

EXPLORING THE CONTINUOUS USE OF KNOWLEDGE-BASED CLINICAL  
DECISION SUPPORT SYSTEMS AND ITS RELATIONSHIP WITH KNOWLEDGE  
TRANSLATION

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## Abstract

*In this study, the continuous use of knowledge-based clinical decision support systems (KB-CDSS) is examined. KB-CDSS not only provides advice to clinicians, but also integrates guidelines with patient information and provides clinicians with tools that facilitate the application of guidelines in patient care. Studying KB-CDSS as a continuous application is important because continuity is a prerequisite to the success of KB-CDSS implementations and is considered as an important motivator for knowledge translation. Previous research in the area of health information systems (HIS) use has focused on the acceptance of these systems through the use of mostly information systems related constructs. Therefore, the theoretical models that explain the use of HIS have been limited and they obfuscated other phases of HIS such as continuous use. Moreover, extant research has not, to a large extent, considered the influence of KB-CDSS use on knowledge translation, the application of clinical guidelines in practice. This study seeks to fill these gaps in the literature by first integrating context-related factors with IS factors. This supports the study of antecedents of continuous use of KB-CDSS systems, exploring the relationship between continuous use and knowledge translation, and exploring changes in system dynamics (how usage patterns change with time). In order to achieve these research objectives, a literature review of healthcare and IS research was conducted, resulting in a comprehensive theoretical model that explains the antecedents of continuous use and its relationship to knowledge translation. To validate this model, data were collected from different sources, including: A questionnaire deployed to 118 physicians using the McMaster Pain Assistant KB-CDSS in three academic clinics in South Western Ontario, followed by five focus groups to further explain the context of using the systems and antecedents of its use, and the analysis of system use through data obtained from system logs and patient charts.*

*The findings of this study show that: (i) Threats to physician professional identity surpasses intention to continue using KB-CDSS, thus influencing its use by physicians in the first six months; (ii) The relationships between factors influencing continuous system use change with time; (iii) System use has a strong relationship with knowledge translation after 6 months of use, but this relationship diminishes after 12 months of use; and (iv) How patients are affected by the system positively influences physician satisfaction with the system and hence their use of the system. This study helps in explaining the theory of physicians' continuous use of KB-CDSS and how the antecedents of use change with time. Methodologically, this study has discovered several techniques that can be used to improve HIS research and physician acceptance of IS methods. Finally, in practice this study presents several suggestions for improving the development and deployment of KB-CDSS to enhance its use during the knowledge translation process.*

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## Chapter 1- Introduction

The increasing cost of health care globally, and the alarming risk of medical errors and quality of care problems in healthcare organizations as a result of lack of coordination between care teams and other human factors have motivated the call for health information systems (HIS) applications to improve the efficiency and quality of clinical care (Institute of America 2001). These motivators have resulted in the adoption of electronic health (e-health) applications such as electronic health records (EHR), and clinical decision support systems (CDSS) in both developed and developing countries (Mars et al. 2010). The adoption of these e-health systems has been further encouraged by government legislation such as HITECH (Health Information Technology for Economic and Clinical Health) (Blumenthal et al. 2010) in the United States. This rewards the use (and meaningful use) of EHR systems in healthcare (Blumenthal 2009). In some countries, such as Denmark, the use of selected e-health applications has also been mandated (Kierkegaard 2013).

The evolving adoption of e-health applications has been accompanied by an increasing interest in studying and evaluating the impact of these systems. As a result, research focusing on studying the effectiveness and benefits of such systems has emerged. For example, numerous studies have found that CDSS improved both patient outcomes and clinicians' performance (e.g., Pearson et al. 2009). Despite this wealth of e-health research, few studies have focused on e-health user behavior, and how this behavior impacts the effectiveness of e-health systems. This lack of behavioral research emphasis is unfortunate, given the role that user behavior plays in the success or failure of the adoption and sustained use of e-health applications. For example, in 2003, an implementation of a CDSS system in the Cedars-Sinai Medical Center in Los Angeles CA failed because of physician refusal to use the system (Freudenheim 2004).

Among the limited research that has focused on clinician behavior, most studies have focused on studying clinician acceptance of new e-health systems (e.g., Bhattacharjee et al. 2007; Pynoo et al. 2013; Yi et al. 2006), with few researchers focusing on clinician continuance behavior (clinician decisions to continue using a system after their initial acceptance of the system) (e.g., Venkatesh et al. 2011b). The early focus on acceptance was justified, given the relatively recent adoption of information systems in health care (Berner et al. 2005). Numerous failed e-health deployments because of clinician resistance have resulted in the need to understand the factors that could encourage clinicians to accept and use e-health systems.

However, global adoption of e-health applications has increased (Mars et al. 2010) and there has been a search for new ways to enhance the value of these applications. The time has come for researchers to move beyond the study of adoption and to redirect their attention towards the continuous use of e-health applications. This focus is motivated by several recent factors including:

(1) Currently, it is not enough to just use e-health applications such as EHRs or CDSSs, but it is important to use them efficiently and effectively in order to improve the quality of care and the resulting care outcomes. For example, the HITECH act requires not just the use of EHR systems, but the “meaningful use” of these systems (Blumenthal et al. 2010; Hsiao et al. 2012). Therefore, it is important to encourage clinicians not just to accept e-health applications but to use them effectively to reap their benefits.

(2) Governments worldwide spend enormous amounts of money to encourage the use of e-health applications and to develop the infrastructure necessary for the use of these applications. For example, the US alone is spending \$25.9 billion dollars through HITECH legislation to encourage the use of e-health applications (Blumenthal 2009). Unless the factors that would encourage physicians to continue using e-health applications is understood, much of the money dedicated for

e-health could be lost with no significant value linked to how these systems might impact patient care.

(3) The current trend of healthcare data analytics and integration of genetic information in clinical decision support requires the continuing use of e-health applications. This is because these applications represent one of the main sources of data used in data analytics. At the same time these applications can exploit the outcomes of data analysis. For example, patient information in EHR systems has been widely used to predict clinical outcomes (e.g., Chanthaweethip et al. 2012). Therefore, it is necessary to encourage clinicians to continue EHR use to enhance the benefits of healthcare analytics. And,

(4) Prior research on continuance behavior (Bhattacharjee 2001) suggested the necessity of studying continuance, independent of initial acceptance behavior, since information system users can discontinue using the system after they initially accept using it.

## **1.1. Research Significance**

Based on the above discussion, it is now timely and important to study the factors that influence clinicians' intention to continue using e-health applications. To address this need, and to address the research gap in studying health information systems (HIS) continuance, this research integrates the information systems and healthcare perspectives of HIS to study physicians' continuous use of a knowledge-based clinical decision support system (KB-CDSS). This is a clinical decision support system that integrates evidence-based guidelines with patient information to guide clinicians in decision making. The intent is to measure how continuous use impacts physicians' adoption of clinical guidelines in practice (knowledge translation).

Specifically, the objective of this research is to examine family physicians' continuous use of *McMaster Pain Assistant* (MPA), a pain management clinical decision support system (CDSS) that is specifically designed to provide guidelines for managing patients with lower back pain and

neuropathic pain. The study also investigates the relationship between continuous use and knowledge translation and hence the success of the MPA system.

This study was conducted by taking an integrated positivist-interpretive perspective to investigate and understand the factors that influence KB-CDSS continuous use. This integrated perspective guided the research methodology by using mixed quantitative-qualitative methods. For quantitative methods, a survey instrument was used to measure and test various constructs embedded within a theoretical model derived from the integration of the Delone & Maclean IS (Information Systems) success model (DeLone et al. 1992) with an attitude-behavior model (Eagley et al. 1993). For the qualitative methods, focus groups were employed to understand the context of why and what motivates (distracts) physicians to (from) continued use of the system being studied.

The outcome of this research demonstrates the use of KB-CDSS to manage patients with pain, (specifically, lower back pain and neuropathic pain). Both affect a significant percentage of the population and are considered challenging to manage. Research has found that lower back pain (LBP) affects about 67% of the population in industrialized countries at some time (Jarvik et al. 2005). In 25% of these cases LPB becomes chronic within one year of appearing (Von Korff et al. 1996). Moreover, LBP is the most common reason for younger adults (those below 45 years) to limit their activities, including work-related activities (Andersson 1999). This leads to lost work days and disability claims (Frank et al. 1996).

Researchers estimated that the yearly cost for a chronic LBP patient is about twenty five thousand dollars (\$25,000) in treatment costs and lost work days in the Netherlands (Gannon et al. 2013). This translates to billions of dollars over the entire population. Fortunately, applying guidelines when managing patients with pain can reduce this cost. For example, following LBP guidelines resulted in a decrease of 3.5% in X-ray prescriptions (Mortimer et al. 2013).

Neuropathic pain (NeP) on the other hand, affects only about 1% of the population (Irving 2005)

but is considered one of the most challenging types of pain to treat (Attal et al. 2010). NeP patients suffer negative influences to their activities that are similar to those experienced by LBP patients.

Despite the potential usefulness of applying LPB pain management guidelines in practice, research shows that primary care physicians generally lack the necessary skills to manage patient chronic pain (Rosenblum et al. 2008). KB-CDSS can help physicians to manage patients with pain and to reduce the cost associated with tests that are not supported by clinical evidence. However, the benefits of using KB-CDSS are contingent on physicians' meaningful and continuous use of these systems (Buntin et al. 2011), and whether they adopt available recommendations in practice or not. This is why continuous use is a part of most knowledge translation models (Davies et al. 2013).

Research in the areas of HIS continuous use as well as the effect of use on knowledge translation has been scarce in both IS and healthcare domains. Therefore, this study will investigate the factors that influence physicians' decisions to continue using a pain management KB-CDSS system and how this use can influence their adoption of clinical guidelines. It is expected that, after physicians use this system, their adoption of clinical guidelines is likely to increase. This in turn will lead to improvements in patient quality of life and decrease the cost of pain management.

## **1.2. Continuous Use of HIS**

The importance of behavior continuity in achieving goals has been recognized for a long time in different contexts including personal and psychological change (Schwarzer et al. 2011), quality improvement (Shortell et al. 1995), and organization success (March 1996). However, achieving personal and organizational objectives is not just related to change, but to sustaining and continuing this change.

In the context of information systems (IS), continuous and sustained use is necessary to reap the benefits of IS (Bhattacharjee 2001) but indeed many organizations fail to benefit from using IS. This is because employees stop using these systems after they have initially accepted them (Devaraj et al. 2003). HIS are no exception. Several studies have indicated that HIS users can stop using a system after the system has been implemented and adopted by the healthcare organization (Archer et al. 2011a). This phenomenon of discontinuing use of a HIS system after initial acceptance is especially true for physicians who highly value their professional values such as autonomy and relationship with patients (Tallis 2006). Therefore, they are likely to abandon a system, despite its usefulness, if they perceive it as threatening to their professionalism (Doolin 2004). HIS discontinuance negatively affects the quality and efficiency goals of the organization, which are important goals of current healthcare systems given the need for quality improvement (Kummervold et al. 2008) and the growing cost of healthcare (Bloom 2002). Discontinuance wastes money, often a large amount, spent on implementing the system. Thus it becomes necessary to study factors influencing continuous HIS use and to understand how to use them to enhance system use and benefits.

Despite the importance of studying HIS continuance, research in this area has been scarce. IS continuance research has mostly focused on business oriented IS such as corporate IS (Bhattacharjee 2001; Bhattacharjee et al. 2004; Venkatesh et al. 2010) and e-commerce (Pavlou et al. 2006). Generalizing the outcomes of these studies to the HIS domain is not possible, given the dependence of factors influencing continuance on the context of IS use (Venkatesh et al. 2011a). Hence, researchers have called for the study of continuance in the HIS context (Archer et al. 2011b). Moreover, IS continuance studies have mostly focused on using either traditional acceptance theories such as the technology acceptance model (TAM) which may have little effect on continuance (Bhattacharjee 2001), or expectation-confirmation theories which have been shown to provide inconsistent results in different contexts (Brown et al. 2014).

Therefore, in this research, a novel model is developed to study physician continuous use of a KB-CDSS. This model is derived from an integration of the widely accepted attitude-behavior model (Eagley et al. 1993), the Delone &McLean IS success model (DeLone et al. 1992) and the knowledge to action framework (Graham et al. 2010). The strengths of this integrated model are that it integrates two research streams, IS and healthcare, to provide a holistic understanding of the use of KB-CDSS and how this use influences knowledge translation. The model also includes the effect of past behavior on future system use; and it accounts for the effect of patients' relationships with their physicians on physician use of the system. This latter relationship has rarely been examined despite its clear importance. The model was tested through periods of six and twelve months use of the system to allow possible time-dependent changes in user attitudes and perceptions about the system. The relationship between use and knowledge translation is a complex relationship that has been studied rarely in the IS and healthcare literature, so this relationship and its change over time was examined closely. This study revealed physician behaviour over time in their continuous use of the KB-CDSS through the use of a novel model and the application of a mixed-methods methodology.

### **1.3. Knowledge Translation in Healthcare**

Knowledge translation has recently gained interest, especially in the medical domain, with concerns about clinician applications of guidelines in practice (Davies et al. 2013; Graham et al. 2010). Knowledge translation may be defined as the process of applying knowledge in practice (Straus et al. 2009). Studying knowledge translation in healthcare is critical due to the fact that disease management guidelines are often ignored in patient care, which can lead to serious adverse effects (Kitson et al. 2013; Pronovost 2013). Few studies have examined the role of HIS in enhancing knowledge translation. Most studies have focused on how the lack of knowledge translation influences practice (Ferguson Jr et al. 2003, Davies et al. 2013), knowledge translation lifecycles, and barriers to knowledge translation (Grimshaw et al. 2012).

Past knowledge translation studies have argued that, as a result of multiple stakeholders in the complex (and dynamic) healthcare environment, changes in this environment, such as applying clinical guidelines to practice, are also complex. Therefore knowledge translation needs continuous reinforcement in order for it to be sustained, say, through use or training (Davis et al. 1999; Ferguson Jr et al. 2003). Sustained system use can then reinforce repeated guideline applications in a context that encourages their use. As such, continuous use of knowledge is an essential component of several proposed knowledge translation models (Davies et al. 2013). Moreover, knowledge translation barriers are similar to HIS use barriers such as the lack of benefits, complexity, and time pressure (Légaré et al. 2013).

#### **1.4. Research Objectives**

The overarching objective of this research is to investigate factors influencing the continuous use of KB-CDSS and the role of continuous use in knowledge translation. The main research objectives are:

1. To investigate and understand the influence of IS and professional identity factors on the continuous use of a KB-CDSS by qualified and training family physicians (residents)
2. To investigate and understand the role of KB-CDSS use on the adoption of clinical guidelines in practice (knowledge translation)
3. To understand the dynamics of system use and knowledge translation. That is, whether the factors influencing the use of KB-CDSS change with time, and whether the relationship between use and knowledge translation changes with time.

In addition to the above objectives, the study has three secondary objectives:



1. To investigate the context in which family physicians would be interested in using a KB-CDSS
2. To study the effects of physician roles (physicians vs. residents) on system use and knowledge translation.
3. To understand the relationship between the use and the success of a KB-CDSS. That is, is continuous use indeed a prerequisite of the success of KB-CDSS?

## **1.5. Research Contributions**

Given the lack of research in the area of HIS continuance behavior and the potential benefits of adopting clinical guidelines in managing patients with pain, this research has the following contributions:

### **A. Theoretical:**

This research creates a theoretical model that integrates two streams of research: IS research and healthcare research. Hence, the model will integrate constructs that have been traditionally used in IS research such as usefulness, with constructs related to the context of medical practice, such as physicians' professional identity and the influence of the medical community on physician decisions. This integration of IS and contextual constructs has been advocated by several researchers (Benbasat et al. 2007; Holden et al. 2010). This research also proposes a new construct (Physicians' perceived quality of care improvement) which reflects patients' influence on physician use of HIS. This effect, to the best of my knowledge, has never been addressed in IS or healthcare research. This is despite its significance since patients are the main customers of an HIS system. Finally, the theoretical model proposed is extended to include knowledge translation. Although the effect of continuous use on knowledge translation has been proposed before and is part of many knowledge translation models, the relationship between knowledge translation and continuous use has rarely been studied in IS research.

## **B. Methodological:**

Physicians have their own expectations for research methodologies and measurement tools. These expectations are the result of medical profession training and requirements. By working closely with physicians, these expectations have been identified and met in this research. Following physician expectations has increased their acceptance of the tool that was developed. Hence, this study will help guide future HIS research in this field of study.

## **C. Practical Factors:**

By understanding the factors influencing the continuous use of KB-CDSS and the relationships between use and knowledge translation, KB-CDSS systems can be developed for required interventions. This will tend to enhance the use of such systems and therefore, enhance physician adoption of clinical guidelines in practice. This will lead to improved care, improved patient satisfaction, and reduction in costs associated with lower back pain and neuropathic pain.

## **1.6. Epistemological Approach**

In order to answer research questions, we take an integrated interpretive and positivist perspective (Creswell 2013; Lee 1991). The design and implementation of this study was influenced by this perspective.

A positivist perspective takes an objective view of the world where causes determine effects. Hence, positivists seek to assess relationships between cause and effect, thus adopting a reductionist approach where relationships are reduced to a set of hypotheses to be tested (Creswell 2013). Positivist researchers adopt quantitative methodologies, including experimental designs (e.g. randomized controlled trials) and non-experimental designs (e.g. theory based surveys) to measure the objective truth. This approach has the strengths of satisfying theory

requirements: *falsifiability, survival, logical consistency, and relative explanatory power*, which are satisfied through the formulation of hypotheses and testing these hypotheses to confirm their consistency and explanatory power (Lee 1991). However, the positivist perspective does not recognize the meaning people attach to social phenomena and does not acknowledge the effects of social processes (Ponterotto 2005)

An interpretive perspective, on the other hand, takes a subjective view of the world in which people seek to understand their world and develop subjective views of their experiences. Thus, researchers seek to understand individuals' view of their world instead of reducing the world into a set of relationships. Researchers depend on eliciting individuals' views about an object or a situation by using qualitative methods such as interviews, open-ended questions, and observations through numerous research designs such as ethnography, grounded theory, and case studies (Creswell 2013; Easterby-Smith et al. 2012). Therefore, qualitative methodologies are ideal to understand social processes and individuals' perceptions (Ponterotto 2005). Despite their power to explain social interactions, qualitative methods are difficult to conduct. This is because of the lengthy time required to collect data, the complexity of analysis, and the bias that may be introduced to research because of the researcher's involvement with research participants. Further, there is a prevailing view that qualitative research is less rigorous than quantitative research (Easterby-Smith et al. 2012).

By integrating positivist and interpretist perspectives, this study exploits the benefits of quantitative methods in formulating and testing research models and hypotheses while explaining the context of using KB-CDSS, from the users' perspective. While there are several ways of integrating both perspectives (Creswell 2013), this study uses a sequential design. This starts with conducting a survey to test theory-based hypotheses and explains physicians' use of a KB-CDSS. This is followed by focus groups (qualitative study) to understand the context of using KB-CDSS and to investigate the social processes underlying system use.

## **1.7. Dissertation Structure**

This dissertation is structured as follows. Chapter 2 provides a contextual overview to understand pain management and the KB-CDSS used for this study as well as the importance of knowledge translation in healthcare. Chapter 3 provides the theoretical background for this research, especially the attitude-behavior model (Eagley et al. 1993), the DeLone & McLean IS success model (DeLone et al. 1992), and the role of professional identity (Stets et al. 2000). Chapter 4 provides the theoretical model and hypotheses for the quantitative part of this study, and Chapter 5 provides the methodology for the quantitative and qualitative parts of this study. Chapter 6 presents the analysis and results of the quantitative study, while Chapter 7 provides the results of the discussion groups. Chapter 8 provides a discussion of the integrated results of the quantitative and qualitative studies, conclusions, and future work.

## **Chapter 2- Exploring the Terrain: Contextual Overview of CDSS, and McMaster Pain Assistant**

After providing an overview of the research questions of this research and a blueprint of the dissertation, chapter 2 explores the terrain of this thesis before laying the theoretical foundation of this research in chapter 3. To explore the terrain, the chapter takes a microscopic view of HIS research. It starts with an overview of CDSS research in IS and healthcare literature based on a literature review, and then moves to KB-CDSS as a sub-category of CDSS. The chapter then describes low-back pain and neuropathic pain guidelines as a prerequisite to understand the functionality of the studied system. It concludes by presenting the McMaster Pain Assistant as a KB-CDSS that will be studied in this research.

### **2.1. Clinical Decision Support Systems (CDSS)**

Computerized clinical decision support systems (CDSS) can be defined as the information and communication systems that provide clinicians or patients with timely, accurate and appropriate knowledge to enhance patient care (Osheroff et al. 2012). Based on this definition, there are two basic features that apply to CDSS systems: (1) The goals of CDSS are to provide access to patient information and to enable users to make informed and optimized decisions, and (2) CDSS users include clinicians such as physician and nurses as well as patients and their families.

The previous definition discriminates between CDSS and expert systems since the latter aim to emulate human decision making instead of only providing the knowledge necessary to do so (Seto et al. 2012). In the historical evolution of CDSS development, both CDSS and expert systems were considered the same. Ever since the introduction of computerized clinical support more than fifty years ago, researchers have attempted to use the (newly found) computer power to facilitate, and even make, decisions on treatment options and diagnosis (Greenes 2011). For example, one of the earliest papers on CDSS discussed selecting among treatment alternatives (Ledley et al. 1959). Diagnostic CDSS prevailed during the first two decades of CDSS use and they

actually offered little benefits to physicians because they lacked the ability to transform clinicians' tacit knowledge into explicit knowledge that could be coded into CDSS, and because they lacked appropriate guidelines to make clinical decisions (Berner et al. 2007). This lack in the capabilities of CDSS made them difficult to integrate into clinician work flow and to provide them with meaningful decision support. The development of evidence based medicine (EBM) in the early nineties (Guyatt et al. 1993) represented a landmark for CDSS. EBM enabled the coding of best practices in guidelines that can be used by physicians to make diagnostic and treatment decisions (Bero et al. 1995). The development of EBM in addition to the development of appropriate protocols for guideline exchange such as the Guideline Interchange Format (GLIF) (Boxwala et al. 2004) enabled CDSS to incorporate these guidelines in the decision making process. This enhanced their effectiveness as diagnosis and treatment support tools.

In addition to the use of CDSS as a diagnostic tool, several other uses of CDSS evolved. For example, one of the important roles of CDSS is to act as a control unit in a utilization care plan, where the care group creates a plan for managing patients and the CDSS controls this plan by monitoring and evaluating user input, and triggering events associated with these inputs (Kawamoto et al. 2005). For example, CDSS can be integrated with computerized physician order entry (CPOE) systems to alert physicians if they provide a medication overdose, or if the patient is allergic to some drug (Horsky et al. 2005). CDSS have also been used to provide reminders to clinicians regarding patient care. For example, CDSS can be integrated with electronic health records (EHRs) to remind physicians of necessary lab tests or prescription renewals (Varonen et al. 2008).

CDSS have gained momentum and acceptance within the healthcare industry over time. There are several underlying reasons to motivate the growing adoption of CDSS in health care.

First, technology advances and the development of other types of health information systems such as EHR and CPOE systems enhanced the role and effectiveness of CDSS. Other HIS provided a context where the benefits of CDSS can be realized. They also provided data which CDSS could use to facilitate decision making (Kawamoto et al. 2005). Moreover, developments in data mining and data analytics enhanced the efficiency of CDSS and their capability to generate decisions. Knowledge resulting from data mining could be built into CDSS to improve decision making (Abouzahra et al. 2014a). The enhanced role of CDSS motivated the medical community to accept and use CDSS.

Second, the development of health information systems resulted in an explosion of information that overwhelmed physicians. Thus it became necessary to find ways to filter this information and provide the most relevant information, especially with the emerging trend of using genetic data to personalize treatments (Banning 2008; O'Donnell 2004). For example, a patient personal health record (PHR) can have a lot of information such as diet and activity details which may not be needed in patient treatment. CDSS can be used to filter this information and provide the physician with only information that is relevant to suggesting patient treatment regimens.

Third, in the past twenty years, healthcare quality has been receiving strong interest from society (America 2001). One of the causes of this interest was the role of medical errors in an increase of preventable mortalities and healthcare costs. For example, preventable deaths because of medication errors were estimated to be 98,000 annually in the United States (Pham et al. 2012) and 16,500 in Canada (Baker et al. 2004). The use of CDSS, especially for alerting physicians about possible adverse effects of over doses, can play an important role in enhancing quality and reducing medication errors (Singer et al. 2013).

Fourth, the increasing cost of care associated with several factors including the aging population in developed countries and the increasing cost of managing aging related diseases

(Colwill et al. 2008) created a need to enhance the efficiency of healthcare in terms of hospital visits, medication, and disease management. Using CDSS can enhance efficiency by, for example, providing physicians with guidelines to best practices in managing diseases, and providing a standard for treatment.

Finally, the recent direction of patient-centred care has a significant effect on CDSS. Patient-centred care calls for the involvement of patients in their own treatment and has resulted in the development of PHR systems that enable patients to communicate with care providers and to take part in the decision making process (Barry et al. 2012). Therefore, new CDSS, traditionally oriented towards clinicians, were re-developed to allow for shared decision making between physicians and patients. For example, CDSS can be used to inform patients about treatment options and risks associated with these options and to elicit their preferences (Ruland 2004).

The factors that influenced CDSS adoption by the healthcare industry are mainly related to the potential benefits of CDSS at different hierarchical levels of healthcare stakeholders. These levels include individuals, groups, organizations, and society at large.

At the individual level, CDSS affects both physicians and patients. For physicians, CDSS enhances their decision making capability (Jaspers et al. 2011), increases their efficiency, and reduces the errors they may commit due to pressure (Jaspers et al. 2011), lack of resources, or overwhelming information. For patients, CDSS encourages patients' involvement in their own treatment (especially when integrated with PHR systems) (Archer et al. 2011b; Sperl-Hillen et al. 2016). CDSS enhance patient safety by reducing medication errors, increasing the effectiveness of disease management, and improving patient satisfaction with treatment (Kawamoto et al. 2005).

For groups, the adoption and use of CDSS may improve group dynamics and care planning among care groups. For example, Pope et al. (2013) discussed the effects of implementing CDSS in emergency departments and how CDSS can impact workflow there. Groups also include



clinicians and patients' groups. For example, physicians as a group may perceive CDSS benefits differently from hospital administration because of their habitual decision autonomy and resistance to change (Doolin 2004). For patient groups, elderly patients may be less receptive to CDSS systems than younger patients due to learning disabilities (Archer et al. 2011b) and hence may benefit less from CDSS capabilities.

On the organizational level, there are different organizations that may be affected by decision support systems such as hospitals and payers. For example, the implementation of CDSS in a hospital can impact its overall efficiency and cost savings (Cox et al. 2015). For payers, CDSS represent a way to standardize decision making and treatment options which may enable them to predict health insurance costs accurately and accelerate their claim processing (Colla et al. 2016). Finally, reductions in medical errors and healthcare costs, and improvement in healthcare quality which result from implementing CDSS can have a direct impact on society. These benefits increase individual trust in the healthcare system and improve the efficiency of health expenditures (Grol et al. 2013).

In addition to the impacts of CDSS on different classes of stakeholders, CDSS can affect the interactions among these classes. For example, the use of CDSS for shared decision making between patients and physicians is likely to affect the quality of the interaction between them as well as patient satisfaction with this interaction (Sperl-Hillen et al. 2016; Varonen et al. 2008)

The propagated benefits of CDSS from individual stakeholder classes (Table 2.1) signifies the importance of CDSS in healthcare and the importance of understanding the factors that motivate the sustained use of such systems to reap their benefits. Despite this importance, my literature review showed that, compared to EHRs, research that focuses on physician use of CDSS in routine care is scarce (Table 2.2). Therefore, there is a need to study CDSS use and how to enhance sustained use of these systems.

**Table 2.1. Stakeholders and Impacts of CDSS Use**

<b>Healthcare Concerns</b>	<b>Stakeholders</b>	<b>Description of Impact</b>
Technological advancement	Patients Clinicians Groups	Involvement in the decision making process  Optimized decision making, alerts, and reminders  Improvements in departmental workflows
Information explosion	Physicians	Providing physicians with tools to filter information and use only relevant information
Healthcare quality	Clinicians Patients Organization Society	Less errors committed because of time and resource pressure  Better treatment and care quality  Overall efficiency/cost reductions/ satisfaction  Reduced healthcare costs, society wellness/ satisfaction
Aging population	Patients Groups Society	Cost savings can be used to improve overall healthcare  Better management of chronicle diseases associated with age  Improved healthcare/cost savings/stakeholder satisfaction
Increasing cost	Clinicians Organization Society	Time savings/less pressure  Standardized decision making/ cost reductions  Healthcare cost reductions
Patient-centered care	Patients Physicians	Engagement in treatment/better adherence  Patient adherence to treatment/ time savings

	Organization	Less hospitalization and fewer hospital visits
	Society	Reduced cost/ enhanced healthcare quality

**Table 2.2. Types of HIS Research**

HIS system	Number of studies
EHR	34
Telemedicine	18
CPOE	10
Adverse effect monitoring	3
CDSS	6
Mobile health	4
Hospital Information Systems	11

## **2.2. Knowledge-based CDSS (KB-CDSS)**

While the previous section reviewed CDSS, their importance, and the need to study their use, CDSS have many categories (Osheroff et al. 2012). Hence in this section, KB-CDSS are reviewed in order to focus this research.

Clinical guidelines can be defined as ” systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances” (Field et al. 1990, p.38). The goals of creating clinical guidelines is to promote evidence-based medicine and to enhance the use of effective medical interventions in patient care

(Chassin 1990) and hence improve the quality of care. Despite the potential benefits of these guidelines, there are several barriers that hinder their use by clinicians (Cabana et al. 1999). These barriers include: lack of awareness or agreement with guidelines (Olesen et al. 1997), absence of perceived benefits of using the guidelines (Woolf 1993), lack of involvement in developing guidelines, threat to control over patient management, lack of credibility of the guidelines, and patient dissatisfaction (Tunis et al. 1994).

KB-CDSS are CDSS that are based on clinical guidelines and evidence-based medicine (Buenestado et al. 2013). KB-CDSS not only provide advice to clinicians, they integrate guidelines with patient information and provide clinicians with tools that facilitate the application of guidelines in patient care. These systems can alleviate the effects of guideline adoption barriers and facilitate the dissemination of medical knowledge (Damiani et al. 2010). Moreover, several knowledge translation models have discussed the benefits of computerized tools such as KB-CDSS in the application of clinical guidelines in practice (Graham et al. 2010). KB-CDSS then can be considered both as eHealth systems and as knowledge management systems that can be used to disseminate evidence-based knowledge among clinicians (Alavi et al. 2001).

There are two main questions that arise from this classification of KB-CDSS. First, will clinicians use KB-CDSS? Past research showed that clinicians may be reluctant to use these systems because of insufficient evidence on KB-CDSS effectiveness (Heselmans et al. 2009) or because of the continuity of guidelines adoption barriers (Buenestado et al. 2013).

The second question is, as knowledge based systems, will the adoption of KB-CDSS increase the adoption of clinical guidelines in practice? In the IS literature, several studies focusing on knowledge management systems (KMS) have found that these systems either have no effect on knowledge translation (Haas et al. 2005) or had a delayed effect on it; further, experienced users are more likely to utilize knowledge in practice because they have a higher absorptive capacity (Ko et al. 2011). Another study found that enterprise resource planning (ERP)

systems enhance knowledge translation in international teams (Merminod et al. 2012). In the healthcare literature, studies have focused more on studying knowledge translation lifecycles (Graham et al. 2007), barriers to knowledge translation (Grimshaw et al. 2012), and how the lack of knowledge translation influences practice (Kitson et al. 2013; Pronovost 2013). However, there is little research on the role of KB-CDSS in enhancing knowledge translation in healthcare.

This thesis attempts to answer both questions by investigating the factors that may influence physician use, or lack of use, of KB-CDSS; and by studying the effect of using the system on the adoption of clinical guidelines in practice. In the next section, more specific details on pain management guidelines are examined for the benefit of understanding the format of clinical guidelines and understanding the functionality of the pain management KB-CDSS being studied.

### **2.3. Lower Back Pain (LBP) and Neuropathic Pain (NeP) Guidelines**

This thesis focuses on studying a pain management CDSS. Briefly discussing the clinical guidelines of LBP and NeP will provide a better understanding of both the complexity and value of the system being studied for improving quality of care.

#### **2.3.1. LBP guidelines**

As mentioned before, LBP is a common condition in developed countries and primary care physicians face challenges in managing this condition. Therefore, many clinical guidelines for physician management of LBP have been created. Since the emergence of the first LBP guidelines (Spitzer et al. 1987), they have been created in many developed countries (Koes et al. 2010). Adherence to LBP guidelines has been found to improve LBP management and outcomes (Bishop et al. 2010).

Despite the multitude of LBP guidelines, these guidelines provide similar recommendations for diagnosing and managing LBP. For example, most guidelines do not

recommend diagnostic imaging for LBP patients unless other conditions exist (Koes et al. 2010).

As an example of LBP guidelines in Canada, the Workers Compensation Board of British Columbia published LBP guidelines (Bishop et al. 2003) for family physicians. Table 2.2 summarizes these recommendations.

**Table 2.2. LBP Guideline Summary for Family Physicians (Bishop et al 2003)**

Management Phase	Recommendation
Diagnostic	<p>0-4 weeks after injury</p> <ul style="list-style-type: none"> <li>• History concerning the event and prior history on similar symptoms</li> <li>• Physical examination</li> <li>• Lumbosacral neurological examination</li> <li>• Red flags (i.e., signs of tumor, infection, spinal fracture, testing, cauda equina syndrome)</li> </ul> <p>5-12 weeks after injury</p> <ul style="list-style-type: none"> <li>• Diagnostic imaging</li> </ul>
Treatment	<p>0-4 weeks after injury</p> <ul style="list-style-type: none"> <li>• Education and reassurance</li> <li>• Activity and work modification exercises</li> <li>• Non-narcotic medications</li> </ul> <p>5-12 weeks after injury</p> <ul style="list-style-type: none"> <li>• Activity and work modifications</li> </ul>

	<ul style="list-style-type: none"> <li>• Work conditioning program</li> </ul>
--	---

### 2.3.2 NeP Guidelines

Although NeP is less common than LBP, it is more costly to manage and can be very severe and crippling (Gilron et al. 2006). Therefore, it was necessary to develop guidelines separate from LBP that facilitate the management of this condition. Several NeP management guidelines exist today including guidelines developed by: The International Association for the Study of Pain (IASP) Neuropathic Pain Special Interest Group (NeuPSIG) (Dworkin et al. 2007); the European Federation of Neurological Societies (EFNS) (Attal et al. 2010) and; the Canadian Pain Society (Moulin et al. 2007). Although these guidelines agree on the general approach to managing NeP, they differ in specific details that represent gaps in the NeP literature (O'Connor et al. 2009). For example, Table 2.3 summarizes recommendations of the Canadian Pain Society (Moulin et al 2007).

**Table 2.3. Canadian Pain Society NeP Recommendation Summary (Moulin et al 2007)**

Management Phase	Recommendation
Diagnostic	<ul style="list-style-type: none"> <li>• Patient history</li> <li>• Physical examination</li> </ul>
Treatment	1st line medication <ul style="list-style-type: none"> <li>• Tricyclic antidepressants</li> </ul>

	<ul style="list-style-type: none"> <li>• Calcium channel – ligands (gabapentin and pregabalin)</li> </ul> <p>2nd line medication</p> <ul style="list-style-type: none"> <li>• SSNRIs (duloxetine and venlafaxine)</li> <li>• Topical lidocaine (for localized peripheral NeP)</li> </ul> <p>3rd line medication</p> <ul style="list-style-type: none"> <li>• Opioid analgesics</li> <li>• Tramadol</li> </ul>
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## 2.4. McMaster Pain Assistant (MPA)

This section provides an overview of the McMaster Pain Assistant (MPA) system, its different components, and its use and its importance in pain management.

MPA is a knowledge-based clinical decision support system developed by the Department of Family Medicine at McMaster University to provide recommendations on the management of patient with LBP and NeP. MPA supports the Canadian Pain guidelines for NeP and the Institute for Health Economics (Alberta) guidelines for LBP management (Harstall et al. 2011). MPA is integrated as a module in the Open Source Clinical Application Resource Service (OSCAR) EMR (Aminpour et al. 2014). OSCAR is an open source EMR was developed by the Department of Family Medicine at McMaster University. It is widely used among family physicians, particularly in Ontario and British Columbia.

Despite the acknowledged value of LBP and NeP guidelines on patients' outcomes (Chou et al. 2007; Fritz et al. 2007), previous research reported low adherence to those guidelines



(González-Urzelai et al. 2003). For example, family physicians often used opioids as first level medication for chronic pain which increased the likelihood of patients' addiction (Furlan et al. 2010; Morley-Forster et al. 2003). Moreover, knowledge translation models propose that the use of electronic tools can enhance the application of guidelines in practice (Graham et al. 2010). Hence, MPA was developed with the goal of providing physicians with LPB and NeP guidelines along with the tools to facilitate the application of these guidelines in practice. MPA was developed after conducting focus groups and usability tests that confirmed the value of MPA (Nair et al. 2015)

Although MPA was developed to take advantage of the new user interface in OSCAR (Version 15) that provides OSCAR users direct access to MPA, it can also be installed in older versions of OSCAR (starting with OSCAR 12.1). However, in this case, users need to go through several screens in order to access MPA. The integration of MPA with OSCAR enhances user familiarity with the system and facilitates distributing MPA among clinics currently using OSCAR. This integration also facilitates transferring patient information between the EMR and MPA.

MPA consists of the following sub-modules (forms)

1. Lower Back Pain Encounter Guide: A guide for the diagnosis and management of LBP (figure 2.1)
2. Neuropathic Pain Encounter Guide: A guide for the diagnosis and treatment of NeP (figure 2.2)
3. PC-PTSD: Questionnaire for Post-Traumatic Stress Disorder
4. Mood PHQ-4: Questionnaire for Depression and Anxiety
5. PSQ-3: Questionnaire for Pain and Sleep
6. Brief Pain Inventory: Questionnaire for Pain and Function (figure 2.3)
7. Opioid Management: to manage treatment using opioids (figure 2.4)

#### 8. Goal planner: For planning pain management with patients

In addition to the above modules, MPA provides clinicians with a set of educational videos developed by physicians to improve awareness of pain management guidelines.

Taken together, the tools of MPA represent a complete suite for the diagnosis, treatment, goal setting, and education for both clinicians and patients designed to enhance clinician compliance with clinical guidelines.

The domain of this research involved KB-CDSS in a hierarchical approach that started from the concept of a CDSS and ended with the implementation of the MPA KB-CDSS. Through the discussion in this chapter, the relevance and significance of studying these systems was introduced as well as the significance of the MPA. Having explored the domain of this thesis research, the next chapters will begin to lay the theoretical foundations of the study as well as to pose and answer its research questions.

**Neuropathic Pain** Clinician:  
Created:

---

**Assessment**

**History**

Enter History

---

**Diagnose Neuropathic Pain**

**What is Neuropathic Pain-Quick Info**  
Knowing whether you have neuropathic pain can make a difference in your treatment. Dr. Moulton explains how to know if the pain is neuropathic.  
[What is Neuropathic Pain](#)

DN4 Questionnaire For Neuropathic Pain Assessment

If not using DN4, are there neuropathic features based on clinical judgement?  
Yes  No  Maybe

---

**Assess For Secondary Causes**

Vitamin B12 level:            Date:  
Drinks per Week:            Date:  
A1C:                                Date:  
Diabetes Type:                Date:

---

**Assess For Other Causes**

	Yes	No	Maybe
Failed Back Surgery/Radicular Fibrosis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Surgical Or Accidental Trauma	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Post-herpetic Neuralgia	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Trigeminal Neuralgia	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
HIV-related Neuropathy	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Multiple Sclerosis	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

---

**Summary of Assessment**

Enter Assessment Summary

---

**Management**

**Neuropathic Pain is Treated Differently-Quick Info**  
Most medications that work for neuropathic pain are not the usual pain killers. Dr. Moulton explains which medications you should try, and how to manage your medications.  
[Dr. Moulton on Treating Neuropathic Pain](#)

- Manage correctable causes
- Manage sleep, mood, social supports
- Pharmaceutical Management

---

**Medication**

Reference: Pharmacologic management of chronic neuropathic pain - Consensus statement and guidelines from the Canadian Pain Society.  
Link to Article: [http://www.canadapainociety.org/pdf/PharmacologicManagementChronicNer\\_05-09-2010-06-09.pdf](http://www.canadapainociety.org/pdf/PharmacologicManagementChronicNer_05-09-2010-06-09.pdf)

Figure 2.2. NeP Sub-Module

**Low Back Pain** Clinician:  
Created:

---

**Assessment** [Tips for history and physical exam](#)

**History**

Enter History

---

Please choose if pain is:

**Acute** (Within 12 weeks) and/or  **Chronic** (More than 12 weeks)

---

**Define the Back Pain**

Identify **Red Flags** Screening for Red Flags is a mandatory part of a back assessment.

Identify Pain Mechanism

Physical Exam

Identify Pain Pattern

---

**Assess Risk for Chronicity**

Identify **Yellow Flags**

Keele STaRT Back Screening Tool

---

**Diagnostic Imaging**

**Pictures are Not Always Helpful-Quick Info**  
X-rays, MRI and CT scans all provide important information about a back problem, but only in rare situations. Dr. Hall explains why most of the time, they will do more harm than good.  
[Dr. Hall on Imaging](#)

Criteria for Diagnostic Imaging

---

**Summary of Assessment**

Enter Assessment Summary

---

**Management**

**Stay Active-Quick Info**  
Movement is medicine. Dr. Hall explains to patients and their providers why it is so important and how to do it.  
[Dr. Hall Back to Activity](#)

**Referring to Surgeons-Quick Info**  
Surgeons can help in specific situations. Dr. Hall explains what these situations are.  
[Dr. Hall on Specialist Referrals](#)

---

**Acute**

Acute and Subacute (within 12 weeks since pain onset)

Figure 2.1. LBP Sub-Module

## Brief Pain Inventory

Clinician:  
Created:

### Measure Pain and Function

BPI: Questionnaire for Pain and Function

Completed by:

Patient or  Clinician

Purpose:

To screen for pain and how it interferes with function.

1. Throughout our lives, most of us have had pain from time to time (such as minor headaches, sprains, and toothaches). Have you had pain other than these everyday kinds of pain during the last week?

Yes  No

2. On the diagram, shade in the areas where you feel pain. Put an X on the area that hurts the most.

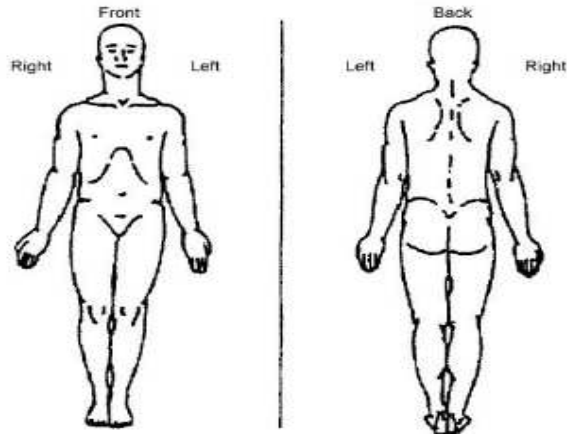


Figure 2.3. Brief Pain Inventory (BPI)

## Opioid Management

Clinician:  
Created:

Completed by:  
 Patient or  Clinician

Gender: Female

### Before you write the first script

- Goals Decided with Patient
- Opioid Risk Tool

### Maintenance & Monitoring

- Maintenance & Monitoring Chart

### When is it time to Decrease the dose or Stop the Opioid completely?

- When to stop opioids
- How to Stop - the essentials
- Aberrant Drug Related Behaviour

### Resources

- [National Pain Centre](#)
- [Patient Contract](#)
- [Patient Information Sheet](#)

Figure 2.4. Opioid Sub-Module

## **Chapter 3- Theoretical Background**

Having explored the study domain in Chapter 2, the theoretical foundation of this study is now laid. This chapter discusses the different theories and previous literature on the use of HIS and on knowledge translation in healthcare. This discussion will be used to support the development of the theoretical model in the next chapter.

Since studying HIS use is the subject of most of this thesis research, the chapter starts with a review of the literature on physician use of HIS and identifies the gaps in this literature. The literature review shows that HIS studies differ between the healthcare and IS domains. This duality is discussed after the review. The dual nature of HIS reveals how and why physicians view these systems differently. This mainly depends on physicians' perceptions of their profession, so these perceptions are discussed as well as how these perceptions are formed and how they influence HIS use. Following this discussion, a theoretical lens focusing on the effects of these perceptions is presented. This involves both the attitude-behavior model (Eagley et al. 1993), and then the DeLone and McLean IS success model (DeLone et al. 1992). An integration of both models is used to derive the theoretical model of this study. The chapter concludes by discussing knowledge translation in healthcare, the theoretical models associated with this knowledge translation, and how using KB-CDSS fits into these models.

### **3.1. Physician use of HIS**

Healthcare has been of great importance to societies for centuries. This importance is reflected in the creation of a large body of healthcare research that studies not only new interventions to improve healthcare, but care processes and how physicians adapt to changes in healthcare. As information systems (IS) developed, their potential value in the healthcare industry was recognized and researchers started to explore ways to use these emerging systems (Ledley et al. 1959). However, HIS research did not start to attract significant attention until the early 2000s

when the healthcare industry began to acknowledge the growing cost of healthcare coupled with an increase in medical errors; HIS was widely proposed as a solution to these problems.

Even as HIS research gained momentum, research followed traditional medical research methods in studying the efficacy of HIS in improving care; at the same time, researchers neglected to a great extent whether and why these systems were being used by care providers (Kaplan 2001). This focus on efficacy resulted in a gap in understanding healthcare provider motivations to use HIS, and in turn led to the failure of numerous HIS implementations due to care provider resistance (Archer et al. 2011a; Doolin 2004). This resulted in major implementation cost over-runs and more importantly in losing opportunities to enhance quality of care.

This research gap in understanding users began to encourage IS researchers to study the factors that impact use of HIS by different types of clinicians, including physicians, nurses, and other medical staff. For physicians, the main focus of this study, I undertook a literature review to assess their use of HIS and the factors that influence this use (Abouzahra et al. 2015). The results showed that physician use of HIS and related research is limited in terms of quantity, theory, and methodology. Table 3.1 shows the most used theories in explaining HIS use by physicians. The most used methodologies were surveys, primarily used by IS researchers, and case studies, mostly used by healthcare researchers.

**Table 3.1. Theoretical Models Used to Study IS and Guideline Adoption**

Theory	Number of papers in IS literature	Papers in healthcare literature (including guidelines)
Technology Adoption Model TAM	24	9
Innovation Diffusion Theory IDT	5	1
Theory of Planned Behavior TPB	4	3
Unified Theory of Acceptance and Use of Technology (UTAUT)	4	2
Identity theories	2	0
Avoidance Theory	1	0
Institutional Theory	2	0
Social Network Theories	6	2
Expectation-Confirmation theory	1	0

Moreover, based on this review, several constructs were studied in relation to HIS use, as follows:

## **A. Acceptance**

Acceptance refers to individual decisions to adopt an information system and their initial use of this system (Davis 1989; Venkatesh et al. 2003). Acceptance of information systems has been studied extensively for different IS including e-commerce (e.g., Gefen et al. 2003; Pavlou et al. 2006), business ((Davis 1989; Venkatesh et al. 2003), mobile banking (e.g., Luarn et al. 2005), and social media (e.g., Brocke et al. 2009; Ren et al. 2012). My literature review showed that acceptance dominated the HIS use literature with more than 90% of the reviewed papers focusing on acceptance (table 3.1) (e.g., Bhattacharjee et al. 2008; Shibl et al. 2013; Steininger et al. 2015; Young et al. 2012). Physician acceptance of HIS focused on two areas. The first area studied factors that caused physicians to resist using an HIS system such as: threats to physicians' time (Tung et al. 2008), poor system quality (Kane et al. 2011), and threat to autonomy (Sambasivan et al. 2012). The other area studied factors that encourage physicians to use HIS including: social influence (Steininger et al. 2015), usefulness (Yu et al. 2009), and training (Young et al. 2012). The dominance of acceptance research in this field can be justified given the relatively late adoption of information systems in healthcare (Berner et al. 2005) and the numerous failed e-health deployments because of clinician resistance. However, as HIS became more recognized for improving quality of care and reducing cost (Bloom 2002), and the call for meaningful use of HIS systems became required by legislation (Blumenthal 2009), the need to study HIS use became extended from acceptance to post-adoption behavior or continuous use.

## **B. Continuance**

IS continuance refers to the post acceptance behavior of IS users. That is, the phase where users re-evaluate their decision to use the system and either continue or discontinue system use (Bhattacharjee 2001; Rogers 2010).



IS continuance has been studied via several lenses. One approach utilized user expectations for system use, such as perceived benefits (e.g., Venkatesh et al. 2003). This approach was criticized since the same expectations are used to study initial acceptance (Davis 1989) and since users can accept a system but then stop using it (Straub et al. 1999). These expectations cannot account for both acceptance and discontinuance at the same time and hence, they must be influenced by other factors during system use and cannot be solely responsible for continuance of use .

More recently, expectation-confirmation theory (ECT) (Oliver 1980; Oliver 1993) has been adapted to the IS context to address the limitations of previous theories; that is, that ECT accounts for the role of using the system to modify user expectations (e.g., Hsu et al. 2006; Kang et al. 2009). Yet, ECT studies suffer from several methodological issues due to the inconsistencies and lack of stability of the outcomes of ECT studies in different contexts (Brown et al. 2014) and it ignores the concept that continuous use may be predicted by the quality of service rather than just confirmation. Moreover, (Brown et al. 2008) found that continuous models that depend only on user experience *perform better* than expectation-based models and expectation-confirmation models. That is, past behavior alone predicts continuous better than the constructs of ECT.

For physician use of HIS, the reviewed literature revealed that less than 10% of published studies focused on physician continuance behavior (e.g., Venkatesh et al. 2011b). However, the current global adoption of e-health applications (Mars et al. 2010) and the search for new ways to enhance the value of these applications require researchers to move towards studying the continuous use of e-health applications. This focus is motivated by several recent factors including: (1) currently, it is not enough to just use e-health applications such as EHRs or CDSS, but it is important to use them effectively and efficiently to improve care. For example, the HITECH act requires not just the use of EHR systems, but the “meaningful use” of these systems (Blumenthal et al. 2010; Hsiao et al. 2012). Therefore, it is important to encourage clinicians not

just to accept e-health applications but to continue using them effectively in order to reap their benefits. (2) Governments worldwide spend enormous amounts of money to encourage the use of e-health applications and on developing the infrastructure necessary for the use of these applications. For example, the USA is spending \$2B US through HITECH legislation to encourage e-health application use (Blumenthal 2009). Without understanding the factors that would encourage physicians to continue using e-health applications, much of the money dedicated to e-health could be lost with no significant value to patients. (3) The current trend of healthcare data analytics and integration of genetic information into clinical decision support requires the continual use of e-health applications. This is because these applications represent one of the main sources of data used in data analytics and at the same time they are major users of the outcomes of data analysis. For example, patient information in EHR systems has been widely used to predict clinical outcomes (e.g., Chanthaweethip et al. 2012). Therefore, clinicians should be encouraged to continue the use of e-health systems to enhance the benefits of healthcare analytics. Finally, (4) prior research on continuance behavior (Bhattacharjee 2001) suggested the necessity of studying continuance independent of initial acceptance behavior since information system users can discontinue using the system after they have initially accepted using it.

### **C. Assimilation**

Assimilation refers to the extent to which physicians integrate the HIS system in their daily routines and care delivery (Mishra et al. 2012). In this sense, assimilation reflects the *meaningful use* of HIS and how the HIS contributes to task performance. This construct has been used in a few papers (Mishra et al. 2012; Serrano et al. 2016) and it represents post-adoption behavior as in continuous use. A reason for using this construct instead of continuance is because of the nature of the healthcare system itself. All studies using this construct were conducted in the United States where physicians are usually mandated to continue using a hospital HIS (Romanow et al. 2012). Hence, it is more meaningful to study how much they integrate these systems into their

routines. This may be different in other healthcare systems such as the Canadian system where physicians may not be mandated to use HIS. Therefore, their decisions to continue using a system become meaningful.

### **3.2. The Dual Nature of HIS**

According to findings from my literature review, HIS can be viewed as having a dual nature. First, a business IS system that is created to enhance the efficiency of the work performed by care-providers is in a way similar to corporate IS (such as an inventory management system or a customer relationship management system). This view is mostly supported by IS researchers and is evident in the prevailing use of the TAM model and its constructs in studying IS use (e.g., Chismar et al. 2003; Hu et al. 1999). TAM was originally created and tested for business IS before expanding to other IS areas. Several researchers (Benbasat et al. 2007; Holden et al. 2010) proposed that TAM may not be suitable to study other contexts of IS use and they suggested using other basic theories (such as the theory of planned behavior) to study these contexts. Other researchers (Holden et al. 2010) called for including contextual constructs with TAM to study IS use, especially in the healthcare domain. Second, these contextual constructs can be identified by considering the nature of HIS to be a change or intervention that aims at improving the quality of care. This view is supported by healthcare researchers and physicians who believe that HIS causes a change to their workflows and requires innovation to improve their role as care-givers. This view is promoted by how physicians see their role as seeking the well-being of their patients and how they see new interventions such as HIS to be supporting this role (Haux 2006). Healthcare research supports this view of HIS by focusing on physician attitudes towards these systems and how this attitude is influenced by the role HIS plays in enhancing physician relationships with their patients.

This dual role of IS is not unique to HIS. It exists in other contexts such as electronic commerce (e-commerce) websites which are viewed as IS and at the same time as product or

service vendors (Gefen 2000). By understanding this dual nature of e-commerce, researchers were able to consider contextual constructs such as trust and to create comprehensive models for using e-commerce. I propose that understanding the dual nature of HIS is essential to building a comprehensive model that explains why physicians adopt or resist HIS systems. By considering HIS adoption as a change in physician practice similar to the adoption of new clinical guidelines, it is possible to identify significant contextual constructs that can be employed in HIS use models.

### **3.3. Physicians' Professional Identity**

Physicians' position in society has long been established, with patients trusting their physicians to make optimal decisions on matters directly affecting patient health. This trust and respect towards physicians is mainly a result of their professionalism and their dedication to patients (Real et al. 2009). Aspects of physicians' professionalism include their autonomy (Blumenthal 2009), decision making and judgment, and their focus on patient best interests (Roland et al. 2011). These aspects are created and enhanced through medical education as well as ongoing communications among physician community members (Freidson 1994).

This research studies the effect of physician professionalism on their use of CDSS using identity theories. Identity theory (Stryker 1987) and social identity theory (Abrams et al. 1990) are two complimentary theories (Stets et al. 2000) that define the individual and social meaning of one's identity. According to identity theory, identity is how one perceives oneself as different from others (Stryker et al. 2000) while social identity theory gives a social meaning to one's identity by studying one's identity as part of a group or collective (Abrams et al. 1990). An important process in both theories is self-categorization, but while identity theory proposes that one categorizes oneself by one's role in society (e.g. a physician, a professor, etc...); social identity theory describes self-categorization as associating oneself with a specific group or collective. The outcome of self-categorization is associating with meanings and expectations based on the role or the group membership of the individual (Stets et al. 2000).

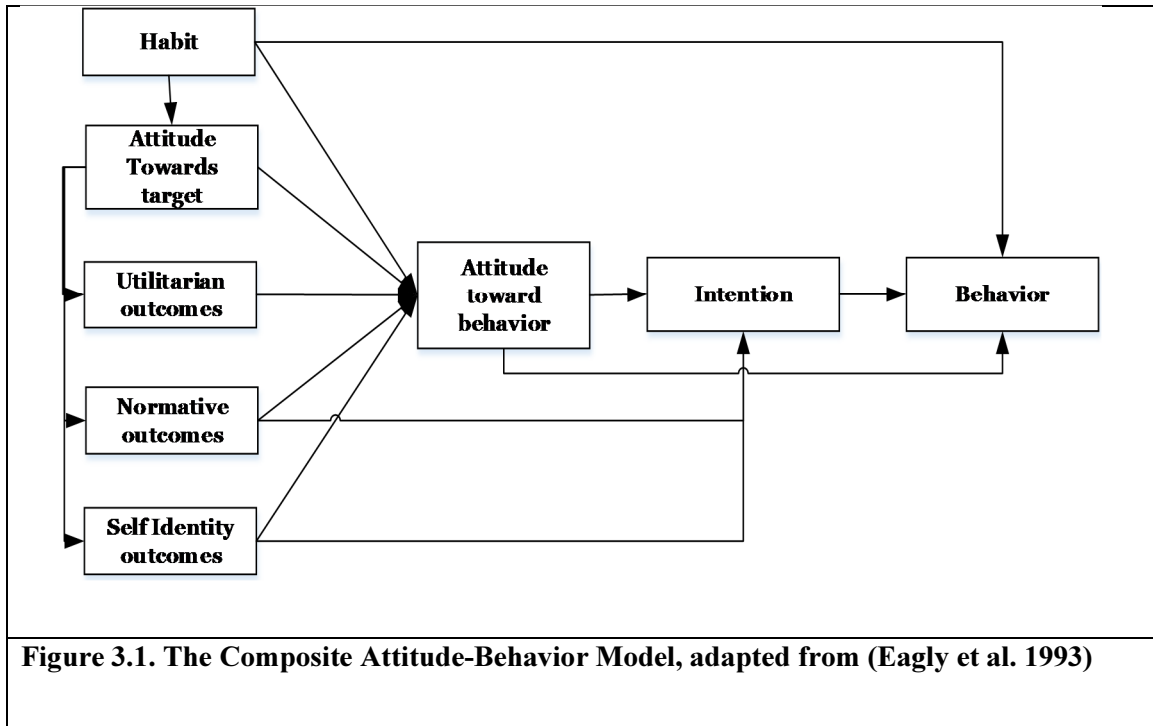
Physicians view their role in society as taking care of patients and making decisions in their patient's best interest (Roland et al. 2011; Tallis 2006). They value their autonomy and decision making independence as a core part of their role. Physicians regard these values as a symbol of their professionalism and commitment to patients beyond their "employment contract" (Tallis 2006). Previous research in healthcare associated physician resistance to change with threats to their care-taking role (Rundall et al. 2002). In HIS, resistance to new healthcare systems has also been associated with threats to this role such as: negative effects on physician-patient communications (Mishra et al. 2012), threats to autonomy (Walter et al. 2008), and threats to control over the care-taking process (Bhattacharjee et al. 2007). Likewise, physicians identify themselves as members of the medical profession and the medical community (Shaw 2014) and they view their belonging to this community as a major factor in establishing their autonomy and independence (Friedson 1970). The significance of this identification with medical society is evident in the importance and power of professional healthcare societies in influencing physician behaviors and decisions.

This study follows Mishra et al (2012) in defining professional identity as the physician's role identity and medical community membership identity. We argue that physicians' professional identity forges their expectations of a CDSS and influences their decision to continue using the system (Stets et al. 2000; Tallis 2006). Although Mishra et al. (2012) studied the influence of professional identity on the assimilation of HIS, they proposed a simplistic model that proposed a direct relationship between professional identity and EHR assimilation. In contrast, my study integrates professional identity with system related constructs to provide a comprehensive model to study CDSS continuance as opposed to the assimilation studied by Mishra et al. (2012). The effects of physicians' professional identity on their continuing use of CDSS are considered to be the threats imposed by the CDSS on their role identity, patient benefits from using the CDSS, and the influence of medical society on physician decisions.

### 3.4. Attitude toward HIS Use

Attitude toward a behavior is the tendency to evaluate the behavior as favorable or unfavorable (Ajzen 2005). Attitude has been studied extensively in psychology since the early 20<sup>th</sup> century, resulting in several models that explain the relationship of attitude with behavior, including the theory of reasoned action (TRA) and theory of planned behavior (TPB). These theories are the basis for most IS use models (e.g. TAM) (Davis 1989). However, when IS use models were tested in corporate contexts, attitude was found to have an insignificant effect on use in the presence of other constructs such as usefulness and ease of use (Venkatesh et al. 2003), and was therefore eliminated from IS use models such as TAM. However, as researchers noted (Benbasat et al. 2007), these business oriented IS models may not work in all contexts and therefore, theories more fundamental to the context need to be considered instead. On the other hand, healthcare researchers consider attitude an important factor in determining physician behavior in adopting guidelines or in HIS use. This is evident in influential models created to explain physician adoption of guidelines (Pathman et al. 1996) and in attitude being the main predictor of HIS and guideline use in healthcare studies (e.g., Cabana et al. 1999; Howes et al. 2012; James et al. 1997; Solà et al. 2014).

There are several models that explain the relationship between attitude and behavior such as TPB (Ajzen 2011) and TRA (Fishbein et al. 1975) which have been widely accepted in attitude and IS research. However, these theories have been criticized for focusing on cognitive factors and beliefs and ignoring affect, identity and prior behavior (Maio et al. 2009). Because healthcare studies indicate a relationship between physicians' identity as care-givers and their related behavior, this study employs the (Eagly et al. (1993)) composite attitude-behavior model (A-B model) which is considered one of the most influential attitude models in psychology (Maio et al. 2009). Figure 3.1 demonstrates this model.



This model was selected as a framework for my research because it considers both normative outcomes and self-identity outcomes. These are proposed to be influential factors in predicting HIS use. Therefore, this model allows an integration of IS related constructs and identity related constructs in a comprehensive framework.

### 3.5. Delone and Mclean IS Success Model (D&M Model)

The D&M model (DeLone et al. 1992) was proposed to define the different dimensions of IS success. Basically, the model proposes that IS success is determined by information quality, system quality, use, satisfaction, and benefits. In 2003, this model was revised to include service quality as another dimension of IS success (Delone 2003). The model suggests that the IS success dimensions are not independent, but rather interrelated and they work together to predict IS success (DeLone et al. 1992).

One of the strengths of the D&M model is its parsimony and its explanation of both process and causal relationships between the constructs (Petter et al. 2008). According to this

model, when a user starts using a system, different aspects of system, information, and service quality are experienced. This experience during use either makes the user satisfied or dissatisfied with using the system. The use of the system and the products of use then impact user performance. In turn, the benefits of using the system as well as user satisfaction influence intention to continue using the system (Delone 2003).

This study uses the D&M model to represent the external beliefs (antecedents) of attitude towards target and utilitarian outcomes. The logic behind integrating the D&M model with the A-B model is explained in chapter 4. D&M model is used in this study for several reasons: (1) Although the D&M model was originally developed to measure system success, it can also be extended to predict usage behavior (e.g., Seddon 1997) especially since the model explains the causal relationships between use and other dimensions of IS success. (2) By incorporating a process view of IS success dimensions, the model is a perfect choice for studying continuance behavior. This is because the model proposes a relationship between previous use of the system, the benefits and satisfaction resulting from this use, and the intention to continue using the system. That is, it links past and future use by proposing that using the system can lead to satisfaction and performance improvement which in turn can lead to intention to continue using the system (Delone 2003). This view agrees with other continuance theories such as the expectation-confirmation model (Bhattacharjee 2001). (3) As stated earlier, there has been an enormous expenditure on e-health systems. The cost associated with e-health system failures to fulfil its role (for example by users abandoning the system after initial adoption), the success of the system becomes a focal point and the main objective for studying continuance behavior. Hence, it makes sense to study continuance behavior through the lens of HIS success.

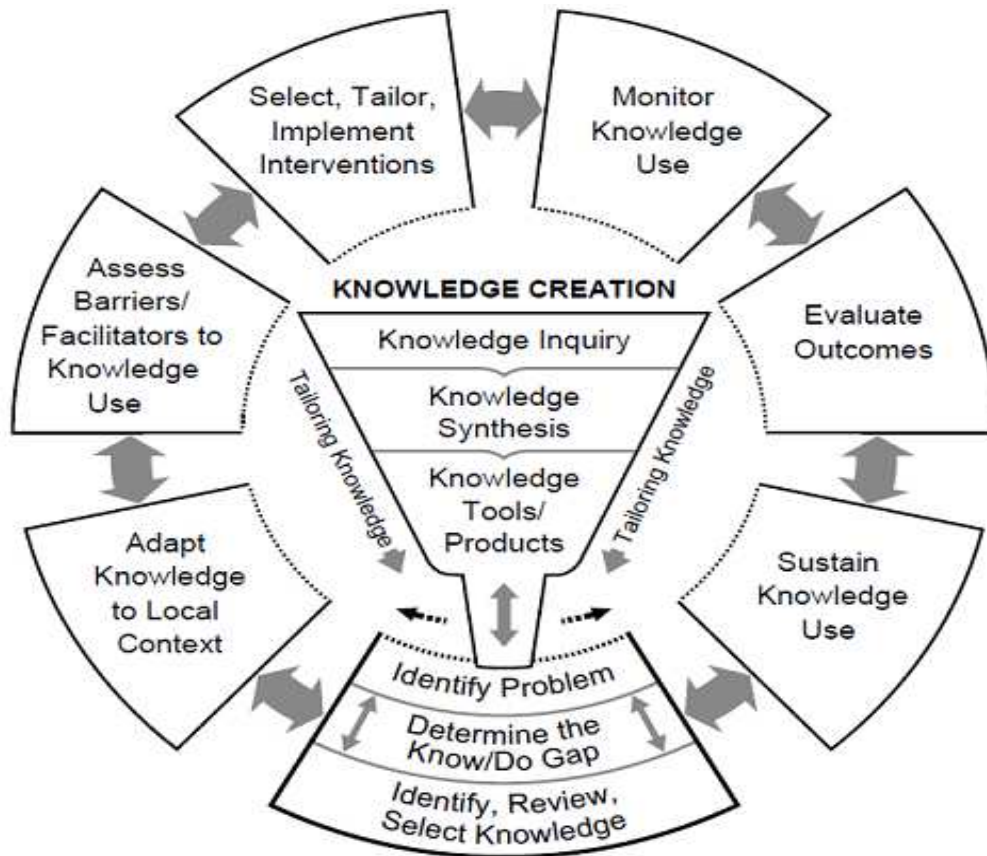
### **3.6. Knowledge Translation in Healthcare**

KT may be defined as the process of applying knowledge in practice (Straus et al. 2009). The study of KT in the IS literature has been scarce. Several studies focusing on knowledge



management systems (KMS) found that these systems either have no effect on knowledge translation (Haas et al. 2005) or had a delayed effect on it and that experienced users are more likely to utilize knowledge in practice because they have a higher absorptive capacity (Ko et al. 2011). Another study found that enterprise resource planning (ERP) systems enhance knowledge translation in international teams (Merminod et al. 2012). In healthcare, KT usually refers to transferring the continuous stream of medical evidence into practice (Straus et al. 2013). Thus, KT in healthcare is challenging given the rate at which new evidence is created.

Several KT models have been created to promote the application of evidence in practice. One of the most influential KT models is the Knowledge-to-Action framework (Graham et al. 2010) to explain the different phases of the knowledge translation process (Figure 3.2). This model has been adopted by the Canadian Institutes of Healthcare Research (CIHR) to promote knowledge translation.



**Figure 3.2. Knowledge-to-Action Framework. Adapted from (Graham et al. 2010)**

The Knowledge-to-Action model consists of two main components:

- A. **Knowledge creation:** This phase represents the creation of knowledge, which includes the generation of new evidence, synthesizing evidence from multiple sources, and creating the tools (for example guidelines or guide-line based CDSS) to provide knowledge in a useful format to users. This generation-synthesis-tool creation phase is common in medicine and has been used to create evidence-based guidelines for decades (e.g., Koes et al. 2010).
- B. **Knowledge-to-Action cycle:** this cycle is built on theories of planned action to create change in medical practice. It consists of several phases that aim to identify the practical

problem, develop a knowledge based solution, adapt this solution to context, implement this solution, and assess the outcome of the implementation.

The Knowledge-to-Action cycle was used in developing MPA as a tool that promotes KT. The cycle emphasizes the role of sustained use of knowledge as a prerequisite of the success of KT in healthcare. Since the continuous use of MPA by family physicians has a main goal of encouraging the application of guidelines in practice, *therefore, this model is used in this study to link the continuous use of the MPA to KT or the application of clinical guidelines in practice.*

Having discussed extant literature on HIS use and knowledge translation, the following chapter integrates this literature into a theoretical model that explains the factors that influence physicians' use of KB-CDSS and how this use influences knowledge translation.

## Chapter 4- Theoretical Model

Chapter 3 highlighted some of the conceptual frameworks, constructs and variables related to McMaster Pain Assistant (see Section 2.4 for a description) continuance use by physicians and residents. Building on this background knowledge, this chapter develops the theoretical model that will be used to address the specific research objectives to be investigated. Specifically, these objectives are: (1) To investigate and understand the influence of IS and professional identity factors on the continuous use of a KB-CDSS by family physicians; and (2) To investigate and understand the role of KB-CDSS use on the adoption of clinical guidelines in practice (knowledge translation).

Section 4.1 discusses how the theoretical model was developed, followed by a discussion of the research hypotheses in section 4.2. The chapter is summarized in section 4.3

### 4.1. Model Development

The attitude-behavior (A-B) model (Eagly et al. 1993) discussed in section 3.3 is used as the main framework for this theoretical model, to understand the factors that influence physicians' continuance behavior. Table 4.1 shows the relationship between the A-B model constructs and the constructs of the theoretical model. To link continuance use and the application of guidelines in practice, the A-B model is integrated with the Knowledge-to-Action knowledge translation model (Graham et al. 2010).

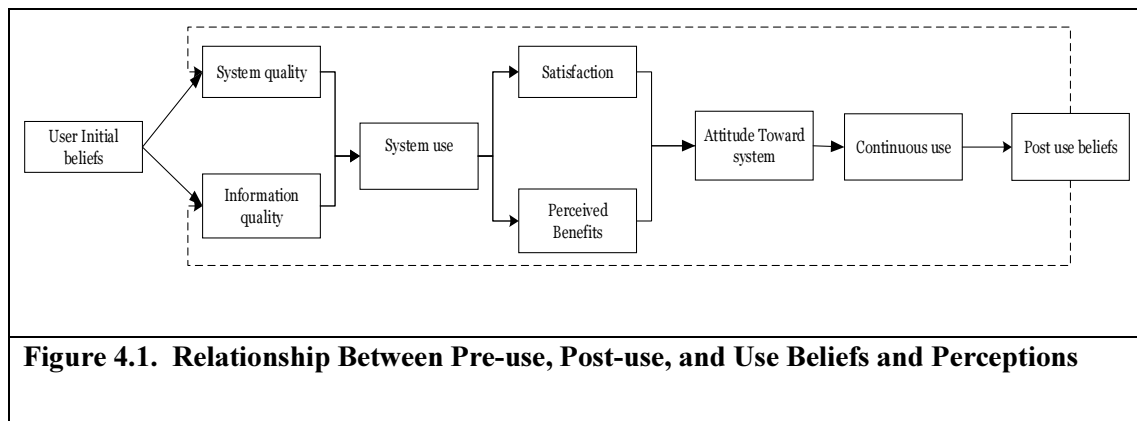
**Table 4.1. Mapping Between A-B Constructs and Proposed Model Constructs**

<b>A-B model Construct</b>	<b>Proposed Model Construct</b>
Behavior	CDSS continuous use
Intention	Intention to continue using CDSS

Attitude toward behavior	Attitude toward using CDSS
Habit	Satisfaction and perceived outcomes are used as proxies for habit
Attitude towards object	Satisfaction
Utilitarian outcome	Perceived benefits
Normative outcome	Influence of medical community
Self-identity outcomes	Threat to role identity

While the A-B model provides a framework to study continuous use, it does not consider specific external beliefs that influence the model constructs. External beliefs are context specific beliefs that apply only to the behavior under study and cannot be generalized to other behaviors and hence these beliefs need to be identified for each context (Ajzen 2005). For example, Gefen et al. (2003) hypothesized familiarity and situational normality (as external beliefs) to positively influence ease of use of online shopping websites. This study employs two sets of external beliefs: (1) identity beliefs, beliefs that influence identity and normative outcomes; and system related beliefs that influence utilitarian outcomes and attitude toward the system.. Following Pavlou et al (2006b) (Pavlou et al. 2006) those beliefs were identified based on a review of healthcare and IS literature (Abouzahra et al. 2015) as: threat to role identity and influence of medical community for identity beliefs (Mishra et al. 2012) and system quality (Escobar-Rodríguez et al. 2012; Salinas et al. 2011), information quality (Dillon et al. 2010; Graham et al. 2005), and perceived quality of care improvement (Brooks et al. 2006). These factors were confirmed by interviews with family physicians and healthcare researchers as explained in chapter 5.

To include the identified system related beliefs in the model, this research employs the Delone and McLean IS success model (D&M model) (DeLone et al. 1992). The D&M model has been widely used in the IS literature to explain the relationship between system quality, information quality, and system use (Petter et al. 2009). The model conceptualization, as given in Figure 4.1, is that as users start using the system with an initial set of beliefs (e.g., usefulness and ease of use), after further use, users will reevaluate their beliefs based on their perceptions of system attributes, (i.e. system and information quality). These perceptions influence users' satisfaction with the system (attitude toward system) and their beliefs about future system use (utilitarian outcome), which in turn modifies their attitude toward the system. Hence, users decide whether to continue with the system. Therefore, the D&M model not only explains the relationship between external beliefs, it also relates those beliefs to system use.



## 4.2. Research Model and Hypotheses

### 4.2.1. Integrating A-B model, D&M model, and The Knowledge-to-Action Model

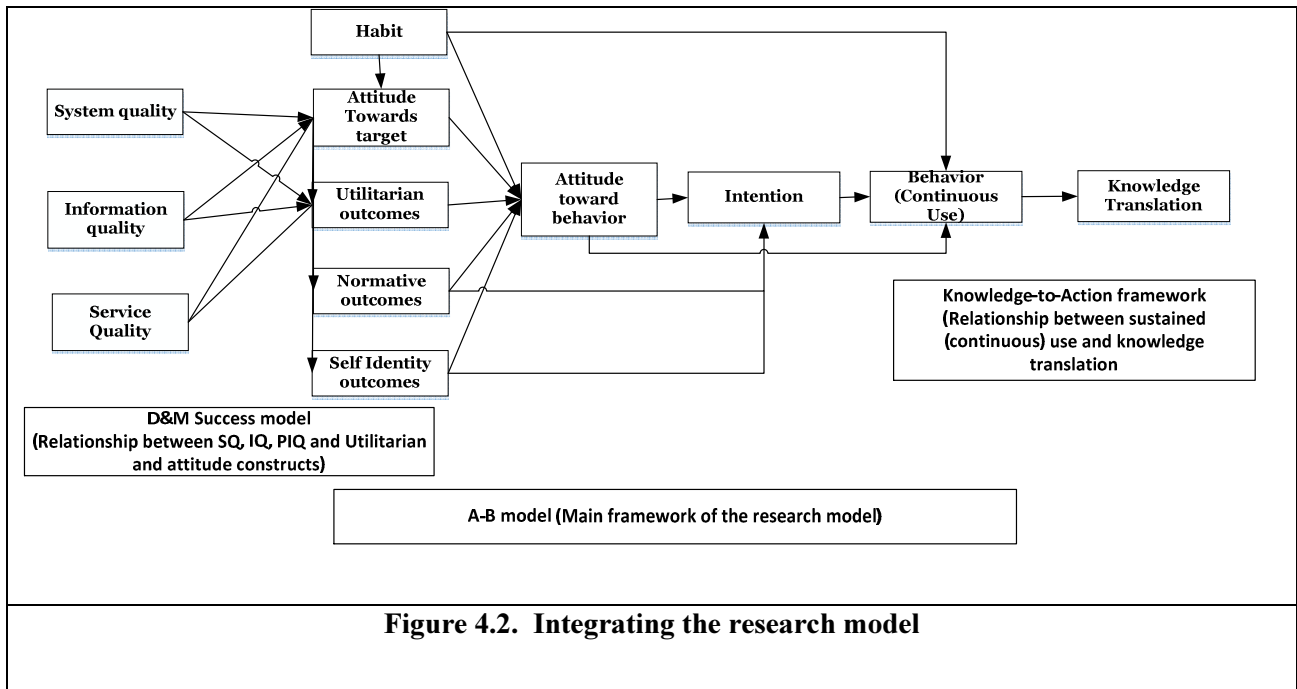
This section discusses the logic behind integrating the three models into the proposed research model and its relationship with the objectives of this study. The main objective of this study is to examine the effect of physicians' professional identity and IS related constructs (as identified through the literature survey (Abouzahra et al. 2015), and focus groups (discussed in

chapter 5). For this reason, the A-B model is utilized as the basic model because it supports the inclusion of identity, normative, and utilitarian outcomes (Eagly et al. 1993) which help address the main research objective. However, the A-B model is parsimonious and does not allow the investigation of antecedents of the identity, normative, or utilitarian outcomes. The A-B model is similar, in its parsimony, to TPB, and TRA (Ajzen 2005). For this reason, when A-B and TPB models proposed using external beliefs (Ajzen 2002; Ajzen 2011; Maio et al. 2009), those beliefs that are context dependent influenced the model constructs. IS Researchers (e.g., Gefen et al. 2003; Hung et al. 2012; Pavlou et al. 2006) often included external beliefs to extend these models. In this study, the proposed external beliefs, based on the literature review, included system and information related constructs, as well as patient related constructs. To include these constructs in the model, this study followed several researchers in using the D&M model to represent external beliefs related to system and information quality. For example, Venkatesh et al. (2008a), when developing version 3 of TAM, used the D&M model and included system quality as a predictor of usefulness and information quality as a predictor of ease of use, Xu et al. (2013) used the D&M model to predict usefulness and ease of use of e-services, and Seddon (1997) used the D&M model to predict system use in a business system. Hence in this study, D&M model is used to represent the antecedents of perceived benefits and satisfaction with system use since both constructs are already a part of both the D&M model and A-B model.

One of the other major objectives of this study is to explore the relationship between CDSS use and knowledge translation, defined as the application of clinical guidelines in practice. For this purpose, this study integrated the A-B model with the knowledge-to-Action model (Graham et al. 2010). While the knowledge-to-action model is a complex framework that aims at explaining how knowledge is assimilated, managed, and translated to action, a key proposal of this model is the relationship between sustained use of guidelines and the translation of these guidelines to practice (as explained in chapter 3). The research model of this study proposes that

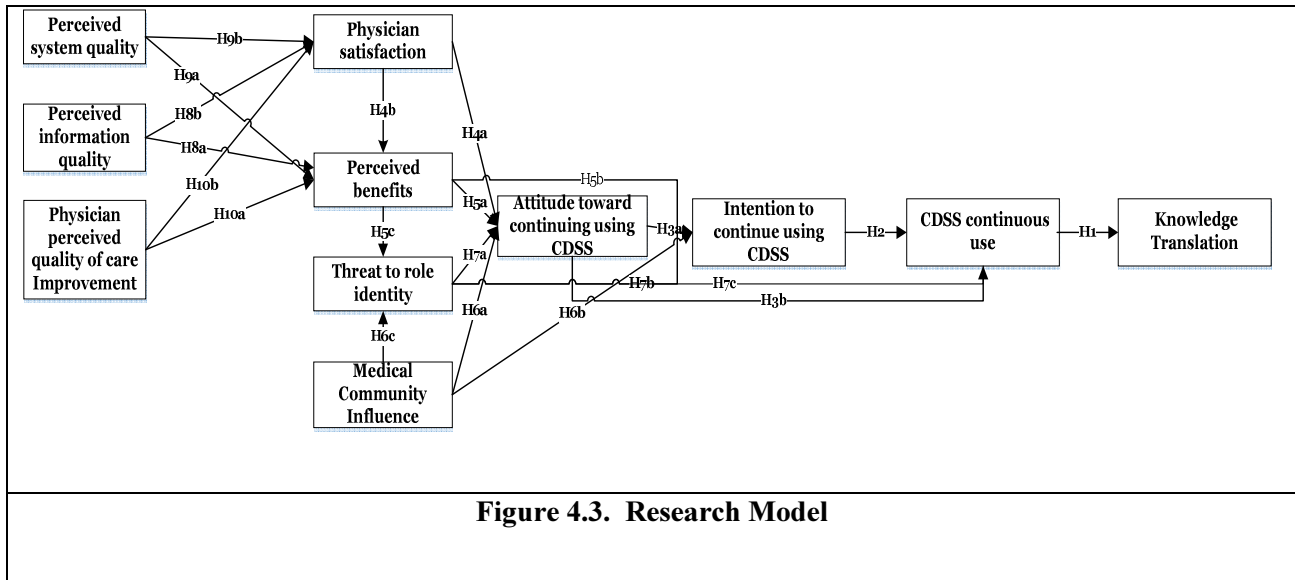
when physicians continue to use the system, they use it to follow pain management guidelines and hence, the continuous use of the system will lead to the application of these guidelines in practice. Although the Knowledge-to-Action model has not been used before in IS research (despite being widely accepted in healthcare), the relationship between IS use and knowledge translation has been proposed in several IS studies (e.g., Haas et al. 2005; Merminod et al. 2012).

Figure 4.2 below shows how the three models were integrated.





## 4.2.2. Research Model



**Figure 4.3. Research Model**

**Figure 4.3** shows the theoretical model used to investigate MPA continuance of use. The model integrates HIS-related and identity-related constructs into a comprehensive framework. As the figure shows, knowledge translation is proposed to be predicted by continuous system use (Graham et al. 2010) which in turn is predicted by the A-B model. System quality, information quality, and perceived improvement in patient care are included as external behaviours in the A-B model, based on constructs derived from the D&M model.

Habit, a direct antecedent of attitude in the A-B model is not included in this model for the following reasons:

(1) Habit, if seen as an automatic behavior that requires little or no self-instruction (De Guinea et al. 2009), requires a stable context (Limayem et al. 2007). Such a stable context is rare in HIS use as physicians regard each patient to be unique. In deciding whether it is suitable to use an HIS with their patients, they also engage in cognitive efforts. Physician behavior is then not automatic and their behavior is mostly performed under “unstable” conditions.

(2) Although past behavior has been proposed to influence attitude, researchers (Burton-Jones et al. 2006) have called for different conceptualizations of system use. For example, Ajzen (2005) cautioned against using past behavior to explain future behavior as it may only reflect the stability of the factors affecting the behavior.

(3) In psychological studies (e.g., Haddock et al. 1994) as well as IS research (e.g., Limayem et al. 2007), attitude is found to be related with satisfaction and the quality of previous behavior more than the frequency of behavior. Therefore, physician satisfaction may act as a proxy for previous behavior.

### 4.3. Model Hypotheses

**Table 4.3** below summarizes the model hypotheses. This set of hypotheses represents research objectives 1 and 2 of this study. The next chapter will provide the methodology that will be used to test these hypotheses.

**Table 4.2 Model Hypotheses**

No.	Hypothesis
H1	Physician continuous use of the CDSS is positively related to the translation of evidence-based knowledge into practice
H2	Physician intention to continue using the CDSS is positively related to continuing to use the CDSS
H3a	Physician attitude toward continuing to use the CDSS positively influences their intention to continue using the CDSS.
H3b	Physician attitude toward continuing to use the CDSS positively influences their continuous use of the CDSS

H4a	Physician satisfaction with CDSS use positively influences physician attitudes toward continuing to use the system
H4b	Physician satisfaction with CDSS use positively influences physician perceived benefits from using the CDSS
H5a	Physicians perceived benefits from using the CDSS positively influence their attitude toward continuing to use this CDSS
H5b	Physicians perceived benefits from using the CDSS positively influence their intention to continue using the CDSS
H5c	Physicians perceived benefits from using the CDSS negatively influence their perceived threat to role identity
H6a	The perceived influence of medical society positively affects physician attitude toward continuing to use the CDSS
H6b	The perceived influence of their medical society positively affects physician intention to continue using the CDSS
H6c	The perceived influence of their medical society negatively influences their perceived threat to role identity
H7a	Perceived threats to physician role identity negatively influences physician attitude toward continuing to use the CDSS
H7b	Perceived threat to physician role identity negatively affects physician intention to continue using the CDSS

H7c	Perceived threat to physician role identity negatively affects physician continuous use of the CDSS
H8a	Perceived information quality positively influences physician perceived benefits from using the CDSS
H8b	Perceived information quality positively influences physician satisfaction from using the CDSS
H9a	Perceived system quality positively influences physician perceived benefits from using the CDSS
H9b	Perceived system quality positively influences physician satisfaction from using the CDSS
H10a	Physician perceived improvement in patient care quality positively influences physician perceived benefits from using the CDSS
H10b	Physician perceived improvement in patient care quality positively influences physician satisfaction with using the CDSS

#### 4.3.1. CDSS continuance -Hypothesis (H1)

*Physician continuous use of the CDSS is positively related to the translation of evidence-based knowledge into practice (H1)*

First, CDSS continuance is defined as physician use of the system after their initial acceptance. The relationship between CDSS use and knowledge translation (the application of the clinical guidelines provided by the system for managing patients), in healthcare has seen little study. However, several knowledge translation models have involved continuous use as a

motivator to knowledge translation (Straus et al. 2013). The knowledge to action model (Graham et al. 2010) proposes that knowledge translation requires changes in care processes and physician routines, and for this change to occur (and stabilize), physicians must use the CDSS continually to motivate these changes. If they stop using it, the workflow changes will no longer be supported and the old workflow will prevail.

#### **4.3.2. Intention to Continue Using CDSS -Hypothesis (H2)**

*Physician intention to continue using the CDSS is positively related to continuing to use the system (H2).*

Intention captures the motivational factors to do a behavior. The intention-behavior relation has been well established in attitude models, including TPB, TAM, and the A-B model, all of which have intention as a predictor of behavior. Empirical research confirms a strong intention-behavior relationship (Ajzen 2005).

#### **4.3.3. Attitude Towards Continuing CDSS Use- Hypotheses (H3a,b)**

*Physician attitude toward continuing to use CDSS positively influences their intention to continue using the system (H3a).*

*Physician attitude toward continuing to use the CDSS positively influences their continuous use of the CDSS (H3b).*

Attitude towards using CDSS may be rated (un)favorable (Maio et al. 2009) depending on how the tendency behavior of continuing CDSS use is to be evaluated. The attitude-intention relation is well established (Ajzen 2005). TPB proposes that individual intention towards performing a behavior is influenced by their attitude towards this behavior. Empirically, this same relationship has been confirmed in past IS studies (e.g., Pavlou et al. 2006). Also, the A-B model proposes a direct attitude-behavior relationship. This is why we propose H3b.

#### **4.3.4. Satisfaction with CDSS Hypothesis (H4)**

*Physician satisfaction with the system positively influences their attitude towards the system (H4a);*

*Physician satisfaction with the system positively influences perceived system benefits (H4b)*

Satisfaction refers to physicians' positive attitudes towards CDSS use, based on their cognitive and emotional appraisal of its performance (Wixom et al. 2005). Satisfaction represents the attitude toward the target factor in **Figure 4.2** (Delone 2003), also representing the quality of previous interactions with the system. Accordingly, when physicians are satisfied with the system, this attitude toward the system will be transferred to their interactions with the system and hence physicians will have a positive attitude toward continuing system use (Zhang 2013). Also, satisfied physicians are likely to have a more positive view of system outcomes (Petter et al. 2008), through positive perceived benefits (DeLone et al. 1992).

#### **4.3.5. Perceived Benefits Hypothesis (H5a,b)**

*A positive relationship exists between physicians' perceived benefits and attitude towards using CDSS (H5a).*

*Physicians' perceived benefits from using the CDSS positively influence their intention to continue using the system (H5b).*

In the A-B model, utilitarian outcomes refer to benefits resulting from using the system (Eagly et al. 1993). The utilitarian outcomes construct is therefore similar to perceived benefits

(Davis 1989) or performance expectations (Venkatesh et al. 2003) constructs. The relationship between perceived benefits and attitude has been supported in IS (Egea et al. 2011; Hu et al. 1999; Melas et al. 2011) and healthcare research (Buenestado et al. 2013; Dünnebeil et al. 2012).

An important point to note here is that although perceived benefits has been considered as a unique construct in IS, several studies proposed that benefits are context dependent. For example, Mishra et al. (2011) used identity theory to show that physicians perceive their benefit from the system depending on their perception of their professional identity as care-givers. This agrees with the sense making theory which proposes that the benefits perceived by users depend on how they perceive the system as related to their role (Jensen et al. 2009). When physicians experience the benefits of the system, they will evaluate their interactions with the system as positive and hence will have a positive attitude toward continuing to use the system (Venkatesh et al. 2003).

Although the A-B model does not propose a direct relationship between perceived benefits (utilitarian outcome) and intention, a positive relationship between perceived benefits and intention to use the system has been proposed in several IS use models including TAM (Davis 1989). Moreover, this relationship can be seen if we consider perceived benefits as a component of self-identity outcomes as proposed by Mishra et al. (2011).

Also, perceived benefits have a negative relationship with perceived threat (*H5c*) because, as physicians perceive more value from using the CDSS, they are likely to see it as supportive to their role as caregivers and perceive less threat from using the system.

#### **4.3.6. Perceived Influence of Medical Society Hypothesis (H6a,b,c)**

*The perceived influence of medical society positively affects physicians' attitudes toward continuing CDSS use (H6a).*

*The influence of the medical community has a positive relationship with physician intention to continue using the system (H6b).*

*The perceived influence of medical society negatively affects physicians' perceived threat to role identity (H6c).*

Social identity theory proposes that when one identifies oneself with a group, one's perceptions are influenced by this identification (Abrams et al. 1990; Chreim et al. 2007). For physicians who identify themselves as members of the medical community, this influence is more salient, given how physicians perceive such a membership as fundamental in their profession and how they associate with such a community more than with their employer (Freidson 1994). As such, we argue that physicians value each other's opinions and experiences highly due to their common education and life-long training (Hilton et al. 2005; Tallis 2006). If a CDSS is widely accepted by the medical society, this is likely to boost physicians' positive evaluation of using the system, and hence will positively influence their attitude toward the system.

Moreover, as physicians perceive that the medical community favors their use of the system, it will directly enhance their intention to continue using the system (Eagly et al. 1993; Venkatesh et al. 2003). Further, the more physicians perceive the system as accepted by the medical community, the more they are likely to trust this system and view it as less threatening.

#### **4.3.7. Perceived Threat to Role Identity Hypothesis (H7a,b,c)**

*Perceived threat to physicians' role identity negatively influences physicians' attitude toward continuing CDSS use (H7a).*

*Threat to physicians' role identity has a negative relationship on their intention to continue using the system (H7b).*

*Perceived threat to physicians' role identity negatively influences physicians' continuous CDSS use (H7c)*



Previous research in healthcare found that physicians may resist change or the use of a HIS because this system represents a threat to how they conduct their tasks (for example, through loss of control or loss of autonomy). This agrees with identity theory which posits that when physicians identify themselves as care-givers, they form their expectations of using the system based on this classification and may label the system as “identity-challenging” (Tripsas 2009) if using the system threatens their role identities. We argue that when physicians perceive the system as threatening to their role identity as care-givers, they perceive the CDSS as identity-challenging (identity-threatening) and hence they will negatively evaluate their use of the system. Moreover, as physicians consider the negative consequences of the system use on their identity, they are likely to be less motivated to continue using the system and hence their intention to continue using the system will be negatively affected.

Finally, the A-B model (Eagly et al. 1993) as well as TPB (Ajzen 2005) signify the role of *perceived behavior control* or *facilitating conditions* as factors that have a direct impact on both intention and behavior. For example, it may be the case that a physician has the intention to use the system, but this intention is countered by the lack of time to use the system or by patient dissatisfaction while using the system. Hence threat to role identity acts as a negative factor that may prevent physicians from using the system even if they intend to use it.

#### **4.3.8. External beliefs influencing HIS use**

When proposing their TPB model, Ajzen (2005) discussed a set of external variables which are context specific, cannot be generalized to other contexts, and can indirectly influence behavior. He suggested selecting five to nine beliefs which are in the same context as the behavior. This set of beliefs would be very important in a healthcare context because there is a variety of HIS which perform different tasks. Therefore, generalizing external beliefs over all HIS systems is inaccurate and can be misleading. At the same time, there is some similarity between these beliefs since they are within the same context.

External beliefs were identified through the literature review, and they were classified into three categories: (1) system quality, which refers to the physicians' subjective evaluation of the quality of the system; (2) information quality which refers to the usefulness and desirability of the information produced by the system; and (3) patient related beliefs which refer to the perceived effect on patients as users of the system. These beliefs, summarized in table 4.3, are characterized by not having a direct relationship with system use.

**Table 4.3 External Variable Constructs**

<b>Class</b>	<b>Construct</b>
System quality	Ease of use Flexibility Accessibility Involvement
Information quality	Agreement Currency Accuracy
Patient related constructs	Perceived improvement in patient care

**4.3.8.1. Perceived Information Quality (PIQ)-Hypothesis H8:**

*PIQ positively influences physicians' perceived benefits (H8a)*

*PIQ positively influences physicians' satisfaction from using the CDSS (H8b).*

PIQ is the usefulness and desirability of the information produced by the system such as information accuracy and currency (Wixom et al. 2005). In the CDSS context, PIQ reflects the accuracy and timeliness of the clinical guidelines and alerts provided by the system as well as the meaningfulness of the information format. The DM model proposes a positive relationship between *information quality*, *system benefits* and *satisfaction* (Petter et al. 2008). In a CDSS

context, PIQ is directly related to CDSS perceived benefits because the system can only be useful if the information it produces reflects disease management guidelines accurately. Also, information is the main outcome of a CDSS use. Thus, physician satisfaction with using the system is likely to be dependent on their perception of the quality of information they get from the system.

#### **4.3.8.2. Perceived System Quality (SQ)-Hypothesis H9:**

*SQ positively influences physicians' perceived benefits (H9a)*

*SQ positively influences physicians' satisfaction from using the CDSS (H9b).*

Perceived CDSS SQ refers to physician subjective evaluation of the quality of the system which may include reliability, flexibility, and familiarity with the system (DeLone et al. 1992). Similar to PIQ, the DM model proposes a relationship between *system quality*, *system benefits* and *satisfaction*. For CDSS, when physicians perceive the system to be of high quality, they are likely to be satisfied using it and more likely to perceive system outcomes as useful.

#### **4.3.8.3. Physician's Perceived Quality Improvement (PQI)-Hypothesis H10:**

*PQI positively influences physicians' perceived benefits (H10a)*

*PQI positively influences physicians' satisfaction from using the CDSS (H10b).*

Physician perceived quality of care can be defined as physician's subjective evaluation of the improvement in patient quality of care due to using the CDSS. This construct is similar to the service quality construct in the modified DM model (DeLone 2003) where the service provided by the system directly influences patient conditions. In healthcare research the existing literature on clinical guidelines proposes that patient acceptance and adherence to guidelines influence physician decisions to use these guidelines (Cabana et al. 1999). Few studies propose that physicians would stop using a system if their patients do not adhere to recommendations based on

system outcome (Brooks et al. 2006). When physicians become aware of improvements in their relationship with their patients and the quality of care experienced by those patients, they are likely to perceive use outcomes as more valuable and become more satisfied with the system.

#### **4.4. Summary**

This chapter has discussed the development of the theoretical model utilized to address objectives 1 and 2 of this study. It started by presenting the rationale of integrating the three conceptual models: knowledge translation (Graham et al. 2010), the A-B model (Eagly et al. 1993), and the D&M model (DeLone et al. 1992) to create the research model. Then the research hypotheses were presented.

The next chapter discusses the methodology used to validate this model as well as the methodology used to address the other research objectives

## Chapter 5- Methodology

This chapter discusses the methodology that is used to answer the research questions of this thesis. Specifically, this methodology has the following goals:

1. Test the theoretical model hypotheses described in chapter 4 and validate the relationship between continuous use and knowledge translation
2. Validate whether the factors that influence physician intention to continue using the system actually change with time
3. Examine changes in usage patterns and the relation between these patterns and knowledge translation
4. Provide a deeper understanding of the context of using KB-CDSS and the factors that influence physician use of such systems

To answer these questions, this study utilizes a longitudinal mixed-methods methodology that combines testing the theoretical model proposed in chapter 4 at two different time points with focus groups conducted at the end of the study. To present the different methods employed, this chapter is organized as follows. Section 5.1 provides an overview of the research procedure. The theoretical model testing methods start in section 5.2 which discusses how the model constructs were operationalized. This is followed in section 5.3 by a discussion of the development of the research questionnaire and challenges faced during this process. Section 5.4 introduces the data collection phase, including the types of data collected and when these data were collected. Section 5.5 presents the procedures used to validate the proposed theoretical model. Examining the detailed relationship between use and knowledge translation starts in Section 5.6. This discusses how the relationship between use and adoption was studied, as well as how the economic value of knowledge translation was measured. The qualitative methods of this study are discussed in section 5.7 including a description of the procedure used for validating and analyzing focus groups. Finally, section 5.8 presents a summary of the methodologies used in the research.

## **5.1. Research Phases**

This section describes the different phases of this research, including the development of study tools and collection of research data. The research was conducted in four phases: Initial focus groups and questionnaires, pre-test, pilot test, and the main study.

### **5.1.1. Initial focus groups and interviews**

The goal of the initial focus groups and interviews was to adapt and refine the questionnaire tools obtained from published literature relating to the context of this study.

While adapting questionnaire tools from the literature is common, researchers (e.g., Vogt et al. 2004) suggest involving the target population in refining these questionnaires. Researchers advocate the use of focus groups and interviews for the development of new questionnaires and for refining existing ones (Nassar-McMillan et al. 2002). Moreover, focus groups can be used to derive knowledge about the research target that can be useful during later research stages (Nassar-McMillan et al. 2002). The use of focus groups and interviews to develop and refine questionnaire tools has been used in both IS (Nelson et al. 2005; Pitt et al. 1995) and healthcare studies (Kelly et al. 2005).

This study employed a focus group of six physicians and healthcare researchers who were involved in system development, along with potential system users. To extend the value of this phase, semi-structured interviews were conducted with two additional healthcare researchers for the purpose of further refining the research tools. The focus groups were used to discuss and refine the questionnaires. An example of the refinements arising from the focus groups is replacing “LBP patients” with “patients with LBP” which is the term used in the medical field. Section 5.2 describes how the focus group and interviews were employed to operationalize the main constructs of this study.

### **5.1.2. Pre-test**

Because of the context difference between scales derived from the literature and pain management CDSS, these scales were adapted to our context following (Boudreau et al. 2001). After the initial refinement of the questionnaires, these tools were sent to a group of physicians, healthcare researchers, and IS researchers for further refinement. The group consisted of two IS researchers, four physicians, and two healthcare researchers.

While the IS and healthcare researchers approved the questions with minor modifications, physicians expressed concerns about apparent statement repetition in the questionnaires. Hence, the questionnaires were modified to overcome physician concerns, particularly by reducing repetitions.

### **5.1.3. Pilot test**

Boudreau et al. (2001) as well as MacKenzie et al. (2011) signified the importance of pilot testing for the validation of questionnaire instruments. Therefore, this study included a pilot test phase where the proposed questionnaires were sent to twenty one (21) participants (11 family physicians and 10 residents) to refine and validate the questionnaire content.

In addition to the questionnaire itself, the participants were asked for their comments on the questionnaire through an open ended question. This phase resulted in further refinements to the language of the questionnaire.

### **5.1.4. The main study**

The research procedures were as follows: Study participants including physicians, residents and nurse practitioners as well as patients (for chart audit) were recruited in three academic clinics: McMaster family practice (MFP), Stone Church family practice (SCFP), and Halton family practice (Halton). Participants were asked to sign a consent form agreeing to

participate in this study. This form was approved by Hamilton Integrated Research Ethics Board (Appendix A). After signing the consent form, participants received a link via email to an initial questionnaire to assess their level of adoption of clinical guidelines. After six (6) months of the study, participants were asked to complete the adoption questionnaire again, as well as the survey tool used to validate the theoretical model. System usage data were collected at the same time. After 12 months of the study, participants were asked to complete the survey tools again. Usage data were collected again for the period between 6 months and 12 months of use and patient charts were reviewed to assess the actual level of adherence to guidelines. Finally, following the second wave of the survey (the survey deployed after 12 months of use), focus groups were conducted at the three clinics to gain a deeper understanding of the use context.

To calculate the sample size required for the validation of the research model, this study followed (Gefen et al. 2000). That is, the sample size should be 10 times the larger of either the number of items in the most complex model construct or the number of paths going into any one individual construct. Since the number of items in the most complex construct is six (knowledge translation) as opposed to four paths going into the “attitude” construct, the minimum number of participants was estimated to be sixty (60) participants.

Moreover, for the multi-level modeling analysis used to study the relationship between system use and knowledge translation, the study followed (Maas et al. 2005) in using the minimum number of 50 level two groups (participants).

Based on the above, the estimated required sample size was 60 participants. However, to accommodate for incomplete or uncompleted questionnaires, the questionnaires were sent to 118 physicians in the three clinics mentioned above.



## **5.2. Theoretical model construct operationalization**

This section focuses on how the study operationalized the main constructs in the theoretical model, which is a major prerequisite to model validation. Previous research (MacKenzie et al. 2011; Segars et al. 1998; Sethi et al. 1991) signified the importance of construct operationalization as a prerequisite to constructing a valid and reliable measurement instrument. Construct operationalization refers to converting the abstract construct concept to a measurable variable(s) by identifying the conceptual domain of the construct (MacKenzie 2003; MacKenzie et al. 2011). This step is necessary to specify what the construct represents (or does not represent) and to differentiate it from other similar constructs (MacKenzie 2003). Hence, the quality of the measurement model depends on an accurate operationalization of its constructs.

The remainder of this section discusses how the constructs of knowledge translation, system use, perceived benefits, threat to role identity, system quality, information quality, and perceived improvement in patient condition are operationalized. Other constructs including attitude, satisfaction, and intention have been defined in the previous chapter. They have been reported repeatedly in the literature and their measurement model is discussed in more detail in the next section.

### **5.2.1. Knowledge translation**

In the medical domain, knowledge translation is defined as the application of clinical guidelines in practice (Straus et al. 2013). Since this study focuses on pain management, this definition can be stated as the application of pain management guidelines in managing patients with neuropathic pain and lower-back pain. In the medical literature, knowledge translation has been measured in different ways as described below. A common compromise between these different ways is to specify the main guidelines used to manage specific patients and then assess the degree to which these guidelines are applied by physicians in practice.

The assessment of knowledge translation is done either by using actual behavior, for example by examining patient charts to determine whether physicians apply the identified main guidelines in practice or not (Hysong et al. 2006), or by using perceived behavior, for example by developing a questionnaire to examine how often the physicians apply guidelines in practice (Mosca et al. 2005). The first assessment method is more accurate since it describes physicians' actual behavior. However, it is expensive since it requires using trained personal to go through a typically large number of patient charts; and it requires patients' consent to go through their charts. The later method is easier to implement but it is self-reported and may be less accurate than the first one (Adams et al. 1999).

This study used both assessment methods (Montano et al. 1995). A group of family physicians specified the main guidelines used to manage patients with LPB and NeP (as specified in chapter 3) and developed a questionnaire (Appendix C) to assess the level of adoption of these guidelines. This questionnaire was based on the Pathman et al. (1996) awareness-to-adherence model (AAA model) which is a widely used model in measuring adherence to clinical guidelines in practice. To assess the economic value of using guidelines, LBP and NeP pain visits were captured and examined by a physician for adherence to clinical guidelines. The economic value of adherence to guidelines (e.g. improvement in prescribing diagnostic imaging for patients with pain) was examined and reported.

### **5.2.2. System use**

Despite the importance of the “system use” construct in IS research (Benbasat et al. 2003) and its role in measuring the success of information systems (DeLone et al. 1992), most IS studies do not include actual use and stop at the intention phase (e.g., Asua et al. 2012; Davis 1989). This is probably because of: a) the difficulty of capturing actual system data, b) the complexity of user behavior (Burton-Jones et al. 2006), and c) because of the strong relationship between intention and behavior (Feldman et al. 1988).

One of the objectives of this study is to examine the relationship between system use and knowledge translation. Therefore, system use is an essential construct in the research model. System use is a complex construct that depends on the user, the task, and the system (Burton-Jones et al. 2006). Hence, some researchers (Burton-Jones et al. 2012; Venkatesh et al. 2008b) have proposed that the conceptualization of system use depends on the system itself and the context of system use.

This study follows (Venkatesh et al. 2008b) in conceptualizing system use as the frequency, duration, and intensity of using the system. However, unlike (Venkatesh et al. 2008b) these attributes of system use are captured from system logs and not through self-reported questionnaires. Frequency of accessing the system is captured by calculating how often users saved system forms in the system. The duration of using the system is measured by how many fields within each form were completed, as a proxy for duration. Intensity of use was measured as the number of different forms (sub-modules) within the system that were used. Because of system limitations, only saved form data were captured. Using different dimensions to operationalize system use allows the study to capture the complexity of this behavior and it follows the suggestions of (Burton-Jones et al. 2006) who proposed individual system use as a construct that involves a user, a system, and a task. They suggest a 2-step approach to conceptualize use that includes selecting the elements of use and the measures that reflect these elements.

### **5.2.3. Perceived benefits**

As mentioned in chapter 4, perceived benefits refer to the benefits users receive from using the system. Several researchers (Jensen et al. 2006; Mishra et al. 2012) argued that perceived benefits are not absolute but depend on the context of system use and on the identity of the users. For example, the benefits the physicians perceive from the system are different from patients' perceived benefits.

To conceptualize the construct of perceived benefits, a literature review was conducted (Abouzahra et al. 2015) to identify how physicians perceive system benefits. A list of potential benefits was created and discussed with physicians and healthcare researchers in two focus groups and several interviews. The outcome of this process was the selection of three dimensions of benefits perceived as important to family physicians, including: improving patient management, improving knowledge of pain management, and improving the efficiency of diagnosis.

#### **5.2.4. Perceived threat to role identity**

Perceived threat to role identity refers to the system outcomes that are perceived by physicians as threatening to their roles as caregivers. Healthcare literature has reported on threats to physician roles of using HIS and clinical guidelines in numerous studies (Doolin 2004; Mishra et al. 2012; Nov et al. 2012; Smith et al. 2014). It can be argued that threats to role identity differs because of different factors including the type of system, the users, and even the geographic location. For example, physicians' perceived threats from using an EMR which focuses on providing patient information may be different to threats perceived from a CDSS that provides suggestions based on clinical guidelines. A major concern for EMR use may be patient privacy (Paul et al. 1999), while for CDSS, it may be control over management decisions (Peirce et al. 2015). Moreover, physicians' perceived threats depend on their positions and responsibilities. For example Mishra et al. (2012) discusses the threat of medical insurance companies on physician use of an HIS. This threat does not normally apply to Canada where the government is the primary payer of healthcare costs.

To operationalize threat to role identity in this study, a literature review was conducted (Abouzahra et al. 2015). This review resulted in a list of potential threats. These threats were discussed with physicians and healthcare researchers in two focus groups and several interviews. The outcome of this process was the selection of three dimensions of perceived threat to role

identity including: the consumption of visit time, negative influence on physician-patient communications, and loss of control over decision making.

### **5.2.5. System and information quality**

The concepts of system quality and information quality are usually considered together in research (DeLone et al. 1992; Nelson et al. 2005; Wixom et al. 2005). The D&M success model specifies both information quality and system quality as antecedents of perceived benefits and satisfaction. Wixom et al. (2005) and Petter et al. (2009) argued that the dimensions of system and information quality differ according to the information system context. This study follows the Wixom et al. (2005) technique on how to select information and system quality dimensions by surveying the literature to identify potential dimensions of both constructs. Running two focus groups and several interviews with potential system users helped to prioritize and select the most important dimensions of both constructs. Users were provided the opportunity to select other dimensions of system quality if these dimensions were not on the list.

The outcome of the above process was three information quality dimensions: accuracy, currency, and completeness; and four system quality dimensions including ease of use, flexibility, accessibility, and comprehensiveness.

### **5.2.6. Physicians' perceived quality of care improvement**

Despite the importance of patient satisfaction with physicians' decisions to adhere to guidelines (Grol 1990), the effect of patient satisfaction on the use of HIS systems has not been studied. In order to conceptualize the effect of patients on system use, several discussions were conducted with healthcare researchers. These showed that patients are very satisfied with their visits most of the time and hence, it would be very difficult to capture the influence of patients' satisfaction on other constructs. Indeed, when patient satisfaction with their visits before and after

using MPA was measured, the average satisfaction level was 4.2 out of 5 and did not significantly change throughout the study.

Therefore, the study opted to measure the indirect effect of patient satisfaction with system use by measuring physicians' perceptions of the improvement in the care process as they perceive it from communicating with their patients. This construct provides insight into the effect on patient satisfaction and is more related to the users themselves.

To operationalize this construct, two focus groups were conducted with physicians to identify the dimensions of this construct and how physicians may perceive improvement in patient care. Following these focus groups, three dimensions of this construct were identified: physicians' perceived improvement in patient experience, perceived improvement in patients' perception of reliability, and perceived improvement in patients' perception of care responsiveness to their needs.

### **5.3. Measurement instrument**

This section presents how the measurement instruments (questionnaires) were developed for this study. It starts with a discussion of reflective and formative constructs, which are both used in the research model, followed by how the questions were formulated for the purpose of this study and finally a discussion of the control variables used in the study.

#### **5.3.1. Reflective and formative constructs**

The use of reflective and formative constructs has been debated for a long time in the IS literature. For example, Petter et al. (2007) argued that more than 30% of published IS research mis-specified formative constructs as reflective constructs, which may result in overall model errors (Cenfetelli et al. 2009; MacKenzie 2003). Therefore it is important to carefully specify the model construct types.

Reflective and formative constructs are specified conceptually before the data are collected. The main difference between the two types of constructs is that while for reflective constructs there is a causality relationship from the construct to its indicators (that is, if the construct changes, the indicators will change accordingly) while for formative constructs the direction of the relationship is reversed (that is, if the value of the indicators change, the value of the construct will change accordingly) (Cenfetelli et al. 2009; MacKenzie et al. 2011). Another difference between the two types of constructs is the effect of indicators on construct coverage. For reflective constructs, removing one (or more) of the indicators does not change the definition of the construct, while for formative constructs, removing an indicator may change the meaning of the construct by removing one of its dimensions. This difference increases the significance of validating the content of formative constructs (Petter et al. 2007). Hence the difference between the two types of constructs is conceptual and should be specified early in the research process.

While it is necessary to specify the type of construct prior to model validation, most constructs can be specified as reflective or formative. For example, Petter et al. (2007) provided an example of *operational excellence* as a construct that can be developed in either a reflective or formative way. In IS research, *information quality* and *system quality* have been studied as either formative constructs (Wixom et al. 2005) or as reflective constructs (Vance et al. 2008). Selecting whether to model a construct as reflective or formative depends on the context and focus of the study (Cenfetelli et al. 2009).

The focus of this study is to examine the effects of different factors of physicians' continuous use of an IS system and on knowledge translation. Therefore, a mix of formative and reflective constructs is used, depending on the construct and how it was used in literature and also depending on study participant perception of the questionnaire as specified in the pre-test and pilot test phases. In all circumstances, the type of construct was specified prior to data collection, based on the theoretical relationship between the construct and its indicators. Content and

construct validity were examined for formative and reflective constructs (Petter et al. 2007).

Because of the importance of construct coverage for formative constructs, this study employed Q-sorting to assess the content and construct validity of formative constructs.

Q-sorting (Straub et al. 2004) is a two-phase content and construct validation technique for formative constructs. In this study, the two phases were run as follow: Prior to data collection, the constructs were sent to six physicians and healthcare researchers along with shuffled items for those constructs. They were asked to arrange the items under the correct constructs. In the second phase the items, without the constructs, were sent to the group and they were asked to come up with constructs to match these items. This process was repeated until “the measures and constructs theoretically identified by the researcher sufficiently match the results of the Q-sort” (Petter et al. 2007, p.639). After the conclusion of this test, both content and construct (convergent and discriminant validity) are confirmed (Moore et al. 1991; Storey et al. 2000).

### **5.3.2. Questionnaire development**

For the purpose of ensuring content validity, the study attempted to use validated instruments from the IS and healthcare literature to measure the model constructs. However, because of differences between the context of this study and previous studies, scales were adapted to reflect the study context. This adaptation was further refined during the pre-test and pilot test phases. For example, “McMaster Pain Assistant” was used as the target system in the questionnaire and the perceived benefits of using the system were modified to reflect the outcome of the focus groups and interviews as discussed in the previous section. The adherence questionnaire was adapted by using specific LBP and NeP guidelines.

However, the construct of *physicians’ perceived quality of care improvement* has apparently never appeared in the literature before. Hence, this study developed the measurement



instrument for this construct. Section 5.2.6 discussed how this construct was developed, and how it was refined during the pre-test and pilot test phases.

All questionnaire questions were based on a 7-point Likert scale. The measurement instrument and sources of scales are presented in appendix B and are briefly discussed below:

- Intention to continue using the CDSS: This construct was a reflective construct measured using a two item scale adapted from (Bhattacharjee 2001) and the items were slightly modified to reflect the system under study.
- Perceived benefits: This construct was a formative construct measured using a three item scale adapted from (Mishra et al. 2012). The items were modified to include benefits specific to the MPA outcomes.
- Attitude towards using CDSS: This construct was a reflective construct measured using a three item scale adapted from (Bock et al. 2005) and the items were slightly modified to reflect the system under study.
- Satisfaction with CDSS: This construct was a reflective construct measured using a two item scale adapted from (Wixom et al. 2005) and the items were slightly modified to reflect the system under study.
- Influence of medical community: This construct was a reflective construct measured using a two item scale adapted from (Mishra et al. 2012) and the items were slightly modified to reflect the system under study.
- Threat to role identity: This construct was a formative construct measured using a three item scale adapted from (Mishra et al. 2012). The items were modified to include the threats deemed important by the system users.
- System quality: This construct was a formative construct measured using a four item scale adapted from (Wixom et al. 2005) and the items were modified to reflect the system quality attributes deemed important by system users

- Information quality: This construct was a formative construct measured using a three item scale adapted from (Wixom et al. 2005) and the items were modified to reflect the information quality attributes deemed important by system users.
- Physicians' perceived quality of care improvement: This construct was a formative construct measured using a three item scale developed as described in section 5.2.6.
- Adherence to pain management guidelines: This construct was a formative construct measured using a 6 item scale adapted from (Pathman et al. 1996)

### **5.3.3. Control variables**

For this study, three main control variables are considered:

- User role: This control variable represents whether the system user is a physician or a resident. Previous studies (Engel et al. 2014; Steininger et al. 2015) argued that residents are less experienced than physicians and that they may not have established workflows yet. Hence their attitudes and behaviors towards using an HIS may be different. It is important to understand these differences quantitatively, so this study will control for the type of system user. User type is coded as either physician (1) or resident (2)
- Gender: Previous IS studies found a difference in the use of information systems based on user gender (Venkatesh et al. 2003). Hence we control for gender to determine if it has any effect on system use. This variable is coded as (1) for male, and (2) for females.
- Clinic: This control variable reflects organizational factors that may influence physician use of MPA. Prior studies indicated that organizational factors including management support (Chen et al. 2012) or the existence of a champion (Liu Sheng et al. 1998) may influence HIS use. This variable is coded as: (1) for Halton, (2) for MFP, (3) for SCFP.

## **5.4. Model Validation**

Model validation was done using structural equation modeling techniques (SEM), specifically partial least squares (PLS) since it suits the exploratory nature of this study (Gefen et al. 2000). It is recommended when formative constructs are used (Petter et al. 2007), and it provides highest accuracy (Fornell et al. 1994). Moreover, PLS has an advantage over covariance based SEM methods by maximizing endogenous variable explained variance and not assuming a normal distribution of the data (Gefen et al. 2000).

To validate the model, the SmartPLS software (version 3.0) was used (Ringle et al. 2015). The choice to use this software allowed the completion of the analysis required for this part of the study. It provided an intuitive interface, and has been used frequently in the IS domain.

This study followed (Chin 2010) in validating the research model using PLS. Specifically, the measurement model was assessed first, followed by an assessment of the structural model.

### **5.4.1. Measurement model validation**

Because of the inclusion of formative and reflective constructs, measurement model assessment is more complex and involves different assessment procedures for both types of constructs (Chin 1998; Chin 2010; Petter et al. 2007). For measurement model validation, the measurement item reliability, construct reliability, and discriminant and convergent validity were calculated (table 5.1)

**Table 5.1. Measurement model validation**

Analysis	Construct type	Test	Comments
Item reliability	Reflective	Item loading	<ul style="list-style-type: none"> <li>Item loading should be more than 0.50 (Gefen et al. 2000)</li> </ul>
	Formative	Multicollinearity	<ul style="list-style-type: none"> <li>VIF &lt;3.3 for formative constructs (Petter et al. 2007)</li> </ul>
Construct reliability	Reflective	Cronbach's alpha	<ul style="list-style-type: none"> <li>Cronbach's alpha should be more than 0.70 (Bernstein 1994)</li> </ul>
	Formative	Significance of path coefficients	<ul style="list-style-type: none"> <li>Path coefficients must be statistically significant (Petter et al. 2007)</li> </ul>
Discriminant Validity	Reflective	Average variance extracted (AVE)	<ul style="list-style-type: none"> <li>AVE captures the “amount of variance that is captured by the construct in relation to the amount of variance due to measurement error” (Fornell et al. 1981, p. 45)</li> <li>Square root of a construct must be larger than the correlation between this construct and other model's constructs (Barclay et al. 1995).</li> </ul>
	Reflective	Item cross loading	<ul style="list-style-type: none"> <li>Items loading on their constructs must be larger than their loading on other constructs (Chin 2010)</li> </ul>

			<ul style="list-style-type: none"> <li>• Difference between loadings should be greater than 0.10 (Chin 2010)</li> </ul>
	Formative	Q-Sorting	<ul style="list-style-type: none"> <li>• Validating that the measures are categorized by subject matter experts under their theoretical constructs</li> <li>• Experts should be able to place measures under their predicted constructs</li> </ul>
Convergent Validity	Reflective	AVE	<ul style="list-style-type: none"> <li>• AVE should be greater than 0.50 (Au et al. 2008)</li> </ul>

#### 5.4.2. Structural model validation

Once the measurement model was assessed, the structural model was validated to find out if the research hypotheses were supported (table 5.2). Because at each interval of the study, participants completed all surveys at the same time, common method bias needed to be checked (Podsakoff et al. 2012). For this purpose, Herman's single-factor test was employed (Podsakoff et al. 2012).

**Table 5.2. Structural model validation**

Test	Description	Notes
PLS path coefficients and significance	PLS coefficients $\beta$ represent the strength of the relationship	<ul style="list-style-type: none"> <li>• Significance of the coefficients are obtained</li> </ul>

	between constructs and are obtained directly from the software	<ul style="list-style-type: none"> <li>using bootstrapping (Chin 2010; Ringle et al. 2015)</li> <li>Several researchers advocated for considering path coefficients and significance as an indicator of model quality especially when the model has formative constructs (Henseler et al. 2013)</li> </ul>
R <sup>2</sup> for endogenous variable:	Represents the variance explained in an endogenous variable by its antecedents (MacKenzie et al. 2011). This test is calculated directly from the software.	<ul style="list-style-type: none"> <li>R<sup>2</sup> is expected to be high (at least 0.10) to achieve explanatory power (Falk et al. 1992)</li> </ul>
Effect sizes (f <sup>2</sup> )	Effect size tests whether an independent variable has a significant impact on a dependent variable (Chin 2010). Retrieved directly from the software	<ul style="list-style-type: none"> <li>This study used the following values for effect sizes: f<sup>2</sup> small (0.02), f<sup>2</sup> medium (0.15) and f<sup>2</sup> large (0.35) (Chin 2010)</li> </ul>
Model fit	The Goodness of Fit (GoF) statistic is usually used to	<ul style="list-style-type: none"> <li>Standardized Root Mean Square</li> </ul>

	<p>assess model fit. However, the introduction of formative constructs in the model indicates that GoF should not be used to validate goodness of fit (Chin 2010; Henseler et al. 2013)</p> <p>However, other goodness of fit measures are used including:</p> <ul style="list-style-type: none"> <li>• Standardized Root Mean Square Residual (SRMR)</li> </ul>	<p>Residual (SRMR ) value should be less than 0.10</p>
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### 5.5. Validating the Relationship between System Use and Knowledge Translation

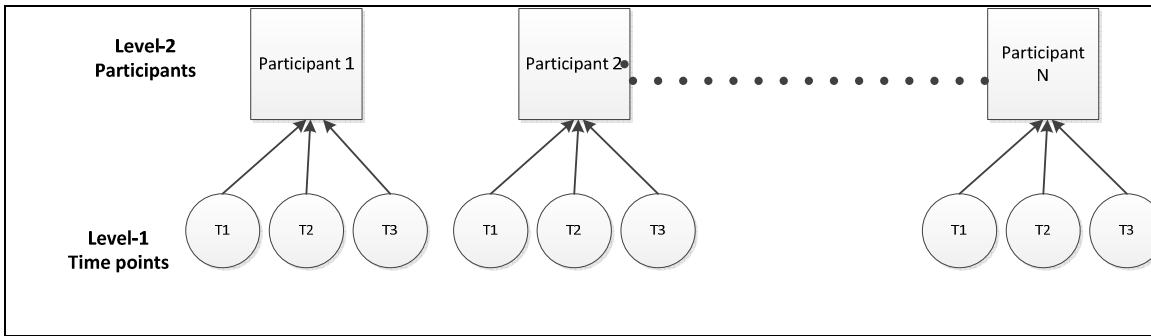
The goal of this section is to present the methodology required to address research objective 3, to understand the dynamics of system use and knowledge translation. Therefore, this section will focus on the tools used to examine system dynamics, how system use and knowledge translation change with time, and the relationship between the two constructs.

To achieve this goal, this study employs a hierarchical linear modeling (HLM) methodology (Raudenbush et al. 2002). Typically, HLM designs are used when the research model has a hierarchical structure. For example, Agarwal et al. (2007) used HLM to study the effects of team-level normative effects on individual technology use, and Zablah et al. (2012) employed HLM to examine the relationship between individual technology use and firm

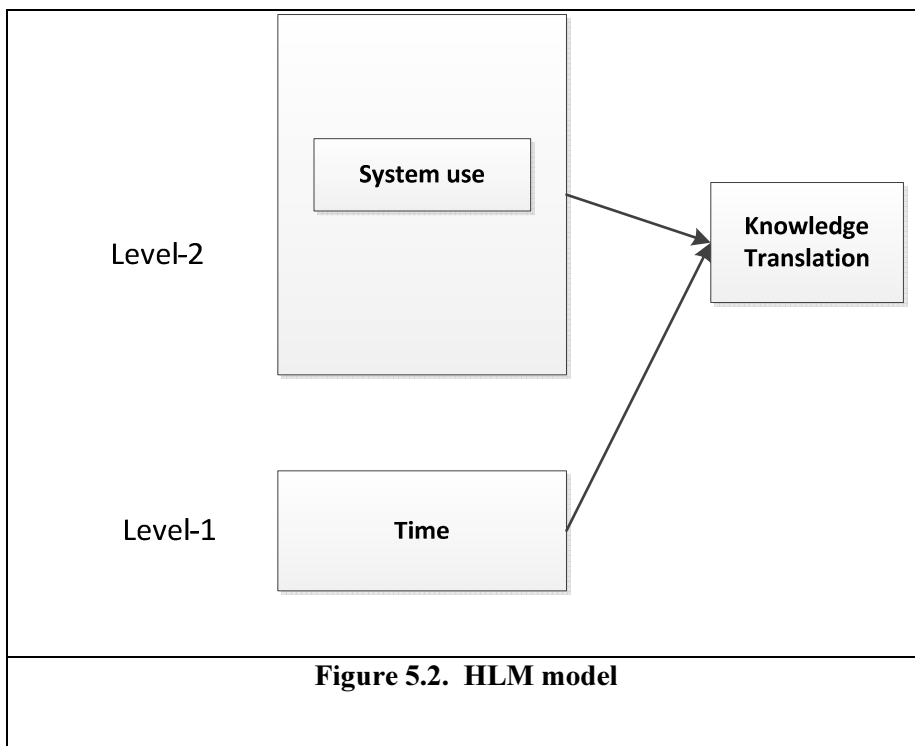
performance. HLM has been used for longitudinal studies to study how a construct changes with time (Willett et al. 1998). In this case, time is considered as a level one variable while the construct of interest is considered a level two variable. HLM has many benefits that make it preferable, compared to both ordinary least square linear regression (OLS) and analysis of variance (ANOVA). First, unlike OLS regression, HLM takes the hierarchical structure between dependent and independent variables into consideration. Several studies that compared the performance of OLS regression and HLM found that HLM models fit hierarchical data better than OLS regression models (e.g., Mithas et al. 2006). Second, HLM does not assume data measurement independence (Raudenbush et al. 2002). This is particularly useful in the case of repeated measurements studies where the same variable is measured for the same individual across time and hence these measurements cannot be assumed independent (Willett et al. 1998). Third, using HLM allows for the inclusion of variables from different levels in the examined model as well as the inclusion of interactions of different level models (e.g., Im et al. 2016; Zablah et al. 2012). Finally, unlike ANOVA, HLM is not sensitive to missing data (Raudenbush et al. 2002). This feature is especially beneficial in repeated measurement designs where participants may choose to complete a questionnaire at one time point but not the other, leading to missing data.

In this study, HLM is employed as follows (figure 5.1): Time is considered the level-1 variable for the study where time measures the points at which participants completed the knowledge translation questionnaires (T1: 0 months, T2: 6 months, and T3: 12 months). The Level-1 variable is consolidated to the individuals who completed the questionnaires. That is, individuals represent level two of the model. Hence, individual related attributes including individual use of the system, type of user (resident or physician), as well as gender are considered level-2 independent variables. The dependent variable is the adoption of clinical guidelines in practice (figure 5.2).





**Figure 5.1. HLM structure**



**Figure 5.2. HLM model**

### 5.5.1. Validating the HLM model

This study follows (Raudenbush et al. 2002; Willett et al. 1998) in the validation of the HLM model. HLM and SPSS software packages were used to assess the model.

Table 5.3 describes the HLM validation tests

**Table 5.3. HLM validation**

Test	Description	Notes
HLM path coefficients and significance (Fixed model)	HLM coefficients $\beta$ represent the strength of the relationship between level 1 and 2 independent variables and the dependent variable (knowledge translation)	<ul style="list-style-type: none"> <li>• Coefficients and significance are obtained directly from the HLM software</li> <li>• A path is considered significant when <math>s &lt; 0.05</math></li> </ul>
Random effects variance and significance (Random model)	Random effects variance represents how the effects vary between individuals. Obtained directly from SPSS software	<ul style="list-style-type: none"> <li>• Variance is calculated for the intercept as well as the slopes of random effects (Hox et al. 2010)</li> </ul>
Model fit	Model fit is calculated using Deviance (-2 log-likelihood) (Hox et al. 2010). Deviance is obtained directly from SPSS software	<ul style="list-style-type: none"> <li>• Model fit is only useful to compare between different models.</li> </ul>

## **5.6. Qualitative Study Methodology**

This study employs focus groups as a qualitative method to triangulate the outcome of the quantitative study and to understand the social context of using KB-CDSS. This study used focus groups as the qualitative method because focus groups are more suitable to study complex interactions than interviews (Krueger et al. 2014; Morgan et al. 1993). Moreover, focus groups have often been used to understand shared norms and to gain insights into physicians' interactions and language (Kitzinger 2006). Therefore, the use of focus groups was adequate for the purpose of this study.

Five focus groups were conducted as a part of this study. Two focus groups were conducted at each of the larger sites (MFP and SCHFP) and one focus group was conducted at Halton. For the larger sites, one focus group was conducted at noon and another one was conducted in the evening to accommodate participants' circumstances. This study followed (Krueger et al. 2014; Morgan et al. 1993; Stewart et al. 2014) in designing and conducting the focus groups. The size of the focus groups was selected to be between 4 and 8 participants. Each focus group consisted of family physicians, residents, and nurse practitioners to capture the full context of system use. A list of high level questions was prepared for each focus group and discussion was allowed to flow naturally among participants without researcher interference. All group discussions were recorded and transcribed.

### **5.6.1. Focus group reliability and validity**

To enhance the reliability and validity of the qualitative study, verification methods (Mays et al. 1995; Morse et al. 2008) were implemented by: (1) Employing purposive sampling to make sure that focus group participants were sampled to cover the whole range of system users in terms of behavior and demographics. In this case, focus groups were designed to contain a representative sample of family physicians and nurse practitioners. Focus groups

included both system users and non-system users to make sure all behavioral and demographic cases were covered; (2) Carrying out data collection and analysis simultaneously: the outcome of one focus group was used to drive subsequent group discussions, creating an iterative process to make sure that all themes were covered. This was done by modifying the list of questions of each group based on the outcomes of the previous ones; (3) Outcomes of the analysis were discussed with participants to refine these outcomes; (4) An audit trail was maintained throughout data collection and analysis, and was verified by IS and healthcare researchers to assess the trustworthiness of the results (Schwandt et al. 2007).

The focus group transcriptions were reviewed by one of the researchers to verify their accuracy. They were coded by two independent researchers from different disciplines (an IS researcher and a healthcare researcher). Cohen's Kappa (Viera et al. 2005) was calculated to assess inter-rater reliability and a Kappa of 0.861 was established. Differences between coders were resolved through discussions.

### **5.6.2. Qualitative data analysis**

Analysis was conducted using thematic analysis (Pope et al. 2000b) to categorize physician behavior, attitude and factors influencing their use of the system. The analysis was used to understand the relationships between emerging categories and to relate them to actual use patterns.

## **5.7. Summary**

This chapter discussed the myriad of methodologies employed to answer the research questions and reach the objectives of this study. Particularly, the research procedures as well as the development and validation of the measurement tool were presented. The methodology in this chapter was used to assess the relationship between system use and

knowledge translation as well as to develop, conduct, and analyze the focus group results. The next chapter discusses the details of the analysis conducted as well as the results of this analysis.

## **Chapter 6- Quantitative Study Results**

While the previous chapter introduced the methodology for obtaining and analyzing the data for this study, this chapter discusses in detail the process of analyzing the quantitative data in order to address all the research objectives of this study. The next chapter will focus on analyzing the qualitative results.

This chapter is arranged as follows: the first four sections (6.1 to 6.4) are focused on analyzing questionnaire data. Section 6.1 introduces the process of collecting survey data. This is followed by section 6.2 which discusses data screening by checking for missing values and outliers. Section 6.3 discusses data quality by examining data distribution and the linearity of the relationships among variables. Section 6.4 presents the demographic data collected during the study. This is followed by a discussion of the analysis of the measurement and structural models in section 6.5 and 6.6. Then section 6.7 reviews how system use changed with time. Section 6.8 introduces the analysis of the multi-level model that describes the relationship between use and knowledge translation, while section 6.9 examines the potential economic benefits of the application of clinical guidelines in managing patients with pain. Finally, Section 6.10 summarizes this chapter and sets the stage for the following chapters.

### **6.1. Quantitative Data Collection**

Data collection started after obtaining HiREB (Hamilton Integrated Research Ethics Board) approval in May 2014. 118 physicians, residents, and nurse practitioners from three academic clinics (MFP, SCFP, and Halton) were asked to sign a consent form prior to participating in the study.

Data were collected in three phases: Phase 1 started in March 2015 and included sending out a questionnaire to assess physician adoption of clinical guidelines in practice (knowledge translation). 100 responses were received in this phase (84.75% response rate). Phase 2 started in

September 2015 (after 6 months of phase 1) and included sending out the knowledge translation questionnaire as well as the attitude-behavior model questionnaire to participants. Because of delays in the deployment of MPA at the Halton site to six months after it was deployed in the other sites, this phase consisted of two sub-phases; data were collected from SCFP and MFP in sub-phase 1 and from Halton in March 2016 as sub-phase 2. Phase 2 resulted in 78 valid responses (66.1% response rate). Finally, phase 3 started in March 2016 (12 months after phase 1) and included participants from MFP and SCFP only, because the duration of the study only extended to this time. 38 responses were obtained in this phase out of a total of 86 participants (after removing Halton and residents who completed their training) with a response rate of 44.18%.

## **6.2. Data Screening**

Once the data for each phase were collected, responses were screened for missing values and outliers (univariate and multivariate). Data screening was completed using SPSS v.23.

### **6.2.1 Missing values**

In phase 1, out of the 100 responses, there were no missing values in the questionnaire responses and all responses were utilized. For phase 2 data, out of the 78 responses received, there was no missing data as well. However, for the third phase, out of the 38 responses, three (3) responses had missing variables (cases 12, 19, and 27) and hence were eliminated from subsequent data analysis. Therefore, only 35 responses from phase 3 data were included in the analysis.

### **6.2.2 Outlier Analysis**

Outliers are “cases with extreme or unusual values on a single variable (univariate) or on a combination of variables (multivariate)” (Meyers et al. 2006;p.65). To conduct univariate outlier analysis, the composite scores of all model reflective constructs were calculated as the

mean of individual questionnaire items for the construct (Tinsley et al. 2000) and the univariate outlier analysis was conducted based on those composite scores. The use of composite scores has the benefit of reducing the effects of outliers on a single item, hence it is preferred for univariate outlier analysis (Petter et al. 2007). Once the composite scores were computed, this study followed (Meyers et al. 2006) in the use of *boxplots*. Box plots are useful tools in identifying outliers. Points beyond the fences of the boxplots are considered potential outliers (Meyers et al. 2006). For reflective constructs, no outliers were identified for any of the constructs (appendix D).

For formative constructs, composite scores could not be used because in this case the individualized items define the construct and the items do not need to covary or share a common theme (Cenfetelli et al. 2009; Petter et al. 2007). Hence, boxplots were drawn for individual items for all formative constructs. As in the case of reflective constructs, no outliers were identified.

Overall, no univariate outliers were identified in the responses

To analyze multivariate outliers, cases with unusual values on a combination of model variables (Meyers et al. 2006), a Mahalanobis distance analysis was conducted. Mahalanobis distance measures “the multivariate distance between each case and the group multivariate mean” (Meyers et al. 2006, p.67). Mahalanobis distance was calculated for each case and validated using a chi-square ( $X^2$ ) distribution with a strict p-value of 0.001 (Meyers et al. 2006). After conducting this analysis, no multivariate outliers were identified.

### **6.3. Data Quality and Assumptions**

Researchers (e.g., Meyers et al. 2006) have pointed out some assumptions that are important in multivariate analysis. These assumptions include normality and linearity. If one or more of these assumptions are violated, the results may be biased. Although PLS, which is used



to test the theoretical model, is a robust technique and is not sensitive to these assumptions (Chin 1998; Chin 2010), these assumptions were examined for completeness of the analysis.

### **6.3.1. Normality**

In order to examine the normality of the model constructs, this study employed two techniques: (1) Examining the skewness (symmetry of the distribution) and kurtosis (the peakedness of the distribution); (2) Examining the statistical normality plots (Q-Q) plots of the constructs.

Table 6.1. below shows the skewness and kurtosis measurements of the constructs and indicators. Meyers et al. (2006) proposed a threshold of  $\pm 1$  for both measurements to indicate whether the distribution is normal or not. Following this rule, all of the items/ constructs in the tested model can be considered normally distributed.

In addition to the above test, Tabachnick et al. (2001) suggested examining the shape of the distribution to confirm the normality of the distribution. Therefore, Q-Q plots have been used to examine the shape of the distribution for model constructs.

As shown in appendix E, QQ plots indicate that the model constructs achieve an acceptable level of normality, confirming the initial linearity analyses.

**Table 6.1. Skewness and Kurtosis for model construct measurements**

Statistics																				
	SAT	Att	MCO M	INT	USE 1	USE 2	USE 3	TH1	TH2	TH3	PPI 1	PPI 2	PPI 3	SQ 1	SQ 2	SQ 3	SQ 4	IQ1	IQ2	IQ3
Mean	4.90	5.22	4.21	5.16	4.69	4.92	5.27	3.27	4.39	2.97	5.19	4.82	5.15	5.27	5.0	4.8	4.8	4.7	5.1	4.8
Median	5.0	5.50	4.0	5.25	4.50	5.00	6.0	4.00	4.0	3.00	5.50	4.0	5.0	6.0	5.0	5.0	5.0	4.0	5.5	5.0
Skewness	-.555	-.455	.570	-.714	-.311	-.564	-.384	-.060	.037	.128	-.223	.668	-.501	.156	.454	.43	.37	.04	.70	.38
Kurtosis	.852	-.365	-.170	.506	.831	.518	-.916	-.438	-.132	-.568	-.707	-.705	.32	.892	.69	.77	.75	.52	.51	.29

### 6.3.2. Linearity

Linearity is a basic assumption for most multivariate assessment techniques, especially correlation based techniques (Meyers et al. 2006). Hence, the linearity of the main model relationships were assessed using the SPSS linearity test (Field 2009). Table 6.2 shows the significance of the linearity for main model relationships

**Table 6.2. Linearity Test for proposed model relationships**

Relationship	Significance	Linear?
ATT -> INT	0.00	Yes
INT->SYSUSE	0.013	Yes
SYSUSE->KT	0.00	Yes
USF->INT	0.00	Yes
SAT->INT	0.00	Yes
SAT->ATT	0.00	Yes
USF->ATT	0.00	Yes
MC->ATT	0.001	Yes
TH->ATT	0.016	Yes
SQ->USF	0.00	Yes
SQ->SAT	0.00	Yes
IQ->USF	0.00	Yes
IQ->SAT	0.00	Yes
PPI->USF	0.00	Yes

ATT: Attitude towards using the system, INT: Intention of using MPA, SYSUSE: System use, KT: Knowledge translation (adoption of clinical guidelines), USF: Usefulness, SAT: Satisfaction, MC: Influence of Medical community, TH: Threat to professional identity, SQ: Perceived system quality, IQ: Perceived Information Quality, PPI: Physicians perceived quality of care improvement.

Moreover, (Hair 2010) and (Meyers et al. 2006) recommended the use of bivariate scatter plots to investigate the linearity of model relationships. A linear relationship between two

variables is indicated by an oval shaped scatter plot. Appendix F shows the scatter plots of the main relationships in the model and these plots indicate linear relationships between the variables.

## 6.4. Demographics

In addition to collecting questionnaire data and use data, data on the demographics of the participants were also collected. These data include the gender of the participants, their role (i.e. physicians, residents, or nurse practitioners), and the clinic where they practiced.

Because of the longitudinal nature of the study, demographics differed at each stage. Table 6.3 describes the distribution of gender for participants who completed the questionnaires throughout the study and table 6.4 describes other demographics.

**Table 6.3. Participant gender**

Gender	Time 0	6 months	12 months
Female	54 (54%)	44 (53.9%)	22 (57%)
Male	46 (46%)	34 (46.1%)	13 (43%)

**Table 6.4. Other participant demographics**

Participant Role	Clinic	0 months	0-6M	6-12M
Physician	MFP	15	13	11
	SFHC	11	10	7
	Halton	6	4	0
Resident	MFP	34	26	5
	SFHC	17	16	2
	Halton	8	2	0
Nurse Practitioners	MFP	3	2	2
	SFHC	6	5	4

	Halton	0	0	0
Sum		100	78	35

## 6.5. Measurement Model Validation

The validation of the proposed model was completed in two steps. The first step, discussed in this section, focuses on validating the measurement model and the next step is evaluating the structural model. Therefore, this section examines the content validity and reliability of the constructs prior to evaluating the structural model in the next section.

Because this model includes both reflective and formative constructs, and given that the validation methods are different for both types, the next subsection discusses the validity and reliability of reflective constructs followed by a discussion of validity and reliability of the formative constructs in the following subsection.

### 6.5.1. Reflective Constructs

To evaluate the reflective constructs, this study follows the process described in (Götz et al. 2010). This evaluation starts by examining the convergent and discriminant validity of the constructs to decide if any items need to be removed because of loading or cross-loading issues.

As table 6.5 below shows, all the reflective indicators loaded most highly on their assigned constructs and with a minimum threshold of 0.50 (Gefen et al. 2000). Because system use was derived from actual use data it was not included in this analysis. Usefulness, adoption of clinical guidelines, threat, system quality, information quality and perceived patient improvement were not included in this analysis because they are formative constructs (Petter et al. 2007).

Moreover, Gefen et al. (2005) proposed that indicator loadings on their theoretical constructs should be higher than their loadings on other constructs by at least 0.10. As table 6.5

shows, this condition holds for all reflective items in the model. Hence, no indicators needed to be removed from the model.

**Table 6.5. Indicator loading and cross loading**

Indicator	KT	ATT	PPI	INT	MC	SQ	IQ	SAT	TH	SYSUSE	USF
ATT1	.162	<b>.916</b>	.667	.612	.455	.581	.564	.612	-.511	.289	.711
ATT2	.071	<b>.961</b>	.712	.683	.421	.584	.571	.623	-.596	.220	.739
ATT3	.057	<b>.951</b>	.664	.702	.511	.587	.563	.687	-.580	.851	.741
INT1	.144	.694	.512	<b>.982</b>	.491	.423	.411	.552	-.662	.328	.672
INT2	.074	.696	.488	<b>.982</b>	.492	.426	.414	.548	-.538	.283	.674
MC1	.251	.401	.566	.612	<b>.983</b>	.671	.613	.602	-.468	.274	.498
MC2	.269	.332	.543	.613	<b>.985</b>	.644	.621	.591	-.455	.281	.471
SAT1	.360	.711	.768	.748	.514	.622	.617	<b>.957</b>	-.618	.288	.786
SAT2	.168	.723	.719	.791	.519	.698	.681	<b>.954</b>	-.588	.353	.790

ATT: Attitude towards using the system, INT: Intention of using MPA, SYSUSE: System use, KT: Knowledge translation (adoption of clinical guidelines), USF: Usefulness, SAT: Satisfaction, MC: Influence of Medical community, TH: Threat to professional identity, SQ: Perceived system quality, IQ: Perceived Information Quality, PPI: Physicians perceived quality of care improvement.

Next, to assess the reliability of the reflective constructs, Cronbach's alpha with a threshold of 0.70 and composite reliability with a threshold of 0.60 were adopted (Bagozzi et al. 1988; Bernstein 1994). As shown in table 6.6 below, the reliability (both composite reliability and Cronbach's alpha) are greater than 0.90, establishing the reliability of the constructs.

**Table 6.6. Construct Reliability Assessment**

Construct	Cronbach alpha	Composite reliability	AVE
ATT	.938	.960	.889
INT	.963	.982	.965
SAT	.905	.955	.913

MC	.964	.987.	.983
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ATT: Attitude towards using the system, INT: Intention of using MPA, SAT: Satisfaction, MC: Influence of Medical community

The convergent validity of the constructs was evaluated using the average variance extracted (AVE). The value of AV should exceed the variance resulting from the measurement error of the construct, (that is AVE should exceed 0.5) (Vinzi et al. 2010), As shown in table 6.7 above, this criteria is met for all reflective constructs.

To have acceptable discriminant validity, the square root of the AVE of a construct should be greater than the correlation between this construct and other constructs (Barclay et al. 1995). Table 6.7 below presents the correlation matrix for the constructs with the square root of the AVE represented as diagonal elements. All reflective constructs meet this criterion.

Given that for all reflective constructs, the square root of the AVE is greater than their correlation with other constructs; and the loading of construct items is greater than cross loadings by at least 0.1, then both requirements for construct validity are met.

AVE is not meaningful for formative constructs since the requirement of covariance of the formative construct items is not assumed (MacKenzie et al. 2011). Therefore, the square root of the AVE of formative constructs were not calculated for formative constructs.

**Table 6.7. Construct correlations and AVE**

	PPI	SQ	IQ	SAT	USF	TH	MC	ATT	INT	SYSUSE	KT
PPI	-										
SQ	.490	-									
IQ	.584	.555	-								
SAT	.619	.621	.589	<b>.956</b>							
USF	.528	.512	.487	.667	-						
TH	-.542	-.538	-.498	-.632	-.640	-					
MC	.449	.475	.448	.564	.452	-.593	<b>.991</b>				
ATT	.491	.560	.503	.617	.535	-.613	.415	<b>.942</b>			
INT	.415	.50	.566	.629	.570	-.642	.499	.542	<b>.982</b>		
SYSUSE	.449	.316	.438	.332	.327	-.469	.428	.267	.311	<b>1.0</b>	
KT	.283	.202	.280	.249	.197	-.302	.268	.10	.112	.626	-

ATT: Attitude towards using the system, INT: Intention of using MPA, SYSUSE: System use, KT: Knowledge translation (adoption of clinical guidelines), USF: Usefulness, SAT: Satisfaction, MC: Influence of Medical community, TH: Threat to professional identity, SQ: Perceived system quality, IQ: Perceived Information Quality, PPI: Physicians perceived quality of care improvement.

### 6.5.2. Formative constructs

Formative constructs are different from reflective constructs in the sense that the expected covariance between indicators for formative constructs is neither expected nor desirable. For formative constructs, the indicators are expected to cover the subfields of the constructs and thus they should not covary (MacKenzie et al. 2011). Hence, the validity and reliability of formative constructs focuses on making sure that the construct indicators cover different subfields and they do not strongly correlate together, but that they have meaningful and significant relationships with their constructs (Cenfetelli et al. 2009; MacKenzie et al. 2011). Chapter 5 discussed the use of the Q-sorting to establish the construct validity and reliability of formative



constructs. This section focuses on examining the co-linearity of formative construct indicators and the relationship between indicators and their constructs.

Petter et al. (2007) proposed that, for the validity of formative constructs, the variance inflation factor VIF should be less than three to avoid multicollinearity between indicators of the same construct. As table 6.6 shows, all indicators meet this condition. Moreover, several researchers (Cenfetelli et al. 2009; MacKenzie et al. 2011) proposed that indicator loadings on their latent construct should be significant. As table 6.8 shows, all indicators had significant loadings on their relevant constructs. Hence the formative constructs have met the reliability and validity requirements.

**Table 6.8. Formative Indicators loadings and VIF**

Indicator	Indicator loading	Loading significance	VIF
KT1	.493	0.00	1.523
KT2	.345	.016	1.526
KT3	.645	0.00	1.582
KT4	.315	0.001	1.909
KT5	.280	.043	1.354
KT6	.268	.047	2.085
TH1	.593	.003	1.499
TH2	.411	.036	1.054
TH3	.918	.00	1.476
USF1	.889	.00	1.868
USF2	.941	.00	1.868
USF3	.908	.00	1.729
SQ1	.801	.00	2.439
SQ2	.986	.00	2.971
SQ3	.924	.00	2.463

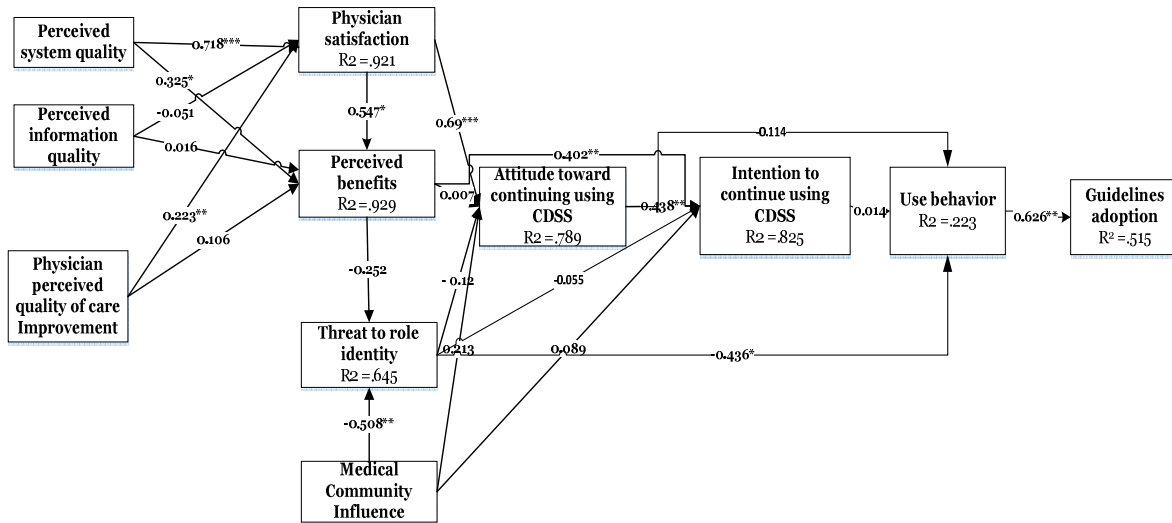
SQ4	.829	.00	2.718
IQ1	.500	.020	2.673
IQ2	.629	.00	2.912
IQ3	.686	.00	2.435
IQ4	..966	.00	1.463
PPI1	.967	.00	2.982
PPI2	.948	.00	2.816
PPI3	.906	.00	2.236

## 6.6. Structural Model Validation

Due to the longitudinal nature of this study, the structural model was validated at two different points of time: (1) after 6 months of using the system; (2) after 12 months of using the system. At both instances, the predictive power of the model was assessed by calculating the  $R^2$  values of the endogenous constructs (Gefen et al. 2000). The recommended threshold by Falk et al. (1992) of  $R^2$  to be at least 0.10 is used as a cut-off threshold.

### 6.6.1. Model validation after 6 months

As shown in figure 6.1,  $R^2$  for all endogenous variables reached the threshold of 0.10. 51.5% of the variance observed in the adoption of clinical guidelines was explained by the model.



**Figure 6.1. PLS model results (6 months)**

Table 6.9 below shows the supported and unsupported hypotheses. These results are further discussed in chapter 8.

**Table 6.9. Model Hypotheses validation-6 months**

Hypothesis	Path Coefficient	t-statistic	Significance	Validation outcome
H1	0.626	3.180	0.002	Supported
H2	0.014	0.065	0.948	Not supported
H3a	0.438	2.983	0.003	Supported
H3b	-0.114	0.455	0.642	Not supported
H4a	0.690	3.645	0.00	Supported
H4b	0.547	3.511	0.012	Supported
H5a	0.007	0.028	0.972	Not supported
H5b	0.402	2.945	0.003	Supported
H5c	-0.252	1.233	0.212	Not supported
H6a	0.213	1.555	.121	Not supported
H6b	0.089	0.826	0.409	Not supported
H6c	-0.508	2.316	0.021	Supported
H7a	-0.12	1.427	0.154	Not supported

H7b	-0.055	0.628	0.530	Not supported
H7c	-0.436	2.147	0.032	Supported
H8a	0.016	0.132	0.895	Not supported
H8b	-0.051	0.514	0.607	Not supported
H9a	0.325	2.114	0.038	Supported
H9b	0.718	4.92	0.00	Supported
H10a	0.106	0.798	0.425	Not supported
H10b	0.223	2.158	0.032	Supported

#### 6.6.1.1. Model Goodness of Fit

Traditionally the Goodness of Fit (GoF) index has been used to evaluate the quality of the structural model (Tenenhaus et al. 2004). However, recent simulations cautioned against the use of this index in assessing model quality (Hair et al. 2012; Henseler et al. 2013). Hence, researchers have proposed other indexes to assess model goodness of fit. One recently developed index that was shown to assess structural model and identify miss-specifications is the Standardized Root Mean Square Residual (SRMR) (Dijkstra et al. 2015; Henseler et al. 2014). In order to avoid model misspecification, the SRMR value should be less than 0.10 (Henseler et al. 2014).

For the structural model in this study, SRMR was 0.089 which is lower than the threshold of 0.10 and hence the model can be considered free from misspecifications.

Some researchers have also proposed that PLS-SEM models are best assessed based on their predictive power, effect sizes and the strengths of the paths among constructs instead of goodness of fit indexes which may be misleading (Hair Jr et al. 2016; Marcoulides et al. 2013). Because for most paths in the proposed model, the path coefficients are of acceptable strength, the model can be accepted as valid.

### 6.6.1.2. Effect sizes

The goal of calculating effect sizes is to assess the impact of independent variables on dependent variables. Thresholds of effect sizes are adapted from (Cohen 1988) as:  $f^2$  small (0.02),  $f^2$  medium (.15) and  $f^2$  large (.35).  $f^2$  was obtained directly from the software as shown in table 6.10

**Table 6.10. Effect sizes-6 months**

Dependent variable	Independent variable	$f^2$ *	Effect size
Adoption of clinical guidelines	System use	0.646	Large
System use	Threat	0.168	Medium
System use	Intention	0.03	Small
Intention	Attitude	0.312	Medium
Intention	Usefulness	0.197	Medium
Intention	Medical community	0.323	Medium
Attitude	Satisfaction	0.308	Medium
Attitude	Usefulness	0.024	Small
Attitude	Threat	0.072	Small
Attitude	Medical community	0.071	Small
Satisfaction	Perceived improvement	0.209	Medium
Satisfaction	Perceived system quality	0.858	Large
Usefulness	Perceived Improvement	0.044	Small
Usefulness	Perceived system quality	0.116	Small

\*All paths not shown in the above table have  $f^2$  of less than 0.02

### 6.6.1.3. Control Variables

As discussed in chapter 5, in addition to collecting data for different constructs, the data for three control variables were collected as well: participant gender, their roles (physicians, residents, nurse practitioners), and their clinic of practice. These variables were assessed to control for their influence on the endogenous constructs of the model.

To assess the impact of these variables, they were added to the model (one at a time) and linked to each endogenous construct of the model. The analysis was then completed using SmartPLS. The path coefficients and significance of the relationship between the control variables and endogenous construct was then examined.

As table 6.11 below shows, four out of 21 relationships between control variables and endogenous constructs were significant. Role has a negative influence on satisfaction with the system, indicating that residents were more satisfied with the system than physicians. Role has a negative impact on system use, indicating that residents used the system more than physicians. Clinic has a positive influence on both system use and usefulness. In-depth discussion of these results are discussed in chapter 8.

**Table 6.11. Control variable analysis- 6 months**

Control variable	Endogenous construct	Path coefficient	Significance
Gender (1= male, 2=female)	Adoption of Clinical Guidelines	0.097	Not significant
	System use	0.071	Not significant
	Intention	0.051	Not Significant
	Attitude	-0.004	Not significant
	Satisfaction	-0.045	Not significant
	Usefulness	0.029	Not significant
	Threat	-0.174	Not significant
Role*	Adoption of Clinical Guidelines	-0.044	Not significant
	System use	-0.138	p<0.05

(1=Resident, 2=Physician)	Intention	-0.004	Not significant
	Attitude	0.016	Not significant
	Satisfaction	-0.105	P<0.05
	Usefulness	0.04	Not significant
	Threat	-0.031	Not significant
Clinic (1=Halton, 2=MFP, 3=SCFP)	Adoption of Clinical Guidelines	0.146	Not significant
	System use	0.338	p<0.05
	Intention	-0.011	Not significant
	Attitude	0.086	Not significant
	Satisfaction	0.047	Not significant
	Usefulness	0.103	p<0.05
	Threat	0.003	Not significant

\*Nurse practitioners were not included in the control variable role because too few nurse practitioners completed the survey to provide a useful explanation of the results.

To assess the predictive power of the control variable, effect size  $f^2$  was calculated for the paths between control variables and endogenous constructs (as in the previous section). See Table 6.12. As the table shows, control variables had a small effect in most cases except for the effect of role on satisfaction, the effect of clinic on usefulness, and the effect of clinic on system use which all had a medium effect size indicating that they do influence the predictive power of the model.

**Table 6.12. Effect sizes for control variables**

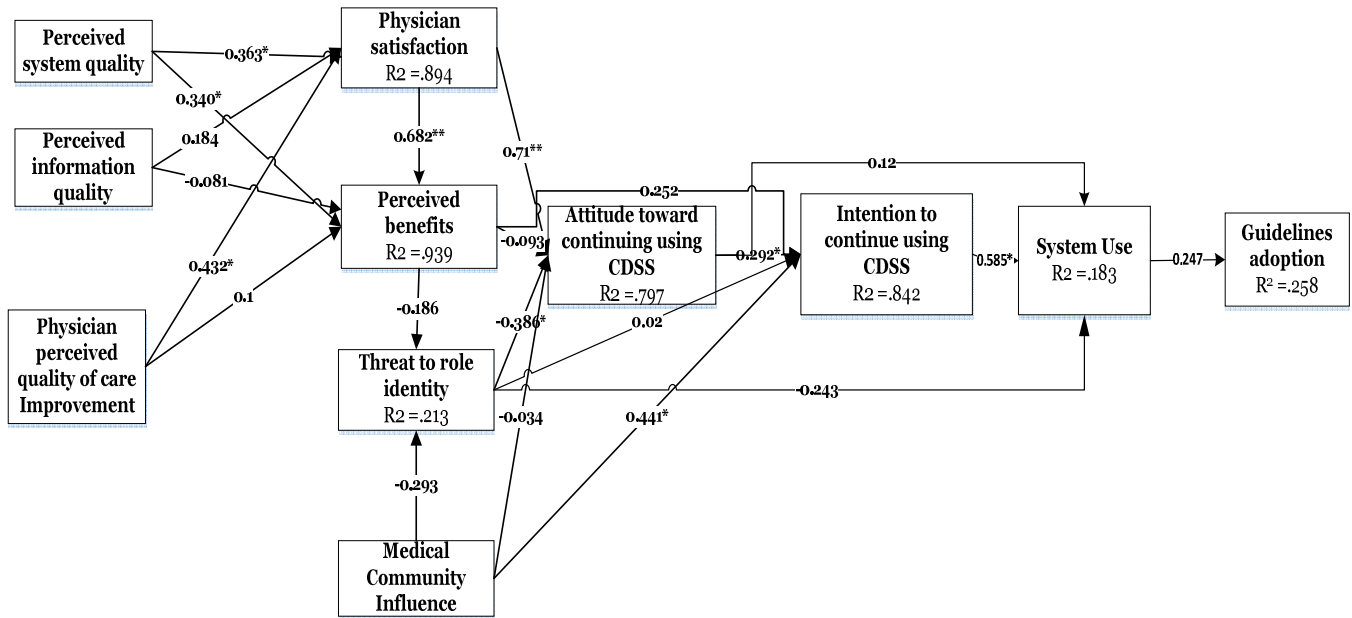
Control variable	Endogenous construct	$f^2$	Effect size
Gender (1= male, 2=female)	Adoption of Clinical Guidelines	0.021	Small
	System use	0.078	Small
	Intention	0.012	Small

	Attitude	0.00	Small
	Satisfaction	0.029	Small
	Usefulness	0.012	Small
	Threat	0.011	Small
Role (1= Resident, 2=Physician)	Adoption of Clinical Guidelines	0.016	Small
	System use	0.021	Small
	Intention	0.00	Small
	Attitude	0.059	Small
	Satisfaction	0.163	Medium
	Usefulness	0.020	Small
	Threat	0.049	Small
Clinic (1=Halton, 2=MFP, 3=SCFP)	Adoption of Clinical Guidelines	0.038	Small
	System use	0.150	Medium
	Intention	0.001	Small
	Attitude	0.035	Small
	Satisfaction	0.030	Small
	Usefulness	0.153	Medium
	Threat	0.00	Small

### 6.6.2. Model validation after twelve months of use

As observed in figure 6.2 below,  $R^2$  for all endogenous variables reached the threshold of 0.10. 25.8% of the variance observed in the adoption of clinical guideline construct data was explained by the model.





**Figure 6.2. PLS model results (12 months)**

Table 6.13 below shows the supported and unsupported hypotheses. These results are further discussed in chapter 8.

**Table 6.13 Model Hypotheses validation-12 months of use**

Hypothesis	Path Coefficient	t-statistic	Significance	Validation outcome
H1	0.147	1.142	0.092	Not Supported
H2	0.585	2.842	0.024	Not Supported
H3a	0.292	1.585	0.048	Supported
H3b	0.12	1.325	0.094	Not Supported
H4a	0.710	2.342	0.01	Supported
H4b	0.628	4.139	0.00	Supported
H5a	0.093	0.789	0.218	Not Supported
H5b	0.252	1.13	0.156	Not Supported
H5c	-0.186	0.802	0.302	Not Supported
H6a	-0.034	0.144	0.443	Not supported
H6b	0.441	1.734	0.042	Supported

H6c	-0.293	1.142	0.296	Not Supported
H7a	-0.386	1.885	0.046	Supported
H7b	-0.02	0.142	0.495	Not supported
H7c	-0.243	1.039	0.218	Not Supported
H8a	-0.081	0.532	0.298	Not supported
H8b	0.184	0.950	0.172	Not supported
H9a	0.340	1.866	0.038	Supported
H9b	0.363	1.811	0.046	Supported
H10a	0.100	0.577	0.282	Not supported
H10b	0.432	2.284	0.012	Supported

### 6.6.2.1 Effect sizes

Table 6.14 shows the effect sizes using  $f^2$  statistics with the same thresholds as section 6.6.1.2.

**Table 6.14. Effect sizes-12 months**

Dependent variable	Independent variable	$f^2$	Effect size
Adoption of clinical guidelines	System use	0.254	Medium
System use	Threat	0.084	Small
System use	Intention	0.132	Small
Intention	Attitude	0.135	Small
Intention	Usefulness	0.094	Small
Intention	Medical community	0.324	Medium
Attitude	Satisfaction	0.234	Medium
Attitude	Usefulness	0.024	Small
Attitude	Threat	0.564	Large
Attitude	Medical community	0.001	Small

Satisfaction	Perceived improvement	0.253	Medium
Satisfaction	Perceived system quality	0.197	Medium
Satisfaction	Perceived Information quality	0.058	Small
Usefulness	Perceived Improvement	0.018	Small
Usefulness	Perceived system quality	0.251	Medium
Usefulness	Perceived Information quality	0.018	Small

#### 6.6.2.2. Control Variables

To assess the impact of the control variables (gender, role, clinic) on endogenous constructs, the same procedure described in section 6.6.1.3 was used. However, **none** of the paths between the control variables and endogenous constructs were significant.

### 6.7. Change in System Use

This section introduces the changes in system use and knowledge translation with time. The results presented in this section are further discussed in chapter 8. As table 6.15 shows, the number of system users dropped significantly from time 1 (after 6 months of use) to time 2 (after 12 months of use). At both time periods, the number of actual system users was low compared to the number of study participants.

**Table 6.15. Number of unique system users after 6 and 12 months of study**

Participant role	Clinic	Used LPB forms-6m	Used NP forms-6m	Total users-6m	Used LPB forms-12m	Used NP forms-12m	Total users-12m
Physicians	MFP	7	2	8	3	0	3

	SFHC	4	1	4	2	0	2
	Halton	1	0	1	0	0	0
<b>Residents</b>	MFP	7	3	8	0	0	0
	SFHC	4	1	4	2	1	2
	Halton	0	0	0	0	0	0
<b>Nurse practitioners</b>	MFP	0	0	0	0	0	0
	SFHC	3	0	3	0	0	0
	Halton	0	0	0	0	0	0

### 6.7.1. Number of form sections saved by users

In order to understand how the MPA was utilized, the number of users or the frequency of using a system is not an adequate measurement because it only represents the breadth of using the system (Burton-Jones et al. 2006). To gain a better understanding of system use, the depth of using the system needs to be examined as well. Therefore, this section looks at the total number of form sections saved by system users. This measurement is used as a proxy for the time users spent on the system (the more sections completed by users, the more the time they spent on the system).

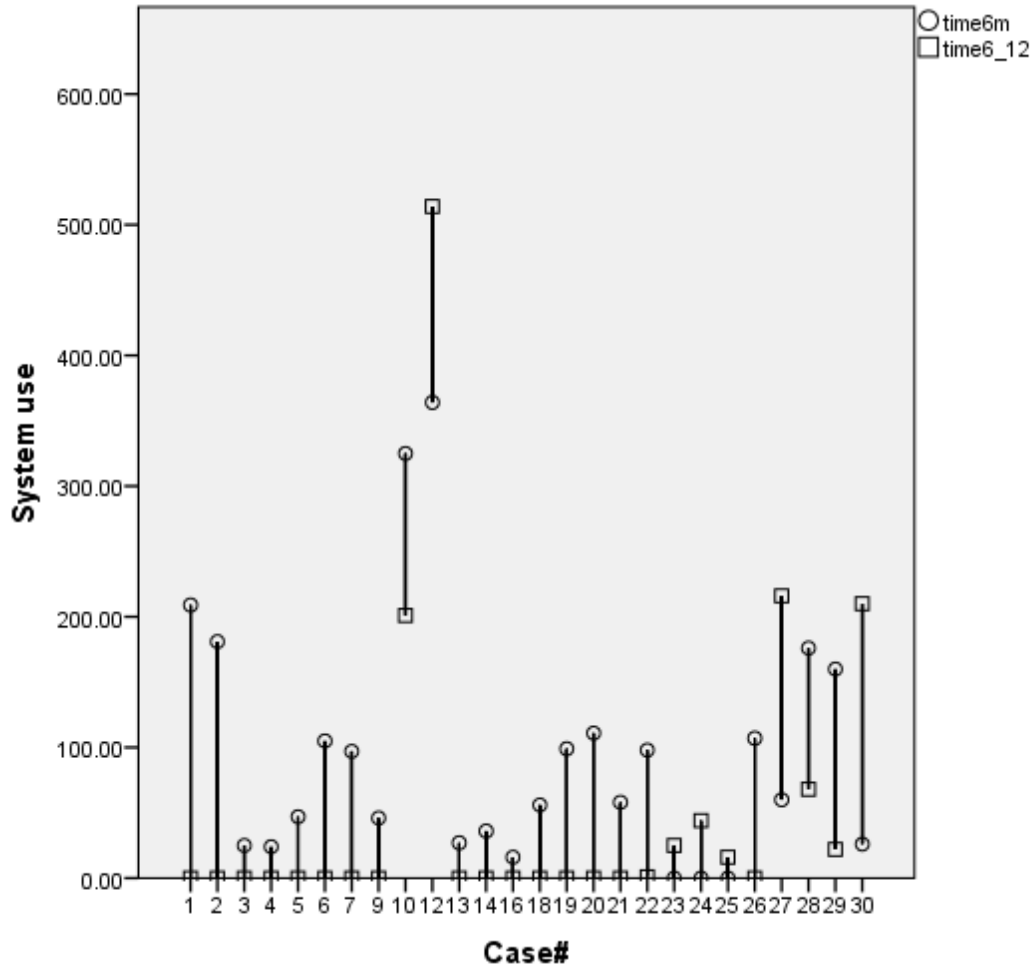
Table 6.16 below describes the number of form sections completed by users. As the table shows, the pain inventory was the most completed form followed by lower back pain forms and then neuropathic pain forms.

**Table 6.16. Sections saved in different MPA forms**

<b>Form Name</b>	<b>Sections</b>	<b>Saved forms</b>			
		<b>MFP</b>	<b>SFHC</b>	<b>Halton</b>	<b>Total</b>
Lower Back Pain Guide		58	52	0	110
	History	32	20		52

	Define the Back Pain	41	48		89
	Assess Risk for Chronicity	25	20		45
	Keele STarT Back Screening Tool	21	14		35
	Diagnostic Imaging	12	6		18
	Summary of Assessment	26	5		31
	Management	27	29		56
	Summary of Management	21	6		27
Neuropathic Pain Guide		27	13	0	40
	History	14	0		14
	Diagnose Neuropathic Pain	26	9		35
	Assess For Secondary Causes	21	11		32
	Assess For Other Causes	16	10		26
	Summary of Assessment	10	4		14
	Medication	5	4		9
	Summary of Management	10	2		12
Brief Pain Inventory		162	91	17	270
Goal Planner		8	2	0	10
Mood PHQ		32	8	0	40
Opioid Management		25	3	0	28
Sleep PSQ-3		3	2	0	5
Trauma PC-PTSD		1	0	0	1

Figure 6.3 below shows the change in system use from 6 months to 12 months. As the graph shows, most of the users stopped using the system in the last six months of the study. It also shows that users who spent more time using the system in the first six months were more likely to continue using it in the last six months. Figure 6.4 and table 6.17 shows that the mean of physician use of the system decreased significantly (marginally) ( $t=2.256$ ,  $df=13$ ,  $p=0.05$ ) while the decrease in system use for residents was not significant ( $t=1.224$ ,  $df=11$ ,  $p>0.05$ ).



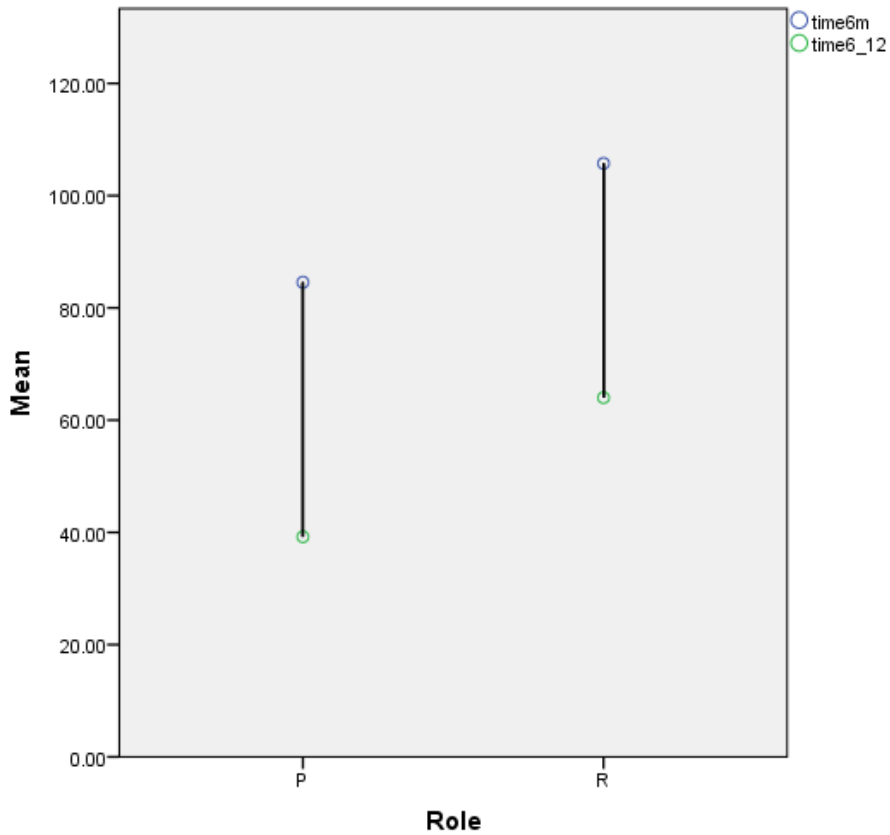
**Figure 6.3. Change in system use for each user from 6 to 12 months of use**

\*the horizontal axis represents users while the vertical axis represents the sections saved of using the system at 6 months and 12 months.

**Table 6.17. Paired t-test results for residents and physicians for system use**

User group	Mean of sections saved- 6 months	Mean of sections saved From 6 to 12 months	Significantly different?	t-statistic	df	Significance level
Residents	105.750	64.00	No	1.224	11	0.246

Physicians	84.571	39.214	Yes (marginally)	2.256	13	0.050
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**Figure 6.4. Changes in system use for physicians (P) and residents (R)**

\*R=Residents, P=Physicians, the vertical access represents the mean of the number of sections saved by users.

### 6.7.2. Changes in users' perceptions from 6 to 12 months of use

Table 6.18 below summarizes changes in the means of the different theoretical model constructs using the t-statistic. The goal of this table is to show how users' perceptions about the system changed during use.

**Table 6.18. Change in model constructs from 6 to 12 months of use (34 degrees of freedom)**

Indicator/Construct	6 to 12 Month Change	T-statistic	Significance
TH1	-0.241	-0.782	Not Significant
TH2	-0.103	-0.406	Not Significant
TH3	0.034	0.162	Not Significant
USF1	-0.483	-2.354	p=0.032
USF2	-0.448	-2.646	p=0.017
USF3	-0.478	-2.543	p=0.024
SQ1	-0.517	-2.243	p=0.046
SQ2	-0.138	-0.891	Not Significant
SQ3	-0.276	-1.548	Not significant
SQ4	0.103	0.892	Not significant
IQ1	-0.724	-3.449	p=0.002
IQ2	-0.310	-1.248	Not Significant
IQ3	-0.517	-2.515	p=0.023
IQ4	-0.069	-0.420	Not Significant
PPI1	-0.172	-1.000	Not Significant
PPI2	-0.207	-1.140	Not Significant
PPI3	-0.241	-1.129	Not Significant
SAT	-0.2586	-1.562	Not Significant
ATT	-0.241	-1.238	Not Significant
INT	-0.139	-0.764	Not Significant
MC	-0.414	-2.288	p=0.037

TH: Threat to role identity; USF: Perceived benefits; SQ: System quality; IQ: Information quality; PPI: Physicians' perceived improvement; SAT: Satisfaction, ATT: Attitude; INT: Intention; MC: Medical community influence

## 6.8. Changes in the adoption of clinical guidelines

This section utilizes multi-level modeling to analyze how the adoption of clinical guidelines changed with time and the relation between adoption of clinical guidelines and system



use. In this case, the assessed model is a two level model with time represented as the level-1 variable and system use represented as the level-2 variable.

The equations for the model are:

$$\text{Level-1 Model: } ADOPTION_{ij} = \beta_{0j} + \beta_{1j}*(TIME_{ij}) + r_{ij}$$

Where (i) represents the time instance (time 0, time 1, time 2), and (j) represents the system user, that is:  $ADOPTION_{ij}$  is the reported adoption of clinical guidelines of user (j) at time (i). The Level 1 equation represents a linear regression equation to predict adoption for a certain user at a specific point of time. Figure 6.5 below shows the above equation for different MPA users (with time centered on 0)

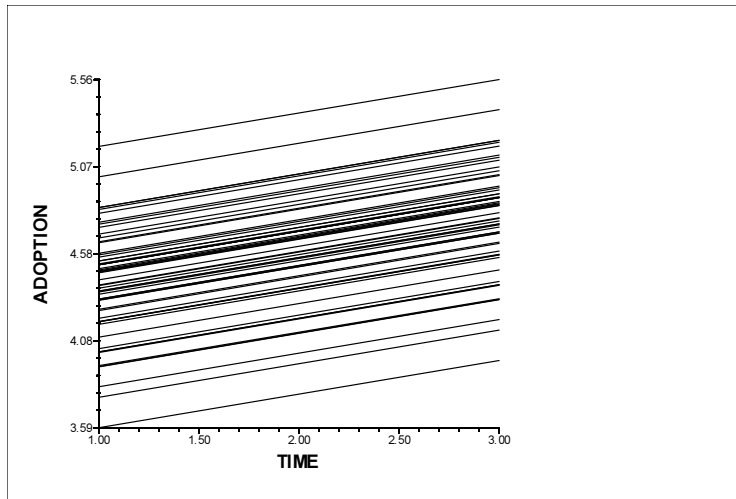
$$\text{Level-2 Model: } \beta_{0j} = \gamma_{00} + \gamma_{01}*(USE_j) + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

The Level 2 model represents the variables that are attached to users (system use) rather than time. In the level-2 model, the level-1 equation coefficients are estimated in terms of level-2 variables.

$$\text{Mixed model: } ADOPTION_{ij} = \gamma_{00} + \gamma_{01}*USE_j + \gamma_{10}*TIME_{ij} + u_{0j} + u_{1j}*TIME_{ij} + r_{ij}$$

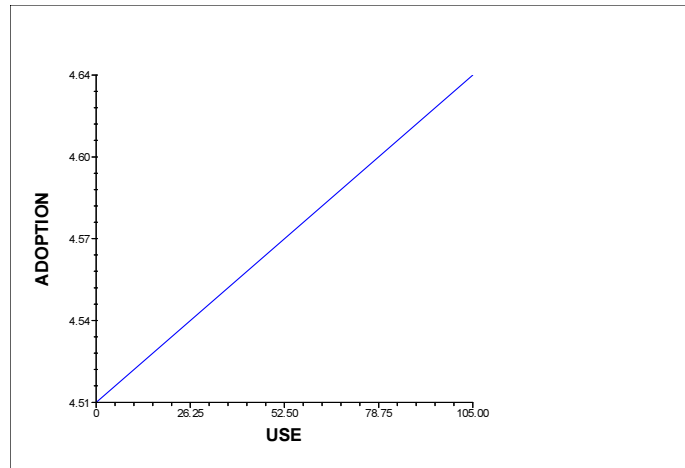
The model was then assessed using HLM software (Zablah et al. 2012). As table 6.17 shows, there is a significant relationship between adoption and time ( $\beta_1=0.190$ ,  $p=0.001$ ) and between adoption and system use ( $\gamma_{01}=0.0012$ ,  $p<0.001$ ). Despite the significance of these relationships, both use and time have small effects on change in adoption of clinical guidelines. Figure 6.6 shows the approximate relationship between adoption of clinical guidelines and system use for all users and time points.



**Figure 6.5. Relationship between adoption and time for different users**

**Table 6.19. Multi-level model parameters**

Predictor	Standardized Coefficient	Standard error	Significance level
Intercept ( $\gamma_{00}$ )	4.170	0.141	<0.001
Level-1 Main effects			
Time ( $\gamma_{10}$ )	0.190	0.057	<0.001
Level-2 Main effects			
System use ( $\gamma_{01}$ )	0.124	0.0241	<0.001



**Figure 6.7. Estimated relationship between adoption and use**

## **6.9. Economic Value of Clinical Guideline Adoption**

While the results above show that KB-CDSS use has a positive influence on adoption of clinical guidelines in practice, this section takes a step forward and asks so what? If physicians indeed adhere to guidelines, how is this likely to affect patient and healthcare system outcomes? To answer these questions, the change in physicians' behavior related to prescriptions of diagnostic imaging is examined. Prescription of clinical guidelines has a healthcare system impact due to its cost and due to diagnostic imaging waiting time. Also, physicians' advice on LBP is examined. Physician advice on the impact of rest on patient work and productivity has a significant economic impact. Hence, comparing diagnostic imaging and rest advice before and after system use may suggest an economic value of using the MPA system.

### **6.9.1. Diagnostic Imaging Changes**

As table 6.18 below shows, on average, the number of diagnostic images used for clinicians in decision making guidance decreased from (.1899) before the system was used to (.1498) after the MPA system was used. That is, there was a decrease of 24.8% in diagnostic imaging prescriptions. However, this change was not significant ( $p=.772$ ).

**Table 6.20. Change in diagnostic imaging prescription before and after system use**

Pre-Post system use	t-statistic	Degrees of freedom
0.0371	0.544	29

### **6.9.2. Physician Rest Advice**

As table 6.19 below shows, on average, the average number of time clinicians advised patients with lower back pain to rest decreased from (4.966) before the system was used to (4.310) after the MPA system was used. That is, a decrease of 13.3% in physician rest advice. However, this change was not significant ( $p=.558$ ).

**Table 6.21. Change in rest advice before and after system use**

Pre-Post system use	t-statistic	Degrees of freedom
0.6552	0.593	29

### **6.10. Summary**

This chapter focused on using the methodology presented in chapter 5 to provide answers for the research questions. Mainly, this chapter analyzed the proposed research model after 6 and 12 months of physician use of the system and validated the model hypotheses. This chapter also examined the changes in system use during the study period and assessed the relationship between adoption of clinical guidelines and system

use. In the next chapter, the results of the focus groups are presented. Chapter 8 discusses the integrated results of the quantitative and qualitative components of this study.

## Chapter 7- Focus Groups

In this chapter, the results of the qualitative part of this study are presented. As mentioned in chapter 5, focus group coding was based on the theoretical model constructs while maintaining sensitivity for new factors that may influence the use of MPA. This chapter starts with presenting the demographics of focus groups participants, followed by presenting the outcome of the coding process. The chapter concludes with a summary of the focus group results.

### 7.1. Focus Groups Participants Demographics

Five focus groups were conducted between April 26<sup>th</sup> and May 11<sup>th</sup>, 2016, with 2 each at SFHC and MFP, and 1 at Halton. Overall, there were 23 participants, which included 10 physicians, 10 residents, and 3 NPs. Table 7.1 below summarizes the demographics of the participants.

**Table 7.1. Focus Groups Participants Demographics**

Participant role	Gender	Number of participants
Physicians	Female	6
	Male	4
Residents	Female	5
	Male	5
Nurse Practitioners	Female	3
	Male	0

## 7.2. Focus Group Coding Outcomes

This section describes the outcome of focus group coding. Focus groups were analyzed using thematic analysis (Pope et al. 2000a). Themes coding follows the theoretical model described in chapter 4 and hence is divided into: threat to role identity, attitude, perceived benefits, satisfaction, influence of the medical community, information quality, system quality, and perceived patient improvement. Table 7.1 summarises the identified focus groups themes.

**Table 7.1. Emerging Focus Groups Themes**

<b>Theme</b>	<b>Dimensions</b>	<b>Example</b>
Threat to role identity	Changes to work flow	<i>“I have always used other tools like charts for lower back pain guidelines”</i>
	Visit time consumption	<i>“Within the constraints of a 15 minute appointment, if it takes more 3 seconds or something like that, it quickly falls off your priority list to do.”</i>
	Interaction with patients	<i>“The real issue with the patients comment about all the time, is when we are at our computers, we’re not making eye contact”</i>
	Patient privacy	<i>“I didn’t feel comfortable leaving the room and having them fill in the brief pain inventory component of it because my whole chart is there”</i>
	Losing visit data	<i>“I trust the information but do I trust it as part of the patient’s chart”</i>
Perceived Benefits	Communicating with patients	<i>“I found it useful often when patients do lose perspective and being able to show them something that they did 3 months ago or 6months ago and then something more recent and say so in fact you have made some improvement”</i>
	Guideline reference	<i>“It has been helpful because it kind of puts everything on one page and you’re kind of just going through it in a more logical way”</i>
	Developing care plans	<i>“You know if we actually had enough time that you could schedule them and you know you inherit them with an alarming number of medications that you wonder about, not the least of which are opioids. And then you try and sort it out and develop a plan”</i>

Medical Community Influence	Overall community influence	<i>"We train our physicians to decide based on evidence and not the opinions of others"</i>
	Supervisor-Resident influence	<i>"And I'll try to get the residents to use it too if I'm supervising. I'll say have you ever used this? And pull it up for them because a lot of times they haven't seen it."</i>
	Resident-Physician influence	<i>"Because I went to a, a resident led thing where they talked me into it and they also said you just press, you just type strep and it's right there."</i>
	Physician-Physician influence	<i>"It wasn't a pop up. It was a social peer pressure media."</i>
	Critical Mass influence	<i>"And I think you also need a little bit of a critical mass. Now I would be the first for every single patient to start the PA because nobody has ever started it before. So and then there is a lot of investment for very little benefit"</i>
System Quality	Accessibility	<i>"MPA would be very beneficial, if we find it"</i>
	Ease of use	<i>"Key is that it shouldn't be something in addition to all your regular typing. It should take away. Like with diabetes it's just, I don't need to type up that stuff right"</i>
	Familiarity	<i>"But I've become very familiar with how to pull it up and use that quite a bit"</i>
Information Quality	No influence	<i>"I have no issues with the guidelines of MPA"</i>
Physicians' Perceived Quality of Care Improvement	Patient involvement	<i>"Sick Kids have a couple of cool tools that they use for their chronic pain patients. But these are Apps that the patients have on their phone that they're filling out and it is a lot of function and goal orientation, that then goes to wherever and then their practitioners can actually see what they're doing and how they're functioning, but that's a relatively small defined group of people"</i>
	Patient communications	<i>"Along P4's point I think if they had a tablet that they could fill stuff out on a site that is patient approved or patient logged to whatever, that might be helpful. Then that data could then go into the chart and to look at it. They could view it in the waiting room"</i>
	Patient education	<i>"Because I actually find it super helpful when patients come in kind of educated"</i>



		<i>and asking questions and challenging management strategies. It's like that's a great idea"</i>
Training and continuous support	Ongoing training and support has a key influence on system use	<i>"I never really was oriented to it. So I was kind of left for the first little while not realizing how to find it. Because I use the old chart version still"</i>
Personal traits	Learning style	<i>"There's always 2 types of learners right. There's a type of learner that just relies on the flow sheet and doesn't internalize and those are the group that will consistently use it. And then yeah there are the learners that will use it, gain capacity and then move on."</i>
Incentives	Audit and legal action	<i>"Like I'm thinking of other times I've started something new and why I have I kept up with it? Like sometimes, it's often, and this is nothing new, but it's often either you have to do it to get paid. You have to do it to not get sued."</i>
	Constant reminders	<i>"When the diabetic flow sheet, we love it, but still first rolled around, there were multiple sort of reminders and many attempts to sort of beat us over the head saying, god damn it, use the flow sheet right. I mean not the least of which was billing, but that going back at it, going back at it, going back at it, going back at it, like I think I now actually, believe it or not, use the damn diabetic flowsheet."</i>
Habit		<i>"The opioid risk assessment form, we have our own, I mean we have the narcotic contract. We have a number of tools in Oscar already. So I don't always use that either"</i>

### 7.2.1. Threat to Role Identity

Focus group participants perceived threat to their role identity in several areas including changes to work-flows, communications with patients, patient privacy, time-wasting, and risk of losing entered data.

#### 7.2.1.1. Changes to work flow

Participants believed that the system altered the work-flows they have been traditionally using to manage patients with pain. For example, several physicians indicated that, over time, they form their own work flow in managing patients with pain and it becomes difficult to change to using a new system.

*“We know they’re trying to establish that protocol or you know systematic approach. But you know if you’ve been around a long time it’s a bit like you’ve got an approach”* [Ph1-SCFC]

This issue of established work flows was evident not just for physicians but for senior (year 2) residents as well.

*“I guess maybe it wasn’t helpful because I was already kind of half way through and I kind of had my own rhythm in doing things”* [R1-MFP]

Workflows were not restricted to mental workflows, but extended to other physical guideline tools used by physicians.

*“I have always used other tools like charts for lower back pain guidelines”* [Ph1-MFP]

Despite the lack of integration between using MPA and physicians’ work flows, some were able to fit MPA into their work flows and use it.

*“well for me doing the extra few clicks to get to that, I think probably saves the efficiency in me remembering what comes next”* [Ph2-SCFP]

#### **7.2.1.2. Visit Time Consumption**

Physicians indicated that the visit time is usually too short to use MPA without interrupting the visit. Pain is usually not the main reason for the visit. Hence, physicians cannot focus the whole visit on managing the patient’s pain symptoms.

*"You know you're with a limited time most of the time with patients. So it's in your mind but you're not really in the moment to look at the form and fill it. The other thing is most of my pain patients don't come in with an hour long pain appointment. It's an opportunistic addressing of things. Yes we're renewing their opioids on top of chasing down a consultation and talking about their blood pressure and talking about their sleep. So to have 5 minutes of the pain part of the visit, refer back to the bundle, when I know I have to do 3 other things in my 15 minutes just makes no sense."* [Ph3-SCFP]

*"...like I thought it was great idea and I was enthusiastic to use it. Within the constraints of a 15 minute appointment, if it takes more 3 seconds or something like that, it quickly falls off your priority list to do."* [R3-MFP]

Physicians proposed modifications to the system that decreases the time it needs during the visit, for example by allowing patients to fill out questionnaires prior to the visit.

*"It certainly speeds things up if the questionnaire is done ahead of time people are seeing a patient. And I just use the smoking cessation questionnaire as an example"* [Ph2-SCFP]

#### **7.2.1.3. Interaction with Patients**

Physicians pointed to the effect of using a computer system (including MPA) during the visit. This focus on MPA prevents eye-to-eye contact with the patients and may cause patient dissatisfaction with the visit.

*"The real issue with the patients comment about all the time, is when we are at our computers, we're not making eye contact okay. And I, and I see that, I haven't supervised for a while but you see it when you're watching the residents. And you know if they're doing this, you often have the patients almost trying to look at their face. So that's a real challenge there, that how do you keep communication"* [Ph4-MFP]

#### **7.2.1.4. Threat to Patient Privacy**

MPA offers a set of patient questionnaires (for example, pain inventory questionnaire). Physicians perceived that leaving patients to complete these questionnaires may give them a chance to see other patients' charts and hence this will threaten the privacy of other patients.

*"I wanted them to answer the questions. Like I didn't feel comfortable leaving the room and having them fill in the brief pain inventory component of it because my whole chart is there."*

[Ph3-SCFP]

#### **7.2.1.5. Losing Visit Data**

Although MPA allows all entered data to be saved in OSCAR patient information, some physicians, because of misconceptions, thought that the information they enter in MPA is either lost or cannot be shared with other physicians.

*"I trust the information but do I trust it as part of the patient's chart"* [Ph5-MFP]

#### **7.2.2. Relationship between Threat and Use**

An interesting theme in the focus groups was the relationship between threat and use. Several physicians mentioned that threat surpasses intention to use the system. That is, some physicians had the intention to use the system, but once they perceived the threats posed by the system, they changed their decision and stopped using the system.

*"I had the best intentions to use it, but when I felt it took away visit time, I wasn't able to [use it]"* [PH3-SCFP]

*"I had great intentions and frankly could never find it and I never ended up using it"* [Ph4-MFP]

*"Does that mean that we shouldn't be incorporating this? And that had been my intention and I have failed to incorporate it"* [R4-MFP]

### 7.2.3. Perceived Benefits

Study participants used MPA for different purposes. Some of these purposes were quite innovative and not intended while the system was being developed. Some physicians used the system to enhance communications with patients and track patient progress.

*“I found it useful often when patients do lose perspective and being able to show them something that they did 3 months ago or 6months ago and then something more recent and say so in fact you have made some improvement” (Ph4-SCFP)*

Other physicians used the system to justify to the patient why they did not prescribe an opioid for their treatment (by showing them that this is part of best practices)

*“I used it more as a way to justify why I would not prescribe a narcotic medication. Because I would go through and I would kind of go through like the different questionnaire. You know based on this really the best thing is anti-inflammatories or physio(therapy) when one was asking for things like medical marijuana or narcotics. So I used it more as a tool to kind of justify to them that I’ve done a good assessment and this is the clinical decision at the end of the day” (R3-SCFP)*

Physicians also used the system to give exercises to patients. Using the system made it easier for the patients to accept and understand the exercises.

*“Because that’s the biggest thing, trying to convince someone when they’ve got back pain to actually be participating in doing something. And often times they are like well I don’t know. So you actually give them this, this is the specific thing that you have to do. Then they, they’re a little more receptive to it.” (R3-MFP)*

Physicians also used MPA as a reference for guidelines. This was the most common use of the system. They used it to walk through the activities required to manage patients with pain.

In some cases, physicians did not enter data into the system and just used it as a reminder of the guidelines.

*“So I tended to, like when I have read it through enough times it gave me that practice and just, just asking those questions. So I use it more as a reference tool I think” (Ph4-MFP)*

*“It has been helpful because it kind of puts everything on one page and you’re kind of just going through it in a more logical way” (R4-MFP)*

One physician pointed out a very interesting use of the system, which was using the system to develop or validate a care plan for the patient. That involves the phases to go through until the patient is cured from pain. This use helped them to eliminate unnecessary use of opioids.

*“You know if we actually had enough time that you could schedule them and you know you inherit them with an alarming number of medications that you wonder about, not the least of which are opioids. And then you try and sort it out and develop a plan. So these tools would be very helpful and I’m sort of thinking I should have done this. I can think of 2 patients already that I probably should have initially taken, you know booked a longer appointment and said okay let’s go over all of this stuff. Rather than doing it piece meal which is what I have been doing.” (Ph2-MFP)*

#### **7.2.4. Medical Community Influence**

While the theoretical model proposed that the medical community in general influences attitude and intention to use MPA, focus groups revealed a richer and more diverse social structure that influences physicians’ decision to use MPA.

For example, one of the physicians who has been supervising residents for a long time mentioned that: *“We train our physicians to decide based on evidence and not the opinions of*

*others*” [Ph1-SCFP]. This shows that social influence does not necessarily have a direct effect on intention.

Supervisors influenced their residents’ use of the system. The influence was focused on showing them the benefits of the system and advising them to use it.

*“And I’ll try to get the residents to use it too if I’m supervising. I’ll say have you ever used this? And pull it up for them because a lot of times they haven’t seen it.”* [Ph1-Halton]

Residents also mentioned the role of supervisors and more experienced nurse practitioners in convincing them to use the system

*“So it seems that each time we get a new component and we really push, it helps. And I think it helps when our supervisors and our NPs are really comfortable with it as well because then when residents come to review, they teach you to look at it. If it’s not engrained, and those people it’s hard to help engrain the residents to make sure they use that as well.”* [R2-SCFP]

Interestingly, physicians said that they may be influenced by residents as well. Residents using the system can demonstrate its value to the supervisors and encourage them to use it.

*“And I’m just thinking what made me do that? Because I went to a, a resident led thing where they talked me into it and they also said you just press, you just type strep and it’s right there. You just put in 1, 2, 3, 4 and then we’re going to audit you and see. And it was something about like I don’t want to be that one doctor who’s not using the strep score”* [Ph4-MFP]

Physicians also discussed the influence of peer effects. Mainly, peers reminding physicians to use the system and checking whether they used it. In contrast to on-screen reminders, these social reminders were effective and acceptable. This result may emphasize the role of having a champion for using the system who can encourage other physicians to use it.

*“It wasn’t a pop up. It was a social peer pressure media.”* [Ph3-SCFP]

*“So I was just wondering with the pain thing, is it good enough that we like, somebody keeps track of how many times we use it? No because sometimes it’s just making us feel guilty.” [PH4-SCFP]*

Another interesting form of medical community influence was observed. The effect of what physicians described as “critical mass”. This effect can be caused on an organizational or medical community level. When physicians observe that most colleagues in the medical community (clinic level or general community level) are using the system, they don’t want to be left behind and hence try using the system.

*“And I think you also need a little bit of a critical mass. Now I would be the first for every single patient to start the PA because nobody has ever started it before. So and then there is a lot of investment for very little benefit. Well if I’m a resident here in 3 years, which I hope not to be then, and all these things have to be filled out and I can follow sort of, then it’s really an advantage to me right. Now it’s, it’s mainly an investment really” [R4-MFP]*

*“Because once everyone gets comfortable with the tool in our unit it seems to work” [Ph5-MFP]*

#### **7.2.4.1. The Vicious Circle**

Focus groups revealed a social pattern that had a negative impact on MPA use. Some physicians believed that they did not need to use MPA because they were already familiar with guidelines. They believed MPA was best suited for residents and advised them to use it.

*“I thought MPA would work best for residents because we know they’re trying to establish that protocol or you know systematic approach. But you know if you’ve been around a long time it’s a bit like you’ve got an approach” [Ph1-Halton]*

However, the relationship between physicians and residents is more complicated than just advice. It is a mentoring relationship



*“you know that the whole learner supervisor thing is a bit of the, it’s like a mentoring supervision. So they’re kind of watching what you do or don’t do and that may not really, you know may not go where you think it’s going to go because you’re not really, you’re not mentoring the approach” [Ph2-Halton]*

Hence, even though the supervisors advised the residents, if the residents do not observe the supervisors using it, they doubt its value and do not use it themselves.

*“So I think even just being really comfortable and kind of find that form quickly. And comfort level with all the supervisors so then it will help the R2 to help the R1s and just kind of that trickle down that it becomes a comfortable thing. And the supervisor also pushing you until you’re feeling comfortable.” [R4-MFP]*

The end result is a low level of usage among both physicians and residents.

### **7.2.5. System Quality**

System quality was a major issue that prevented the users from realizing MPA benefits. The relationship between system quality and perceived benefits was evident in many physicians’ and residents’ discussion.

*“MPA would be very beneficial, if we find it” [Ph3-MFP]*

Several dimensions of system quality were discussed by physicians such as ease of use, familiarity with the system, and accessibility. For example, physicians found the system difficult to use due to the fact that the system was developed for a version of OSCAR different than the version used by physicians and because they believed it required too much data entry.

*“Key is that it shouldn’t be something in addition to all your regular typing. It should take away. Like with diabetes it’s just, I don’t need to type up that stuff right” [Ph4-SCFP].*

Because MPA was designed for a different user interface, physicians found it a complicated process to access the system and hence they were not able to use it. This was the most common complaint about MPA system quality.

*“Can it be made easier to access somehow? I’m trying to think, trying to remember the steps of getting to it” [Ph5-MFP]*

*“And I’ve shown a few residents how to go in. When I’m showing them I think oh this is actually why I don’t use it is because it’s kind of buried” [Ph3-SCFP].*

Familiarity came out several times while discussing MPA system quality. When physicians become familiar with the system, they use it more, but lack of familiarity prevents them from using it. Physicians may be more familiar with other sources of guidelines and prefer to use these sources rather than using MPA. Another dimension of familiarity is related to guidelines. Physicians may use the system more for guidelines they are less familiar with. Lack of familiarity makes physicians unaware of where to find things (e.g. their previous notes) leading to them perceiving the system as less useful and hence not using it.

*“No the same thing happened to me. I’ve sort of gone back to my standard back exercise, get it out, because I know where it is and print it off in a heartbeat.” [Ph3-SCFP]*

*“But I’ve become very familiar with how to pull it up and use that quite a bit” [Ph2-SCFP]*

*“Almost sounds to me like once you get in there and have some experience with it, it sells itself. Until you get in there that’s the issue right” [Ph1-MFP]*

#### **7.2.6. Information Quality**

When all participants were asked if they had any issues with the content of MPA (e.g. guidelines), all physicians and residents agreed that they believed the information provided by MPA was of high quality.

*“I have no issues with the guidelines of MPA” [PH4-MFP]*

### **7.2.7. Physicians’ Perceived Quality of Care Improvement**

Interestingly, physicians indicated a relationship between how using the system improves patient conditions or relieves their suffering and their satisfaction with the system (but not perceived benefits).

*“I would be totally satisfied with the system if it contributed directly to patient care” [Ph4-MFP]*

*“if you could harness 10% of the daily frustration these patients feel in the service of them considering their own circumstance - so if that means them filling out a rating scale every day but then come having a different conversation, I’m all for it” [Ph2-SCFP]*

Physicians focused on the concept of patient involvement and improved communications with patients as factors of how they would perceive a direct influence of the system on patients. For example, they proposed having a patient application that allows them to complete questionnaires before coming into the clinic or before seeing the physician

*“Sick Kids have a couple of cool tools that they use for their chronic pain patients. But these are Apps that the patients have on their phone that they’re filling out and it is a lot of function and goal orientation, that then goes to wherever and then their practitioners can actually see what they’re doing and how they’re functioning, but that’s a relatively small defined group of people” [Ph4-SCFP]*

*“Along Ph4’s point I think if they had a tablet that they could fill stuff out on a site that is patient approved or patient logged to whatever, that might be helpful. Then that data could then go into the chart and to look at it. They could view it in the waiting room” [R5-MFP]*

*“I wish a lot more patients knew that. It always sort of feels like a, it often feels like I’m withholding something that they think is going to be sort of wanted or helpful. But there’s always*

*complex reasons for that and it's not just the kind of you know a lot of it is wrapped up in the addictions and stuff so.” [Ph1-MFP]*

Another area of perceived quality of care improvement was educating patients about pain. For example, allowing patients to view videos before they show up for the visit would make patients more responsive.

*“Because I actually find it super helpful when patients come in kind of educated and asking questions and challenging management strategies. It's like that's a great idea” [Ph3-MFP]*

### **7.2.8. Other Factors Influencing MPA Use**

In addition to the above factors that were derived from the theoretical model, new factors appeared that had an impact on physician use of the system. Those factors include continuous training and support, personal traits, incentives, and habit.

#### **7.2.8.1. Training and Support**

Physicians agreed that their problems with accessing the system and using it are mainly due to lack of continuous training on using the system. Although the study team provided several sessions on using the system for physicians in all clinics, this training was not enough. Physicians “forgot” how to access the system or were not aware of specific features of the system and hence were reluctant to use it.

*“I never really was oriented to it. So I was kind of left for the first little while not realizing how to find it. Because I use the old chart version still” [R4-MFP]*

*“After the initial info session like for instance because not all of us are back to Family Medicine using the EMR so I forgot where everything was. So relearning like almost reminding myself and then reminding myself not only where it was but then reminding to use it for a back pain patient” [Ph2-SCFP]*

*“Just a little bit more education is just what you need. Because if the care providers aren’t familiar enough with it then we can’t always promote it as well as the residents.” [Ph1-SCFP]*

*“I found it initially I did really want to try and use it. And then I had this whole period where I really didn’t seem to have a patient that it applied and then you lose your skill right? And you lose, like you forget that it’s there and you don’t utilize it that much” [R1-SCFP]*

Physicians showed great appreciation for having a “site liaison” that can show them how to accomplish different tasks in MPA.

*“I found it helpful when I signed up to talk to [Site Liaison] like just as a refresher. Just to go through again where to find everything because a couple of times I was stuck and then she showed where I could go and find the things” [PH4-MFP]*

#### **7.2.8.2. Personal Traits**

Physicians linked continuing to use the system with some personal traits including learning style. Physicians may use the system until they are very familiar with the guidelines and then they feel the system is not useful and stop using it.

*“There’s always 2 types of learners right. There’s a type of learner that just relies on the flow sheet and doesn’t internalize and those are the group that will consistently use it. And then yeah there are the learners that will use it, gain capacity and then move on.” [Ph3-MFP]*

Other users (residents) said that using a system interferes with their learning style. At their residency changes, they are trying to learn new techniques and establish their workflows, and using the system prevents them from researching and selecting their preferred work flows.

*“Yes I guess as a resident, I mean when we first assess a patient we don’t, we don’t always automatically jump to a tool to use because we want to try and learn how to assess a situation ourselves. So then in that situation we probably wouldn’t turn to it” [R3-MFP]*

### 7.2.8.3. Incentives

Physicians discussed several incentives that could increase their use of the system. First, they mentioned that using the system can be motivated by constant reminders by others and by the system itself. Constant reminders are mostly because of an administrative benefit of using the system such as billing.

*“When the diabetic flow sheet, we love it, but still first rolled around, there were multiple sort of reminders and many attempts to sort of beat us over the head saying, god damn it, use the flow sheet right. I mean not the least of which was billing, but that going back at it, going back at it, going back at it, going back it, like I think I now actually, believe it or not, use the damn diabetic flowsheet.”* [Ph5-MFP]

Other motivations included auditing and legal action. Family physicians may be audited to examine their use of opioids. Using the system and following the guidelines it provides simplifies the auditing process and makes physicians’ decisions justifiable.

*“But I mean if you get audited and somebody wants to talk to you about it, then you probably will do it. Or the College comes to review and say yeah we want to see your 14 charts with opioid, how you manage you know patients on opioids. I’m pretty sure they’re going to have a pretty standardized check off list saying yes it’s there or not there”* [Ph3-Halton]

*“Like I’m thinking of other times I’ve started something new and why I have I kept up with it? Like sometimes, it’s often, and this is nothing new, but it’s often either you have to do it to get paid. You have to do it to not get sued.”* [Ph5-SCFP]

### 7.2.8.4. Habit

Some physicians indicated that they did not use MPA because they were already used to other tools. Hence, changing to MPA was not appealing to them.

*“The opioid risk assessment form, we have our own, I mean we have the narcotic contract. We have a number of tools in Oscar already. So I don’t always use that either” [Ph3-SCFP]*

### **7.3. Conclusion**

This chapter presented the results of focus groups coding and analysis. The results of the focus groups confirm quantitative results and demonstrate the roles of threat, usefulness, medical community, system quality, and perceived quality of care improvement in encouraging MPA use. It showed that indeed, physicians highly value their professional role and are willing to sacrifice using a useful system if it opposes their role. Focus groups also showed that the involvement of physicians in the development of the system improved physicians’ acceptance of the quality of advice provided by the system.

Moreover, the focus group coding revealed other factors that influence the continuous use of MPA including continuous training and support, habit and incentives.

The next chapter will analyze the combined quantitative and qualitative results of this study to explain factors influencing the use of CDSS and the relationship between use and knowledge translation.

## **Chapter 8- Discussion and Conclusion**

This chapter discusses the quantitative and qualitative results presented in the last two chapters and how these results address the research objectives. The chapter starts by discussing the factors influencing the continuous use of KB-CDSS, followed by a discussion of system dynamics, specifically on changes in system use patterns and how the influence of factors influencing continuous use can change with time. This is followed by a discussion of the relationship between use and adoption of clinical guidelines (knowledge translation). After this discussion, the theoretical, methodological, and practical contributions of this research are presented. Finally, we present the conclusion of this research, its limitations, and future work.

### **8.1. Research Question 1- Factors Influencing KB-CDSS Use**

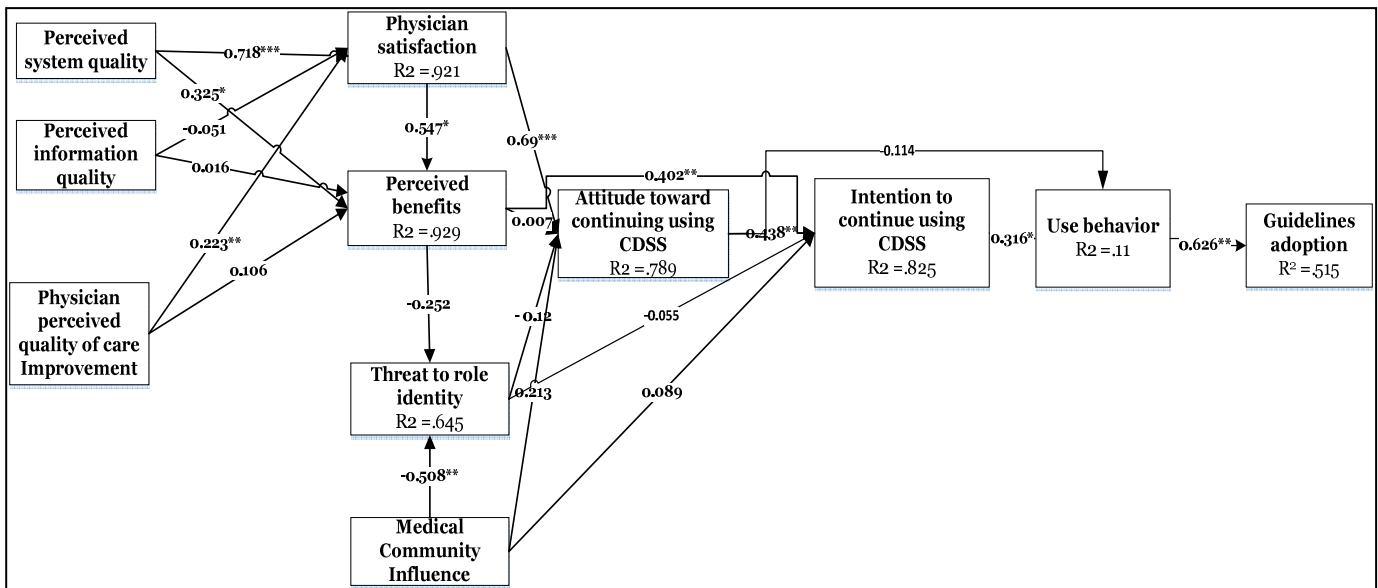
This section discusses the first research question, which relates to the factors that influence physician use of KB-CDSS. This section also discusses how these factors changed from the initial six to the final twelve months of use. It overlaps with a partial discussion of the second research question related to system change and dynamics.

The first significant result obtained was that while threat to role identity was the strongest predictor of system use, with a path coefficient of (-0.436) physicians' intentions to continue using KB-CDSS did not have a significant effect on the actual behavior of continuing to use the system. This result contradicts most adoption and behavior research that assumes intention is a strong predictor of behavior (Egea et al. 2011; Gefen et al. 2003; Hu et al. 1999; Melas et al. 2011). To the best of my knowledge, all of the previous studies on HIS adoption that used a theoretical model did not extend beyond intention. Thus the relationship between intention and use has not been examined before in a healthcare context, suggesting that this result is unprecedented in HIS use research. To explain this result, the outcome of the focus groups needs to be considered. As presented in chapter 7, many physicians mentioned that they had intended to use the system, but this intention was suppressed by the threats and challenges they faced while



trying to access it. Therefore, it can be proposed that when threat is considered by physicians, intention becomes insignificant. In other words, the influence of threat from system use surpasses that of intention. To validate this explanation, the theoretical model was re-analyzed after removing the relationship between threat and behavior (figure 8.1) to see if intention would have a significant effect on system use.

As figure 8.1 shows, when threat was absent, the effect of intention on use became significant (0.316,  $p=0.022$ ), and the explained variance in system use fell from 22.3% to 11%, which confirms the findings from the focus groups. This result shows that physicians indeed develop a care-giver role through their training and education. If physicians perceive a threat to their role, they stop using the system despite its usefulness and their prior intention to use it.



**Figure 8.1. Validation of Theoretical Model without the Relationship between Threat and Use**

After 12 months of use, the relationship between threat and use became insignificant while the relationship between intention and use became significant (path coefficient =0.585,  $p<.05$ ). This change in the relationship between threat and use and between intention and use can be explained by noticing that, the relationship between threat and attitude became significant after

12 months of use while it was not significant after 6 months of use. This implies that after the users get used to the system (either by using it or deciding not to use it), they form an attitude towards using the system based on their previous evaluation of the threat to their role identity. Hence, threat no longer influences use directly. Threat influences use indirectly through the change in attitude and hence, intention becomes the main predictor of use.

Another interesting result is the influence of the medical community on attitude (H6a), intention (H6b) and on threat (H6c). It was found that after 6 months of use, medical community did not have a significant effect on intention or attitude. However, it had a significant effect on threat to role identity and hence an indirect effect on system use. These results can be justified through the focus group outcomes. Participants mentioned that one of the goals of medical training is to train physicians on independent decision making, and to form their own opinions based on their own assessment. Hence, physicians' attitude and intention are not significantly influenced by how the medical community perceives the system. On the other hand, when physicians observe that the medical community has accepted the system, their perception of threat decreases. They perceive the system as less threatening to their professional identity since others, with the same training, do not perceive the system as threatening. This results agrees with extant IS research that found social norms have an indirect effect on user behavior (Kim et al. 2009). This is confirmed by the results of healthcare research focused on guidelines finding that, when the guidelines are developed by physicians, physicians view them as less threatening (Cabana et al. 1999).

After 12 months of use, the influence of medical community on intention to use the system (H6b) became significant. This outcome is closely related to the previous result that, as users form their attitudes towards the system, the direct effect of threat on use becomes insignificant. Threat then becomes a component of user attitude and influences intention through attitude. Hence, medical community effect on threat is shifted to intention after 12 months of use.

Attitude was found to have a significant effect on intention after 6 months and after 12 months of use (H3a) but it had no significant influence on system use. This result agrees with previous results in HIS research (Carlsen et al. 2011; Carter 2008; Ernstmann et al. 2009; Khan et al. 2011) findings that attitude influences HIS use and guideline adoption. Another explanation of the change in the medical community influence is that, in the first six months, since physicians started using the system at the same time, there was not enough system users to create an influence on other users, while in the last 6 months of use, there was enough users to represent a critical mass and directly influence other physicians' intention to use the system.

Perceived benefits were found to have a significant effect on intention to continue using the system after 6 months of use. This result agrees with most IS adoption research that found perceived usefulness predicts intention (Egea et al. 2011; Gefen et al. 2003; Hu et al. 1999; Moon et al. 2001; Tung et al. 2008). However, no direct relationship was found between perceived benefits and attitude. This result also agrees with previous research (Davis 1989; Venkatesh et al. 2003) that found perceived usefulness to influence only intention and not attitude in technology acceptance models.

After 12 months of use the effect of perceived benefits on intention became insignificant. This implies that system users have formed their attitudes towards using the system in the first six months. Therefore user attitudes represent their evaluation of other factors and become the main predictor of intention.

User satisfaction with the system was found to have a significant influence on attitude towards using the system (H4a) after 6 and 12 months of using the system. This relationship was proposed by the A-B model and agrees with previous research in HIS (Davis et al. 2009; Heeks 2006) and IS research (Wixom et al. 2005). User satisfaction with the system represents their evaluation of the quality of the system and the value this system represents. Hence, if users are satisfied with the system, this satisfaction extends to their behavior and they have a positive

attitude towards using this system (Eagley et al. 1993). Satisfaction was also found to have a positive influence on perceived benefits after 6 and 12 months of use (H4b). This agrees with previous research in IS that found this relationship to hold (Petter et al. 2009). When physicians have evaluated the system positively, they are likely to perceive future benefits of using the system.

This study proposed a positive relationship between perceived information quality and perceived benefits (H8a) and between perceived information quality and satisfaction with the system. However, the results show that these relationships were not significant after both 6 months and 12 months of using the system. This means that perceived information quality had no effect on physicians' satisfaction or their perceived benefits from using the system. This result was confirmed in the discussion groups. Physicians showed anonymous agreement on the quality of the information provided by the system. This result may be attributed to the fact that the system considered in this study was designed by the Family Medicine Department at McMaster and the guidelines were selected by a group of family physicians. Prior research in the area of guidelines showed that guidelines are more acceptable if physicians are involved in their development (Cabana et al. 1999). Another potential reason for physician acceptance of the quality of information provided by the system may be due to the series of awareness sessions provided to physicians on pain management guidelines. Hence they were aware of the quality of the user guidelines even before the system was deployed. This result is interesting because it is different than the findings of most IS studies (Petter et al. 2009). It shows that physicians trust the medical community. This trust makes information quality a given when the system is designed by other physicians, and disables its effect on satisfaction and perceived benefits.

Unlike perceived information quality, perceived system quality was found to have a positive relationship with perceived benefits (H9a) as well as with satisfaction (H9b) after 6 and 12 months of use. This result agrees with numerous studies that utilized the D&M success model

which found similar relationships (Petter et al. 2009). The focus group results showed that system quality, especially ease of use and accessibility, were major factors for physicians, profoundly influencing how they perceived system benefits. It appears that users evaluate the system and estimate the benefits they can get from it, based on how easy it is to access and get what they need from the system.

Physician perceived quality of care improvement (PIQ) is a construct developed in this study to account for the influence of the improvement in patients' condition that physicians perceive as a result of using the system. This construct was developed to account for patient influence on physician decisions to use the system, a factor that has been rarely studied in IS or healthcare literature. It was found that PIQ has a positive influence on satisfaction with the system (H10b) but its influence on perceived benefits was not significant (H10a) after both of either 6 and 12 months of system use. This was an interesting result because patients are at the center of care (Barry et al. 2012). Hence, one would think that PIQ would have a direct influence on the benefits physicians perceived from using the system. The context of these relationships was thoroughly examined during the focus groups. It was found that physicians clearly differentiate between their satisfaction with the system (a perfect system, a killer system) and their perceived benefits from the system. Perceived benefits are related to the effect of the system on how physicians do their work, for example improving efficiency or as a guideline reference. The benefits received by the patient are implicit and not directly considered by physicians. This perception of benefits stems from physicians' perceived role as caregivers. All their work is directed at improving patients' conditions (Friedson 1970). Hence, if their efficiency or effectiveness improves, this will reflect on the patient, and PIQ does not have a direct influence on perceived benefits.

On the other hand, the focus groups showed that physicians' satisfaction with the system is influenced by PIQ. Physicians, as caregivers, try to do their best for their patients. However,

they are sometimes met by resistance from patients or have difficulties convincing patients to adhere to their advice (Zolnierek et al. 2009). These difficulties have been found to influence physician decisions to adopt clinical guidelines (Lau et al. 2007). Physicians are satisfied with the system if it helps to alleviate these difficulties by convincing patients to follow their advice or by getting physicians more involved in their care. Hence PIQ has a direct relationship with physician satisfaction with the system.

The results of the focus groups identified other factors that influence the use of KB-CDSS. First, ongoing training and support. While physicians in the three clinics received training before the system was deployed, they indicated that, because they do not regularly use the system, they forgot where things were and required continuous support and training on the system. This finding agrees with previous HIS research that found training to be important in the adoption and use of HIS (Escobar-Rodríguez et al. 2012; Glodek 2013). However, very little literature has discussed the need for ongoing training and support, relating to the fact that HIS continuous use has also seen little research.

The results also point to the role of incentives such as easier auditing or legal responsibility in using the system. These incentives imply two things. First, these factors are important not just in the use of HIS but in medical practice in general (Chaix-Couturier et al. 2000; Irani et al. 2009; Kessler et al. 1996); this indicates that physicians indeed view HIS as a change or extension to their medical practices rather than as only a system to enhance efficiency. Second, even if physicians work in a healthcare system where they are not mandated to use a specific HIS system, there are incentives that can persuade them to use this system.

Finally, focus groups showed that the role of social influence on KB-CDSS use extends beyond the general medical community. It extends to peers, supervisors, and even residents. All those with a direct contact with a system user can motivate system use either by reminding them to use the system, by demonstrating system benefits, or by forming a culture that encourages

using the system. Although the role of important others has been discussed in IS (Davis et al. 92; Venkatesh et al. 2012) and HIS literature (Venkatesh et al. 2011b), this study explored and explained this role in more depth than most existing research.

### **8.1.1. Control Variables**

This study considered three control variables: Gender, role and clinic. Gender had no influence on any of the constructs in this model. Although prior research found that gender may influence perceived benefits of system use (Venkatesh et al. 2003), the context of previous studies was different than this one. The findings from this study may be attributed to the common training received by male and female physicians, resulting in similarities in their professional identities. This likely influenced their decisions to continue using the system.

The second control variable considered was the user's role. It was found to influence satisfaction with the system and system use after 6 months of system use. Focus groups showed that physicians and residents differ in the value they expect from the system. While residents focus more on learning and building their knowledge base, physicians are more concerned with efficiency in managing their patients and the relative advantage of the system over current tools. From another perspective, physicians have already developed their workflows and tools to manage patients with pain while residents are still building their workflows. Hence, residents are more open to try using the new system in their efforts to develop these workflows. And they are more likely to be satisfied with the system even if it only partially satisfies their needs.

After 12 months of use, the influence of the user's role diminished. This could have been caused by the difficulties faced by both physicians and residents in accessing and using the system; these difficulties were the strongest factor influencing user satisfaction for both physicians and residents. Moreover, after 12 months of use, residents may have started to develop

their own workflows in managing patients. This would indicate that they did not need to use the system as they did on the first six months.

The third control variable in this study was the clinic where the user worked. This yielded surprising results. Despite similarities in the training sessions and the physician population among clinics, the clinic was found to influence both system use and perceived benefits. In order to explain this influence on physicians, the differences among clinics were investigated. The only difference found was the existence of a champion in these clinics and the activities of the champion in each case. For MFP and SCFP, two of the study investigators worked at these sites and acted as champions. Based on personal observations of both sites, the SCFP champion included the system in most of her presentations and study groups involving pain management. For Halton, no physician acted as a champion and users were not continuously reminded to use the system. Prior research showed that champions can play an important role in encouraging system use and demonstrating system benefits to users in an HIS context (Ash 1997; Ludwick et al. 2009; Sittig et al. 2010). Moreover, in the focus groups, users mentioned that they were more likely to use the system if they are constantly reminded by other physicians to use it.

After 12 months of use, clinic influence diminished. By that time, users had enough experience with the system to form their own perceptions and to decide whether or not to continue using the system.

To summarize the important findings needed to answer the first research question, the results of this study show that threat to professional identity is the prominent predictor of system use. In the first six months of use, threat influences use directly. That is, even if users have a positive attitude towards the system and an intention to use it, when they realize the potential threats of the system, they do not use it. In the next six months, threat becomes a factor that forms their attitude towards the system and hence, intention becomes the prominent predictor of use. The results also show that the influence of medical community on use is indirect through threat in



the first six months and then with use, creating a direct relationship between the influence of medical community and influence to use the system. Finally, PIQ, a construct developed to capture the influence of patients on use, was found to have a positive relationship with physician satisfaction with the system but not with benefits perceived from using the system.

## **8.2. Research Question 2- System Dynamics**

While the previous section partially examined how the influence of different theorized constructs changed with time, this section will focus on system use patterns and the change in these patterns after 6 and 12 months of use.

As presented in chapter 6, the change patterns were significantly different among clinics (Table 6.15), with SCFP using different modules more frequently than MFP and Halton. As discussed in the previous section, this result was due to the influence of the champion in different clinics, and the SCFP champion was very active in encouraging the use of the system among both physicians and residents.

Another result from the same table in chapter 6 is that LPB modules were used more frequently than NeP modules. This result can be attributed to the differences in the populations of NeP patients which represent 1% of the population (Irving 2005) vs. LBP patients which can be up to 67% of the population (Jarvik et al. 2005). The brief pain inventory was the most used module because it was common for both NeP and LBP and an important and useful tool to communicate with patients.

As figure 6.3 shows, usage dropped significantly after 12 months to considerably less than after 6 months of use. Use dropped for all system users, and the majority of the users stopped using the system altogether. Focus groups showed that the reason behind this are that first, the system issues faced by the users during the first six months of use degraded their perception of system benefits, which had a negative influence on their intention to use the system. This reason

was confirmed by users who continued to use the system. They compared the difficulties they faced when accessing the system with the benefits it offered, and their perception of the benefits was higher so they decided to continue using the system. The second reason was the lack of support. Not every visit required the physicians to use the system. Hence, they forgot how to use the system or to access specific areas within the system. Therefore they stopped using the system. The third reason was that after using the system for some time, physicians became familiar with the guidelines, and just stopped using the system.

Another result from figure 6.3 is that users who used the system frequently in the first six months were more likely to continue using it after 6 months. This result can be justified in several ways. First, it can be translated as the effect of habit. If system use became habitual to users through frequent use in the first six months, it became part of their pain management workflows, so they continued to use it. The role of habit in HIS use has rarely if ever been studied before and no previous study found that habit influenced HIS use. This is an important finding of this study. The second reason is that factors that influenced physician use in the first six months continued to influence them in the final six months. That is, if perceived benefits of the system overcame the threat of the system, they continued to use it. After the first 6 months of use, those physicians had the same positive evaluation of the system so they continued to use it. This explanation has been discussed before in the literature (Ajzen 2005). It was also evident in the focus group discussions with users. Those who continued to use the system commented that “what are a few clicks to access the system compared to MPA benefits”.

This study also found that although system use of the system decreased in the final 6 months, resident use of the system was still significantly higher than physician use (figure 6.4). This result was discussed in the previous section and is repeated here for completeness of the discussion.

As shown in table 6.18, when examining changes in users' perception between 6 and 12 months of use, several interesting results emerge. First, as users continue to use the system, their perception of system use increases as well as their perception of information quality. At the same time, users' satisfaction and attitude towards using the system do not change. This confirms the result explained in section 8.1. That is, physicians differentiate between system usefulness and satisfaction with the system and that perceived threat has more influence on physicians' attitude and system use than the perceived benefits from using the system. Table 6.18 also shows a significant increase in medical community influence. This result, when combined with focus groups results, show that peer influence can have a significant impact on users' behavior.

### **8.3. Research Question 3- Relationship between Use and Knowledge Translation (KT)**

The quantitative results of this study show that there was a strong relationship between use and knowledge translation (adoption of clinical guidelines in practice) after 6 months of use but this relationship became insignificant after 12 months of use (H1). As a result the explained variance in KT went down from 51.5% at 6 months to 25.8% after 12 months. Likely the main reason behind this finding is that pain management guidelines became part of the tacit knowledge of system users (Alavi et al. 2001) and they were able to continue using this knowledge even though they stopped using the system. This may explain previous findings in IS research regarding knowledge translation. The results of these previous studies were mixed, with one study showing no change in KT after an IS was used (Haas et al. 2005) and another showing delayed change (Ko et al. 2011) . It may be the case that for the first study, users already had absorbed this knowledge tacitly so the effect of the IS was diminished. In the second study, users had not absorbed this knowledge yet and therefore needed to continue using the system. A further possible reason is that the deployment of the first system was accompanied by awareness and training sessions on the importance of pain management guidelines and the consequences of not

adhering to these guidelines, so physicians adopted the guidelines even though they did not use the system.

To further investigate the change in KT behavior and its relationship with system use, I used multilevel modeling to examine the change in adoption with time. It was found that KT improved linearly with time. This means that as physicians continued to use the system, they continued to apply guidelines in their pain management practices, and this application of guidelines improved as they used the system. The significant increase of KT after 12 months of use from before the system was deployed emphasizes the value of the system in improving knowledge translation and adherence to guidelines. To examine if system use had a significant effect on KT, I included use as a level-2 variable in the multi-level analysis and indeed there was a linear relationship between use and KT. However, this relationship was weak. This confirms the previous finding that system use was most effective in improving KT until the pain management guidelines became part of physicians' tacit knowledge and they applied them automatically even without using the system.

The main goal of KB-CDSS systems in general, and the MPA system in particular, is to encourage physicians to apply evidence-based medicine. The findings from this study show that these systems are indeed successful in reaching their goals. Physicians, depending on their learning style, apply guidelines in practice either by directly using the system or by having guidelines as part of their tacit knowledge and practice workflows. Either way, patients indeed benefit from using the system. This final result raises an interesting question on the definition of IS success. While previous studies (e.g., Delone et al. 1992) considered continuous use a prerequisite to system success, the results of this study showed that the system was successful in delivering its expected outcomes despite the significant decrease in system use. Hence, this result shows that the success of an IS system is contingent on the achievement of its intended outcome rather than its use. For the MPA system, this shows that its role, as perceived by user, was a

knowledge management system that converted explicit knowledge (clinical guidelines) to implicit knowledge (physicians' workflows) (Alavi et al. 2000) rather than a decision support system and hence users stopped using the MPA once they realized its intended outcome.

### **8.3.1. Benefits of KT**

As discussed above, using the system led to an improvement in KT and in the application of clinical guidelines in practice. The question now is whether KT was beneficial in improving the efficiency and effectiveness of pain management. Consequently, was the development of KB-CDSS justified?

To answer this question, I used actual patient charts to examine the effect of KT on physician behavior. This study focused on two areas: (1) Whether physicians prescribed diagnostic imaging for patients with LPB; (2) Whether physicians advised patients to rest or to be more active; These areas were selected because they reflect the economic component of pain management as well as the effectiveness of NeP management.

As the results presented in section 6.9 show, there was an improvement in all the considered areas. However, this improvement was not statistically significant. This may be due to the small number of physicians considered in this study. In all circumstances, these results agree with previous findings (Blackmore et al. 2011) and show a potential for KB-CDSS in improving efficiency and reducing the economic impact of disease management.

## **8.4. Study Contributions**

This study has several theoretical, methodological, and practical contributions to IS research in general and HIS area in particular. These contributions are detailed below.

### **8.4.1. Theoretical Contributions**

Although the adoption and use of HIS has been commonly studied in IS literature, this research has been limited in terms of theory (Abouzahra et al. 2015). Moreover, continuous use of HIS after initial adoption has been studied only rarely. This research extends the HIS literature by studying continuous use of HIS using a novel model that incorporates not only IS-based constructs, but contextual factors such as physicians' professional identity, the role of the medical community, and the influence of patients on HIS use.

Most previous theoretical studies on IS use in general and HIS use in particular considered intention to be the main predictor of system use (e.g., Venkatesh et al. 2000). Hence, the theoretical models considered in these studies stopped at the intention and scarcely included actual use behavior as part of the model. These studies followed a meta-analysis that showed a strong correlation between intention and behavior in different contexts (Feldman et al. 1988). This current study, however, shows that although intention has an influence on continuous use, this influence is surpassed by the influence of threat to physicians' professional identity. This result was established through both quantitative and qualitative findings of this study. This result is a novel one in both IS and HIS literature. Even in previous IS research that considered both intention and threat as a part of the theoretical model (e.g., Nicolaou et al. 2006; Walter et al. 2008), none of these studies included actual behavior and therefore the influence of threat on use was not captured. The significance of this finding is that it identifies the role of context in the study of IS use and the importance of including user (in this case physician) identity in future research. This finding also supports previous calls (Benbasat et al. 2007) to include context related constructs in IS use models.

Interestingly, the above relationship between threat, intention, and use is not stable through time. Instead, it changes as users become familiar with the benefits and shortcomings of the system. As users grow to understand the system more, threat becomes one of the factors that form physician attitude towards the system. In other words, as time goes on, physicians evaluate

the system based on its usefulness, their previous experience with it (satisfaction) and the threat it poses. They then form their attitude towards the system based on these factors. Although several published IS studies were longitudinal in design (Brown et al. 2014; Venkatesh et al. 2003) these studies either did not include threat or did not include actual behavior in their theoretical models. To the best of my knowledge, my research is the first time that changes in the relationship between intention, threat, and use has been quantitatively captured.

Another theoretical contribution is the relationship between the medical community and threats to role identity. Several studies have examined the influence of medical community on intention (Anderson et al. 1985; Kohli et al. 2004; Venkatesh et al. 2011b). However, this study found that, for physicians, the influence of medical community on use is not direct, but is instead fully mediated by threat to role identity. This relationship changed after long use of the system. Moreover, the influence of medical community on HIS use is multidimensional. Physicians are influenced by their colleagues, their supervisors, residents, and the medical community at large. Again, this result reflects the importance of context in studying HIS use and the complexity of the relationship between the influence of medical community and use.

Despite the discussion of the role of patients in motivating physician use of guidelines (e.g., Winston et al. 2011) in several qualitative studies, this role has, to the best of my knowledge, never before been conceptualized in the area of HIS adoption or in a theoretical study. This is unexpected because of the current interest in patient-centric care and several calls to include patients in the development of care plans (Barry et al. 2012; Montazemi et al. 2011; Sperl-Hillen et al. 2016). This study conceptualized the influence of patients on physician use of HIS in the construct “Physicians’ perceived quality of care improvement” which captures how physicians perceive patient attitude towards care due to system use. This concept is a novel one and it was found to be theoretically distinct from other model constructs like “perceived benefits”. This construct has a strong influence on physician satisfaction with the system but not

their perceived benefits. The value of this construct was validated in the qualitative component of this study, with physicians relating their satisfaction with a system that can include patients in care plans and motivate them to adhere to physician advice.

Another related contribution is the differentiation between physician satisfaction with the system and their perceived benefits from using the system. While satisfaction and perceived benefits are two distinct constructs that reflect users' evaluation of the system as a whole and their perceptions of the value they receive from the system, previous IS research usually considered both constructs to have similar antecedents (Petter et al. 2009). However, this study found that physicians' perceived benefits are related to how physicians directly manage their patients (e.g., communicating with patients or using clinical guidelines). This is mainly influenced by perceived system quality, while satisfaction is related to how the system influences overall care quality in addition to system quality.

Differences in HIS use between residents and physicians has rarely been examined in the literature. This study found that residents were more likely to use KB-CDSS systems than physicians and that the relationship between physicians and residents can influence system use. This is probably due to the previous experience of physicians and their established workflows as opposed to the less experienced residents. This is confirmed by the finding that residents found the system more useful than physicians.

While the role of a champion in encouraging use has been discussed repeatedly in IS literature (Ash 1997; Ludwick et al. 2009; Sittig et al. 2010), there has not been much literature on this topic in the HIS domain and most of these studies were qualitative in nature. This study showed that a champion can significantly improve system use in clinics.

Finally, the relationship between system use and knowledge translation is a major contribution of this study. While continuous use of knowledge tools such as KB-CDSS was



theorized to influence knowledge translation in healthcare (Graham et al. 2010), this relationship was not shown quantitatively before. Even in the non-HIS literature, the influence of system use on knowledge translation has been studied rarely and with conflicting results. This study does not just show that there is a significant relationship between use and knowledge translation, but it can help to explain the conflicting results of previous IS research. Some studies (Haas et al. 2005) found no effect of system use on knowledge translation. This study shows that this is possible if the system has been used for a long time and the knowledge provided by the system has become tacit knowledge to system users. Users then applied this knowledge even if they did not use the system. Other studies showed that system use has a delayed influence on knowledge translation and that this influence fades after a period of time (Ko et al. 2011). This study also shows this is true. The results were obtained after 6 months of use, showing that system use indeed influenced knowledge translation. However, this influence faded away after 12 months of use when the knowledge provided by the system became less useful to the users. It is worth noting that Ko et al. (2011) explained their results by proposing that users need time to digest the knowledge and apply it in practice. This is not applicable to this study because system users, whether physicians or residents, are highly skilled users and can take early advantage of knowledge provided by the system. Comparing the result of this study and prior studies on knowledge translation show that system user characteristics have a significant influence on the extent to which they apply knowledge in practice. More skilled users are likely to use the knowledge faster than less skilled users and will abandon the system once they have converted the system's explicit knowledge to tacit knowledge.

#### **8.4.2. Methodological Contributions**

This study has contributed to the IS literature by reviewing the differences between IS and healthcare researcher expectations in terms of methodology and how to overcome these differences to create HIS research of high quality.

In healthcare, research is considered an essential component of medical practice. Physicians are encouraged to adopt an evidence based approach by evaluating medical studies and weighing evidence in order to make decisions (Kegeles et al. 2015). Therefore, healthcare research needs to be compatible with physicians' approach to medical practice in order to facilitate their use of research outcomes. This means that healthcare research is influenced by the nature of medical practice and physician professionalism. Aspects of physician professionalism includes autonomy (Blumenthal 2009), decision making and judgment, and a focus on patient best interests (Roland et al. 2011). These aspects are created and enhanced through medical education as well as ongoing communications among physician community members (Freidson 1994). This professional-influenced attitude towards research is visible in several ways. First, most healthcare studies are conducted with an intention to improve quality of care rather than to explain healthcare user behavior towards a system. This is evident through the lack of theory in healthcare literature (Abouzahra et al. 2015) and the focus on using research outcomes to promote practice (Abouzahra et al. 2014b; Kaplan 2001).

Taking physician expectations into consideration, this study developed a methodology that addresses physician expectations and enhances collaborative works with physicians. This led to the success of the study, consisting of the following components:

- (1) Including physicians in focus groups that developed the questionnaires. This resulted in questionnaires that were clear and understandable to the study participants.
- (2) Using formative constructs instead of reflective constructs. Physicians resisted the use of reflective constructs and considered the survey items redundant and useless. This agrees with the expectations of physicians. Physicians are trained to approach cases

categorically. That is, examining certain symptoms and making a decision based on whether a specific symptom exists or not (Streiner et al. 2014). This categorical approach is reflected in healthcare research as well. Most healthcare questionnaires ask about different aspects or factors of a phenomenon rather than focusing on establishing questionnaire reliability (Kelly et al. 2005; Pincus et al. 1983). Hence, changing the questionnaire constructs to formative, wherever possible, enhanced physician response rate and their willingness to complete the questionnaires.

- (3) Using Q-sorting for the validation of formative constructs. This helped a lot in clarifying the theoretical model constructs and demonstrating the validity of the questionnaire items. I would highly recommend using this validation technique in future healthcare studies since it helps to get IS and healthcare researchers on the same page and increase confidence in the meaning of constructs.
- (4) Employing mixed-methods design. The healthcare environment is a complex one, evolving dynamically with many stakeholders working together to provide patient care (Kohli et al. 2016). Healthcare data also come from different sources, including patient charts, system logs, guidelines, and patient outcomes, in addition to data gathered from surveys and interviews. In order to gain a better appreciation of the healthcare environment, this study sourced several types of data, and used both surveys and focus groups. This mixed methods approach enabled capturing the complexities of the healthcare environment and led to several interesting results.

### **8.4.3. Contributions to Practice**

This study made several contributions to practice. Specifically, to the development and deployment of KB-CDSS and to enhancing knowledge translation in healthcare. While several of

these recommendations have been discussed before, this study presents that data to backup those recommendations and clarify their context.

- (1) It is not enough to develop systems that are useful to physicians. These systems must seamlessly integrate with existing workflows in order to be accepted by physicians. As discussed above, when it comes to HIS use, threat surpasses intention, making it necessary to integrate system use into workflows. This can be accomplished in different ways. For example, KB-CDSS can be integrated with systems currently used by physicians so that they surface when needed without interrupting physicians' work. KB-CDSS should also present information in accordance to the natural flow of the patient visit.
- (2) Related to the above point, the system may have to interrupt workflows or create new ones, for example if the system creates an evidence-based workflow that differs from the one currently followed by the physician. In this case, system deployment should include change management activities by using incentives, continuous training sessions and continuous technical support. Employing champions in deployment sites can also alleviate physician concerns and improve the likelihood of system success.
- (3) System development and deployment should consider significant physician involvement. In this study, physician involvement improved their confidence in the quality of the information provided by the system. As a matter of fact, information quality was considered a given and it did not influence physician perceptions of the system. This agrees with previous research (Mishra et al. 2012) that found that physicians consider other physicians to be less threatening than system developers such as insurance or pharmaceutical companies. Physicians should also be included in the system deployment phase. As this study shows, if the system is acceptable by the medical community, physicians perceive it to be less threatening and hence are more likely to use it more.

Interestingly, pharmaceutical companies use a similar approach to market new drugs. They involve key figures in the medical area they are targeting even before the drug is fully approved and they participate in conferences to gain buy-in from physicians and from the medical community (Smith 2014). A similar approach for KB-CDSS development and deployment would improve system adoption and use.

- (4) Physician satisfaction with the system depends on the role of the system in improving patient care. Therefore, KB-CDSS should contain components that guarantee patient involvement in the care process. In the case of MPA, physicians tied their satisfaction to developing components that allow patients to complete pain questionnaires prior to visits. They also suggested developing mobile applications that guide patients with pain through pain management exercises and that facilitate patient adherence to physician advice.
- (5) System quality influences both satisfaction and perceived benefits. Physicians, because of their experience with HIS systems, are strongly influenced by the quality of the system. Hence, KB-CDSS developers should focus on the quality of the developed system. This includes creating systems that are accessible, easy to use, and flexible enough to accommodate physicians' needs. It should be noted here that the concept of system quality extends to system deployment and maintenance as well. For example, if the system fails because of infrastructure problems, physicians may still consider the system to be of low quality even though this is not a system problem. Hence, there should be a strong support structure for KB-CDSS systems and HIS systems in general.
- (6) First impressions last. Because of the longitudinal design of this study, this study shows that while physicians may have positive attitudes and intentions to use the system, they may not use the system if it is threatening to their practice. The problem is that, with time, this threat becomes part of the attitude towards the system and may result in changing physician attitudes towards the system to negative ones. This may result in the long term failure of the system since it is usually difficult to convince them to change

their attitudes to the system. Therefore, it is recommended that system deployment be carefully planned as discussed above and physicians' concerns be addressed in a timely and satisfactory way. Otherwise, the system may be abandoned.

- (7) KB-CDSS can improve knowledge translation. In order to improve physician application of clinical guidelines, KB-CDSS could be used more. They should present information in a way that is easily understood and trusted by physicians, in order to enhance their adoption of guidelines.

## **8.5. Limitations**

As with any research project, this study has some limitations that are summarized in this section. First, this study was conducted in clinics in southwestern Ontario. Therefore, caution should be taken when generalizing results to other geographical areas and within different healthcare cultures. However, the outcome of this study can apply to other provinces in Canada. This is because of the similarities between educational, training, and healthcare systems across provinces. Moreover, the outcome of this study is likely to apply across North America due to the continuous interactions among physicians in North America through conferences and publications.

Second, the study was conducted within academic clinics. While physician education is similar in academic and non-academic clinics, the results are applicable to non-academic contexts as well. Both residents and physicians in academic clinics may be more ready to apply guidelines in practice due to the educational nature of these clinics. Hence, caution should be considered when generalizing the results of this study to non-academic settings.

Third, the focus of this study is KB-CDSS. Hence, generalizability of the results is limited to this type of CDSS.

Fourth, due to the exploratory nature of this study, not all factors influencing system use or knowledge translation were considered. This can be observed from the explained variance in both constructs. While the qualitative part of the study discussed several of these factors, they still need to be validated using quantitative methods.

Fifth, the questionnaires used in this study were deployed after 6 and 12 months of physician use. This limited the study ability to capture changes in system dynamics within smaller periods of time.

Finally, the low number of respondents after 12 months of use may limit the validity of results at this time period. However, these results were confirmed using focus groups that involved 23 physicians and residents. Moreover, my experience with analyzing the results shows that the results are stable even for small numbers of respondents.

## **8.6. Future Work**

The results and limitations of this dissertation open the door for several opportunities for future research. First, the factors that influence KB-CDSS use that were found in qualitative focus groups could be included in future quantitative studies. These factors include continuous support, peer influence, and incentives.

Second, Habit represents an interesting construct that requires more examination. As discussed in chapter 4, physicians perceive patients differently. Therefore, logically, habit is not expected to be significant in studying KB-CDSS use. However, habit has other dimensions. The habit of applying guidelines in practice may influence a physician's decision to use the system because the system might be more supportive to their work. At the same time, if physicians are used to certain workflows, they may reject the system if it requires changing these workflows as they may perceive HIS as threatening to their role. Therefore, future research should focus on

understanding the role of previous habits in encouraging physicians to use KB-CDSS and how to develop systems that facilitate change instead of creating threats to physician workflows.

Third, Patient related constructs have often been ignored in CDSS use research. There is abundant research on how HIS can affect patient outcomes but to the best of our knowledge, there are no studies that examine the effect of patient outcomes or satisfaction on physician use of HIS. This effect can logically be deducted given how physicians perceive their role in society as caregivers and how they perceive their mission as making decisions for the benefit of their patients. A reason behind the lack of research in this area may be that patients usually rate their physicians high on satisfaction surveys (Streiner et al. 2014). Therefore, there may be no motivation to study the effect of patient satisfaction on HIS use. While this study employed the “physicians’ perceived quality of care improvement” as a proxy for patient-related constructs, future work should consider patient-related constructs. This could lead to the development of research projects that focus on understanding the influences of patient perceptions and satisfaction on physician use of HIS systems.

Fourth, this study should be extended to non-academic settings. Although, the results are expected to hold in other settings, it would still be interesting to find out if other factors influence physician continuance of use in these contexts. This is especially important since research comparing academic and non-academic environments in the context of HIS use is relatively scarce.

Fifth, the qualitative focus groups pointed to an interesting influence of the relationship between residents and physicians on the use of KB-CDSS systems. This relationship, to the best of my knowledge, has never been studied before. Hence, it is recommended that this relationship should be studied in more detail. For example, a study can be designed to capture the interactions between physicians and residents and how these interactions influence system use for both roles.



Social analytics techniques (Lazer et al. 2009) can be used to capture such interactions, while system logs can be used to capture actual system use for residents and physicians.

Sixth, while this study demonstrated how system dynamics and relationships among constructs change between 6 and 12 months, a more detailed study might be useful to the understanding of such changes in smaller time periods (for example every 3 months)

Finally, it may be useful to compare the results of this study in different geographical areas and in different cultures.

## **8.7. Conclusion**

This study addressed several important research gaps. First, a lack of research on the continuous use of KB-CDSS systems. Second, the disintegration of healthcare context-related factors in KB-CDSS use research, and third, the scarce literature on the role of KB-CDSS in enhancing knowledge translation in healthcare. This study extended current literature by conducting a comprehensive literature review and creating a theoretical model that encompasses IS and healthcare context-related constructs to explain physicians' continuous use of KB-CDSS and the relationship between continuous use and knowledge translation. The model was empirically validated and focus groups were conducted to further understand the context of systems use and how users perceived the meaning of different constructs. Several interesting results were found. First, the relationships among factors influencing the continuous system use differed after 6 months and after 12 months of use. Second, physicians highly value their professional identity as caregivers to the extent that the effect of this identity surpasses their intention to use the system. With time, physicians' professional identity plays an important role in defining their attitude towards using the system. Third, continuous use of KB-CDSS influences knowledge translation and this influence decreases with time. This result may explain contradicting results in the extant literature. Fourth, the results of this study signify the

importance of context in understanding IS user behavior and calls for the inclusion of context in future IS use research.

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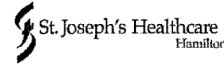
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# Appendix A-Ethics Board Approval



**Hamilton Integrated Research Ethics Board (HIREB)**  
293 Wellington St. N., Suite 102, Hamilton, ON L8L 8E7  
Telephone: 905-521-2100, Ext. 42013  
Fax: 905-577-8378

April 8, 2014

**PROJECT NUMBER:** 14-253

**PROJECT TITLE:** Uptake, Impact and Acceptance of the McMaster Pain Assistant Computerized Clinical Decision Support System

**PRINCIPAL INVESTIGATOR:** Dr. Dale Guenter

We wish to confirm this study was presented at the April 2, 2014 meeting of the Hamilton Integrated Research Ethics Board and was given *final* approval from the full HIREB.

The following documents have been approved on both ethical and scientific grounds:

- > The submission
- > Study Protocol version dated March 11, 2014
- > Patient Consent & Healthcare Provider Consent Forms version dated March 11, 2014
- > McMaster Pain Assistant Information Sheet version dated March 11, 2014
- > Email from PI to be sent to OSCAR users for recruitment of clinicians version dated March 11, 2014
- > Clinician questionnaire; Care Questionnaire (patient satisfaction); Brief Pain Inventory Questionnaire, versions dated March 11, 2014
- > Chart Audit Data Fields for electronic collection version dated March 11, 2014

**Please note** attached you will find the Information/Consent Form with the HIREB approval affixed; all consent forms used in this study must be copies of the attached materials

We are pleased to issue final approval for the above-named study for a period of 12 months from the date of the HIREB meeting on April 2, 2014. Continuation beyond that date will require further review and renewal of HIREB approval. Any changes or revisions to the original submission must be submitted on an HIREB amendment form for review and approval by the Hamilton Integrated Research Ethics Board.

PLEASE QUOTE THE ABOVE-REFERENCE PROJECT NUMBER ON  
ALL FUTURE CORRESPONDENCE

Sincerely,

Dr. Raelene Rathbone  
Chair, Hamilton Integrated REB

The Hamilton Integrated Research Ethics Board operates in compliance with and is constituted in accordance with the requirements of: The Tri-Council Policy Statement on Ethical Conduct of Research Involving Humans; The International Conference on Harmonization of Good Clinical Practices; Part C Division 5 of the Food and Drug Regulations of Health Canada, and the provisions of the Ontario Personal Health Information Protection Act 2004 and its applicable Regulations; for studies conducted at St. Joseph's Hospital, HIREB complies with the health ethics guide of the Catholic Alliance of Canada

## Appendix-B: Attitude-behavior model questionnaire

<b>Questions</b>
<p><b>Information Quality</b></p> <ol style="list-style-type: none"> <li>1. The clinical recommendations provided by the McMaster Pain Assistant are accurate</li> <li>2. The clinical recommendations provided by the McMaster Pain Assistant are up to date</li> <li>3. The McMaster Pain Assistant provides me with all the information I need to manage my patients with pain</li> </ol>
<p><b>System Quality</b></p> <ol style="list-style-type: none"> <li>1. The McMaster Pain Assistant makes pain management clinical recommendations very accessible</li> <li>2. Overall, I would give McMaster Pain Assistant high marks in terms of functionality</li> <li>3. I find the McMaster Pain Assistant easy to use</li> <li>4. I find McMaster pain assistant flexible enough to accommodate my pain management preferences</li> </ol>
<p><b>Perceived Benefits</b></p> <ol style="list-style-type: none"> <li>1. Using McMaster Pain Assistant helps me with making a diagnosis efficiently</li> <li>2. Using McMaster Pain Assistant enhances my effectiveness in managing my patients with pain</li> <li>3. Using McMaster Pain Assistant improves my knowledge of pain management guidelines</li> </ol>
<p><b>Satisfaction</b></p> <ol style="list-style-type: none"> <li>1. All things considered, I am satisfied with McMaster Pain Assistant</li> <li>2. Overall, my experience with McMaster Pain Assistant is satisfying</li> </ol>
<p><b>Attitude</b></p> <ol style="list-style-type: none"> <li>1. To me, The idea of continuing to use McMaster Pain Assistant is good</li> <li>2. The idea of continuing to use McMaster Pain Assistant is valuable to me</li> <li>3. I favor the idea of continuing to use McMaster Pain Assistant</li> </ol>
<p><b>Threat to role identity</b></p> <ol style="list-style-type: none"> <li>1. McMaster Pain Assistant strains my relationship with my patients.</li> <li>2. McMaster Pain Assistant lowers the need for specialized skills for pain management.</li> <li>3. Using McMaster Pain Assistant decreases my control over clinical decisions</li> </ol>
<p><b>Influence of medical community</b></p> <ol style="list-style-type: none"> <li>1. My decision whether to continue using the McMaster Pain Assistant is driven by its acceptance by the family medicine community.</li> </ol>

2. The pain management guidelines implemented by McMaster Pain Assistant are widely accepted by family physicians

**Physician perceived quality of care improvement**

1. Considering patient experience, by using the McMaster Pain Assistant, I believe that my patients have had a better experience of care
2. Considering patient experience, by using McMaster Pain Assistant, I believe my patients with pain find the care provided to them more reliable
3. In general, after using McMaster Pain Assistant, I believe my patients with pain find the care provided to them more responsive to their needs

**Intention to continue using CDSS**

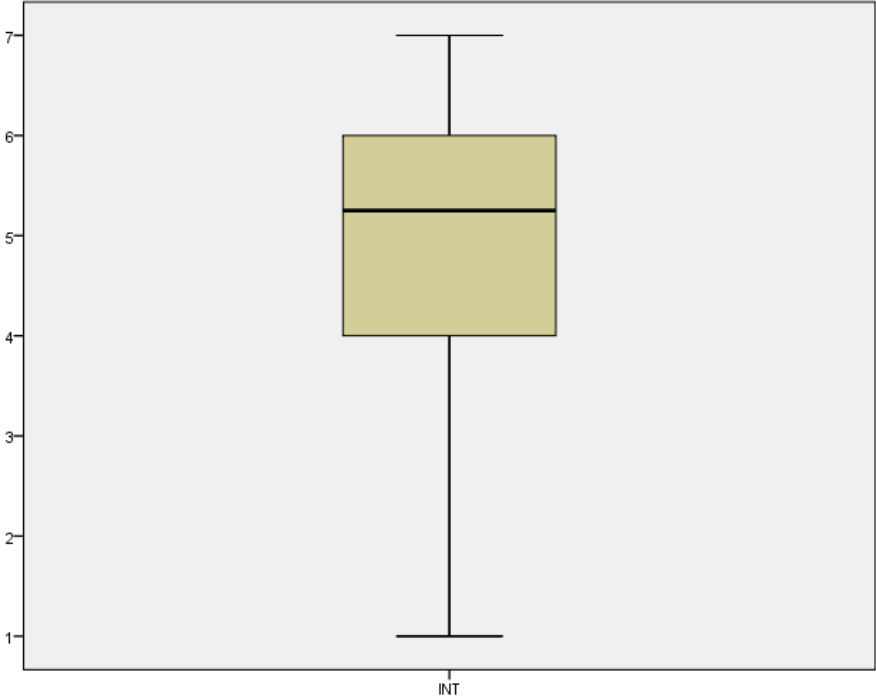
1. I intend to continue using at least one component of the McMaster Pain Assistant
2. I plan to continue using at least one component of McMaster Pain Assistant

## Appendix C- Knowledge translation (Adherence to clinical guidelines questionnaire)

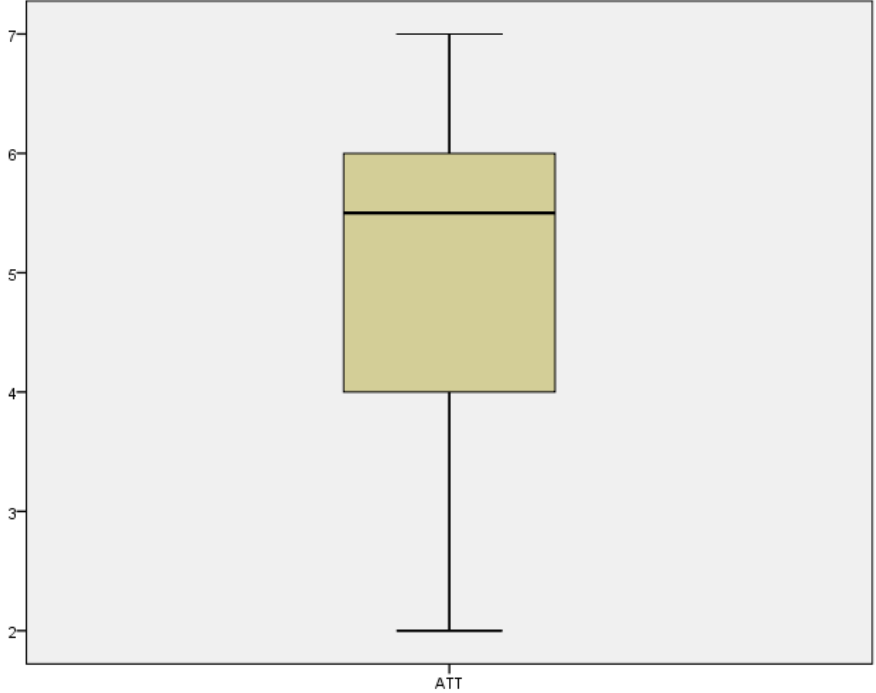
In what percentage of your patients with new onset low back pain (< 12 weeks) do you check for the following criteria as an indicator for an urgent situation?   Checking for widespread neurological signs
In what percentage of your patients with new onset low back pain (< 12 weeks) do you check for the following criteria as an indicator for an urgent situation?   Severe unremitting (non-mechanical) worsening pain, especially at night or when lying down
In what percentage of your patients with new onset low back pain (< 12 weeks) do you advise them to stay active?
9. In what percentage of your patients with new onset low back pain do you use the following criteria for imaging?   Bone Scan: infection, systemic inflammatory process
In what percentage of your patients with chronic pain do you screen for neuropathic pain?
In what percentage of your patients with neuropathic pain do you use agents like Tricyclic antidepressants or Gabapentinoids as first line analgesic options in their pain management?

# Appendix D: Boxplots

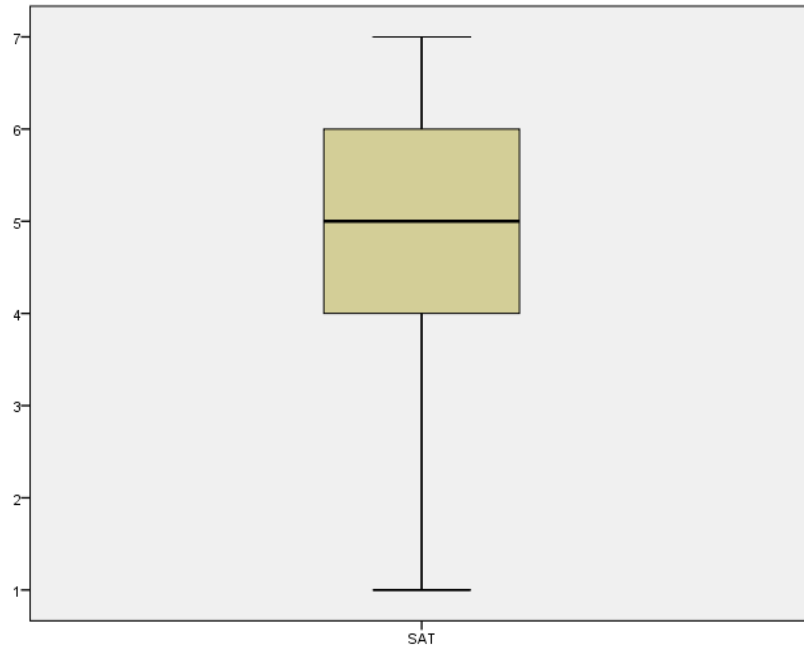
**Intention**



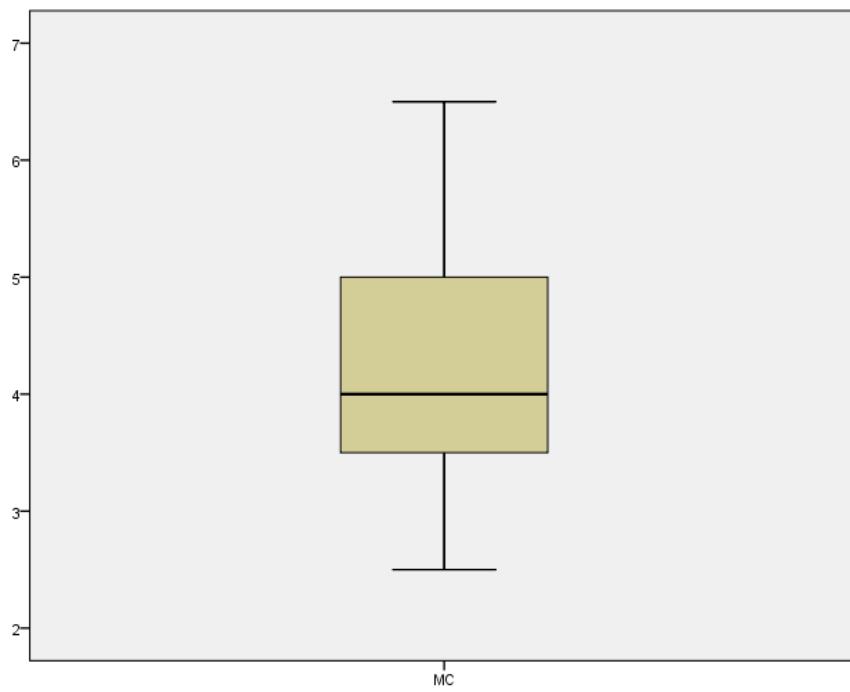
**Attitude**



## Satisfaction

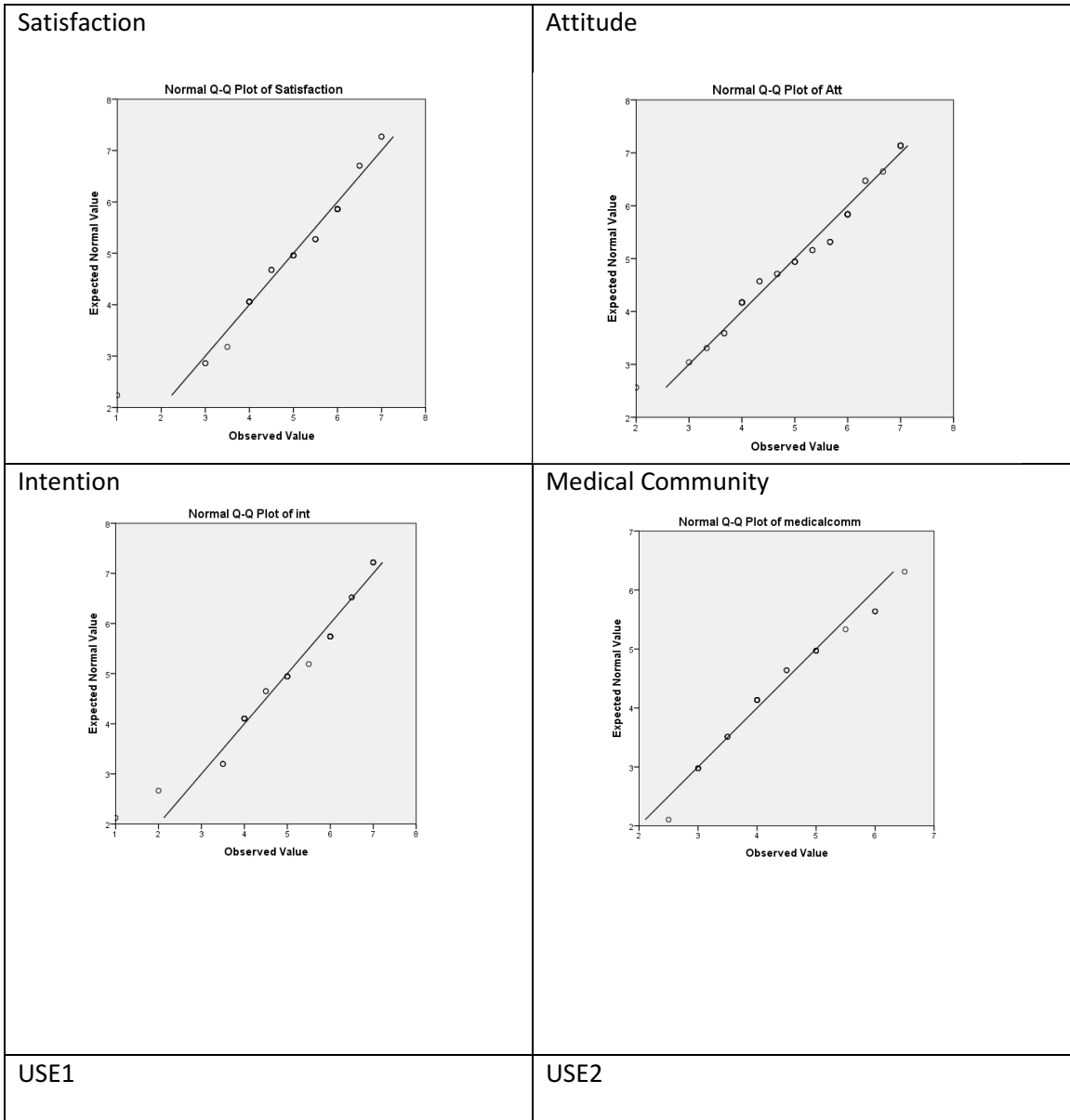


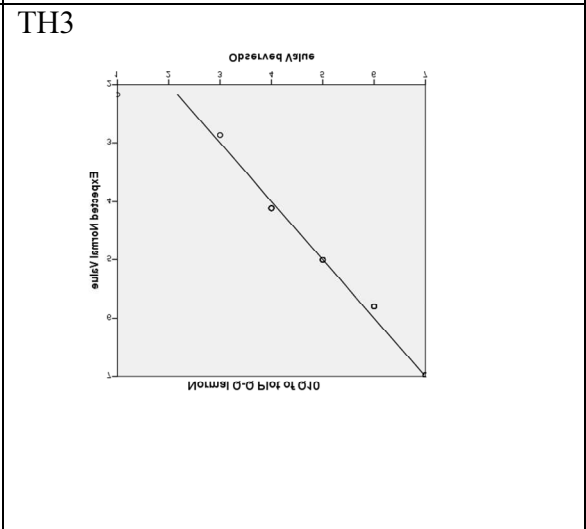
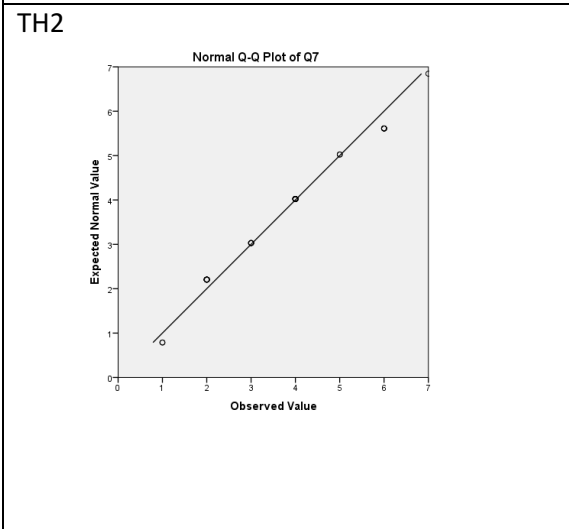
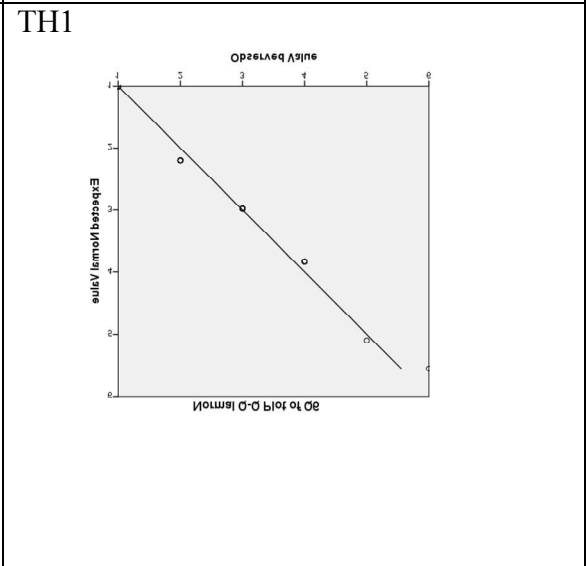
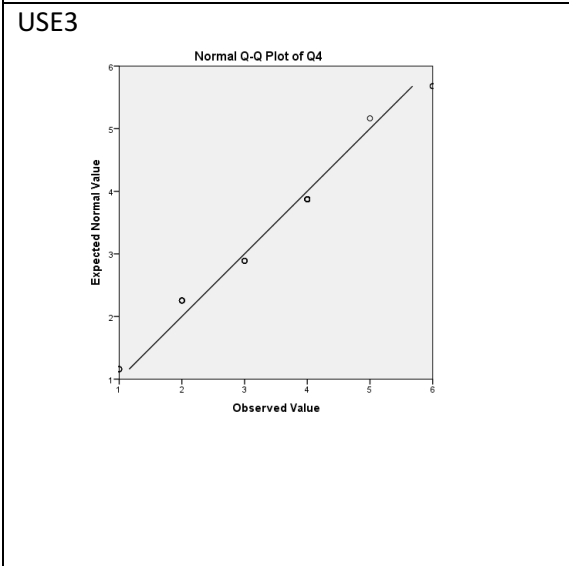
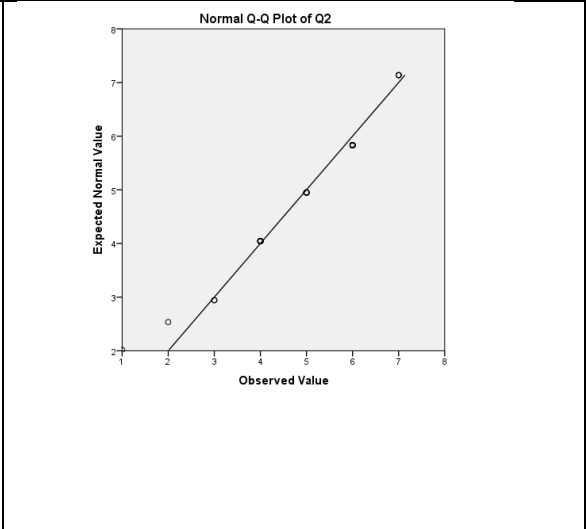
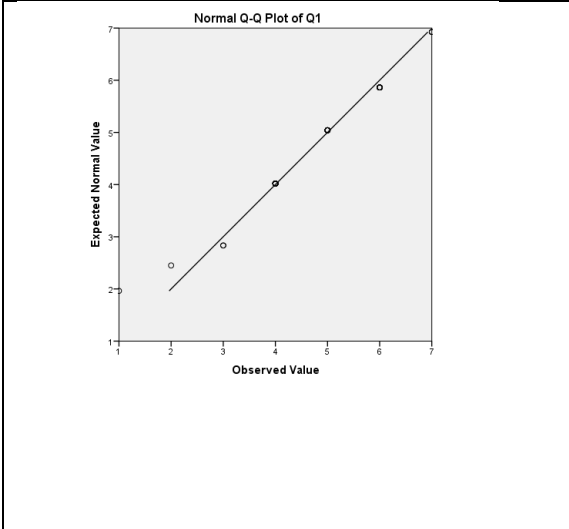
## Medical community





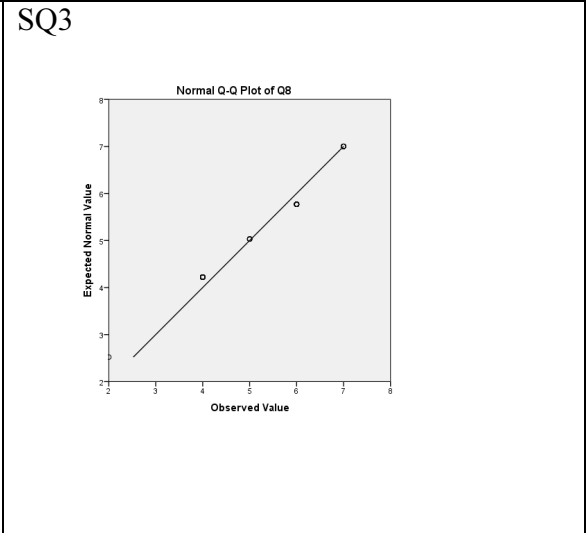
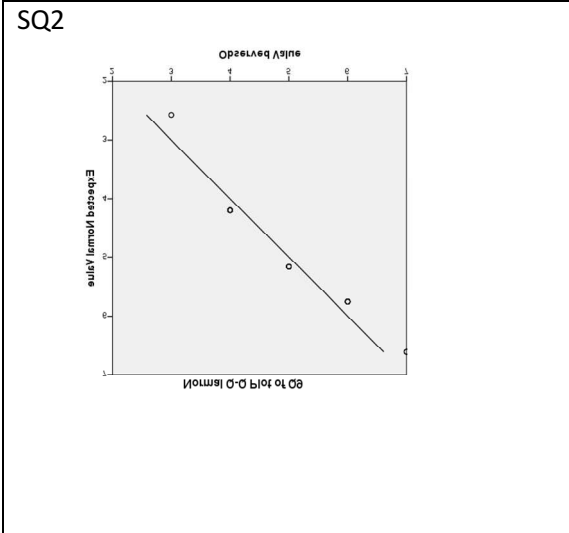
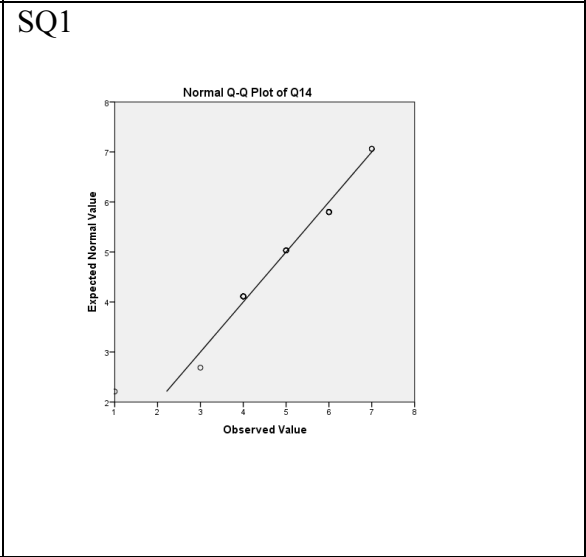
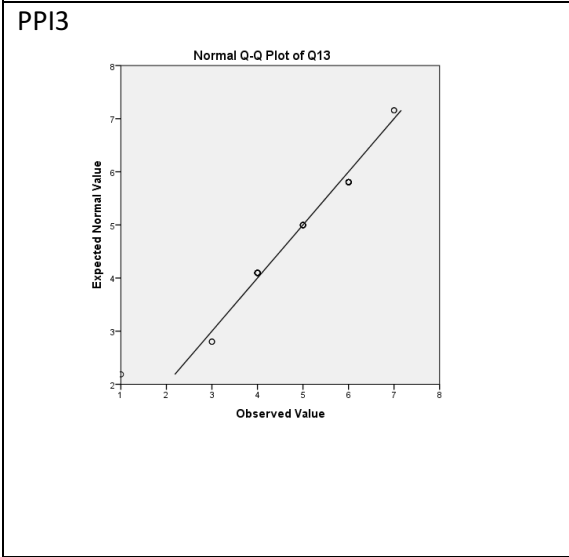
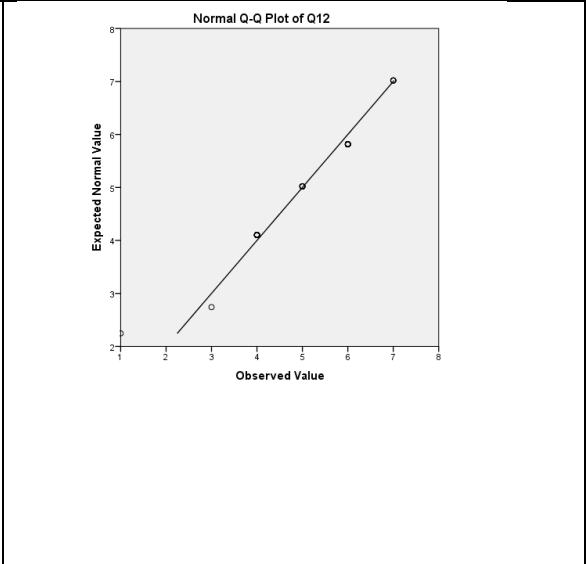
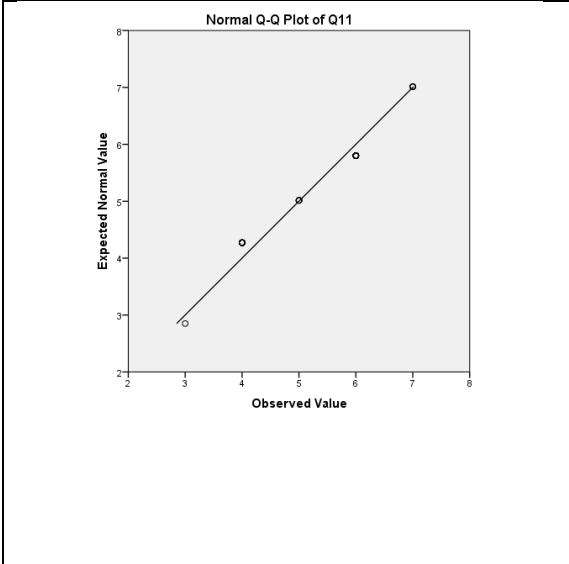
## Appendix E- Q-Q plots





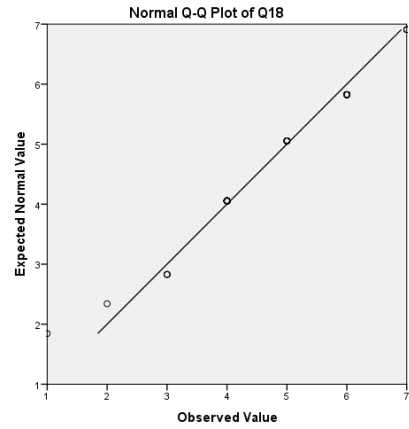
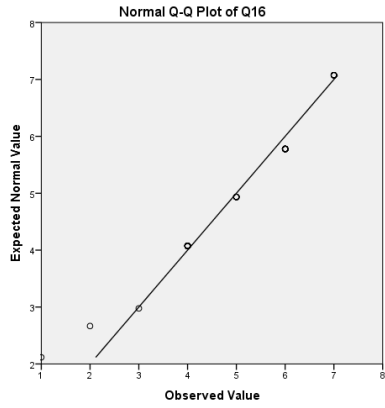
PPI1

PPI2

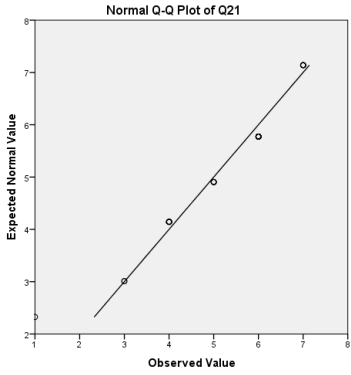


SQ4

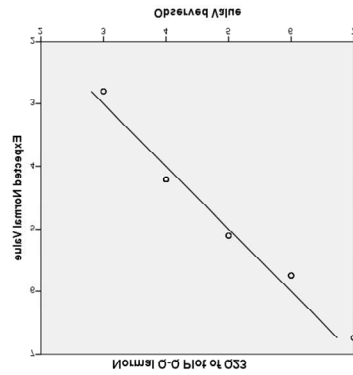
IQ1



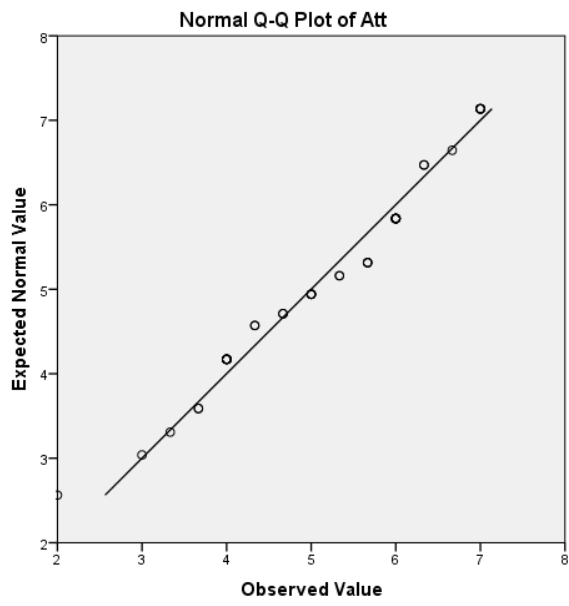
IQ2



IQ3



## Attitude



# Appendix F- Linear relationships

