS operates and perceive control over the technology. It is this perceived control which enables users to feel more confident in conducting tasks using the MHS. That is, when MHS perform in an unanticipated behaviour (e.g. crashes, technical issue, alterations to features/functionality, etc.) users lose control over the technology and mistrust the technology. Therefore, trusting the technology establishes positive perceptions of one's ability to use IT artefacts in the accomplishment of a task.

The weak association between technology trust and time-criticality established in this study means that trust in technology does not impact one's willingness to use MHS in urgent situations. A possible explanation for this finding is that users (i.e. healthcare practitioners) still have to perform tasks in urgent situations whether they trust the system or not. If healthcare practitioners withhold necessary healthcare services to patients then detrimental consequences can occur to the extent that it can impair a patient's life and a practitioner's career.

The discrepancies between the qualitative and quantitative findings in terms of the association between technology trust and time-criticality may be attributed to the maturity of the MHS. Although healthcare practitioners in the UK case-study desired improvements to be made to the MHS, they were minimal in comparison to the Canadian case-study. The majority of healthcare practitioners surveyed (82%) in the Ottawa Hospital desired improvements to be made to the MHS. Improvements to the MHS reported, for example, include integration with other systems, method of data entry and stability. Such desires to improve the MHS could explain the weak

association between technology trust and time-criticality as healthcare practitioners were not fully satisfied with the functionality/reliability of MHS in urgent situations.

#### 7.2.1.6 Task Behaviour and its Association with Other Determinants

The concept of task behaviour has been investigated in IS research (e.g. Lee et al., 2005; Sharma and Yetton, 2007; Gebauer, 2008; Bagayogo et al., 2010; Yuan et al., 2010). However, it has not been empirically examined in MHS infusion research to date. This study adds to the MHS infusion research and confirms research in the wider IS domain.

Task behaviour, in the context of this study, was established from the qualitative findings and found to indirectly impact MHS infusion. To reiterate, task behaviour refers to the activities that team members perform using MHS to carry out a task (adapted from Chung and Guinan, 1994). First, a positive relationship between task behaviour and time-criticality was found in this study (H7, Figure 7-1). The positive relationship corroborates and enhances the findings from the qualitative case study. It supports the qualitative case study findings by identifying that the documentary practices performed by team members, via MHS, impacts fellow healthcare practitioners' use of the technological tool in urgent situations. Second, a positive relationship between task behaviour and habit was established in this study (H8, Figure 7-1). Similarly, this association corroborates and enhances the findings of the qualitative case study by highlighting that working as part of a team influences healthcare practitioners MHS behaviour. The positive relationship identified between task behaviour and both time-criticality and habit enhances the findings from the qualitative case study by depicting the association/direction of the relationship (i.e. positive).

This positive, direct relationship between task behaviour and time-criticality can be interpreted as follows: the willingness to use MHS in urgent situations increases when fellow team members electronically document patient data in a complete and comprehensive manner via the MHS. Electronic documentation and communication among staff in a healthcare domain is imperative as MHS facilitates the flow of

patient-related information at a workgroup level. This suggests that the information culture within an organisation appears to influence how MHS are utilised in practice. That is, the values and attitudes toward information and what 'to do' and 'not to do' pertaining to information processing, publishing, and communication (Davenport, 1997) must be expressed to all team members to ensure that clinical care in urgent situations is coordinated and achieved without delay.

Building from this, a strong positive association was found between task behaviour and habit. This finding means that habitual routines are seen to increase with higher instances of task behaviour (i.e. clinical based activities that team members perform using MHS). In post-adoptive scenarios, healthcare practitioners would have frequently interacted with fellow colleagues (e.g. peers, superiors, and subordinates) and can often be influenced by the actions of those around them (Gallivan and Srite, 2005). When other users in one's work group, therefore, utilise the IS in certain ways the user would assimilate the prevalent norm (referred to as 'unconscious influences' by Newell and Shanks, 2012). This would shape his/her operational stance accordingly, thereby, establishing habitual routines.

#### 7.2.1.7 Perceived Risk in Technology and its Association with Infusion

Perceived risk in technology has been shown to influence the adoption of IT in IS literature (c.f. Grazioli and Jarvenpaa, 2000; McKnight, D.H. et al., 2002; Im et al., 2008; Brewster, 2010). Based on this evidence, the researcher set out to examine if this determinant impacts MHS infusion. This association had previously gone unnoticed in the domain due to the immaturity of the MHS infusion field (see Appendix 1). This study, however, found that Perceived Risk in Technology did not impact the infusion of MHS by healthcare practitioners. It emerged from the qualitative case study, nonetheless, that Perceived Risk in Technology is more of a concern for early phases of IT implementation, which is outside the scope of this research.

### 7.2.2 Discussion of Findings Pertaining to Outcomes of MHS Infusion

Individual Performance was established in this study from the infusion of MHS by healthcare practitioners (see Figure 7-2). It was also established that knowledge is not created from infusing MHS. Exploring the outcomes of MHS infusion is significant because a dearth of research exists examining the results from infusing MHS (see Chapter 2 and 3). A significant association was found between infusion and individual performance (Figure 7-2).

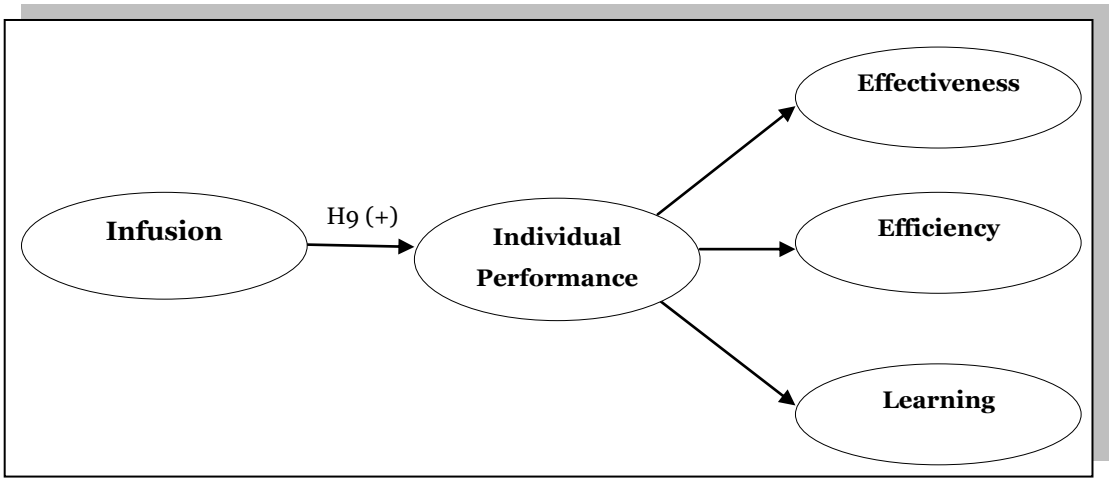



**Figure 7-2: Outcomes of MHS Infusion by Healthcare Practitioners**

This section now discusses individual performance from the infusion of MHS in this study. It also discusses knowledge creation, although this was found not to be an outcome from MHS infusion. Knowledge creation and individual performance are analysed as they relate to extant literature and a discussion of the study's findings are presented in Sections 7.2.2.1 and 7.2.2.2.

#### 7.2.2.1 Infusion and its Association with Knowledge Creation

IS research has found that knowledge creation has been facilitated via technology (Nonaka et al., 2000; Hislop et al., 2002; Sher and Lee, 2004; Sabherwal and Sabherwal, 2005). However, limited studies exist which focus on the possibility of knowledge creation from the infusion of MHS by healthcare practitioners. Building from this, the researcher examined this association.

No evidence from the qualitative case study was reported, however, between infusion and knowledge creation when data was gathered in the first phase of this research study (Section 5.3.1.3). This is a significant finding as it indicates that more needs to be incorporated within MHS development programs to facilitate the creation of knowledge.

One possible explanation for the fact that infusion does not impact knowledge creation could be the complex nature involved with capturing knowledge creation. This explanation is further strengthened by the fact that knowledge is said to be created when individuals are involved in the same context as the creator (Baskaran et al., 2004). Yet, individuals often work in collaboration with various specialities and/or departments when delivering healthcare services. Therefore, patient documentation is often reviewed by a different person in a different context. As a result, this patient documentation is not knowledge but information as the current interpretation of the patient notes loses its 'creation context' and thus becomes information.

#### 7.2.2.2 Infusion and its Association with Individual Performance

Aforementioned, individual performance was established in this study from the infusion of MHS by healthcare practitioners. In the wider adoption literature researchers have found that mobile technologies impact performance of mobile workers and promote efficiency (Abraham, 2004; Basole 2004; Rossi et al., 2007; Lee et al., 2007; Hsiao and Chen, 2012). In particular, MHS research has shown that infusion can lead to increased individual performance in terms of effectiveness, efficiency and learning (c.f. White et al., 2005). This research extends the work of White et al., (2005) by quantifying the extent to which infusion impacts individual performance. It also examines healthcare practitioners' infusion of MHS in a clinical domain as opposed to medical students in an education context.

Individual performance, in the context of this study, was established from the literature and found to be directly impacted by MHS infusion (H9, Figure 7-2). Moreover, the relationship between MHS infusion and individual performance was

found to be positive. The positive relationship corroborates the findings from the qualitative case study.

The positive association between MHS infusion and individual performance established in this study implies that as MHS infusion increases, there are subsequent improvements in (1) delivering clinical care to patients, (2) the work flow of healthcare practitioners when delivering healthcare services and (3) learning.

Building from the previous paragraph, the diagnosis and treatment of patients and monitoring and management of disease within the hospital setting improves from MHS infusion. A possible explanation for this association is that the software utilised by healthcare practitioners in the qualitative case study was developed in-house allowing both clinical and technical staff to work in collaboration and develop a clinical application which satisfied the needs of the users. Unlike off-the-shelf healthcare solutions which offers limited customisability and imposes a rigid way of utilising the software (Drummond, 2010), individuals were able to request technical changes overtime (originating through long term use of MHS, experiences and exploration) which assisted them in the effective delivery of care.

It is further noted that infusion of MHS can lead to increased individual performance in terms of efficiency. A possible explanation for this finding is as follows: the unique attributes of mobile IT artefacts, such as portability, reachability, and accessibility (Krotov and Junglas, 2006) allow healthcare practitioners to access and utilise patient-related information independent of their location within the hospital. This can save time as individuals are not required to present themselves at a stationary desktop, which may be occupied upon their arrival. Moreover, by infusing the MHS, healthcare practitioners can coordinate their work practices more easily thus, saving time.

Over time, all successful IS are enhanced or reconfigured (Fadel, 2012), reflecting in an increased understanding of the work system (Saga and Zmud, 1994). During this adaptation process healthcare practitioners engage in new activities, thus obtaining a better insight into how work practices can be performed. Another possible

explanation for the positive association between MHS infusion and learning could be the result that healthcare practitioners in both the UK and Canadian hospitals had access to medical reference resources (e.g. British National Formulary and Medline) via the MHS. Accessing medical reference resources is an important part of a healthcare practitioner's daily work practice. This finding indicates that access to medical reference resources is required for individual learning.

Section 7.3 uses the key findings presented in Section 7.2 and identifies contributions of this study to both academia and practice.

## 7.3 Research Study Contributions

This research study offers a number of contributions to both academia and practice. As a result, this section comprises two subsections. The first subsection (Section 7.3.1) identifies the contributions this research makes to extant knowledge in MHS infusion (Section 7.3.1.1) and wider IS (Section 7.3.1.2) literature. The second subsection (7.3.2) presents the contributions of this study to the practitioner community. It is evident from these subsections that this study has a number of unique contributions which add to existing knowledge.

### 7.3.1 Contributions to Theory

Building from Section 7.2, this section presents the contributions that this research makes to extant knowledge and is divided into two components; Section 7.3.1.1 describes how the study's body of research enhances the MHS literature, while Section 7.3.1.2 describes how the study's findings contribute to extant IS research. In each section, a description of how this study improves our understanding of both the strengths and limitations of extant literature in supporting the infusion of IT artefacts is outlined.

#### 7.3.1.1 Contributions to MHS Infusion Research

Contributions to MHS infusion research include (1) developing a model of MHS infusion, (2) examining of undocumented determinants and relationships, (3)

identifying prerequisite conditions that healthcare practitioners can employ to assist with MHS infusion, (4) revealing the organisations role in assisting healthcare practitioners to infuse MHS, and (5) demonstrating the outcomes of MHS infusion.

*Model of MHS Infusion*

One of the main contributions of this research study is the establishment of a model for explaining and predicting the *determinants* of MHS infusion and subsequent healthcare practitioner related *outcomes* (Figure 7-3). This model is composed of six determinants of MHS infusion, of which two determinants and their associated relationships (i.e. time-criticality and task behaviour) have not been previously documented in the MHS infusion literature. It also comprises individual performance-related outcomes of MHS infusion. This model is among the first to be specifically developed for the infusion of MHS in a healthcare domain.

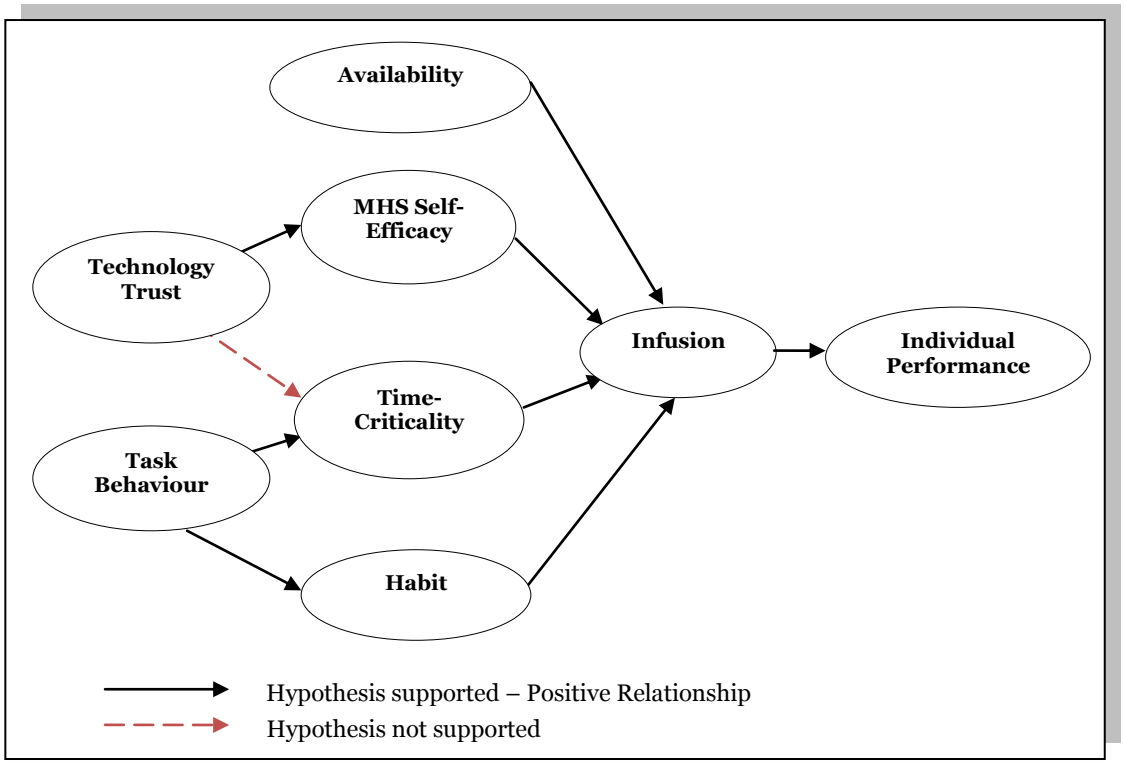



**Figure 7-3: Model of MHS Infusion**

*Undocumented Determinants and Relationships*

This study adds to extant research on MHS infusion by examining previously undocumented (i) determinants; namely, Time-Criticality and Task Behaviour (established from the qualitative case study), and (ii) relationships between various determinants (i.e. [a] Time-Criticality and Infusion, [b] Technology Trust and Time-Criticality, [c] Task Behaviour and Time-Criticality, [d] Task Behaviour and Habit, [e] Availability and Technology Trust, and [f] Availability and Habit). As a result, additional insights of MHS infusion are presented which enhances the current understanding of scholars in relation to this domain.

*Healthcare Practitioners' Role in MHS Infusion*

The study contributes to extant knowledge, pertaining to MHS infusion, by exemplifying that healthcare practitioners require procedural knowledge (i.e. how to perform clinical activities using the MHS) and knowledge of the various features/functionality of MHS to develop their skill-set for infusing MHS within their daily activities (Sections 5.2.2 and 6.4.2.2). The research findings highlight the importance of establishing 'good' habitual routines for promoting infusion (Sections 5.2.4 and 6.4.2.2) and identifies that 'good' habits should be formulated at earlier stages of IT implementation, primarily in the phase immediately preceding infusion (i.e. routinization, as per Cooper and Zmud, 1990).

The research findings further contribute to the MHS infusion domain by highlighting that technology trust is not always required in urgent situations but is required to build confidence when using MHS in non-emergency conditions. This study establishes that perceived risk in technology does not impact infusion (Section 5.2.7). It does, however, reveal that the maturity and stability of MHS is essential to reduce any potential perceived risks in the MHS arising.

For MHS infusion to occur, this study demonstrates that healthcare practitioners should first be willing to use the MHS in urgent situations. Healthcare practitioners can leverage the mobility associated with MHS by exploiting its time and efficiency utilities at any time and place. However, if utilising the MHS hinders the delivery of

patient care then healthcare practitioners will refrain from using it in urgent situations. It also demonstrates that healthcare practitioners who can anticipate how that particular artefact will respond under different conditions (e.g. operate reliably) are more confident in their ability to use MHS. Therefore, trust in the MHS technology is required.

*Healthcare Organisations' Role in MHS Infusion*

This study also augments extant MHS infusion research which primarily examines resources such as time and finance and show that technology resources are also necessary for the infusion of MHS by healthcare practitioners (Sections 5.2.1 and 6.4.2.2). In doing so, this study contributes to the MHS infusion literature by identifying that organisational readiness for infusion and facilitating conditions (IT support and technological, time and financial resources) within the organisation is imperative for healthcare practitioners to fully embed MHS within their work practices. Moreover, this study found that an information culture within an organisation is imperative for MHS infusion and that some member of the healthcare organisation should promote the infusion of MHS artefacts.

It reveals the importance of studying the context in which the IT artefact is utilised (i.e. urgent situation) as healthcare practitioners are often required to complete tasks in time-critical situations (Sections 5.2.3 and 6.4.2.2). It is therefore important that the MHS facilitates this process, to facilitate for the infusion of same. Building from this, the research findings also demonstrate that the system and content must be of high quality and decision-making capabilities should be incorporated within the MHS to enable the infusion of the technology.

*Outcomes of MHS Infusion*

The study's findings contribute to the MHS infusion domain by providing empirical evidence to an area of research which has been under-investigated to date (only two papers by White et al., 2005 and Idowu et al., 2006 was identified by researcher to examine MHS infusion). This study contributes to extant MHS infusion research by moving beyond the examination of just the determinants of infusion, to investigating

the outcomes resulting from MHS infusion. More specifically, this study provides empirical evidence surrounding the benefits of MHS; namely Individual Performance in terms of Effectiveness, Efficiency, and Learning (Sections 5.3 and 6.4.2.2). As result, it provides additional insights into the benefits which can be achieved by MHS infusion and enhances the academic field. This study did not find any association between infusion and knowledge creation. Empirical evidence shows that MHS infusion leads to improvements in clinical care, workflow and learning. A summary of the study's contributions to MHS infusion research is presented in Table 7-1.

**Table 7-1: Contributions of this Study to MHS Infusion Research**

| | Contributions to MHS Infusion |
|---|---|
| Model of MHS Infusion | Identifies determinants which facilitate the infusion process. Moreover, it identifies numerous benefits from the infusion of MHS. |
| Taxonomy of IT Infusion | Differentiates among two levels in which MHS infusion can be examined. |
| Availability | Enhances research which primarily examines resources such as time and finance. |
| MHS Self-Efficacy | Knowledge of the features/functionality of MHS and procedural knowledge (how to accomplish clinical activities using MHS) is required for infusing MHS. |
| Time-Criticality | Previously undocumented in research. MHS must be able to operate consistently and appropriately for all clinical activities and assist in clinical decision making. Established from the qualitative case study. |
| Habit | Good routines should be established early (prior to the infusion phase) as not to hinder the infusion process. |
| Technology Trust | Previously undocumented in this research domain. System and content quality influences one's self-efficacy. |
| Task Behaviour | Previously not examined in this research domain. Illustrates that the culture and context in which groups collaborate impact the usage of MHS. Working in a team can influence one's task behaviour. Established from the qualitative case study. |
| Perceived Risk in Technology | Previously undocumented in research. Was not found to impact MHS infusion. Maturity and stability of the MHS are required to reduce the possibility of perceived risk in technology. |
| Individual Performance | Enhances the limited knowledge in relation to outcomes of MHS infusion. Provides empirical evidence that shows that MHS infusion leads to improvements in clinical care, workflow and learning. |
| Knowledge Creation | Previously undocumented in research. Was not found to be an outcome from MHS infusion. |

#### 7.3.1.2 Contributions to IS Research

This study also contributes to the IS domain by (1) examining the infusion of mobile IT as opposed to stationary desktop IT, (2) illustrating how a theory building approach can provide rich insights into an under-investigated area of extant research, (3) confirming extant literature, and (4) developing a taxonomy for examining IT infusion to support future research.

*Confirms Existing Knowledge in Extant Literature*

The findings in this study confirm IS research which highlights the importance of resource availability, self-efficacy, habit and system/content quality for IT usage by individuals. It also confirms research which identifies that perceived risk in technology is a concern at early stages of IT implementation, and that IT usage is necessary for improvements in effectiveness, efficiency and learning.

*Model of MHS Infusion*

This study illustrates how a theory building approach can provide rich insights into an under-developed area of extant literature. The study's findings highlight the importance of capturing the context in which technology is utilised. The findings reveal that information culture is important and that individuals may not always perform tasks based on perceived social pressure to engage or not in a particular behaviour (subjective norms), as they may be unconsciously influenced by others. It also highlights that knowledge creation from IT usage remains under-investigated in the IT infusion domain.

*Taxonomy for Examining IT Infusion*

The study's findings shed light on how infusion can be defined and operationalised. This study identified that there exists a large variety of definitions for infusion and considerable uncertainty surrounding the operationalisation of infusion. To reduce this ambiguity, a taxonomy for examining IT infusion is developed in this study (Figure 7-4). This taxonomy provides conceptual refinement of infusion and

categorises keywords and indicators for each level of IT infusion to ensure that infusion is assessed accordingly to enhance future research. This will assist in maturing the IS field (and MHS infusion) in relation to IT infusion.

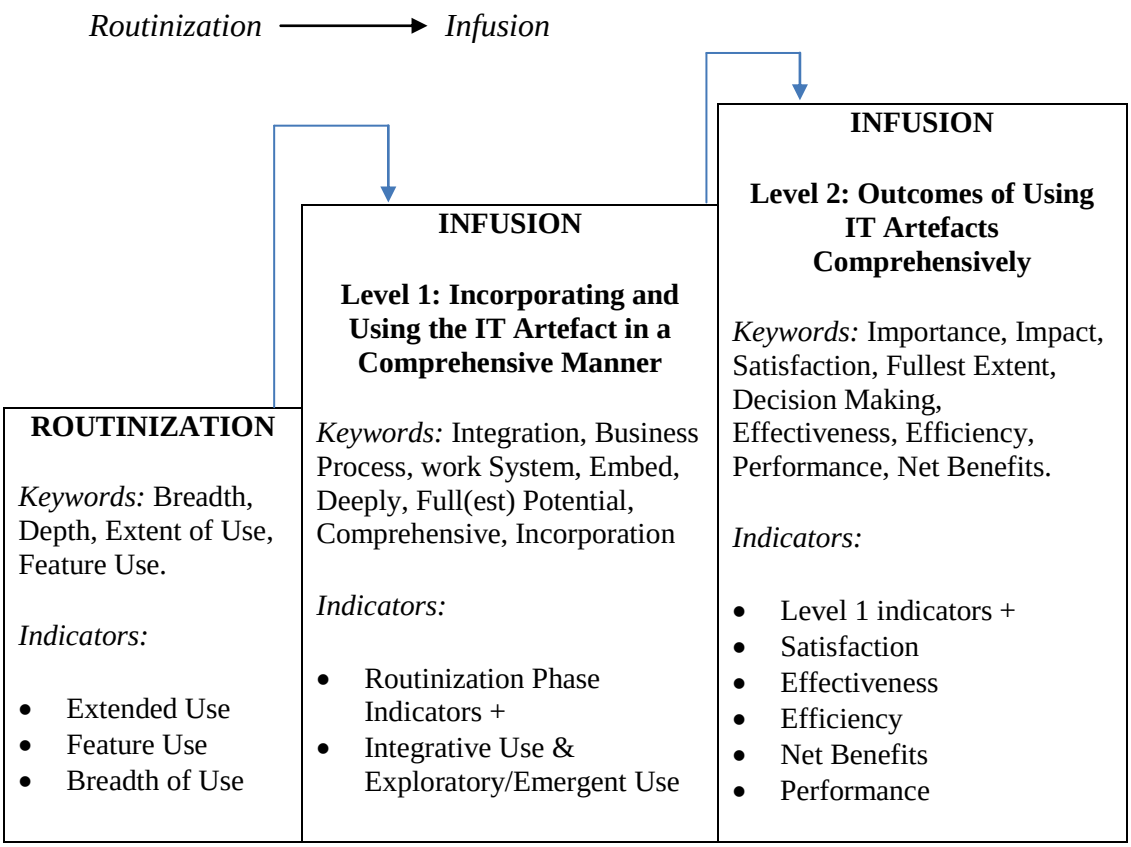



**Figure 7-4: Taxonomy for Examining IT Infusion**

A summary of the study's findings to IS infusion research is presented in Table 7-2. Section 7.3.2 now describes the contributions the study's findings make to practice.

**Table 7-2: Contributions of this Study to IS Research**

| | Contributions to IS Literature |
|---|---|
| Model of MHS Infusion | Illustrates how a theory building approach can provide rich insights into an under-developed area of extant literature. |
| Taxonomy of IT Infusion | Provides conceptual refinement of infusion to reduce ambiguity in future research and assist in maturing the field. |
| Availability (Technology) | Confirms existing research which highlights the importance of resource availability for IT usage. |
| MHS Self-Efficacy | Confirms existing research which highlights the importance of individuals' self-efficacy for using technology. |
| Time-Criticality | Highlights the importance of examining the context in which IT artefacts are used. Examines willingness to use IT in a specific context (i.e. urgent situation). |
| Habit | Lends empirical support to research which highlights that habit can impact IT usage by individuals. |
| Technology Trust | Lends empirical support to research which established that system and content quality can indirectly influence aspects of infusion. Functionality must be modified to meet with changing requirements. Therefore, change management is important. |
| Task Behaviour | Identifies information culture as important where individuals may not always perform tasks based on the perceived social pressure to engage or not to engage in a behaviour (subjective norm) as they may be unconsciously influenced by others. Leadership can also promote the infusion of MHS. |
| Perceived Risk in Technology | Identified that this determinant is more an issue at early stages of implementation. |
| Individual Performance | Confirms extant research which argues that the use of technological tools leads to improvements in individual performance. |
| Knowledge Creation | Highlights that the concept of knowledge creation remains under-investigated in some domains (for example, IT use in healthcare). |

### 7.3.2 Contributions to Practice

This section presents the contributions that this study makes to the practitioner community. It describes how the study's findings can be utilised in practice to assist healthcare practitioners with the infusion of MHS as part of their daily work practices.

A model is presented which healthcare practitioners can utilise to assist practitioners when infusing MHS as part of their daily work practices (Figure 7-3). Moreover, this research study examines an IT artefact; namely, MHS, which are becoming

increasingly commonplace in healthcare practitioners work practices. As a result, the study's findings inform healthcare organisations and vendors as to the performance of MHS in a healthcare organisation. It identifies the determinants of MHS infusion and that infusion leads to improvements in clinical care and individual learning (Sections 5.3 and 6.4.2.2).

This thesis contributes to practice by examining a phase of post-adoption which can assist healthcare practitioners in overcoming issues associated with abandonment and under-utilisation of IT artefacts (Section 2.3.1). Moreover, it establishes that organisations must put in place strategies for backing up clinical data at early phases of IT implementation to minimise risk perceptions of healthcare practitioners in latter phases such as infusion (Section 5.2.7).

It is necessary that sufficient amounts of MHS should be implemented in a healthcare organisation to facilitate the infusion process (Sections 5.2.1 and 6.4.2.2). This study also establishes that training often ceases after healthcare practitioners are first introduced to MHS (Section 5.2.2). This finding contributes to practice by identifying that on-going training in latter stages of implementation is imperative to develop skill-sets of healthcare practitioners, especially in scenarios where features and/or functionality changes occur frequently.

This study reveals that MHS must perform well in urgent situations to ensure healthcare practitioners will infuse the technology within their daily work practices. It identifies that battery performance of MHS can hinder usage of same and that it is imperative that the MHS does not malfunction when needed in urgent situations. Moreover, it should have the necessary functionality (e.g. search) to allow staff to obtain the correct information for the correct patient on demand. Therefore, information overload to users should be avoided in time-critical situations (Sections 5.2.3 and 6.4.2.2).

Infusion of MHS by healthcare practitioners is further facilitated by having appropriate decision-making capabilities built into the MHS. Therefore, vendors and in-house developers should consider integrating a Clinical Decision Support System

with the MHS application (Sections 5.2.3 and 6.4.2.2) and provide access to medical reference resources, via the MHS (Sections 5.3.1 and 6.4.2.2). The study identifies that both medical and IT staff should work in collaboration when developing MHS. This ensures that both technical knowledge and clinical knowledge is utilised to develop an application which should be utilised by healthcare practitioners (data transcriptions).

It further contributes to practice by identifying the importance of promoting good habitual routines, surrounding exhaustive use of MHS among healthcare practitioners at early stages of MHS implementation (Sections 5.2.4 and 6.4.2.2). Last but not least, this study establishes that the creation of a safe environment to exploit the system's ability is required to assist with the infusion of MHS by healthcare practitioners. This ensures that users go beyond routine and standardised usage of MHS and explore the full range of services the MHS has to offer. This provides individuals with the opportunity to explore the system without affecting existing data in the MHS.

## 7.4 Implications for Theory and Practice

The previous sections have interpreted the findings made by this study, as well as the significance of those findings with regard to existing knowledge. This section now presents the implications of the study. It focuses on the implications of the study's findings for MHS infusion research (Section 7.4.1), IS research (Section 7.4.2), and practice (Section 7.4.3).

### 7.4.1 Implications for Future MHS Infusion Research

This research study builds upon two empirical papers (White et al., 2005 and Idowu et al., 2006) identified by the researcher which examine the infusion of mobile artefacts in a healthcare domain. In doing so, a number of implications for MHS infusion research arose.

As this study was exploratory in nature the researcher calls for further research to confirm the findings presented in this study. This study identified six determinants

which explain 56% of MHS infusion (Section 6.4.2.2); however, more research is required to identify other determinants of MHS infusion. Moreover, the researcher calls for further research to be conducted in the MHS infusion domain focusing on different levels of analysis (e.g. organisational level, group level, inter-organisational level).

A model of MHS infusion was established in this study based on handheld mobile technologies. However, additional mobile technologies are utilised by healthcare practitioners such as mobile trolleys, sensors, and laptops. Therefore, future research should employ the model built in this study and investigate other mobile artefacts in the healthcare sector. This would allow future researchers to compare and/or contrast their findings with the findings established in this research.

This study examines MHS at the infusion phase of implementation only. No study was identified by the researcher to examine the assimilation of MHS from early phases of implementation to latter stages of implementation. Thus, the researcher calls for studies in this under-investigated area using a longitudinal study. This would provide a more detailed overview of how mobile IT infusion is achieved.

Individuals use mobile IT devices for hedonic and utilitarian purposes (Wakefield and Whitten, 2006). This study focused on the infusion of MHS from the perspective of utilitarian purposes. However, with the introduction of smart technology (e.g. tablets and smartphones) healthcare practitioners are increasingly using mobile technological tools for both hedonic and utilitarian purposes. Building from this, future research should examine the infusion of mobile artefacts which are consumed for both work and personal purposes. This might shed new light on additional determinants of infusion which are not previously reported in the literature.

An author centric approach is documented in this research (Appendix 1) which assisted the researcher in identifying a gap in the literature. Future research could examine this table and identify additional neglected areas of MHS infusion research (e.g. level of analysis, technology infusion, and industry).

The infusion of MHS was examined in this study from a clinical e-health perspective. That is, transactions which involve the collection, transmission and analysis of clinical data from the healthcare practitioners perspective. Thus, future research can examine the infusion of mobile artefacts in a healthcare domain from different e-health perspectives (i.e. business and consumer e-health). The need for reforming the delivery of healthcare services to accommodate the needs of modern societies has been witnessed globally with the aim of managing and controlling the costs of healthcare. Future research should focus on MHS infusion with a business e-health perspective (i.e. financial and administration transactions to conduct the daily operations of healthcare). Moreover, patients are now playing an important role in the delivery of healthcare services. Future research is required to understand consumer e-health which combines business and clinical e-health but also incorporate the consumer (i.e. patient) in health-related activities.

This study not only has implications for MHS infusion research but also for wider IS research, which is subsequently discussed (Section 7.4.2).

### 7.4.2 Implications for Future IS Research

This study focuses on MHS infusion in the healthcare domain. More research is required to understand the infusion of mobile artefacts across many industries. More specifically, research should examine how the unique features of mobile artefacts (e.g. portability, ubiquity, etc.) impact individual infusion of such technological tools.

Future research should examine the infusion of hedonic IS whether stationary or mobile, as this study focused on the infusion of MHS from a utilitarian perspective. Results of such studies could be compared and contrasted to distinguish between the infusion of utilitarian and hedonic IS. This might provide insights into the consumer infusion of MHS, outcomes of which may be customer loyalty.

A taxonomy was derived in this research study to provide for a better understanding of infusion. This taxonomy identifies similarities and differences among infusion definitions and indicators. This thesis focuses on one aspect of infusion (i.e. infusion

at level 1) therefore future research should focus on other aspects of the taxonomy (i.e. infusion at level 2).

This research study found that the use of MHS in urgent situations is an important aspect considered by numerous healthcare practitioners. Therefore, future research could investigate the degree of urgency that a task needs to be performed using IT in post-adoptive scenarios.

Future researchers should identify some conditions within the context of their study which could impact IS usage. The researcher further argues that research on mobile technology offers potential opportunities for future research in the IS domain.

The implications of this study are far-reaching. Concluding this section, therefore, are the implications for practice (Section 7.4.3).

### 7.4.3 Implications for Practice

This study demonstrates the benefits of embedding MHS within healthcare practitioners work practices. A number of contributions to practice were identified previously (Section 7.3.2). This section builds upon Section 7.3.2 by identifying the implications of this study for practice. This study establishes the importance of change management protocols. Any technology which has been implemented for a long period of time commonly involves some element of change. It is imperative that change management protocols are in place to ensure that any changes to the MHS will be communicated to the relevant parties.

The study further establishes the importance of adapting the MHS to users work practices. Changes in work practices within healthcare environments are often dictated by external forces (e.g. pharmaceutical society introduces new guidelines for dispensing drugs). For infusion to occur, it is imperative that the MHS continuously evolves and adapts to changing work practices.

It is important for healthcare organisations to have a dedicated team to support MHS. Infusion of MHS will not occur overnight. Having senior personnel to champion the

MHS from early phases of implementation right through to latter stages (i.e. infusion) will encourage other healthcare practitioners to utilise MHS. If time and financial resources are available, this team should meet frequently with various user groups (e.g. nurses, doctors, pharmacists, dieticians, surgeons) to discuss any issues and/or updates made to the MHS.

Having identified the implications of this study for both theory and practice the final section of this thesis (Section 7.5) identifies potential limitations of this study and future research opportunities.

## 7.5 Potential Limitations and Future Research Opportunities

Certain provisions were employed by the researcher to ensure the integrity of the research study. Each phase of the research approach in this study is described in detail (Chapter 4). For each phase of the research approach, data was electronically captured, where permitted, and analysed using established procedures in the IS literature (Chapter 4). Furthermore, implementing validity and reliability techniques during both phases of the research ensured the integrity of the research study.

Although the research study achieved its objective, the results of this study should be interpreted in the context of its limitations. Firstly, the initial model guiding this study was derived following certain criteria (depicted in Section 3.2). As a result, other constructs could have been excluded from the initial model. Future research could examine additional post-adoption theories in IS research and enhance the current MHS Infusion Model to provide richer insights into the concept.

Due to time constraints a single case study was employed to gather qualitative data in the initial phase. Moreover, in the second phase of data collection, the survey was only implemented in one hospital. This inevitably may raise concerns regarding generalisability of the findings in this study. Future research can employ the conceptual model derived from the qualitative findings and/or the survey instrument across a variety of healthcare organisations which have been utilising MHS for an

extended period of time. The robustness of the results would then be established and would also support the efficacy of the conceptual model and/or survey.

The second phase of this study presents the extent to which (i) determinants impact MHS infusion by healthcare practitioners and (ii) infusion impacts individual-level outcomes. This inevitably does not explain why the figures were derived in the study. However, future studies could conduct qualitative research to provide an in-depth, contextual picture to explain these results.

The sample size for both the qualitative and quantitative components of this research could be observed as inadequate. Although rich data was obtained from participants in the study to develop and validate a conceptual model, future research could conduct similar empirical work using the MHS Infusion Model derived in this study with a larger study population. This will further validate the research model.

To further strengthen the argument that knowledge creation is not an outcome of MHS infusion, this should have also been examined quantitatively. As the researcher did not obtain any data depicting this relationship the concept was omitted from the survey design in the second phase of this study. Future research should examine the relationship between MHS infusion and knowledge creation in-depth to provide a better understanding of outcomes from infusing technology as part of one's work system.

Finally, criterion sampling was employed in this study. As a result, some healthcare practitioners who would also be able to provide relevant information could have been excluded. Moreover, this study focused on the infusion of mobile handheld devices from the perspective of the healthcare practitioner. A wide range of mobile devices are utilised by healthcare practitioners all of which are not necessarily handheld (i.e. mobile trolleys and electronic sensors). Thus, using the conceptual model in this study, future research can conduct a comparative analysis of different MHS infusion. This will provide for a richer interpretation of MHS infusion by individuals.

Bringing this dissertation to the end are some concluding remarks, which are subsequently stated in Section 7.6.

## 7.6 Concluding Remarks

Understanding *infusion of mobile health systems* in a healthcare context can play an important role in transforming the delivery of healthcare services to patients at the point-of-care. It is argued that many healthcare organisations are spending vast sums of money implementing mobile health systems (Catwell and Sheikh, 2009); in many cases without fully understanding what the benefits are for medical practitioners (Abu Bakar, 2003). The model of MHS infusion developed and presented in this thesis identifies the determinants of infusion and the benefits medical practitioners can achieve via MHS infusion, a gap identified in extant knowledge. A mixed methodology, consisting of qualitative and quantitative data collection and analysis, was performed sequentially by the researcher. This enabled the researcher to delve deeper into the research domain and gain additional insights to enhance current understanding of MHS infusion. As a result, this study identifies a number of significant contributions and implications for both theory and practice. Overall, this study advances research within the MHS infusion and IS academic domains.

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## APPENDIX 1: AUTHOR CENTRIC TABLE OF INFUSION PAPERS (1985-2013)

| Study | Infusion Definition | Level of Analysis, Industry and Methodology | Time Frame | IS/Technology | Dependent Variable(s) | Independent Variables |
|---|---|---|---|---|---|---|
| Sullivan (1985) | The degree to which Information Technology (IT) has penetrated a company in terms of importance, impact, or significance. | *LoA:* Organisational<br>*Industry*: N/A<br>*Methodology*: Theoretical. | N/A (yearly) | IT | Strategic Planning (matrix) | |
| Cooper and Zmud (1990) | "Increased organizational effectiveness is obtained by using the IT application in a more comprehensive and integrated manner to support higher level aspects of work." | *LoA:* Organisational<br>*Industry:* Manufacturing<br>*Methodology*: Survey with telephone interviews – 62 respondents. | N/A | MRP (Material Requirements Planning) | IT Implementation Adoption, Infusion | Technology complexity, Compatibility (D)<br>Task characteristics, Technology Characteristics, Task Complexity (ID) |
| Wynekoop and Senn (1992) | "The extent to which an innovation is used completely and effectively and improves the organisation's performance." Infusion involves two related concepts: the level of utilization of the innovation and the effectiveness of its use in meeting organizational goals. | *LoA:* Organisational<br>*Industry:* Utility/energy and insurance<br>*Methodology*: Interviews and questionnaires -52 respondents. | 18-24 months | COBOL (CASE tool) | Diffusion and infusion | Resources, Training, Champions, Sponsors of Innovation, Communication |

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| Zmud and Apple (1992) | The extent to which the full potential of the innovation has been embedded within an organization's operational or managerial work system (Incorporation). | *LoA:* Organisation<br>*Industry:* Retail-supermarket<br>*Methodology*: Archival data (80 chains), survey (52 respondents) and interviews (16). | N/A (examined earliness of adoption which ranged from 2-9 years) | Electronic Scanners | Infusion, Routinization, Earliness of Adoption, Diffusion (did not allow for an examination of causal relationships) | |
| Ruppel and Harrington (1995) | "A stage marked by the extent of the use of the innovation within the organisation once the innovation has been adopted." | *LoA:* Individual<br>*Industry:* Various<br>*Methodology:* Questionnaire – 293 respondents. | N/A | Telework | Adoption and Infusion | Formulization, Centralization, Specialization, Middle Management Support, Administrative Intensity, Size, Professionalism |
| Bhattacherjee (1996) | "The extent to which IT is operationalized as the number of correct functionality utilised by subjects in performing an assigned task." | *LoA:* Individual<br>*Industry:* Education<br>*Methodology:* Laboratory experiment of students and questionnaire. | N/A | Excel SOLVER | Actual Acceptance, Perceived Acceptance, Actual Infusion, Perceived infusion | Behavioral Intention [D], Outcome -based incentive, Behavior -based Incentive [ID], Monitoring, Behavioral Evaluation, Repeated contract |
| Ash (1997) | Infusion looks at comprehensiveness or sophistication of use of an innovation. It is the one measure of depth related to diffusion. | *LoA:* Organisations (viewed through the perspective of individuals)<br>*Industry:* Education/Health<br>*Methodology:* Survey – 144 respondents. | N/A | Computer-Based Patient Record | Diffusion and Infusion | Innovation Attributes (attributes inherent in the CPR itself); Organizational Attributes; and Boundary-Spanning Attributes (related to marketing efforts). |

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| Ash and Goslin (1997) | Infusion looks at sophistication, or depth, of use of an innovation. | *LoA:* Institutional<br>*Industry:* Healthcare<br>*Methodology:* Survey – 41% response rate (of 1,335 individuals). | N/A | E-mail | Diffusion and Infusion | lnnovation Attributes Variables (Voluntariness, Image, Ease of use, Result demonstrability, Visibility), Organisational Attributes Variable (Communication, Decision making, support, Champions, Rewards),Boundary-Spanning Attributes Variable (Relative Advantage, Compatibility, Generation of marketing intelligence, Dissemination of marketing intelligence, responsiveness of marketing). |
| Dasgupta (1997) | Infusion includes the "integration of new information technology with the organization's system to support higher levels of organizational work." | *LoA:* Organisation<br>*Industry:* N/A<br>*Methodology:* Theoretical paper. | N/A | IT | Diffusion (each stage of Cooper and Zmud model) | Organisational Culture |
| Patnayakuni and Rao (1998) | Infusion in the *technical core* is defined as 'the degree to which tasks are to focus on the efficiency and effectiveness of processes | *LoA:* Organisation<br>*Industry:* Manufacturing and Services<br>*Methodology:* Survey -123 respondents. | N/A | Client / server computing architecture | Infusion | Software Development Technology Characteristics (Scope, Compatibility with Development Methodology, Compatibility |

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| | Infusion in the *administrative core* is defined as 'the degree to which collaboration and empowerment are present'. Infusion in the *informational core* is defined 'as the degree to which management processes are fact-based'. Infusion in the *informational layer* of the organization would be indicated by the continuous observation of transactional environments and their integration into decision making." | | | | | across tool(s), and System Restrictiveness) |
| Beaudry and Pinsonneault (1999) | "Conceptualized as emerging from post-implementation appropriation behaviors of users consisting of an integration of IT in both one's work system and one's work habits and routines." | *LoA:* Individual<br>*Industry:* N/A<br>*Methodology:* Theoretical paper. | N/A | Not empirically tested | Individual Performance | Level of Infusion (D) IT-Work System Integration, IT-Work Habits/Routines Integration, - Appropriation based infusion process, Organisational Incentives, Individual Characteristics (ID) |
| Moorell (1999) | Infusion occurs "as IT applications become more deeply imbedded with the organization's work processes and results when the IT | *LoA:* Individual<br>*Industry:* N/A<br>*Methodology:* Theoretical paper. | N/A | N/A | Work process reconceptualization intention | Motivational state [d], Consequency Validation, Consequency Expectancy, Environmental, |

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| | application is used within the organization to its fullest potential." | | | | | personal expectancy, Perceived WPR Type, Absorptive capacity. |
| Winston and Dologite (1999) | Increased breadth (number of integrated IT applications and users) and depth (extent of individual it use and satisfaction). | *LoA:* Organisational<br>*Industry:* N/A<br>*Methodology:* Theoretical paper. | N/A | Process Model Development – Not empirically examined | Infusion | Structure, IT experience [Organizational], experience, training, involvement, incentives [end-user], knowledge, strategy, involvement [owner], and strategic alliances, IT consultants [extra-organizational situation]. |
| Raisinghani and Ramsaroop (1999) | "Higher levels of work are achieved as the new system is used in an integrated and comprehensive manner." Also known as Activity Based Management. | *LoA:* Organisational<br>*Industry:* N/A<br>*Methodology:* Theoretical paper. | N/A | IT innovation | Implementation of any innovation | Support of (a) the necessary individuals (b) information technology and/or (c) IS team |
| Castner and Ferguson (2000) | "The extent to which an organisation relies on its software." | *LoA:* Organisation<br>*Industry:* Medium-sized firms (Private sector)<br>*Methodology:* Mailed questionnaires – 130 usable respondents. | We focus on the probability-of-replacement-within-1-year item because levels of diffusion and infusion are more likely to be stable within this time period. | Spreadsheet software | Likelihood of Software Replacement | Degree of Software Diffusion, Degree of Infusion (D) |

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| Fichman (2001) | "The extent to which an innovation's features are used in a complete and sophisticated way." | *LoA:* Organisational<br>*Industry:* IT Departments (various)<br>*Methodology:* Survey – 608 usable responses. | 1-7 years | Software Process Innovations: (1)relational database management systems (RDB), (2) computerised software engineering tools (CASE), and (3) object-oriented programming languages (OOP). | Measures of Organizational Innovation (OOP infusion, OOP Time, OOP Assimilation, RDB Assimilation, OASE Assimilation, SPi Adoption, SPI Assimilation) | Learning-Related Scale, Diversity, OOP Related Knowledge, IT Size, Specialization Education [D] |
| Eder and Igbaria (2001) | "Infusion refers specifically to the degree of integration with existing business processes." | *LoA:* Organisational<br>*Industry:* Cross Sectional<br>*Methodology:* Surveys – 281 usable responses. | N/A | Intranet | Diffusion, Infusion | Earliness of Adoption, Top Management Support, Organizational Structure, Organizational Size, IT Infrastructure, IS Structure |
| Gallivan (2001) | "This notion of depth of usage and level of impact is labelled technology infusion, where the infusion metaphor refers to the innovation penetrating down into the organization." | *LoA:* Multi-level<br>*Industry:* Firms implementing client/servers<br>*Methodology:* Interviews – 53 across four firms (longitudinal). | N/A | Client/server implementation | Assimilation Stage (including infusion) | Managerial Intervention (Authority Decision to Adopt or Captive use, Training, Support), Subjective Norms, Facilitating Conditions (Innovation, Organizational, Individual Sttributes) [ID}. Secondary (individual) adoption Process [D]<br>Not studied: Organisational |

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| | | | | | | Consequences and Primary Authority Adoption Decisions. |
| Chang and Lung (2002) | This paper argues that infusion must correspond with two essential points:<br>"(1) It must exhibit the technology's potential to improve or enhance the capabilities of operating an organization's OMWSs in order to accomplish tasks efficiently.<br>(2) It must realize the technology's potential to achieve the objective of the organization's performance in order to gain benefits." | *LoA:* Organisational<br>*Industry:* Manufacturing<br>*Methodology:*<br>Questionnaire – 50 companies. | N/A | Advanced manufacturing technology - Computer-Integrated Manufacturing (CIM) system | Infusion Effectiveness | Organizational Change Variables, including Centralization of Structures, Skill Variety, Task Identity and Feedback of Task; Individual's Attitude, Sufficiency of Tducation and Training. |
| Jones et al., (2002) | Infusion refers to the extent of technology use. | *LoA:* Individual<br>*Industry:* Sales<br>*Methodology:* Survey – 85 respondents. | Investment of SFA for 24 months (email sent to initial respondents 6 months after adoption) | Sales Force Automation (SFA) | Infusion of SFA | Personal Innovativeness, Perceived Usefulness of New System, Attitude Toward new System, Compatibility with Existing System, Facilitating Condition & Subjective Norms (D) Ease of Use (ID) |
| Meister and Compeau (2002) | Multi-dimensional phenomenon consisting of intensity of use, scope of use and satisfaction with the | *LoA:* Individual<br>*Industry:* Education<br>*Methodology:* Survey – 2 pilot studies. Study 1 MBA students in Queen's | N/A | Medical records system (Meditech)<br>Study 1: PDA<br>Study 2: | Infusion is a three-dimensional construct: intensity, scope and satisfaction. | |

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| | innovation. *Individual infusion* as "the extent to which the full potential of the innovation has been embedded within an individual's work system." We further define "full potential" to be "the usage in all possible and appropriate applications"; "embedded" as "permanently and inherently adopted"; and "individual's work system" as "the processes that an individual uses to fulfill their organizational role." | MBA for Science and Technology program (56 respondents).<br>Study 2 - MBA students at the University of Denver (66 respondents). | | Learning Software | | |
| Wilson Green (2003) | **"Process:** Increased organizational effectiveness is obtained by using the information technology application in a more comprehensive and integrated manner to support higher level aspects of organizational work." **"Product:** The information technology application is used | *LoA:* Organisational *Industry:* Organisations who adopted EDI *Methodology:* Interviews, Historical and contextual records. | Time since adoption ranged from 3 to 9 years. | EDI (Electronic Data Interchange) | Decision to Adopt Information Technologies, Extent of Implementation Achieved after Adoption. | Rationalistic (strategic Choice) and Institutional (Institutional Isomorphism) Considerations, Decision to Adopt IT. |

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| | within the organization to its fullest potential." | | | | | |
| Ahuja and Thatcher (2005) | Where IT applications become deeply embedded within the organization's work processes (Saga and Zmud 1994) – extended, integrative, emergent. | *LoA:* Individual<br>*Industry:* Education<br>*Methodology:* Survey -263 respondents. | N/A | IT- not explicitly defined | Trying to Innovate with IT | Autonomy, Overload (D & ID), and Interaction of Autonomy and Overload (D) |
| Gharvai et al., (2005) | "Infusion is a special type of communication concerned with the spread of messages that are perceived as new ideas." "Embedding an IT application deeply and comprehensively within an individual's or organization's work systems" (Saga, 1994). | *LoA:* Organisational<br>*Industry:* Stockbroking Sector<br>*Methodology:* Interviews – 50. | N/A | Internet | Adoption and Extent of Use (leading to infusion) | Influence of Regularity Bodies. |
| Abdinnour-Helm and Saeed (2006) | Not Defined | *LoA:* Individual<br>*Industry:* Education<br>*Methodology:* Survey – 1032 responses. | The average experience of using SIS was two and half years (1-13+ years) | Student Information System (SIS). | Extended Use, Integrative Use, Exploratory Use | N/A |
| Fadel (2006) | Infusion denotes "the degree to which an IS is fully integrated into an organization's or individual's work practices, and the degree to which the full potential of the IS is being exploited. | *LoA:* Individual<br>*Industry:* Healthcare<br>*Methodology:* RIP paper – qualitative interviews and a quantitative survey. | Each site has been using the EMS for at least several months, thus allowing sufficient time for infusion of the technology | Enterprise System (Electronic Medical System - EMS) | Infusion<br>Extended Use<br>Integrative Use<br>Emergent Use | Is Use, Adaptation Behaviours, Problem-Focused Adaptation, Emotion-Focused Adaptation (D), Behavioural Intentions, Individual Cognitions (ID) |

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| | Represents the extent to which an information system is used completely and effectively and improves the individual's performance." | | to occur. | | | |
| Idowu et al., (2006) | "The degree to which a different information technology tools are integrated into organizational activities. More specifically, information technology infusion pertains to the frequency of technology usage, the full use of the applications capabilities, the level of integrated and complementary use of different technologies and the usage of technology for organizational purposes." | *LoA:* Organisational *Industry:* Healthcare *Methodology*: Questionnaires and interviews. | Teaching hospitals were visited toascertain the level of acceptance as well as the impact of the IT indicators on the health care delivery systems in the last five years. | IT – Internet, mobile phones, PC | Derive an IT infusion models for popular IT indicators that are in use in Nigeria (Personal computers, Mobile phones, and the Internet) and subsequently investigates their impacts on the health care delivery system in Nigerian teaching hospitals. | |
| Li et al., (2006) | Not Defined | *LoA:* Inter-organisational *Industry:* IT Management Association (ITMA, Singapore) endorsed - various *Methodology*: Survey – 89 usable responses. | N/A | Information Technology (not explicitly stated) | Organizational Innovative Usage of Information Technology | Age, Tenure, Education Level [Demographic Characteristics], Openness, , Conscientiousness, Extraversion [personality |

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|---|---|---|---|---|---|---|
| | | | | | | characteristics] |
| Shumarova (2006) | "Infusion implies using the application in a comprehensive and integrated manner." | *LoA:* Individual<br>*Industry:* N/A<br>*Methodology*: Theoretical Paper. | N/A | N/A | IT adoption/usage decision processing | prior use, use, habit, and post-adoptive behaviour & external search, and internal search (mediating) |
| Tanoglu and Basoglu (2006) | Infusion refers specifically to "the degree of integration with existing business processes." | *LoA:* Individual<br>*Industry:* N/A -<br>IT was critical in achieving business goals.<br>*Methodology*: Survey – 30 respondents. | 9 months | Enterprise Resource Planning (ERP) | IT Infusion and Diffusion, Managerial Decision Making Process | Characteristics of the Individual (Age, years of use, functional area, user/key user), Perceptions regarding the technology (Ease of Use, Usefulness, Flexibility) |
| Wang and Hseih (2006) | Employees can use the system in a more comprehensive and sophisticated way to support their works. | *LoA:* Individual<br>*Industry:* Manufacturing<br>*Methodology*: Survey – 385 respondents across 2 organisations. | The two firms had used ERP systems for more than two years. | Enterprise Resource Planning (ERP) System | Symbolic adoption, Extended use, Emergent use. | Perceived Usefulness, Confirmation of Expectation, Satisfaction (D) |
| Grover et al. (2007) | IT infusion is the "incorporation of information technology into the work structures that the technology supports. Infusion culminates in the technology being used within the organization to its fullest potential. Infusion culminates in the technology being used within the organization to its fullest potential." | *LoA:* Interorganisational<br>*Industry:* Various industries<br>*Methodology*: Survey, 154 senior IS executives. | 1) were currently being used; 2) were widely deployed | Telecommunications technologies | Innovation | IT infusion (D): integration, formalization, complexity, centralization (D & ID), Size, Environmental Uncertainty (ID) |

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| Kishore and McLean (2007) | Infusion "captures the extent to which an innovation's features and functionality are used in a complete and sophisticated manner in organizational work processes." | *LoA:* Individual<br>*Industry:* Finance Services<br>*Methodology*: Survey – 30 respondents. | N/A | HPS CASE technology | Infusion Behaviour | Organizational Alignment, Relative Advantage, Compatibility, Voluntariness (D) Ease Of Use (ID) |
| Sundaram et al., (2007) | "The notion of effective use is captured in the concept of infusion, or the extent to which a salesperson fully uses the technology to enhance productivity (Jones, Sundaram, & Chin, 2002)." | *LoA:* Individual<br>*Industry:* Sales<br>*Methodology*: Survey – 164 (wave one)<br>85 - (wave two) | 6 months after first wave of surveys | Sales Force Automation (SFA) | It-Enabled Administration Performance, It-Enabled Salesperson Performance | Infusion, Routinization (D), Frequency of Use, Prior Intention to Use, Prior Attitude Towards IT (ID) |
| Hsieh and Wang (2007) | Infusion refers "to the process of embedding an IT application deeply and comprehensively within an individual's or organization's work systems." | *LoA:* Individual<br>*Industry:* Manufacturing<br>*Methodology*: Survey – 200 respondents. | Successfully implemented a popular enterprise resource planning solution for more than 2 years. | Enterprise Resource Planning (ERP) | Extended Use | Confirmation of Expectation, Perceived Usefulness, Perceived Ease of Use, Satisfaction. |
| Wainwright and Waring (2007) | "Technology infusion is seen more as the extent to which an innovation is used completely and effectively – perhaps more at the level of the individual." | *LoA:* General Practice Organisations<br>*Industry:* Healthcare<br>*Methodology*: Interviews at 5 research sites within NHS. | N/A | Electronic Patient Record | Organizational Consequences | Secondary Adoption and Organizational Assimilation Process, Primary Authority Adoption Decision |

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| Berger and Benyon-Davies (2008) | "The depth of use of the features and functions from the situation perspectives." | *LoA:* Organisational<br>*Industry:* UK government<br>*Methodology*: Longitudinal Study - Interviews and observation. | Business began to infuse technology after 3 years | RAD-type Iterative Application Development (IAD) | Successful diffusion of IAD | User Involvement, Requirements Negotiation and Decision-Making Activities, Characteristics of the JAD Workshops |
| Ramamurthy et al., (2008) | "Regularity of use, Exploiting all the embedded capability, Being integrated with the firm's operations, Proportion of firm's applications using DW (breadth of use), and Extensiveness of DW functionality (depth of use)." | *LoA:* Organisational<br>*Industry:* Various<br>*Methodology*: Survey with follow up interviews – 153 responses from 117 firms. | 57% of the firms having started to use DW within the past three years. | Data Warehousing (DW) | Organisational level Outcomes; Organisational Benefits, Stakeholder Satisfaction | Extent of Data Warehouse Infusion (D), Organizational Support, Business Scope for DW in the Operating Environment, Organization Analytic Decision Culture, IS-business Relationship, Project Management Process, Compatability of DW, Complexity of DW (ID) |
| Saeed and Abdinnour-Helm (2008) | Not defined. | *LoA:* Individual<br>*Industry:* Education<br>*Methodology*: Survey – 1032 respondents. | The average experience of using SIS was two and half years (1-13+ years) | Web-based Student Information System (SIS) | Extended usage, Exploratory usage | IS Usefulness, System Integration, Information Quality |
| Vega et al., (2008) | Infusion measures the "extent of use of an application in organizations by measuring the types of transactions and the quantity of transactions per type." | *LoA:* Individual<br>*Industry:* SME<br>*Methodology*: Case Study – interviews – 6 program organizations and 10 SME adoption processes. | N/A | e-Business Systems | Process model | |

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| Li et al., (2009) | Infusion refers "to the process of embedding an IS application deeply and comprehensively in the work system." | *LoA:* Individual<br>*Industry:* Telecommunications<br>*Methodology*: Survey – 193 respondents over 2 large companies. | At the time of data collection, the BI system had been functional for more than one year, implying that the implementation status could be classified as the post-acceptance stage. | 1) Customer Support Information Systems (CSIS), 2) Business intelligence information systems (BIIS) | Innovative Use, Routine Use | Extrinsic Motivation, Intrinsic Motivation |
| Ng and Kim (2009) | "Represents the highest level of use and consists of three subtypes (Saga and Zmud 1994): extended use, integrative use and emergent use. This study defines extended use as using more of the system features to complete tasks; integrative use as using the system to reinforce linkages among tasks; and emergent use as using the system in an innovative manner to support tasks." | *LoA:* Individual<br>*Industry:* Manufacturing<br>*Methodology*: Survey – 206 respondents. | N/A (ERP was introduced in 2007 and study published in 2009). | Enterprise Resource Planning (ERP) | Extended Use, Integrative Use, Emergent Use | User Competence, Usage Impact, Usage Meaning, User Self-Determination (D), Habit (mod) |

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| Pongpattrachai et al., (2009) | IT infusion "focuses on how an organization uses IT to the fullest potential to support their work." | *LoA:* Organisational/Firm<br>*Industry:* Audit Firms<br>*Methodology*: Semi-structured, in-depth interviews across multiple-case studies (7 firms) | N/A | Spreadsheets | Infusion | Hierarchy:<br>L4: Management involvement<br>Availability of IT Champion<br>External support<br>Self-efficacy<br>L3: Relative advantage<br>Observability<br>Staff self-efficacy<br>Availability of resources (for self-study e.g. time)<br>Staff turnover<br>L2: Task variety<br>Required audit procedures<br>Availability of infrastructure<br>L1: Staff IT competency – Education, attitudes toward IT<br>Training<br>External IT support |
| Wu and Subramaniam (2009) | Infusion "means that RFID applications are used within and across the organizations in supply chain to RFID fullest potential." | *LoA:* Organisational<br>*Industry:* Retail Supply Chain<br>*Methodology*: Web-based Survey – RIP paper, not empirically validated. | N/A | RFID | RFID Adoption/ Intention,<br>RFID Infusion | RFID Adoption/ Intention, Technological Goodness (Perceived Benefits; Complexity; Compatibility; Maturation of Technology), Organisational Readiness (Financial Resources; IT |

| | | | | | | |
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| | | | | | | Sophistication; Top Management Support), External Pressure (Competitive Pressure; Trading Partner; Enacted Trading Partner Power; External Support) (D). |
| Yu et al., (2009) | "The extent to which IT is utilized in an intensive manner for performing the target business process (Cooper and Zmud 1990) – as inclusive of both the breadth and depth dimensions of IT use within the organisation." | *LoA:* Organisational<br>*Industry:* Procurement<br>*Methodology*: Web-based surveys –193 usable responses. | N/A | e-Procurement Applications | Performance (expressed in terms of infusion) | Intensity of Use (d), Organisational Acceptance (d), Procurement Process Readiness, Business Knowledge, Organisation Integration, Slack Resources (ID) |
| Tennant et al., (2011) | Infusion relates to advanced and comprehensive use of IS. | *LoA:* Individual<br>*Industry:* N/A<br>*Methodology*: (RIP) | N/A | Complex Information Systems | Performance | System, Task, User, Infusion |
| Thatcher et al., (2011) | Infusion is "associated with users learning to use systems to their full potential and identifying new ways for IT to enable work processes." | *LoA:* Individual<br>*Industry:* Various<br>*Methodology*: Study 1: 162 business students at a large public university in the Southeastern United States (Questionnaire) Study 2: knowledge workers employed in the IT industry in India – 155 respondents. | Respondents were in their 3rd year (study1), Subjects had been in their present job more than four years (study 2) | Knowledge Management System | Intention to Explore | Perceived Usefulness, Perceived Ease of Use(D), Technology Trust, Trust in IT Support |

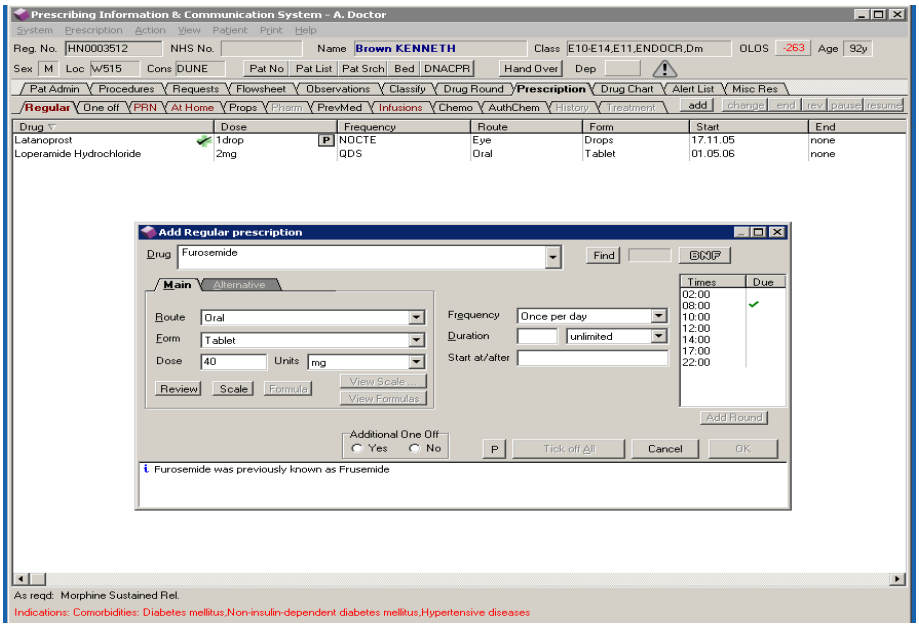
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| Shaw and Manwani (2011) | Features become more embedded through extension (Jasperson, et al., 2005; Sullivan, 1985; Zmud & Apple, 1992) and users create functionality 'that goes beyond typical usage leading to better results' (Hsieh & Wei, 2007, p. 217). | *LoA:* Individual<br>*Industry:* Healthcare<br>*Methodology*: Semi-structured interviews and questionnaire (for demographic information only) 53 interviewees. | One year or more. | Electronic Medical Record | Feature Usage | Perceived Ease of Use (D), Subjective Norms (D), Perceived Usefulness (D) Facilitating Conditions, Computer Self-Efficacy, satisfaction with past use, (ID) Task fit, Professional Association guidance, knowledge of benefits (d) |
| Fadel (2012) | Conceptualises infusion as the degree to which individual technology users employ the full range of features offered by the technology, or the degree to which they use the technology to its fullest extent. | *LoA:* Individual<br>*Industry:* Healthcare<br>*Methodology*: Online Survey (validated with interviews with individual employees within relevant organisation) – 57 respondents. | At the time of data collection most employees had been using the system for an average of approximately one year. | Enterprise System (Electronic Medical System) | Infusion | Problem-Focused Adaptation, Approach-Oriented Emotion-Focused Adaptation, Avoidance-Oriented Emotion-Focused Adaptation (D) |
| Kim et al., (2012) | The IS infusion stage refers to the state of using IS to its full potential. | *LoA:* Individual<br>*Industry:* Services<br>*Methodology*: Survey with 236 responses. | Organisation needs to have at least two years of experience in using their system. | Enterprise System (not explicitly named) | IS Infusion | User Commitment (D) Job fit, Technology Competence, Task Competence, Self-Determination with Technology & Self-Determination with Task |
| Oakley and Palvia (2012) | Infusion as measured through three distinct subtypes:<br>Extended use, Integrative use, and Emergent use. | *LoA:* Individual<br>*Industry:* Not Defined - Individuals<br>*Methodology*: Multi-Method – qualitative (focus group) and | The majority of the respondents had owned mobile phones for only 1-3 | Mobile | IS Infusion (Extended usage, Integrative usage, Emergent usage) | Mobile Self-Efficacy and Mobile Emotional Attachment (D) |

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|---|---|---|---|---|---|---|
| | | quantitative (survey – 111 respondents). | years. | | | |
| Senapathi and Srinvasan (2012) | "Increased usage in a more comprehensive and integrated manner results in increased effectiveness of systems development." | *LoA:* Organisational *Industry:* R&D *Methodology*: Case Study following a criterion approach. | The organisation had been using agile practices for at least 2 years. | Agile Development | Not infusion specific | |

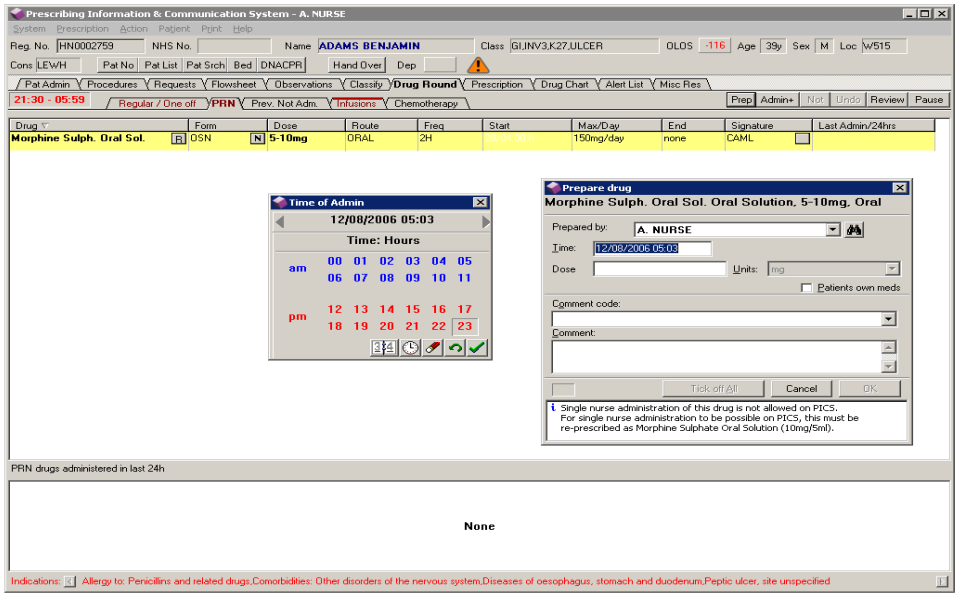
N/A = Not Available || RIP = Research in Progress

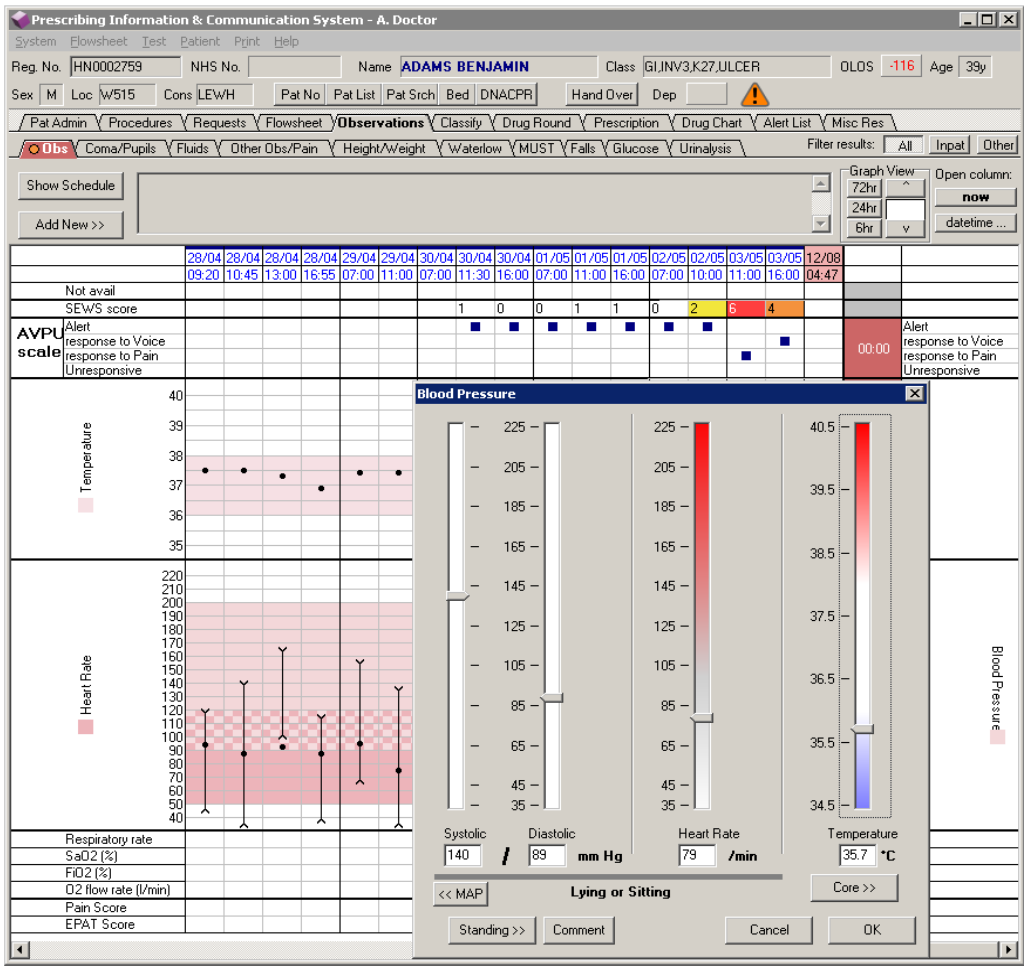
# APPENDIX 2: SCREENSHOTS/PICTURES OF PICS

The following are screenshots of the PICS in the UK case study, with Permission from Dr. Jamie Coleman, University Hospitals Birmingham, NHS Foundation Trust.




***Typical view of PICS client***

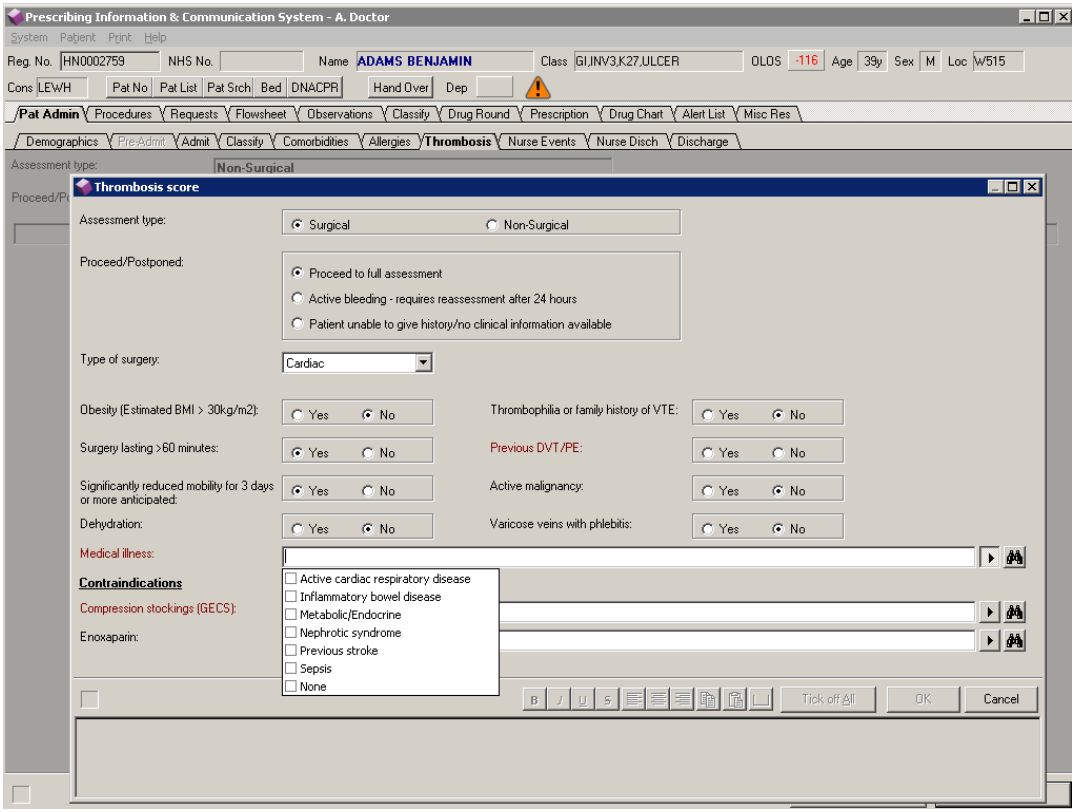





***UI designed to be easily used when using stylus for observation entry***



***Motion C5***




***VTE Risk Assessment – note radiobuttons and multicheck boxes in UI (above)***



***Healthcare Practitioner inputting vital sign data via MHS***

## APPENDIX 3: INTERVIEW GUIDE

1. Could you provide some background information on your daily work practices?
2. What IT tools/applications do you use?
3. How long have you being using MCA?
4. What features of the MCA do you use on a daily basis? What features do you not use and why?
5. In what respect have you integrated MCAs into your daily work practices? (How do you use MCAs?)
    a. Do you use the system for a standard series of tasks?
    b. Do you explore new uses of the MCA or proactively look for new ways to use familiar or additional features of the MCA?
6. In your experience have you altered your work practices from using the system?
7. From using MCAs do you believe that you created knowledge within your work environment?
    a. In your opinion what types of knowledge can be created when using MCAs?
8. Have you found that utilisation of the system has led to you completing tasks in a more efficient/effective manner?
    a. What other aspects on your performance have changed from using the system?
9. What other benefits/issues have you encountered in using MCAs?
10. What determinants impact upon your use of MCA's?
11. Is it required to Trust the MCA before you use it? If yes/no, why is this so?
12. Does content/system quality impact upon your levels of trust in the system?
    a. Thinking about the MCA (your perception on the hardware, software – network, device and operating system) what dimensions of the mobile artefact (MCA) are important to you for trusting mobile technologies in a work setting?
    b. Thinking about the content stored in the MCA (data and information) what characteristics of the content are important to you for trusting mobile technologies?

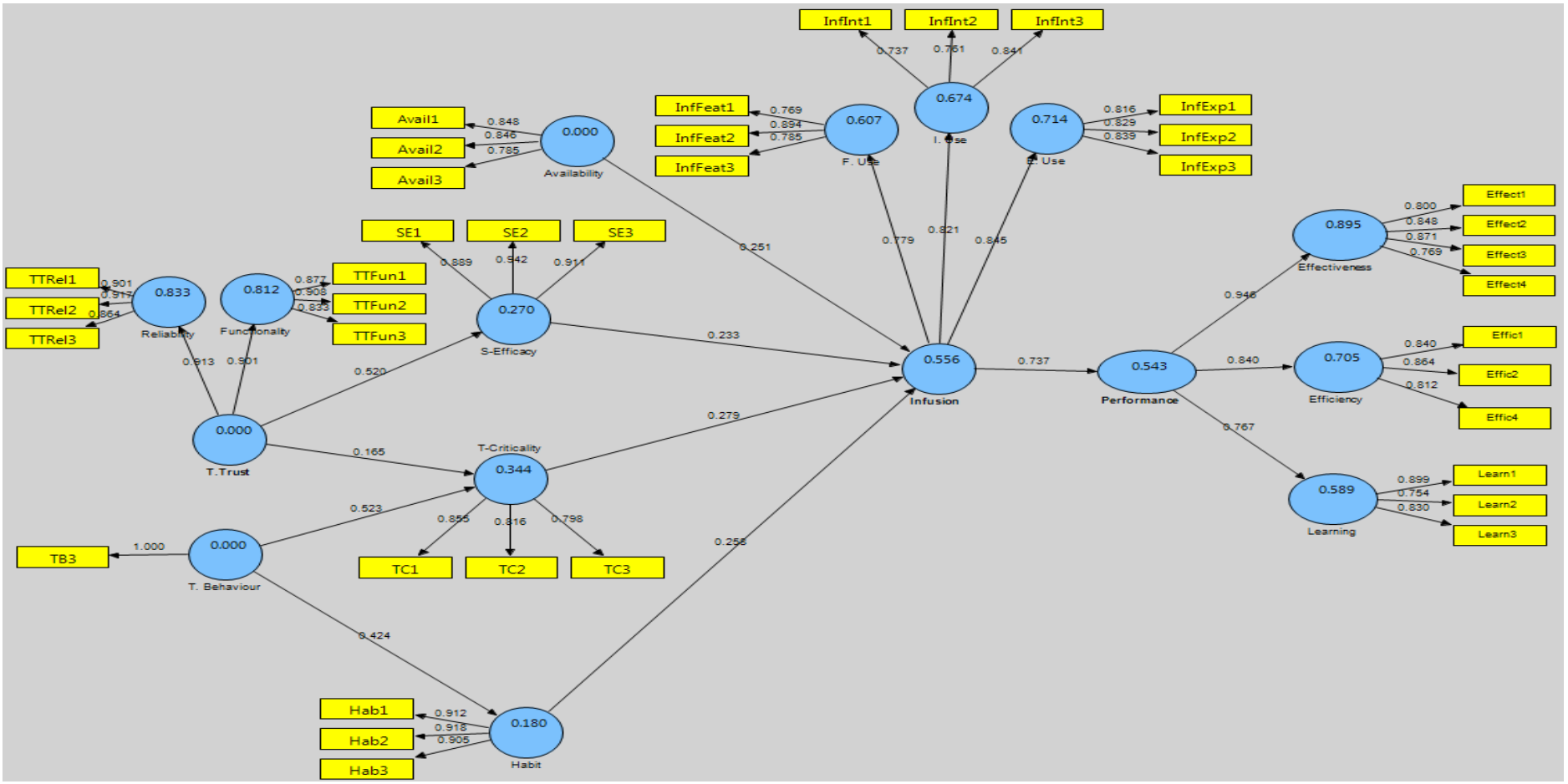
13. Do you perceive there to be a risk when using the system? If yes/no, why is this so?
14. If you have trust in the technology but perceive the technology to be risky would you use the MCA as part of your clinical practice? If yes/no – why?

# APPENDIX 4: SNAPSHOT OF WARDS USING TABLETS

| [18]Ward code | Tablet Login | Total Number of Logins | % of Logins on Tablet |
|---|---|---|---|
| 57 | 12231 | 13672 | 89.5% |
| 56 | 20989 | 24369 | 86.1% |
| 58 | 11429 | 14081 | 81.2% |
| 38 | 11607 | 17318 | 67.0% |
| 6 | 2317 | 3486 | 66.5% |
| 45 | 12435 | 19597 | 63.5% |
| 52 | 281 | 491 | 57.2% |
| 48 | 12632 | 22627 | 55.8% |
| 37 | 8279 | 14954 | 55.4% |
| 1 | 1120 | 2024 | 55.3% |
| 29 | 10073 | 18439 | 54.6% |
| 55 | 4307 | 8883 | 48.5% |
| 31 | 8720 | 18019 | 48.4% |
| 28 | 7551 | 15701 | 48.1% |
| 50 | 9728 | 20567 | 47.3% |
| 36 | 7687 | 16271 | 47.2% |
| 49 | 11433 | 24851 | 46.0% |
| 26 | 9941 | 21860 | 45.5% |
| 12 | 1706 | 3777 | 45.2% |
| 34 | 5243 | 11894 | 44.1% |
| 59 | 9710 | 22083 | 44.0% |
| 47 | 6169 | 14832 | 41.6% |
| 60 | 3916 | 9466 | 41.4% |
| 27 | 5977 | 14698 | 40.7% |
| 41 | 5232 | 13327 | 39.3% |
| 25 | 4727 | 12086 | 39.1% |
| 51 | 7950 | 20955 | 37.9% |
| 61 | 17688 | 46716 | 37.9% |
| 39 | 6210 | 17059 | 36.4% |
| 33 | 5012 | 14208 | 35.3% |
| 32 | 4655 | 13429 | 34.7% |
| 53 | 4778 | 13870 | 34.4% |
| 30 | 4908 | 16289 | 30.1% |
| 54 | 99 | 335 | 29.6% |
| 42 | 1670 | 6304 | 26.5% |
| 35 | 3106 | 14504 | 21.4% |
| 46 | 1591 | 10868 | 14.6% |
| 14 | 4 | 28 | 14.3% |
| 40 | 439 | 5321 | 8.3% |
| 44 | 31 | 1110 | 2.8% |

[18] Tablet usage data for November 2011 was provided by Sarah McDowell in association with Dr. Jamie Coleman of University Hospitals Birmingham, NHS Foundation Trust.

## APPENDIX 5: PLS MODEL



*“That which does not kill us makes us stronger.”*

- Friedrick Nietzche