Implementation of Barcode Medication Administration System in Public Sector Medical Units in the UAE

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By: Safa Al Mustafa, 1047882

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Safa Al Mustafa

Approved:

Mehmood Khan, PhD

Associate Professor, College of Business Administration

Abu Dhabi University

Committee Chair

Matloub Hussain, PhD

Associate Professor, College of Business Administration

Abu Dhabi University

Committee Member

Dr. Christos Pitelis

Dean, College of Business Administration

Abu Dhabi University

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List of Abbreviations

A	Awareness
ABCR	Assessing Bar-Coding Readiness
ADEs	Adverse Drug Events
AHP	Analytical Hierarchical Process
AHRQ	Agency for Healthcare Research and Quality
BCMA	Barcode Medication Administration
C	Culture
CA	Costs Assessment
CIAS	Clinical Information and Alert System
CPOE	Computerized Physician Order Entry
D	Documentation
DIT	Diffusion Innovation Theory
DLP	Drug Labeling and Packaging
DoH	Department of Health
E	Education
EF	Environmental Factors
ER	Emergency Room
EMR	Electronic Medical Record
EU	Ease of Use
FDA	Food and Drug Administration
GST	Ground System Theory
HAAD	Health Authority Abu Dhabi
IPSG	International Patient Safety Goals
IT	Information Technology
JCIA	Joint Commission International Accreditation
L	Leadership
MAE	Medication Administration Event
MEs	Medication Errors
MC	Management of Change
MRE	Medication Related Event

MCDM	Multi-Criteria Decision Making
MTA	Multidisciplinary Teams and Committees
P	Process
PE	Patient Education
PI	Performance Improvement
QPRM	Quality Processes and Risk Management
QS	Quality & Safety
ROI	Return on Investment
SS	Staff Satisfaction
ST	Staff Training
T	Technology
TAM	Technology Acceptance Model
TC	Task Characteristics
TS	Technology Specifications
U	Usefulness
UAE	United Arab Emirates
UDMS	Using Data to Improve Medication Safety
US	User Support
WHO	World Health Organization

Abstract

Patient safety and quality of care are a priority for the healthcare sector worldwide; this is mandated by global and international organizations World Health Organization (WHO, 2013, 2017), and local health authorities in UAE, for instance the Department of Health (DoH), the regulatory body in the Emirates of Abu Dhabi. As per JCIA "Joint Commission International Accreditation "patient safety is the first goal of the International Patient Safety Goals (IPSG), having the potential to affect patient life significantly; however, there is an increase in the cost of healthcare services, arising from dealing with subsequent patient complications and the cost of legal liabilities, and causing inefficient utilization of healthcare organization resources. To prevent medication errors, healthcare infrastructures have started to focus on establishing an efficient, reliable, and usually electronic medication administration process and management. However, mainly human who are vulnerable and prone to errors control the current process. Barcode medication administration (BCMA) is one of the latest technologies used to respond to this problem, and it offers a solution that may contribute to improved safety. The main objectives of this study are to determine the preparatory needs for introducing a Barcode Medication Administration System (BCMA) and to identify, categorize, and prioritize the main criteria for a successful implementation of this technology in healthcare facilities, and to draw a roadmap for effective and efficient implementation of the system. This would lay the groundwork for generalizing BCMA in the UAE health system and highlight the main factors that would lead to successful BCMA implementation. This study would also help to identify challenges and facilitators that affect new technological adoptions in the healthcare system in the UAE and prioritize them to inform similar technology implementation projects in the future.

This research was conducted in four different medical units with a 300-bed capacity located in a tertiary public hospital in the Emirates of Abu Dhabi, United Arab Emirates. Nurses, who are usually the expert clinicians responsible for administering medication, were used as the population for this study. An extensive literature review was performed to develop a theoretical framework, and twenty expert nurses were interviewed through a simple, pairwise-comparison questionnaire. An analytical hierarchical process (AHP) was employed to describe systematic decision-making by identifying and prioritizing the different factors that affect the successful implementation of BCMA technology. Major factors were identified following the data analysis, and these were organized in domains that included leadership-related factors, technology-related factors, process-related factors, education-related factors, and quality- and safety-related factors. Interestingly, leadership-related factor was the most important factors with the highest priority weight, followed by process- and education-related factors.

Keywords: *BCMA, AHP, Technology, Leadership, Quality & Safety, UAE*

Chapter I: Introduction

1.1 Introduction

The World Health Organization (WHO) has confirmed that safe, effective, people-centered, timely, equitable, integrated, and efficient healthcare is a human right to which all countries and their governments need to commit (World Health Organization, 2017). Safety is embedded within the universal healthcare ethical principles of beneficence and no maleficence (Pozgar, 2014). Safety topped the characteristics list of a quality healthcare system in the previously mentioned report, giving extra emphasis to this concept. Even earlier in 2010, the regional European Union office of the WHO focused its attention on the issue of safety in healthcare institutions and the quality of healthcare (Virone and Tarasenko, 2010) (WHO, 2010). The office report on patients' safety and rights indicated that there was significant existing evidence on the magnitude of healthcare-related harm to patients, (8–12)% of patients were subject to healthcare-related adverse events in the European Union, but these reported errors were highly preventable. This situation has prompted European Union actions that focused on patient safety and the quality of healthcare.

To mitigate medical errors and control risk factors in the clinical environment, the WHO established the World Alliance for Patient Safety, which emphasized that "*Achieving safer health care requires global leadership, concerted efforts and a commitment to learning from errors and patients' experiences*" (World Health Organization, 2013). A concept related to safety that is commonly used in healthcare is the "culture of safety" or the "safety culture" (Agency for Healthcare Research and Quality, 2017). The Agency for Healthcare and Quality stated that the concept of safety culture originated outside healthcare, in the organization's reliability and its consistent effort to minimize adverse events and medical errors. Committed organizations maintain a reasonable adherence to safety at all levels, and in all times and contexts, from frontline

providers to managers and executives. This commitment establishes a "culture of safety." A culture of safety is one important element that plays a big role in medical error prevention (Naveh et al., 2005).

Medication errors are currently considered a significant global concern that can cause critical medical outcomes for patients (Alsulami et al., 2013). According to the National Coordinating Council for Medication Error Reporting and Prevention, a medication error is defined as a preventable incident that may “cause or lead” to incorrect medication use or even maybe “patient harm” (National Coordinating Center for Medication Errors Reporting and Prevention, 2018). The scale of the problem is alarming in the United Kingdom, as per National Patients Safety Agency report between (2001 up to June 2008) that more than 800,000 medical incidents were reported in England as an adverse event that affected the patients. The majority of these occurred in secondary care (i.e., hospitals), with about 71,000, i.e., just under 9%, related to medications (Assiri et al., 2016).

Serious medication errors are common in hospitals and often occur during ordering, transcription, or administration of medication (Alsulami et al., 2013). The number of deaths due to medication errors can be as high as 7,000 per year in a country (Dennison, 2007). Technology can be introduced to improve the accuracy of medication administration by incorporating barcode verification within an electronic medication-administration recording system (Radley et al., 2013; Alsulami et al., 2013). Information technology (IT) is one of the recent strategies used by the healthcare industry as a promising solution in preventing medication errors (Poon et al., 2010; Radley et al., 2013). It is hoped that by utilizing this technology in healthcare the quality of care and patient safety will improve and healthcare costs will be reduced (Young et al., 2010).

Technological advancements have grown dramatically in the healthcare setting during the last decade. For instance, electronic billing, electronic medical records (EMR), computerized physician order entry (CPOE), and barcode medication administration (BCMA) have been implemented in varying degrees at many major hospital institutions across the United States (McGrath et al., 2010). The healthcare industry is constantly changing and evolving, and new technologies emerge more frequently these days, based on the needs of and innovation in the healthcare sector. Implementation of new systems and technologies will always need an effective change management process. Using a theoretical framework is an important methodology to reduce resistance to change and facilitate successful implementation. Numerous deficiencies affect the quality of care in the current healthcare environment, including a lack of automation, duplication of effort, dependence on manual documentation, minimal use of decision support capabilities, and a lack of timely access to data and information at the point-of-care (Cobb, 2004).

Although a large amount of knowledge and information is available, manual paper-based patient charts can hamper distribution and dissemination of important patient information. According to Cobb (2004), information technology (IT) could be the key to minimizing medical errors and maximizing patient-centered care. Hardmeier et al. (2014) reported a low rate (5%) of medical record fair compliance with the six safety processes on two pediatric units and one neonatal unit following BCMA implementation. However, BCMA implementation did not eliminate medical record errors, but it did reduce the rate of occurrence (Hardmeier et al., 2014).

Alahmadi (2010) and Greenfield et al. (2011) argued that BCMA is an important intervention to improve medication-safety outcomes. Verified orders become available in the nursing staff's point-of-care BCMA. The Virtual Due List is the electronic counterpart of a medication administration record (MAR) and is used to display medications and the appropriate

administration timeframe for each one. Medications scanned and administered, following medication orders verification by a registered nurse (Wideman et al., 2005). While the literature was optimistic in the predicted benefits of implementing the BCMA to reduce medication errors in healthcare settings, there have also been concerns about the possible risks and problems that might occur as a result of full dependence on technology to ensure patient safety (Cobb, 2004).

The information about medication errors (MEs) is quite limited in the Middle East. This may be attributed to the immature structure of reporting incidents; the fear among practitioners; or the culture that discourages disclosure and reporting. Zaghloul et al. (2018) reported forty-five studies from the Middle East that focused on four types of errors: prescribing errors, administration errors, dispensing and documentation errors. These error rates varied from 7.1% to 90.5% in prescription and from 9.4% to 80% in administration. They argued that these errors are still under-reported in the Middle East. A major issue with reporting these errors is the lack of classification of the medication errors in the Middle East (Zaghloul et al., 2018). This highlights the significance BCMA to curb MEs that can cause serious consequences for patients, especially those with acute complex medical conditions (Alsulami et al., 2013). Medication errors will always lead to patient distrust, increased costs, and increased mortality (Carroll, 2003). Moreover, the incidence of medication errors will decrease staff morale, which will, in turn, hurt the patient, possibly placing the patient's life in jeopardy (Dennison, 2007).

Currently, to ensure safe practices, healthcare professionals (nurses) follow the Five Rights of Medication Administration. These five rights are as follows: 1). right patient, 2). right medication ordered, 3). right time of administration, 4). right dosage, and 5). right route, while administrating the medication at the patient’s bedside (Elliott & Liu, 2010). The goal of adhering to these “rights” is to reduce medication errors through safe administration of any/all medications.

Despite its comprehensive nature, the manual implementation of the administration through human agents might have affected the quality of its implementation. Despite the long implementation of this process, medication errors still persist as a threat to global healthcare system integrity as highlighted earlier. It is anticipated that the automation of these elements through BCMA technology will rectify this situation because the system automatically and electronically follows the same comprehensive process with the handheld barcode reader that registers the patient and each medication, and the software verifies the correct medication was ordered and administered on time. The correct dosage is measured, while at the same time documenting the actual administration of the medication. This process confirms that the "five rights" of the universal standard of medication administration is maintained. Once the medication administration procedure has been completed, the nurses use the missed medication function to generate a report of omitted medications and take steps to resolve any reported discrepancies (Wideman et al., 2005). Based on previous evidence, it can be concluded that if we have a successful implementation process for BCMA within the UAE healthcare system, this should help to prevent and reduce medication errors by improving patient safety and quality of care through the efficiency of the system.

1.2 Problem Statement

Patient safety and quality of care are the pillars of the current healthcare industry. The efforts to maintain and mitigate these threats have long been started on the international arena and in the UAE as well. While treating for the illnesses of patients, healthcare institutions can also be a source of risk and threats to these very patients. Errors in medical care can cause a significant harm to patients either physically or emotionally. For example, the number of deaths, only in the US, due to preventable medical errors, is between 210,000 and 400,000 people each year (Gulf

News, 2013). Truter et al conducted a study in South African care setting and reported that about 51% of these errors are related to administration while 33% to medication (Truter et al., 2017).

In an attempt to build a "World-Class" healthcare system, the UAE follows a clear direction to match their level of service in healthcare to those in the most developed countries UAE vison for 2021 (Dhabi, 2008). Healthcare organizations have started identifying strategies to reduce risks and errors in the current healthcare environments. Medication error tops their agenda to prioritize the involved risks. These errors take place during transcription or administration of medication, because of physicians' poor prescription, nurses' poor pharmacological knowledge and heavy workload, poor guidelines for administration as well as miscommunications between healthcare professionals. The lack of knowledge among doctors and nurses contributes to the most in these errors in the Middle East (Alsulami, 2013). A new technology has been introduced to help prevent, control and reduce these errors, by incorporating barcodes in an electronic medication administration recording (MAR) system. Barcode Medication Administration (BCMA) is believed to reduce medication errors while administering drugs to patients. BCMA is a handheld barcode reader that registers each medication to be administered (Wideman et al., 2005).

This study identifies and prioritizes factors that influence the successful implementation of BCMA in the UAE healthcare system. An analytical hierarchical process (AHP) model is introduced to identify and prioritize the main and sub criteria in order to have this technology successfully implemented in the UAE hospitals.

1.3 Context of the Study

While the Department of Health (DOH) is the regulatory body responsible for the Emirate of Abu Dhabi, and the largest healthcare provider in the Emirate is the Abu Dhabi Health Services Company (SEHA) which covers 56% of all inpatient episodes and 36% of all hospital outpatient

episodes (HAAD, 2015). The main standard of DoH and the vision of SEHA are to provide the best quality and the safest care to patients and their families. The Emirate of Abu Dhabi intends to successfully compete in this market by developing "World-Class" healthcare facilities, building the best quality of care using advanced technology (Dhabi, 2008). BCMA is one strategy and technology provide a safe healthcare practices by preventing medication errors as one of the main causes of patient harm and one of the leading causes of death (Poon et al, 2010). This technology will reflect the aspiration of the United Arab Emirates (UAE) and Abu Dhabi visions for 2021 and economic vision of 2030, to be a leading country in providing a 'First Class Healthcare System' to its citizens and leading the growth in the Gulf Region and the world (Dhabi, 2008). The UAE wants to ensure that high-quality healthcare services are provided across all the Emirates by identifying the main factors affecting the implementation phase of BCMA and being the leading support to have this technology successfully introduced and sustained in Abu Dhabi's healthcare organizations.

The research is conducted in four medical specialty units in Abu Dhabi tertiary hospital, which is accredited by the Joint Commission International (JCI). Tertiary hospitals are typically major facilities handling complex and high-risk patient cases, and they offer a full complement of services, including pediatrics, obstetrics, general medicine, gynecology, and various branches of surgery and psychiatry (Flegel, 2015).

1.4 Purpose of the Study

The main purpose of this study is to identify and rank the important factors affecting the implementation stage of BCMA. This identification would lead to a more efficient implementation of BCMA and will help the plans for the future by highlighting the factors that might affect these projects. A further goal is to identify the differences in the perspectives of four stakeholders: the

customer, contractor, consultant, and government/regulatory authorities in this technology and the implementation process. Ultimately, this study will highlight the importance of technology in the improvement of the quality of patient care, in specific to the practice that is related to medication errors and preventing patient harms. Moreover, it will focus on the implementation phase of barcode medication administration (BCMA) in UAE tertiary hospitals and identify the main pillars to have a successful implementation, as highlighted earlier, since the main transitional phase has been identified as the most important phase.

1.5 Study Implications

The results of this study maybe generalized to other future technology-adoption projects. Thus, help healthcare authorities to understand the mechanisms necessary to improve the efficiency and effectiveness of similar organizational change processes. The outcome of this study could form a model that can inform future UAE healthcare authorities' efforts to achieve their strategic objectives to deliver high-quality healthcare. This study will provide a significant contribution to the BCMA implementation literature. The results of this study will strengthen prior studies and will provide valuable information about the importance of situational factors, such as focusing on personal characteristics to enhance adaptation behavior in healthcare organizations. Significant and accurate information about BCMA system will allow healthcare sectors to assess the level of connection between main implementation criteria and sub-criteria. Also, to measure the system contribution to an effective and efficient healthcare delivery.

1.6 Study Objectives

a. To explore the issue of effective BCMA implementation in health care organizations.
b. To identify the main factors leading to successful BCMA implementation within the UAE healthcare system.

c. To propose a hierarchical framework for BCMA implementation in health care organizations.
d. Rank these mitigating factors according to their effect on the successful implementation of BCMA.

1.7 Structure of the Dissertation

Chapter one has covered the study's introduction, context, purpose, problem statement, and study objectives, as well as providing an overview of the study and description of the aims that the study is expected to achieve. In addition, this study will review the literature, highlight the main advantages and disadvantages that have been identified and examined by researchers, and expose the gaps and other barriers not identified or addressed in the studies, to enhance and improve the use of technology in healthcare, and discover what are other factors that may lead to medication errors.

Chapter two is the literature review. It will highlight the importance of barcode medication system in healthcare and significance in reducing and preventing medication errors. It will discuss the influence of BCMA on patient care and safety. Through this chapter the main factors will be identified from previous studies and discover the major impact of those factors during the implementation of BCMA system. Furthermore, we will explore the different factors that might affect the implementation BCMA in correlation with different theories.

Chapter three focuses on two theories that were repeatedly mentioned throughout the literature review and highlighted in different studies. Those theories are: Diffusion Innovation Theory, and General System Theories. Through this study many variables have been identified that were related and connected to those theories.

Chapter four aims to build a model for implementing barcode medication administration systems in public sector medical units in the UAE. The research model, with AHP approach, is a hierarchical framework, starting with the main goal, main criteria, sub-criteria, rating scales, and alternatives. A hierarchal model was presented to assess the process of prioritizing between main criteria and sub-criteria, and to increase understanding about the most significant factors that impact BCMA during the implementation phase.

Chapter five explores different methodologies used to address Multi-Criteria Decision Making (MCDM) problems and provides justification for choosing the AHP methodology for this study using a comparative analysis of the proposed methodologies to deal with MCDM problems. Additionally, the chapter describes the processes used to develop the questionnaire, select the research sample, collect the data, the process of pairwise comparisons, and validation of consistency.

Chapter six presents result of the respondents' groups of 20 experts from different medical specialty units. Results were obtained from several statistical analyses conducted to prioritize the main criteria of (leadership, technology, process, education, quality and safety) and 22 sub-criteria's by using AHP model.

Chapter seven discusses the results of each of the twenty respondents, and then elaborates on the results in a comparative way. This chapter will explain and discuss more details for each main and sub criterion.

Chapter eight discusses the empirical implication, the research managerial implications of the study, it will highlight the study limitations in general and in relation to the sample size and participant behaviors will be justified.

1.8 Chapter Summary

This chapter provided the context of the study by presenting essential background information on Patient care quality and safety as essential and important factors in the current healthcare industry. The chapter presented the problem statement, purpose of the study, context of the study, implications for the study and detailed the specific objectives to be achieved. Finally, the remaining sections of the thesis were presented. The next chapter provides a critical review of literature in which the study will be situated. Figure 1 presents the design of research in this dissertation.

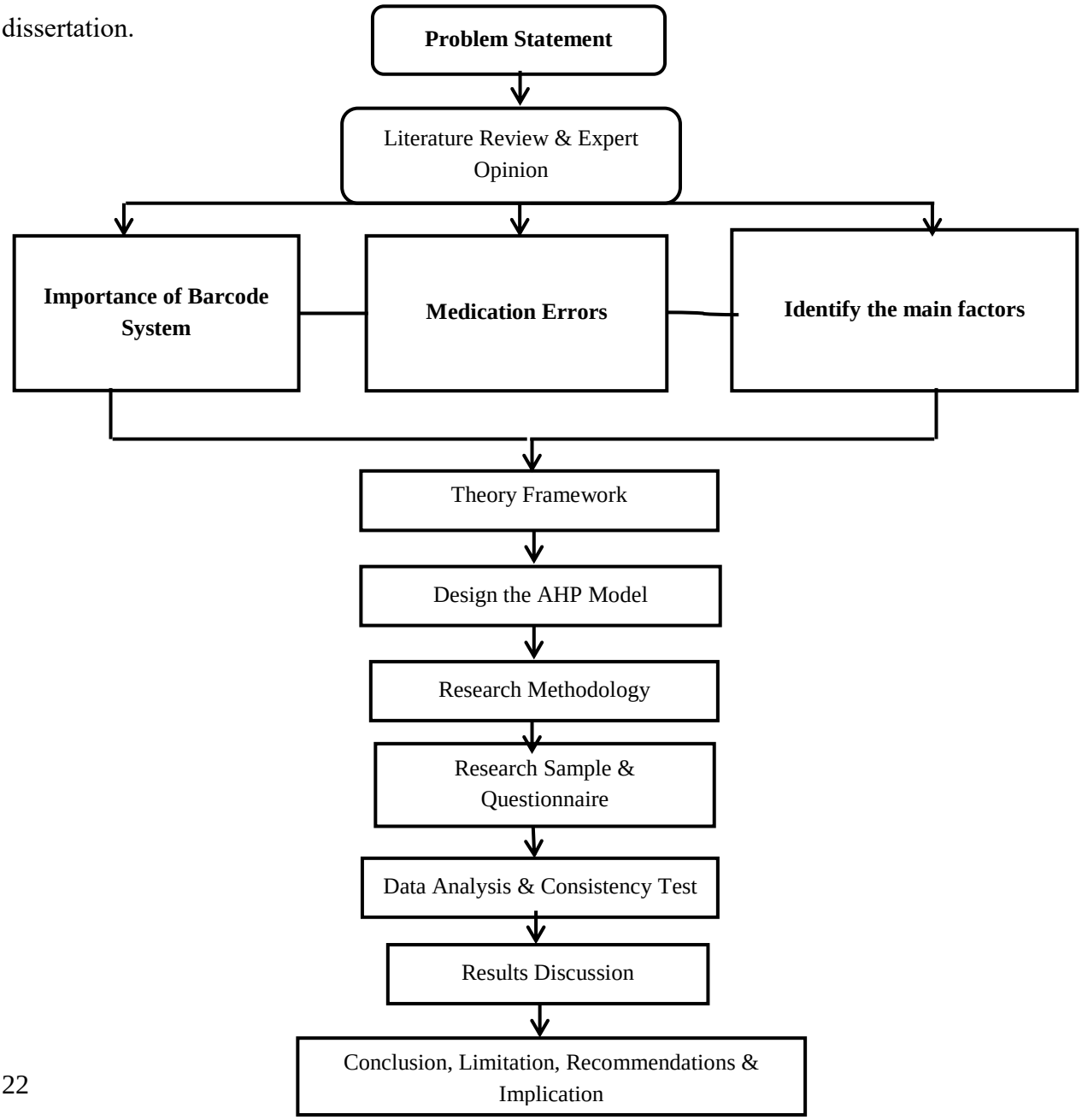

Figure 1*: Research Program*

Chapter II: Literature Review

2.1 Introduction

A critical factor at the core of healthcare service quality is patient safety, which is defined as "*the prevention of harm to patients caused from failures in the healthcare system itself*." Since the late nineties, preventable medical injuries have been recognized as a major cause of death and disability in many countries (Cure, 2011). In November 1999, the Institute of Medicine (IOM) reported that 44,000 to 98,000 deaths in U.S. hospitals each year are caused by medical errors, which makes medical errors the leading cause of death in the United States (Donaldson et al., 2000). Additional costs due to medication errors have been reported as approximately $8 million annually (Cobb, 2004). Therefore, it is important to promote a culture of healthcare safety focusing on patient safety (Leape et al., 2002). Traditionally, physicians have been placing medication orders manually by transcribing drugs through a medication-administration record, triggering nurses to carry out and finalize the administration of those medications (Leape et al., 1991). As part of its ongoing efforts to improve patient safety, the U.S. Food and Drug Administration (FDA) made it mandatory to use barcodes on the labels of thousands of human medications and biological products by the year 2006 (Food and Drug Administration, 2004).

In this context, the Joint Commission of International Accreditation (JCIA) has identified six main approaches to patient safety and has named them the International Patient Safety Goals (Almidani et al., 2014). Medication safety is one of these important healthcare goals (JCIA, 2013). The use of technology is known to considerably reduce medication errors because it reduces the human factor by setting preprogrammed standards (Chan et al., 2008). By 2020, healthcare administrators will need to have the ability to integrate technology with mobility and portability in relationships, interactions, and operational processes (Huston, 2008). This will create a culture

that recognizes quality healthcare and patient and staff safety as paramount (Edwards et al., 2008). Information technology (IT) has the potential to improve the quality, safety, and efficiency of healthcare, which might be the best tool to prevent medications administration errors. One of the major risks in the traditional paper-based medication system is human error (Hersh, 2002). Apparently, nurses have been responsible for direct patient care and management. Therefore, software development teams must collaborate with nurses during the design, development, and testing of an electronic medication system (Kirk et al., 2005). Nurses can also identity important weaknesses in the system, allowing for the development of tailored interventions (McBride-Henry & Foureur, 2007). It is quintessential in healthcare that patients receive the highest quality of care at an optimal level of operational efficiency and cost (DePhillips, 2007).

Healthcare units use various strategies to control and, possibly, eliminate errors. The use of technology is one such strategy, and it is now an integral part of every healthcare setting. A barcode medication administration system (BCMA) is one of the technologies used to eliminate medication errors. The literature identified several factors that affect the implementation of BCMA in healthcare organizations. The factors identified include leadership in the healthcare, type of technology, processes, proper education, and quality and safety. The Agency for Healthcare Research and Quality (AHRQ) defined the safety culture of an organization as the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management (Sammer et al., 2010). AHRQ also identified the need to develop the skills to integrate/interface various information system technologies throughout the organization (Aad et al., 2010).

2.2 Medication Errors

A medication error is "*any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer*" (Hughes & Blegen, 2008). In clinical settings, nurses function in fast-paced, complex, unpredictable settings with high-stake patient care situations. They administer hundreds of medications daily to multiple patients with multiple disease processes and via multiple routes (Flynn et al., 2012). Therefore, medication administration is a complex task that requires extensive knowledge and skills to perform correctly (Unver et al., 2012). While antibiotics and analgesia are the most frequently reported medication classes involved in errors, common medicine-associated errors include morphine, paracetamol, and gentamicin. These errors result in no harm (74.9% cases), mild harm (11.7% cases), moderate harm (10.5% cases), and severe harm (1.3% cases) (Rishoej et al., 2017). It should be noted that the five most common causes for medication errors are: (i) difficult-to-read or illegible handwriting, (ii) distractions, (iii) fatigue and exhaustion, (iv) similar names of drugs, and (v) miscalculation of dose (Mayo and Duncan, 2004).

There are a number of studies in the literature highlight the medication errors with different conclusions and recommendations. For example, Bates et al. (1998) found an increase in medication errors over the years (Bates et al., 1995). Elixhauser and Owens (2007) pointed out that 8% of these errors occur during the administration of medication (Elixhauser & Owens, 2007). Medication errors have become a major challenge for healthcare organizations all over the world. The World Health Organization (WHO) reported that the major areas where patient misidentifications occur include drug administration, phlebotomy, blood transfusions, and surgical interventions (WHO, 2009). The number of deaths, only in the US, due to preventable medical

errors, is between 210,000 and 400,000 people each year (Gulf News, 2013). Truter et al conducted a study in South African care setting and reported that about 51% of these errors are related to administration while 33% to medication (Truter et al., 2017). Medication errors are also a leading cause of medical injuries in hospitalized patients and a primary area of focus for quality-improvement initiatives within healthcare institutions. These errors may lead to patient morbidity and mortality. Thus, an effective program to reduce medication errors requires an implementation plan to complete actionable steps (Jordan et al., 2017). This new system-level approach is required to improve patient medication safety to avoid the risk of adverse events resulting from medications.

2.3 Barcode Medication Administration Record

Barcode medication administration (BCMA) is usually performed in conjunction with an electronic medication-administration record (eMAR) (Stone et al., 2007). This system offers several levels of functionality by helping to enforce the patient rights of medication administration, which is mainly a nurse's job. A real-time closed-loop medication administration system contributes to improving patient safety by preventing potential errors (Hwang et al., 2016; Kimmel and Sensmeier, 2002). However, competition among the wide range of available eMAR software and systems can help drive positive improvement in hospital performance through low implementation costs (Henneman et al., 2010), though the implementation phase can be complex (Boonstra et al., 2014).

Hughes & Blegen (2008) identified four causes associated with medication errors: (i) medications look alike (similar names or packaging), (ii) uncommonly used medications, (iii) commonly used medications to which many patients are allergic, and (iv) medications that require testing to know the proper treatment level (Hughes & Blegen, 2008).

Though the literature has little evidence on the effectiveness of BCMA, the technology has been reported to have decreased errors in other industries (Bates, 2000). The results and conclusions have limited value due to their anecdotal nature, but they do illustrate how barcode innovations for medication administration have been matched, refined, and restructured by some healthcare systems as a promising approach to reducing errors (Risør, Lisby, & Sørensen, 2017). Puckett (1995) demonstrated that, in case of errors, the system would generate an alert to nurses who commit errors in different ranges – wrong drug (by 33%), wrong time (43%), and omitted doses (52%). In another study, the researchers reported that errors in a university medical center were reduced from 13,340 to 1,822 per year. The wrong dosage errors decreased by 100%, followed by decreases in omitted dose (92%), wrong time (77%), and wrong drug (51%) (Thielke, 2003). As part of its ongoing efforts to improve patient safety, the U.S. Food and Drug Administration (FDA) made it mandatory to use barcodes on the labels of thousands of human medications and biological products by the year 2006 (Food and Drug Administration, 2004).

2.4 Factors Affecting the Implantation of BCMA

Though BCMA increases real-time medication administration documentation, it comes along with a decrease in errors with enhanced records for medication retrieval (Kelly et al., 2016). BCMA is a promising intervention that can be used in future nursing practices (Berdot et al., 2016). The major factors that currently affect the implantation process of BCMA were addressed and highlighted through the literature review. Those factors are components that the healthcare sector should focus on during the implementation process.

2.4.1 Leadership

The literature demonstrated that leadership is one of the crucial factors affecting the successful implementation of BCMA and that there are underlying factors that make leadership important.

Decision-makers must weigh the need to improve medication management systems against numerous competing demands. Leadership is an important characteristic of highly reliable organizations. Leaders are required to have the ability to critically appraise team processes and outcomes on the path toward achieving a shared goal (Fowler et al., 2009). Vanderboom and his colleagues concluded that leaders participate in health policy development, although participation is limited and not consistent across all stages of health policy development, and it is recommended that the health policy development process should be pluralistic and inclusive of all leaders practicing in positions related to policy development, and the process must be open to their ideas and suggestions. Investment in the resources necessary to support system evaluation, a balance between safety and production costs, and engagement with front-line staff is also needed (Vanderboom et al., 2016).

Top management and leadership support are important for any change, whether new projects or initiatives (Prasad et al., 2015, Fowler et al., 2009). The stability of an organization and its ability to manage change will ultimately determine the success of implementation. Recognition of organizational characteristics and past experiences with implementing new technology should be considered in the planning stages (Strauss et al., 2009). The diffusion of innovation theory highlighted the importance of leadership opinion; it has the most influence during the evaluation stage of the innovation-decision process and on late adopters. The systems most likely to respond easily and quickly to innovation are ones that have a culture of creativity and innovation, a

relatively flat hierarchical system, and strong leadership that is committed to affecting change (Goleman et al., 2002). These organizational cultures are characterized by respected and trusted leadership, although this sometimes develops during collaborative efforts, but this is an important factor that should be considered by leaders (Stone & Keenan, 2011).

Healthcare organizations need strong leadership, planning, and multidisciplinary collaboration to improve medication safety. They need systems for identifying, reporting, analyzing, and reducing the risk of medication errors (Prasad et al., 2015). A non-punitive culture of safety must be cultivated to encourage frank disclosure of errors and near misses, stimulate productive discussions, and identify effective system-based solutions. Strategically placed quality-control checks are also necessary (Fowler et al., 2009). Quality-improvement tools, including SBAR (Situation, Background, Assessment, Recommendation), process mapping, PDSA (Plan, Do, Study, Act) cycles, and quality metrics are used with this process improvement (Looper et al., 2016).

Simple redundancies that support a system of independent double checks for high-risk, error-prone processes promote the detection and correction of errors before they reach and harm patients (Prasad et al., 2015). Transformational leadership for medication safety education is characterized by a focus on the role of nurse educators and mentors in the development of students' abilities, the creation of a supportive culture, and enhancement of students' creativity, motivation, and ethical behavior. This prepares nursing graduates with the competencies necessary to be diligent about medication safety and the prevention of errors (Hawkins et al., 2017). Healthcare leaders must appreciate the complexity surrounding the electronic medical record system and understand the safety issues to mandate sound design, development, implementation, and use. They reported that all new systems under study including the BCMA generate unintended adverse

consequences to patient safety, that may relate to design or implementation problems (Karsh et al., 2006). Staffing pattern deficiencies, excessive workloads, and complex work processes are also factors underlying a broad range of errors (Fowler et al., 2009).

Change management is one sub-criterion that flows under leadership to consider prior to any implementation of new technological system. Lewin's change management theory could help promote acceptance by front-line nurses by involving them in all aspects of planning and implementation (Sutherland, 2013). Nurses are often forced to change practice without having the opportunity to provide input, which erodes their trust of the organization over time. By using Lewin's theory, we can help to reduce stakeholder resistance and fear of change through the development of a carefully crafted plan and allowing active participation in the change process. Moreover, in 2009, Garrett and colleagues concluded that addressing restraining forces can ease adoption and help ensure a smooth implementation of the BCMA system, which can result in reduced medication errors. Environmental factors, such as poor lighting, cluttered work spaces, noise, interruptions, high patient acuity, and nonstop activity, contribute to medication errors because healthcare providers cannot remain focused on appropriate medication use (Garrett et al., 2009).

Moreover, organization management needs to create policies and procedures that minimize the impact of change. Looking closely at human resources and communication strategies can affect employees' attitudes toward the changes that are implemented (Weber, P. S., & Weber, J. E., 2001). Denton identified four approaches to leading change. These approaches include having a clear goal and the creation of trust and buy-in from those involved. These rules add to the importance of having valid measures of performance and of testing reality (Denton, 1996). Duncan and Breslin stated that innovation in healthcare is rather difficult for various reasons: 1). A lack of vertical

integration is one of the most important ones. 2). Collaboration between care providers is another difficulty that could lead to less innovation in healthcare (Duncan & Breslin, 2009). The change involving IT projects has many barriers and encounters resistance in various ways (Bartoli & Hermel, 2004).

Essentially, medication barcoding modules at the bedside and within critical pharmacy operations have a relatively small impact on overall health informatics system cost, yet their absence may have a significant impact on the overall organizational cost, performance metrics, and the facility's public and governance reputation. It is particularly important that the chief finance officer (CFO) and chief information officer (CIO) work closely with nursing and pharmacy practice leadership to understand the safety effectiveness and secondary financial benefits of medication barcoding systems, so effective strategic plans can be created and implemented (Vaida et al., 2014).

In a 2010 study, Poon and his colleagues highlighted that the use of the barcode eMAR system substantially reduced the rate of errors in order transcription and medication administration and potential adverse drug events, although it did not eliminate such errors, which will lead to a reduction in patient care costs (Poon et al., 2010). Cost is an important factor, so leadership should measure it during the implementation of BCMA. During BCMA implementation, costs will include hardware, software, and implementation costs. This will include costs for workflow process redesign, initial training of IT personnel, and conversion of historical paper chart information into electronic data usable by the BCMA, training (introduction of a new system will require both initial and ongoing training of end-users), and temporary reduction in staff productivity (Larrabee and Brown, 2003). Another study by Thomas, using general system theory, found that BCMA technology can reduce providers' paperwork burden, thus creating additional

time during the patient encounter to deliver care (Thomas, 2013). Moreover, evidence suggests that BCMA use can improve medical staff relations by increasing physicians' workflow efficiency and satisfying the information needs of practicing clinicians (Chan et al., 2010). Another reasonable indication of the positive impact of barcode verification systems are secondary system benefits, such as qualitative medication-process improvement and documentation (Vaida et al., 2014).

In summary, this section highlights that delayed executive action on known issues of preventable patient harm may result in future poor organizational safety and quality performance metrics**.** A lack of support for staff needs coupled with evidence of nonconforming medication system practices are indicators of organizational or implementation failure.

2.4.2 Technology

Healthcare technology and information systems support the functions in an organization by integrating information, facilitating communication, documenting healthcare interventions, and maintaining records (Szydlowski and Smith; 2009). Implementation of BCMA technology improves patient safety by decreasing the overall rate of adverse drug events (ADEs) and the rate of transcription errors. These technologies also reduce the harmful impact to patients caused by administration errors, which are parts of the nursing role (Truitt et al., 2016). Most of the literature related to the barcoding systems linked to medication administration practices refers to different studies carried out in Western countries, but not in the developing world (Alsulami et al., 2013). This technology in the healthcare sector is only in the initial stages of implementation in the UAE.

Ideally, a hospital would integrate multiple technologies (Hunter, 2011) for all clinical systems to achieve the maximum safety benefits for patients and efficiency for the organization (Radley et al., 2013). This might include order entry, pharmacy systems, a laboratory system, and

technology-supported medication-administration processes (Ash et al., 2012). These systems are usually embedded incrementally by organizations (Poon et al., 2010). Medical science and technology have developed at an extraordinary pace during the past half-century (IOM, 2001). The Agency for Healthcare Research and Quality (AHRQ) has identified that a healthcare organization needs to develop successful experience with integrating/interfacing various information system technologies throughout the organization (Davis et al., 2010).

Health information technology (IT) has the potential to improve the health of individuals and the performance of providers, yielding improved quality, cost savings, and greater engagement by patients in their own healthcare (Buntin & et al., 2011). Since we know that one of the important functions of nursing is to give direct care to the patient and administer medications, nurses are the most likely clinician and expert that would be responsible for working with BCMA. Saravani and Sheikhtaheri assessed the readiness of nurses for the application of BCMA systems by examining nurses' competency, training, and attitudes about BCMA in teaching hospitals. They concluded that a lack of training and the absence of training plans related to barcodes and BCMA could obstruct implementation of the system (Saravani & Sheikhtaheri, 2017) Benefits accrue more often to large organizations that were early adopters of health information technology, and these benefits are more widely attainable than previously thought (Bates & Bitton, 2010). Technology also affects care delivery and patient satisfaction (Middleton et al., 2013). The use of technology in the healthcare setting has risen dramatically during the last decade in areas such as electronic billing, electronic medical record (EMR) usage, computerized physician order entry (CPOE), and barcode medication administration (BCMA) technology, which have been implemented in varying degrees at many major hospital institutions around the world. Many of these innovative

technologies were created for the sole purpose of promoting safety in the healthcare environment by removing the potential for human error (McGrath et al., 2010).

Holden et al. (2012) surveyed twenty-nine pharmacists and ten technicians at a pediatric hospital (USA) after the implementation of a BCMA system, using qualitative, observational, and free-response survey data based on an integrated planned behavioral theory. The results of the BCMA system's perceived ease of use were rated low to moderate by the pharmacists and technicians, and the system was not useful for improving either personal job performance or patient care. Perceptions explained 72% of the variance in intention to use BCMA and 79% of variance in satisfaction with BCMA. These results indicated poor resource allocation (Holden et al., 2012). Legrisa et al. (2003) found that the technology acceptance model (TAM) is a useful theoretical model in helping to understand and explain behavior in information system implementation. It has been tested in many empirical research studies and has proven to yield statistically reliable results. Venkatesh (2000) argued that an individual's general beliefs regarding computers were the strongest determinant of system-specific perceived ease of use, even after significant direct experience with the target system.

Health information technology (IT) benefits both patients and providers with respect to healthcare quality and perceived usefulness. Although existing research provides a preliminary understanding of nurses' perception of health IT, perceptions do not guide actions. Effective health IT must be congruent with nursing expectations (Zadvinskis et al., 2014).

Ease of use is one of the factors that were identified through a research study in 2003 by Mustonen and his colleague. They used the diffusion of innovation theory to examine the information system (IS) process innovation adoption, using a longitudinal data set of IS process innovation adoptions. The study showed several important factors recognized in the diffusion of

innovation theory. Namely, the factors were the adoption of an information system, technological infrastructure, past technological experience, own trials, autonomous work, ease of use, learning by doing, and standards (Mustonen et al., 2003). Ease of use is an important component of the technology acceptance model (Davis, 1986). Information technology (IT) systems are key components of a multifaceted management strategy to prevent medication errors and improve patient safety (Agrawal & Glasser, 2009). Leaders and managers must effectively respond to the requirements of all standards and legislation. Any system must also comply with these requirements. The developed system must also build employee competence and meet the expectations of the employer to achieve safety, efficiency, and productivity (Varghese, 2014).

2.4.3 Process

To achieve successful implementation of a new technology, there should be a process in place that ultimately needs to employ safe practices, specifically when the technology deals with human health and well-being. A process is a set of actions or steps, each of which must be accomplished properly in the proper sequence and at the proper time to create value for a customer or patient (Hook et al., 2008). During the implementation of BCMA, the failure mode affected the process of BCMA, so it was recommended to do a post-implementation audit to address such issues and ensure that the BCMA objective of improving medication safety is achieved (Foo et al., 2017). Primary processes serve the external customers in healthcare: the patients and their families. Primary processes are easier to see, but internal processes are also necessary to create value in the primary process (Alharthi et al., 2015).

Nurses prepare and administer medications for one patient at a time. Many errors are preventable simply by minimizing floor stocks, restricting access to high-alert drugs and hazardous chemicals, and by distributing unit-dose packages of drugs from the pharmacy in a timely fashion

(Radley et al., 2013). To facilitate the proper identification of drugs, healthcare organizations should provide all medications in clearly labeled unit-dose packages and should take steps to prevent errors with drugs that look the same or have similar names or that have ambiguous drug packaging or confusing or absent drug labels. The ISMP Medication Safety Alert and/or other current literature is reviewed regularly to identify drug labeling, packaging, and nomenclature problems, and alerts are built into the pharmacy computer software to remind practitioners. Point-of-care technology can be interfaced with the barcode system to provide nurses with relevant alerts (Prasad et al., 2015).

Medication-use process is long and complicated. The last stage of this process is medication administration. This step carries a high risk of errors; one study showed that 44% of medication errors in intensive care units (ICUs) happened during administration (Cullen et al., 1997). Moreover, out of the forty-five studies in Middle Eastern countries, 9.4% to 80% of medication errors happened during the administration of medication by nurses in the medical adults' units (Alsulami et al., 2013).

Carayon (2007) reported the significant need to assess changes in workflow and tasks that result from the use of the technology. This study shows the use of direct observation in helping to identify the work-system factors that facilitate or hinder medication administration tasks. This information can help healthcare organizations identify opportunities to redesign the process and/or the technology to maximize worker efficiency, interaction with the technology, and patient safety. Another study examined the information system (IS) process of innovation adoption by using the diffusion of innovation theory longitudinal data set of IS process (Mustonen et al., 2003).

Based on the general system theory concepts, Zhu analyzed the complexity of processes in implementing IT systems. The computerized healthcare system provides a pragmatic structure for

approaching complex, interacting, multilevel, and transient states of constructs in the real world by embracing, consolidating, and unifying key constructs from published implementation theories (Zhu et al., 2006). Angst and Agarwal (2009) applied the planned behavioral theory within the emerging context of the digitization of healthcare and found that the process of electronic health records (EHRs) implementation constitutes a significant technological advance in the way medical information is stored, communicated, and processed by the multiple parties involved in healthcare delivery. Using the general system theory as a theoretical model, Saleem et al., (2009) highlighted that integrating the methods, tools, and lessons learned from BCMA implementation shows that human factors affect the design of the system. Designing the right workflows is vital for this project's success to improve clinical information systems and healthcare delivery. Rack et al (2012), who studied the barriers of BCMA implementation, used the same theoretical model. They found that most of the BCMA failures came from staffs' workarounds. Some of these workarounds originated because the health system did not provide the proper resources (Rack et al., 2012).

McNutly et al. (2009) identified the successful key factors in the post implementation of BCMA as demonstrating executive dedication, creating a culture of ownership by engaging frontline nurses in the solution design, and providing a strong support system. However, Alper et al. (2012) reported different factors, which are related to skipping steps during the implementation of BCMA; it was the main reason for noncompliance with this technology. The use of barcode verification during medication administration in five medical departments for three weeks proved that the frequency of barcode verification was one of the compliance issues affecting system implementation (Van et al., 2008).

Gooder (2011) studied BCMA implementation by applying Rogers' diffusion of innovation theory. The participants (BCMA n = 33; control n = 26) were given the questionnaire one month

prior and five months following the implementation of a pilot unit. Participants in the experimental group indicated difficulty determining which medications had been given ($p < 0.000$). There was a decrease in the overall satisfaction with the medication process following implementation of the BCMA system ($p = 0.001$). This study demonstrates that implementation of BCMA systems may have a negative impact on nurses' attitudes toward the medication administration process and may make work processes more difficult (Gooder, 2011). Another study by Holden, employing the planned behavior theory, found a consistent theme related to the perceived emotional and instrumental outcomes of EMR use; perceived external and personal normative pressure to use those systems; perceived volitional control over use behavior; perceived facilitators and barriers to system use; and perceptions about the systems and how they were implemented. EMR is commonly believed to both improve and worsen the ease and quality of personal performance, productivity, and efficiency and patient outcomes (Holden, 2010).

Although BCMA systems are intended to advance medication safety, integrating BCMAs within real-world clinical workflows requires critical attention to ensure that technology safety features are used as intended and that systems are designed to support this use. As with any technology in complex organizations, workarounds will occur (Koppel et al., 2008). These workarounds can result from many causes, e.g., administering medications without scanning, omission of process steps, and more (Mariani et al., 2010). Omission of process steps and its effect on the BCMA implementation related to workarounds can appear in many different behaviors (Novak et al., 2013). To avoid scanning the patient's actual identification wristband, users were found to affix extra copies of patient ID barcodes on desks, scanner carts, doorjambs, supply closets, or clipboards or to wear extra copies themselves on their belt loops or arms (Novak et al., 2013). In two different studies, they applied the theory of planned behavior to show that when staff

performed steps of the process out of order, the results highlighted that workarounds, such as documenting medications as administered before administering the medication or observing patient ingestion or administering medications and documenting it much later, shows a problem in compliance (Morriss et al., 2009 and Hassink et al., 2012). This workaround describes the changes that impact and affect the overall process steps and results in mistakes related to adding or removing new steps (Hassink et al., 2012). Another study referred to the main causes of noncompliance with the BCMA system as task-related, organizational, environmental, and patient-related causes (Bargren & Lu, 2009).

The Donabedian model is a conceptual model that provides a framework for examining health services and evaluating the quality of healthcare (Donabedian et al., 1982). According to the model, information about the quality of care can be drawn from three categories: "structure," "process," and "outcomes." (Donabedian, 1988). In a study examining the implementation of technology, the researchers found that staff handling barcode medication administration must collaborate closely with information management staff as rapid computer response time is crucial to the success of a computerized medication administration system (Nouhi et al., 2012).

2.4.4 Education

With accelerating advances in health information and technology, physicians, nurses, and other health professionals must maintain and improve their knowledge and skills during their careers to provide safe, effective, and high-quality healthcare for their patients (Agrawal and Glasser, 2009). The knowledge and skills related to medication administration are a fundamental element of nursing education. With the increased use of electronic medication-administration technology in practice settings where nurses work, nursing educators need to consider how best to implement these forms of technology into clinical simulation (Booth et al., 2017). Doyle used the

diffusion of innovation theory and the findings to show that implications for education include careful review and revision of training material. This is to avoid conflicting statements about the capability of BCMA and to emphasize critical thinking about the five "rights" of medication administration. (Doyle, 2005). In addition, procedures for BCMA that cannot be accommodated due to unit environment or workflow can be met through continued education programs, clinical workshops, and international conferences as adequate arrangements for increased awareness and knowledge about telemedicine technology and its applications. Using the planned behavioral theory concepts, they found that having experience in highly demanding educational and specialized training will help minimize medication errors that stem from medication administration (Chau and Hu, 2002).

Healthcare providers frequently talk to patients about their diseases instead of educating them in the daily management of their conditions. To address this need, therapeutic patient education is designed to train patients in coping, processes, skills, and self-management or adaptations in treatment to address characteristics of their particular chronic disease. Therapeutic education should also contribute to reducing the cost of long-term care to patients and to society (Hook et al., 2008). Efficiency was evaluated for a barcode-enabled and integrated medication-tracking system that was successfully implemented into the medication-distribution process (Louden et al., 2017). This was complemented by McNulty et al., (2009), who explored methodologies for sustaining compliance with BCMA and identified staff education as one of the factors that may help effective implementation and sustainability. Probst et al., (2016) reported that there are different methods used to illustrate and educate health professionals of the potential pathways to obtain standardized patient identification across healthcare systems that incorporate human factors principles. Paterson et al., (2002) reviewed lessons learned in the post-

implementation evaluation of a barcode medication administration technology implemented at a major tertiary-care hospital, and they reported that healthcare professionals' education leads to systematic sustainability of the gains achieved by implementing BCMA.

We should not forget the important role of our patients during the implementation process; they can play a vital role in preventing medication errors when they have been educated about their medications and encouraged to ask questions and seek understandable answers. Patients and their families are the final link in the process. Healthcare providers should seek their input in related quality improvement and safety initiatives and should teach patients (and families) how to protect themselves from medication errors (Ricketson et al., 2014). Although education in itself is a weak error-reduction strategy, it can play an important role when combined with system-based error-reduction strategies (Agrawal & Glasser, 2009). Activities with the highest leverage include an ongoing assessment of healthcare providers' baseline competencies and education about new and non-formulary medications, new technologies related to medication use, high-alert drugs, and medication-error prevention strategies are important (Fowler et al., 2009).

2.4.5 Quality and Safety

Many people view quality healthcare as the principal umbrella under which patient safety resides. For example, the Institute of Medicine (IOM) considers patient safety as "*indistinguishable*" from the delivery of quality healthcare. Work groups, such as those in the IOM, have attempted to define the quality of healthcare in terms of standards. Initially, the IOM defined quality as the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge (IOM, 2001). To guide appropriate drug therapy, healthcare providers require readily available demographic information (e.g., patient identity and location), clinical information (e.g., age,

weight, allergies, diagnoses, and pregnancy status), and patient monitoring information (e.g., laboratory values, vital signs, medication effect) (Hook et al., 2008). Sherwood and Nickel found that most medication related events (MRE) would not be captured by traditional event-reporting systems. Facilitated MRE reporting provides a robust information source about potential breakdowns in medication-management safety and opportunities for system improvement (Sherwood and Nickel, 2017). To minimize the risk of error, the drug formularies must be tightly controlled, and up-to-date drug information must be readily accessible to healthcare providers through references, protocols, order sets, computerized drug information systems, medication administration records, and regular clinical activities by pharmacists in patient care areas (Ricketson et al., 2014).

Menachemi, et al., (2007) explored the relationship between overall IT adoption and patient safety performance in hospitals across Florida. Primary data on hospital IT adoption was combined with secondary hospital discharge data. Regression analyses were used to examine the relationship between measures of IT adoption and the patient safety indicators (PSIs) of the Agency for Healthcare Research and Quality. They found that eight PSIs were related to at least one measure of IT adoption. Compared with administrative IT adoption, clinical IT adoption was related to more patient safety outcome measures. Preventing medical errors and improving patient safety are among the most important potential advantages of adopting information technology (IT) in healthcare.

Higgins et al., (2010) conducted a retrospective analysis of data from an existing safety reporting system with anonymous and non-punitive self-reporting at Baystate Medical Center, a 655-bed general acute-care tertiary teaching hospital. Their main objective was to document the reduction in medication errors after the introduction of barcode scanning and positive patient

identification (PPID). The results showed that the number of reports increased from 20 to 38 per million doses dispensed immediately post intervention. However, errors reaching patients decreased from 3.26 to 0.8 per million despite the increase in near misses. During the study, they faced some technical issues during the implementation stage of PPID, such as scanning failures, which occur if barcode labels are covered or smudged, and others related to an update of the product identifiers that had not been done through the system, and a further issue was related to the printer. In addition, Higgins and his colleagues found that the PPID initiative increased the number of mobile stations, especially in intensive care units and with infected patients. The limitation in this study was related to self-reporting for safety issues; employees considered it positively and used the reports only as opportunities for process improvement and never for employee discipline. However, Higgins and his team did not find clear evidence that reporting rates changed from pre- to post-PPID implementation. They concluded that PPID barcode scanning for dispensing and administering reduced the number of medication errors reaching the patient by 75% immediately after implementation. Provider training and manufacturing changes were necessary to reduce the rate of technical malfunctions (Higgins et al., 2010).

Poon et al. (2010) conducted a quasi-experimental study in an academic medical center that was implementing the barcode eMAR (electronic medication-administration record). They highlighted that the barcode eMAR is an important intervention to improve medication safety. They noticed that medication errors dropped substantially, but not all errors were eliminated for two reasons: 1). Patient – safety technology is effective only if it is used as intended. 2). the study hospital used an early version of the software (Poon et al., 2010). One article from *Patient Safety Journal* published a systematic review by Young et al. (2010) to determine whether implementation of the barcode medication administration system (BCMA) was associated with

reductions in the medication administration error (MAE) rate. They evaluated the effectiveness of barcode technology on the five rights of administering mediation in two phases, before and after adoption, and assessed the change in error rates. Young and his colleagues went through the literature and databases from 1999 to 2009, and they only found six articles that met the criteria; three studies out of six showed a decrease in overall medication error rates after implementation of BCMA technology. They found few studies reported errors related to the wrong patient, wrong drug or route, but the most common errors related to the wrong dose and the wrong time. They recommended that the institution should focus on and consider the human and system factors and to continue to monitor and collect data on the medication-administration process using technology such as barcoding (Young et al., 2010).

Staff performance is one component that affects patient quality of care and safety. Alahmadi identified teamwork, a spirit of collegiality, collaboration, and cooperation among healthcare professionals as key to patient safety (Alahmadi, 2010). Communication was identified as a patient safety factor in a large number of studies (Cima et al., 2011; Groves, Meisenbach & Cawiezell, 2011; Russ et al., 2013), where an individual staff member, no matter what his or her job description, has the right and the responsibility to speak up on behalf of a patient. Learning leads to expanded knowledge and utilizes mistakes to improve future practices through patient centeredness, as identified in a literature review conducted in Just Culture (Sammer et al., 2010).

In a systematic review, Morello et al. (2013) concluded that structural factors contributing to unsafe care is a major contributor to the breakdown of complex systems, which some have called "organizational accidents." These breakdowns arise from a combination of factors originating at different levels of the system and can involve latent failures or poor oversight. The same finding was found by Barry and Edgman-Levitan (2012) when they studied shared decision making in a

patient-centered environment. Their study added other key structural issues that may affect safety to include the organization's patient-safety culture to previous findings. This refers to shared attitudes, values, and norms related to safety. The evidence suggests that medical devices can also cause substantial harm (Paxton, Inacio & Kiley, 2012). Improving patient safety through information technology is one of the first principles of healthcare strategy to reduce patient harm" (Cobb, 2004). The implementation of barcode medication administration (BCMA) is an example of using technology that is designed to reduce adverse drug events. This aim can be achieved through the development of models that explicitly consider risk sources, are kept up to date, and are developed in collaboration with managers, providers, patients, and researchers (Cure, 2011).

From a staff perspective, these changes may involve new work locations, organizational structures, teams, roles, work practices, or procedures. They often involve the merging of services, teams, and professional groups. Mergers, by their very nature, imply the coming together of different cultures, i.e., different ways of doing things and different values and underlying assumptions. Culture is not receptive to change in the way structures and processes are. To sustain change over the long term, the cultural and the people aspects of change must be addressed. This includes addressing deeply embedded traditions and practices through an inclusive partnership process (Arbaugh, 2002).

Chapter III: Theoretical Framework

3.1 Introduction

Literature reviews are used to determine how other researchers have defined identified key concepts in different, related studies, and inform the theoretical framework. A theoretical framework provides scientific justification for the research criteria and is important to clarify any notable links between key concepts.

A review of literature associated with the implementation of a new technology in healthcare, such as a barcode medication administration system (BCMA) revealed number of theories related to the topic. Some of these theories emphasized leadership support during the implementation stage as a key element of successful implementation. Other theories focused on the importance of the process used to introduce a new technology as essential for the success of the implemented technology.

Two theories that were most relevant to the present study are diffusion innovation theory (DIT) and general systems theory (GST). These theories are discussed in this chapter and will help in understanding the connections among factors that affect implementation of the BCMA process in medical units. These theories will also aid in understanding the role of leadership, technology, process, education, and quality and safety during the implementation of the new BCMA system.

3.2 DIT

DIT aims to explain how, why, and at what rate new ideas and technology spread. Rogers (2002) defined diffusion as "*the process by which an innovation is communicated through certain channels over a period among the members of a social system."* That author further described innovation as "*the idea, practice, or object that is perceived to be new by an individual or other unit of adoption*" (Rogers, 2002). Diffusion research focuses on conditions that increase or

decrease the likelihood that a new idea, product, or practice will be successfully adopted by those to whom it is introduced. DIT predicts that both media and interpersonal contacts provide information, and influence opinion and judgment. Rogers (2002) argued that innovation comprises four stages: invention, diffusion (or communication) through the social system, time, and consequences. Rogers further defined five "adopter" categories or groupings of individuals in a social system that can be further classified based on their level of innovativeness: innovators, early adopters, early majority, late majority, and laggards (Rogers, 2002). These categories highlight the importance of leadership support and opinion and how much this adds value through the implementation phase, leading to the innovation being successfully adopted. Opinion leaders exert influence on audience behavior via their personal contacts, thereby increasing the proportion of those who join the early adopters and early majority categories. The second important element of DIT is process. Given that BCMA is a healthcare innovation, DIT suggests that the implementation process is one of the main factors that should be considered. Another important element of DIT is knowledge when applying an innovation; knowledge about the new innovation should be shared and spread to staff via education that is comprehensive and conducted by different means. Education is therefore considered an element that may impact the BCMA implementation process and will be explored in this study. Details of DIT are set out in Appendix I. In summary, the five elements of DIT are:

1) The characteristics of an innovation that may influence its adoption;
2) The decision-making process that occurs when individuals consider adopting a new idea, product, or practice;
3) Characteristics of individuals that make them likely to adopt an innovation;
4) Consequences for individuals/society of adopting an innovation; and,

5) Communication channels used in the adoption process.

The propositions and assumptions of DIT highlight factors that may affect successful implementation of new innovations and the essential elements of the innovation implementation process. This means DIT is well-situated to provide a theoretical framework to inform the study methodology and interpretation of the results.

3.3 GST

GST can be attributed to Bertalanffy (1969), whose work informed later theorists. GST conceives a system as comprising cohesive, interrelated, and interdependent parts that are surrounded and influenced by the wider ecological system or environment. A system is characterized by a certain structure, purpose, and way of functioning. An important construct of GST is that changing one part of a system usually affects other parts, as well as the system as a whole. The main goal of this theory understands a system's dynamics, constraints, conditions, and other factors that affect that system (Wikipedia, no date; Bertalanffy, 1969). This is particularly important if change is planned, so that the change can be introduced and integrated in the system in a way that is compatible with the system components, goals, and patterns of functioning. Boulding (1956) defined this systematic interdisciplinary approach as:

> A phenomenon for almost universal significance for all disciplines is that of the interaction of an "individual" of some kind with its environment. Each discipline studies some kind of "individual"—electron, atom, molecule, crystal, virus, cell, man, family, corporation, and so on. Each of these individuals exhibits "behavior," action or change, and this behavior is related in some way to the environment of the individual—that is, with other individuals with which it comes into contact or into some relationship. (Boulding, 1956).

GST suggests that resources are taken from the external environment, transformed within the organizational system, and then output to the external environment. This process is affected by external elements, which affect all components of the system. The system uses continuous sources of information to gain feedback from the external environment, which is then used to make necessary changes to adapt and thrive. GST is outlined in more detail in Appendix II (A).

Systems technology refers to problems arising in modern technology and society, including "hardware" (e.g., control technology, automation, computerization) and "software" (e.g., application of system concepts and theory in social, ecological, and economical problems). In the 1960s, systems theory was adopted by the post-John Von Neumann computing and information technology field, and formed the basis of structured analysis and structured design (Morgeson et al., 2015). It also provided the basis for early software engineering and computer-aided software engineering principles (Alter, 2013).

When applied to organizations, the organizational system is made up of micro systems that run the operations; these micro systems interact with each other to form a complete picture (Whitney et al., 2015). Variables identified based on GST that play a role in organizational operations are: 1) external environment; 2) leadership; 3) management; 4) practices; 5) work unit climate; 6) motivation; and 7) individual and organizational performance. Each of these components is affected by subsystems to form the macro system of the organization. These subsystems are: 1) mission and strategy; 2) structure and resources; 3) individual tasks and skills; 4) organizational culture; 5) policies and procedures; and 6) individual needs and values. For more detail, refer to Appendix II (B).

GST is also relevant to the current study. Use of this theory provides perspectives on how the different components in the system within which BCMA is applied are affected, how the

system reacts to the change, how its functions might be altered, and the interaction patterns that may positively or negatively affect the implementation process. This theory provides much-needed direction for the design of this study and interpretation of the results.

3.4 Chapter summary

This study identified two relevant theories to use in its theoretical framework. Together, these theories provide guidance on the design of the study and interpretation of the results. DIT research attempts to explain the variables that influence how and why users adopt a new innovation, and how leaders exert influence on an audience's behavior in terms of adoption of an innovation via their personal contacts. Additional intermediaries, called change agents and gatekeepers, are also included in this process of diffusion (Rogers, 2002); these components may also affect the BCMA implementation process.

GST describes how a system is formed, functions, interacts with the environment, and how it may react to change, along with many other important components. The theory highlights how a system uses continuous sources of information and feedback from the external environment to make necessary changes to survive and grow. The elements of this theory are therefore relevant to the present study. Figure 2 illustrates how these two theories may affect BCMA implementation.

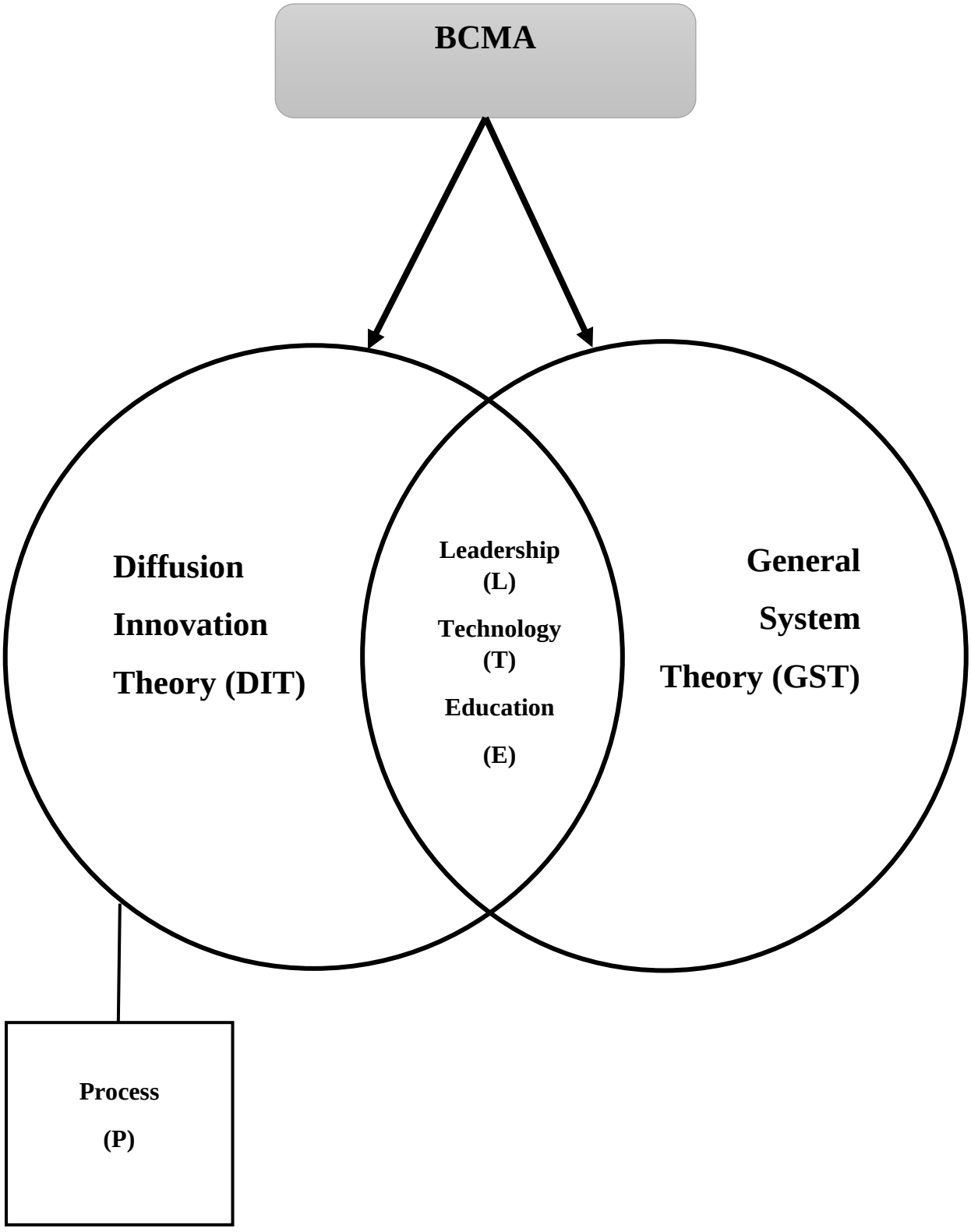

Figure 2: *Relationship Between Theories and BCMA System*

Chapter IV: Research Model

4.1 Introduction

There are two learning modalities. The first concerns examining and studying something to the extent that it has various possessions, combining the findings, and making conclusions based on observations. The second involves studying an entity in relation to other similar entities and correlating results by making comparisons. The practice of using judgments has been questioned when objectivity is the standard. However, we need to validate the idea that we can use judgments to derive tangible values to provide greater weight and support for using judgments when intangibles are involved (Saaty, 2008). Primarily, we are all decision-makers; we decide things consciously or unconsciously. As a result of some decisions, we gather information that helps us to understand occurrences, develop good judgments, and make further decisions about these occurrences. However, not all information is useful for improving our understanding and judgments, and many factors are in play when significant decisions are made.

For groups to proceed to the best possible solution, decisions should start with clarification of the main goal and purpose to identify the needs and facilitate discussion with experts (Skibniewski & Chao, 1992). The next step is determining the best alternative, or in the case of resource allocation, identifying priorities for alternatives in terms of allocating an appropriate share of the available resources. Decision-making, for which we gather most of our information, now becomes a mathematical science (Greco et al., 2005). The previous chapter identified different factors and variables that affect the implementation of a new healthcare technology (BCMA) (Table I). Most previous research has been conducted in hospitals in various countries outside the United Arab Emirates (UAE). This chapter aims to construct an Analytic Hierarchy Process (AHP) model to support the safe and successful implementation of new technology (BCMA) in a

healthcare system in the UAE public sector, with the goal of improving the standard of care and patient safety.

Table I

Literature Synthesis

Authors/ year	**General system theory**	**Diffusion Innovation Theory**	**Leadership (L)**	**Technology (T)**	**Process (P)**	**Education (E)**	**Quality & safety (QS)**
Angst & Agarwal, 2009				√	√		
Bradely et al., 2009			√	√		√	
Buntin et al., 2011				√			√
Bussard, 2006		√		√		√	√
Carayon, 2007				√	√		
Chan, 2010				√	√		
Chu, 2005				√		√	√
Davis, 1989				√			
Doyle, 2005		√		√		√	
Fowler et al., 2009			√			√	√
Goleman et al., 2002		√	√	√			
Gooder, 2011		√		√	√		
Hasman, 2016		√		√		√	
Higgins, 2010				√		√	√
Holden et al., 2012				√		√	
Holden, 2010				√	√		√
Hook et al., 2008				√	√		
Karsh et al., 2006	√		√				√
Leape et al., 1995	√					√	√
Mc Grath 2010				√			√
McKinsey, 2003			√		√	√	
Menachemi, 2007				√			√
Mutonrn, 2003		√		√	√		
Prasad et al., 2015			√		√		√
Radly, 2013				√			√
Ruck, 2012	√			√	√	√	
Saleem et al., 2009	√			√		√	
Schein, 2010			√				√

Squires et al., 2010			√			√	
Sutheland, 2013			√	√	√		
Wideman et al., 2005				√		√	√
Zhu et al., 2006	√			√	√		
Safa's Model and Study	√	√	√	√	√	√	√

4.2 Process to Identify Main Criteria and Sub- Criteria

Three processes or sources of information were used to identify the criteria and sub-criteria. The first source involved a literature review using CINHAL, the Cochrane database, and Google Scholar. The literature review introduced and explained the importance of patient safety and the positive impact on quality of care and clarified the concept of the relationship between medication errors and patient safety. Moreover, the literature review highlighted technological practices in healthcare, specifically those concerning important systems (BCMA) that prevent and manage medication errors. The second source was the two theories selected to form the theoretical framework (DIT and GST). The third source was interviewing clinician experts (nurses), who play an important role in dealing directly with administering medications to patients and will use the new BCMA system to identify patients throughout medication administration stages. This provided further validation of the criteria identified as affecting the implementation BCMA in a tertiary hospital setting.

Five main criteria were identified and chosen to for examination using the AHP; namely: leadership, technology, process, education and quality and safety. These criteria were further divided into 22 sub-criteria (Table II). These criteria and sub-criteria were selected based on relevant literature, and through active consultation with user-experts from inpatient medical units at the surveyed UAE hospital.

Table II

Criteria and sub criteria of prequalification of contractors.

Main criteria	**Sub Criteria**
1. Leadership (L)	1) Environmental Factors (EF) 2) Management of Change (MC) 3) Assessing Bar-Coding Readiness (ABCR) 4) Staff Satisfaction (SS) 5) Costs Assessment (CA) 6) Multidisciplinary Teams and Committees (MTC)
2. Technology (T)	7) Technology Specifications (TS) 8) Usefulness(U) 9) Ease of Use (EU) 10) User Support (US)
3. Process (P)	11) Workflow of Medication Administration (WMA) 12) Drug Labelling and Packaging (DLP) 13) Task Characteristics (TC)
4.Education (E)	14) Documentation (D) 15) Clinical Information and Alert System (CIAS) 16) Staff Training (ST) 17) Patient Education (PE) 18) Awareness (A)
5. Quality & Safety (QS)	19) Quality Processes and Risk Management (QPRM) 20) Culture (C) 21) Using Data to Improve Medication Safety (UDMS) 22) Performance Improvement (PI)

4.3 AHP Model Design

A clear and defined statement of the problem encountered by organizations is suggested as the starting point of AHP, along with clarification of the elements (criteria) and alternatives for decision-making (Saaty, 2008). This structured decision-making framework is often used for important and complex issues where many interconnected variables are scattered and await decision. As a hierarchical model, AHP classifies the goal, decision criteria, and variables into

levels. The highest level represents the overall goal, level 2 the criteria, and level 3 the sub-criteria. In some cases, level 4 represents alternatives for decisions. Figure 3 illustrates a classical structure

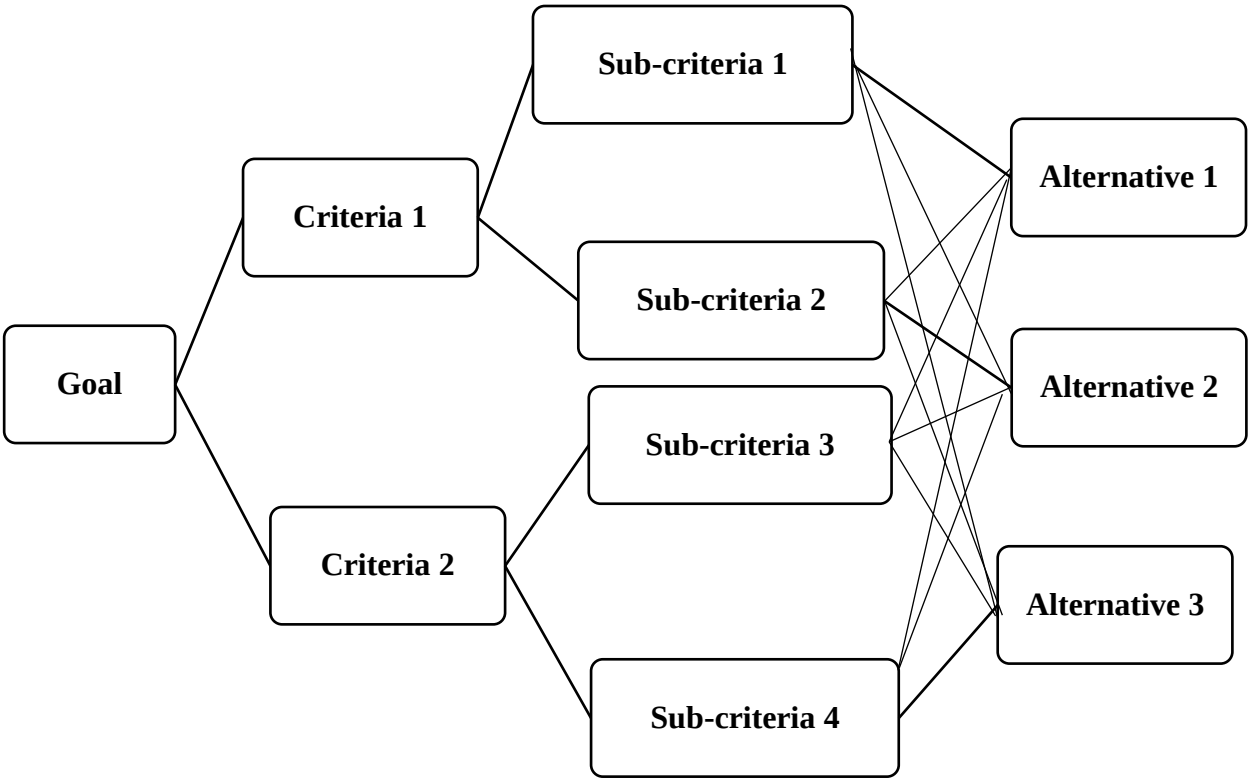

Figure 3: *Classical Structure of AHP Model*

of an AHP model.

The AHP model comprises various factors that were identified by the consulted experts as potentially affecting the BCMA implementation process. Figure 4 represents the hierarchy of the proposed AHP model.

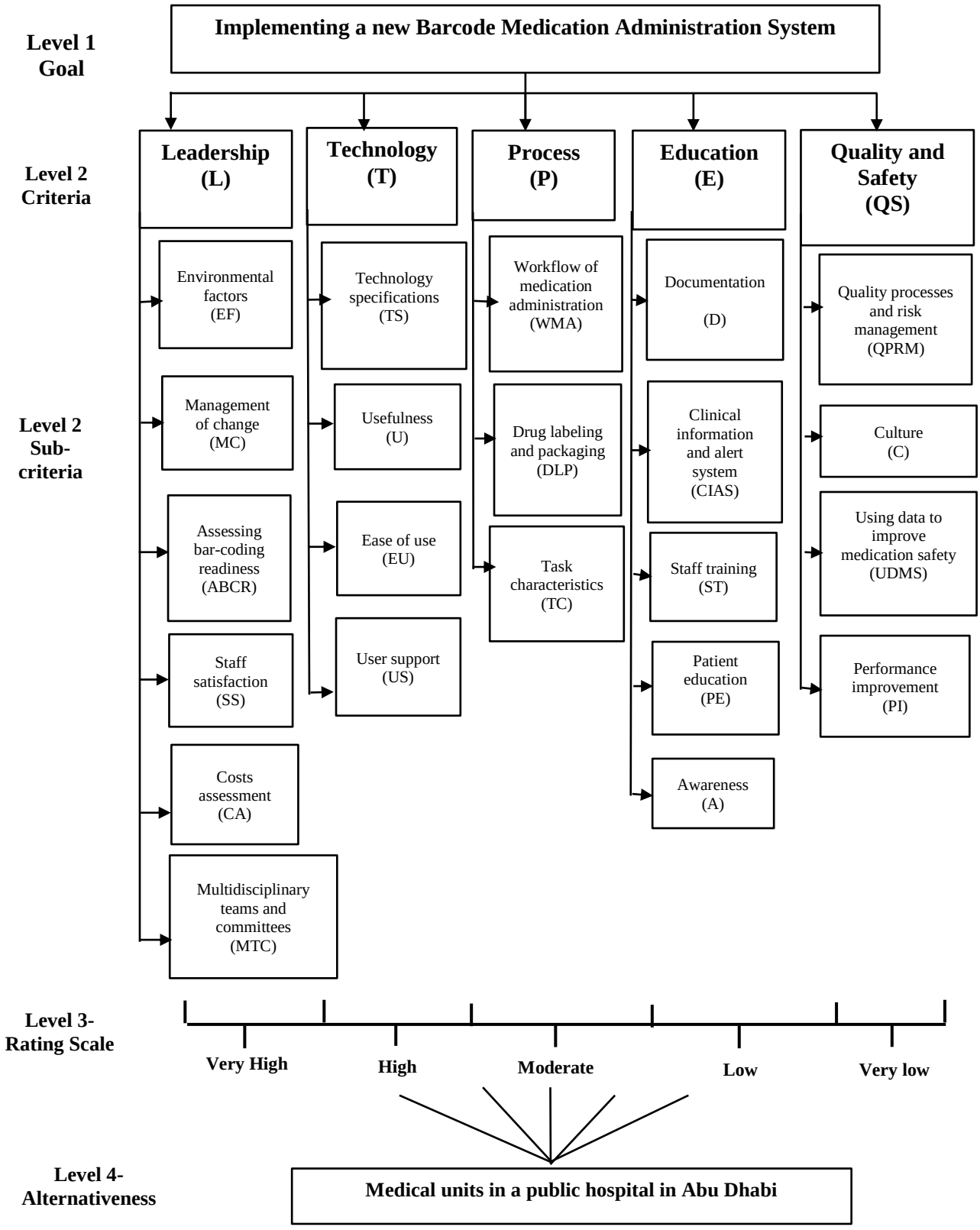

Figure 4: *AHP Model for Evaluating the Implementation of BCMA* System

4.4 Chapter Summary

The works cited in this chapter describe the suitability of AHP as a decision-making framework, and one that can facilitate the implementation of a BCMA system in the hospital setting. However, there has been a dearth of academic attention to the application of AHP, or any other decision-making framework, for healthcare sourcing decisions. This study aimed to contribute to the literature by implementing an AHP model in the UAE healthcare sector. This model was used to assess the implementation process of the BCMA system, to identify and determine the priority of the criteria/sub-criteria on which to focus in the first phase of BCMA implementation. The identified variables were leadership, technology, process, education, and quality and safety. By focusing on these domains, it should be possible to overcome any barriers that may delay or obstruct successful implementation of BCMA and ensure a successful change in practice.

The goal of this chapter was building an AHP model for BCMA implementation. This aimed to support the safe and successful implementation of new a technology in the UAE public healthcare sector and drive an improved standard of patient care and safety. The model itself is a key contribution of this study. This study also enriches research in the UAE context regarding important factors that affect the process of implementing a BCMA system in the hospital setting, and how to support successful outcomes when initializing new healthcare technology.

Chapter V: Research Methodology

5.1 Introduction

Many different multi-criteria decision-making (MCDM) methods are used in practical and academic applications. The AHP and the related Analytic Network Process (ANP) are formalized decision-making methods that consider quantitative factors alongside qualitative factors. AHP may be described as a general method of representing problems that have a hierarchical structure, which defines each problem in terms of objectives, criteria, and alternatives. Although, ANP (an evolution of AHP) introduces the concepts of interdependence and feedback into the model. Therefore, ANP is able to represent problems in which the importance of alternatives may in turn modify the importance attributed to the criteria (Saaty, 2008). AHP has advantages over other methods that address MCDM problems. These advantages include: ease of use and flexibility, the ability to identify inconsistencies, and scalable models that can be adjusted to fit many sized problems. However, the main drawback of AHP is the possibility of inconsistent judgment (Innes & Booher, 2004; Saaty, 2013; Velasquez & Hester, 2013). Various decisions need to be made, often in conflicting situations, to complete the project and reflect the hopes and needs of customers. Therefore, to make decisions and achieve the objective, we should have a clear process as a measurement to evaluate our data and make sure this serves our purpose (Cabala, 2010). An AHP model provides a simple multiple criteria methodology for evaluating alternatives (Hemalatha & Sivakumar, 2009).

Another advantage of AHP is the use of a multi-level hierarchical structure for the objectives, criteria, and alternatives. Pertinent data are then derived from pairwise comparisons to weight the importance of decision criteria relative to the required performance. This mechanism has been proven to lead to improvement of an organization's performance (Gupta et al., 2013).

Using this process, we can prioritize and identify the criteria that could have the most effect on the implementation phase. The present study explored previous literature to identify criteria and sub-criteria relevant to implementing the BCMA system in the largest tertiary hospital in the UAE; this was an essential step in developing conceptual content around the research topic.

5.2 Overview of AHP

AHP is one of the most widely-known methods of determining the elements that lead to better prioritization and decision-making. It was developed to optimize outcomes in situations involving a mix of qualitative, quantitative, and sometimes conflicting factors that must be considered. AHP has been effective in enabling complicated and irreversible decisions (Saaty, 2012). Thomas Saaty developed AHP in the 1970s as a way to deal with weapons trade-offs, resource and asset allocation, and decision-making when he was a professor at the Wharton School of Business and a consultant with the Arms Control Disarmament Agency. There, he was faced with the problem of dealing with high costs, along with a host of considerations that had many conflicting factors that were not easily specified (Saaty, 2012).

AHP uses decision-makers' judgments to decompose problems into hierarchies. Problem complexity is represented by the number of levels in the hierarchy, which combine to form a model of the problem to be solved for the decision-maker. The hierarchy is used to derive ratio-scaled measures for decision alternatives, and the relative values of these alternatives against organizational goals (e.g., customer satisfaction, product/service, financial, human resources, and organizational effectiveness) and project risks. AHP uses matrix algebra to arrange factors and arrive at a mathematically optimal solution. This is a time-tested method that has been used in multi-billion-dollar decisions (Saaty, 2012). As AHP deals with human judgments in complex problems, the choices made by respondents are sometimes inconsistent. An example of

inconsistent feedback from respondents is: if A is more important than B and B is more important than C, then C is more important than A. Typical applications where AHP have been used include:

1) Prioritizing factors and requirements that impact software development and productivity;
2) Choosing among several strategies to improve safety features in motor vehicles;
3) Estimating costs and scheduling options for material requirements planning;
4) Selecting desired software components from several software vendors; and
5) Evaluating the quality of research or investment proposals.

The prioritizing approach is important, as it filters the factors that have the most influence in the implementation of BCMA. Multiple prioritizing techniques were examined (e.g., quality function deployment, opportunity scoring, story mapping, "MoSCoW," and the AHP model).

5.3 Why AHP

BCMA is necessary for patient safety and quality of care. Therefore, this study has defined the main factors that affect the process of implementing BCMA in the UAE health sector and lead to successful implementation. This study was evaluated multi-criteria decisions that were discussed and emphasized by expert nursing staff from medical units over several interviews, and from which the main criteria for this study were identified. It has been argued that after ANP emerged, it was considered a rival to the AHP method. Nevertheless, the AHP method is commonly used and regarded as an appropriate method in similar research. For example, many scholars to identify and rank critical parameters in different sectors (Chung & Lee, 2009; Barzekar et al., 2011; Bereketli & Genevois, 2013; Ren et al., 2013; Dinarvandi et al., 2014) have used AHP. It also has the advantage of incorporating qualitative and quantitative data (Ghodsypour & O'Brien, 1998; Kurttila et al., 2000; Korpela et al., 2001; Wrisberg et al., 2002; Lee & Hsu, 2004; Masozera et al., 2006).

AHP solves the problem of "survey fatigue" by only asking participants to compare the importance of two needs at a time. These comparisons are called judgments. A judgment of two items is much easier for participants than comparing a list of 20 items simultaneously. The judgments applied in making paired comparisons combine logical thinking with intuitive feelings developed through experience. Pairwise comparisons generate more information, and therefore improve judgment consistency. The first step is to identify the problem, and the second to develop a hierarchical model figure 5.

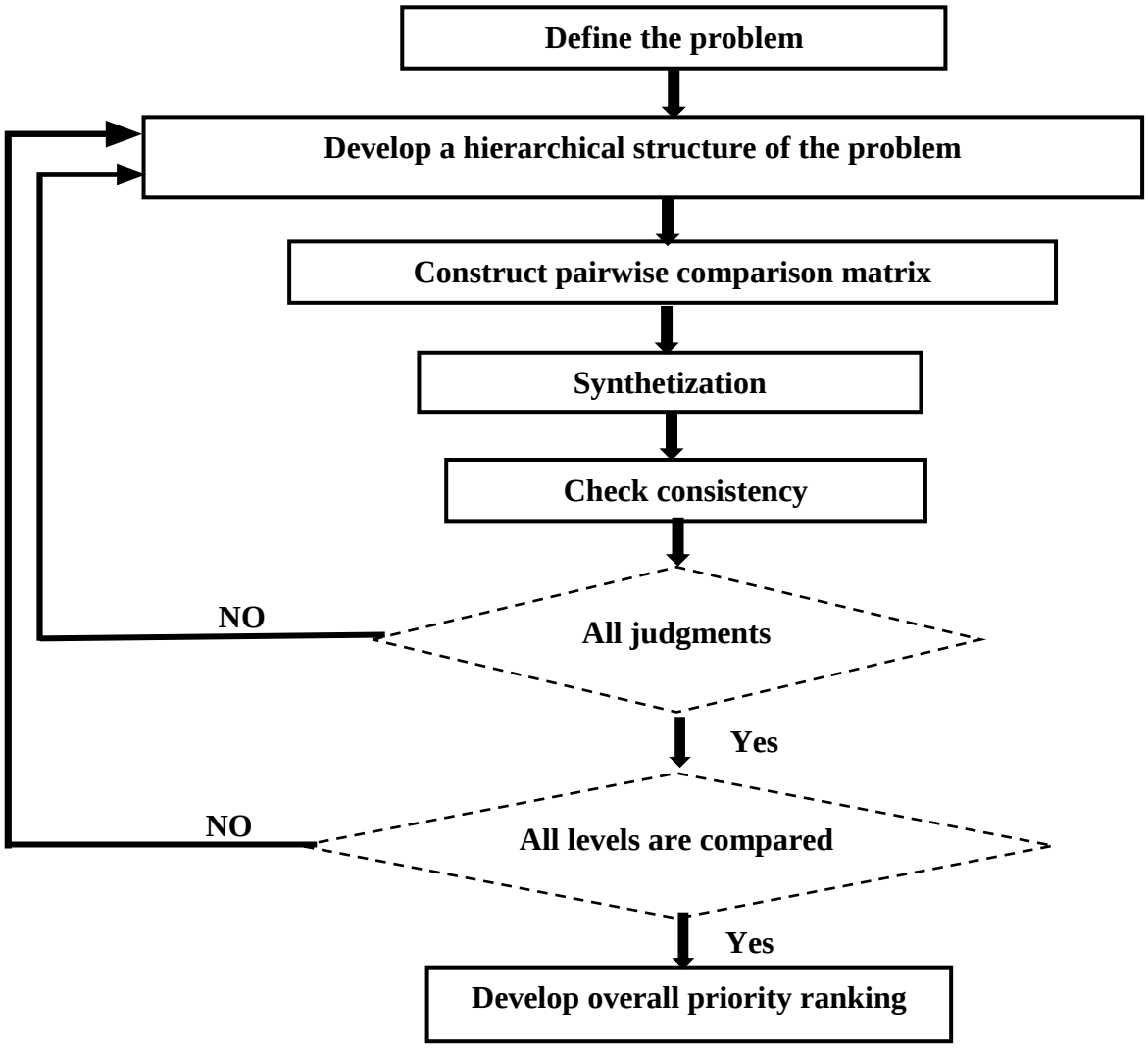

Figure 5: *Flow Diagram of AHP Method Employed*

5.4 Using AHP decision matrix in implementing the BCMA

The AHP method comprises four phases: first structuring the decision problem, then data collection and measurement, followed by determination of normalized weights, and synthesis concluded by finding solutions to the problem (Tummala & Wan, 1994). An AHP model for BCMA implementation was formulated using this four-phase approach. This classified the goal, decision criteria, and variables into three major levels. The highest level was the overall goal; for example, selecting the unit in which BCMA is to be implemented. Level 2 represents the criteria and sub-criteria used in implementing the new system. This study identified five criteria (leadership, technology, process, education, and quality and safety) and 22 sub-criteria. Level 3 represents decision alternatives that affect successful implementation of the new system.

5.5 Research Sample

A major advantage of AHP is that the analysis does not always require a statistically significant sample size. The simplicity of the AHP approach is unlike other "conjoint" methods; the qualities (or levels) of different attributes are not directly compared. The AHP approach therefore removes the need for complex survey designs and can even be applied (in extreme cases) with a single respondent (Dutta, 2007). Expert opinion is valuable in the decision-making process, especially when dealing with complex MCDM problems (Morgan, 2014; Hussain et al., 2017; Huang et al., 2016). In assimilating experts' opinions, the number in a sample does not necessarily have to be large. The essential issue is that the model should build on and use the best available research and analysis, and be undertaken only when this is achieved (Morgan, 2014). The sample in the present study included 20 experts from medical units, each with more than 5 years of experience as a healthcare professional. The participating experts were of different nationalities and volunteered to participate and share their opinions and experience about the process of

implementing the BCMA system (a new technology introduced into their healthcare work environment). This approach enhances knowledge and analysis of identified factors perceived as affecting the BCMA implementation process.

5.6 Data Collection

The main goal and purpose of this part of the study was to meet with different experts to discuss all criteria and sub-criteria that were clarified and compiled through a meta-analysis of previous research and review of various theories. Interviews with experts were conducted in the hospital. No personal information was collected, voluntary participation was emphasized, and participants' identity was kept anonymous. Three sessions were held to complete the survey, as it was challenging to get all participants to attend one session owing to factors such as work commitments and shifts. All participants were received a 20-minute introduction session to demonstrate the survey method and the mechanism of completing the questionnaires. Each participating expert was interviewed for 30 minutes to ensure that they understood the process clearly, and were able to complete all questionnaire sections related to the main and sub-criteria. The survey was completed individually, and no respondent influenced the assessment of any others.

Consistent with Saaty's (1993) recommendations, the questionnaire was designed using a nine-point scale as presented in Table III, based on the five criteria and 22 sub-criteria for implementing the BCMA system. As far as one of the important criteria of AHP methodology is to have an expert opinion who is dealing with this technology and have the exposure of this practice. The survey was distributed to and completed by expert nurses from four medical units. As those units are considered the only specialty that been started a "BCMA" technology in the entire public hospital. Therefore, those experts whose daily work involves using BCMA during patient medication

administration practice. As these participants were the key persons using the BCMA system and had sufficient experience in the subject matter, their responses are likely to be valid. Please refer to Appendix III for the questionnaire items.

Table III

1 to 9 Scales for Analytic Hierarchy Process Preferences

Intensity of importance Definition explanation	**Definition**	**Explanation**
1	Equal importance	Two criteria contribute equally to the objective
3	Moderate importance	Judgment slightly favor one over another
5	Strong importance	Judgment strongly favor one over another
7	Very strong importance	A criterion is strongly favored, and its dominance is demonstrated in practice
9	Absolute importance	Importance of one over another affirmed on the highest possible order
2,4,6,8	Intermediate values	Used to represent compromise between the priorities listed above

5.7 Chapter Summary

Many different MCDM methods are used in practical and academic applications, including AHP. AHP has advantages over other methods that address MCDM problems, including ease of use and flexibility, an ability to identify inconsistencies, and being a scalable method that can be adjusted to fit many sizes of problems. However, the main drawback of AHP is the possibility of inconsistent judgments. AHP is a widely used method to determine elements that lead to better prioritization and decision-making. It was developed to optimize outcomes in the context of a mix

of qualitative, quantitative, and sometimes conflicting factors that must be considered. AHP is effective in enabling complicated and irreversible decisions.

The AHP method comprises four phases: structuring the decision problem, data collection and measurement, determination of normalized weights, and synthesis concluded through finding solutions to the problem. An AHP model for the BCMA system was formulated using this four-phase approach, with the goal, decision criteria, and variables classified into three major levels. Another advantage of AHP is that the analysis does not always require a statistically significant sample size. The AHP approach is unlike other conjoint methods, as the qualities (or levels) of different attributes are not directly compared. This approach removes the need for complex survey designs and can even be applied (in extreme cases) using only a single respondent.

Chapter VI: Results

6.1 Introduction

The previous chapter discussed the research methodology in terms of building a hierarchal model, the process of pairwise comparisons, developing the questionnaire, selecting the research sample, data collection, and checking consistency. In this chapter, the results of the respondent groups will be analyzed. The hierarchical framework was divided into five main criteria (goals) (e.g., leadership, technology) and 22 sub-criteria (e.g., environmental factors, usefulness, documentation). Then, each group performed pairwise comparisons for the five primary criteria involved in implementing a new technology in healthcare (BCMA system) to support prevention of patient harm. This chapter presents the priority weights generated for the criteria and sub-criteria, the results for each group, and the combined analysis. The main focus of this study was identifying and prioritizing the factors involved in successful implementation of BCMA in healthcare. To achieve this, the AHP pairwise comparison matrix seemed the most appropriate technique described in the available literature.

6.2 AHP Methods of Analyzing the Data

After building the AHP hierarchy, the next phase was measurement and data collection. Data were collected from 20 experts (medical unit nursing staff). As suggested by Saaty (2012), a questionnaire was designed based on the five main criteria related to the implementation of BCMA (e.g., leadership, technology, process, education, quality and safety), using a nine-point scale as presented in Table III. The questions were discussed and explained to each participating expert, who volunteered to be interviewed. All participating experts worked with and were fully conversant with the implementation stage of the BCMA in their medical units. The main aim of the interviews was to explore factors affecting implementation of BCMA in these medical units.

In addition, we aimed to confirm the literature review findings and verify the criteria informed by the two theories chosen for the theoretical framework of the present study (DIT and GST). The interviews confirmed five major domains/criteria. Respondents highlighted the most important factors that may affect the BCMA implementation process and underlined the importance of technology in healthcare. Some stressed that quality and safety were the main concern for implementation of a new technology for administering medication (BCMA) to patients. Others emphasized that management of the BCMA process was an important factor that should be clearly communicated to ensure employees understand the correct process flow. Leadership engagement and support was considered essential for the successful implementation of BCMA. Discussion of the main factors that were raised and shared by different experts during the second interview had similar outcomes, with a focus on having quality measures in place during and after implementation. Establishing the correct medication administration process with a proper BCMA implementation plan was also seen as essential; this plan should have leaders onboard within a correct and clear process.

This research aimed to identify and prioritize factors involved in successful implementation of BCMA. The AHP pairwise comparison matrix an appropriate technique, and has been applied in this research. The next step was using AHP for pairwise comparisons of the identified criteria. As previously mentioned, Saaty (2012) suggested a nine-point scale to define pairwise comparisons. For example, if a participant identifies leadership as moderately more important than technology, the former is rated "3" and the latter "1/3." The consistency index (CI) was used to check the consistency. Saaty (2012) defined consistency as: $CI = (\lambda_{max} - n) / (n - 1)$, where "$\lambda_{max}$" is the maximum Eigen value of the matrix of importance and *"n"* is the number of factors. Then, the consistency ratio (CR) was used to assess whether a matrix was sufficiently consistent. This is

the ratio of the CI to the random index (RI), which is the CI of a matrix of comparisons generated randomly: CR = CI / RI. Random pairwise comparisons have been simulated to produce average RIs for different sized matrices. RI values are presented in Table IV. The inconsistency is acceptable if the CR is smaller than or equal to 0.10 (Saaty, 2012).

Table IV

Random Index

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.48

Note: n is number of factors

The geometric mean approach was used to combine the individual pairwise comparison judgment matrices to obtain consensus pairwise comparison judgment matrices for all evaluators (Saaty, 2012). The geometric means of pairwise comparisons for the main criteria showed that leadership (L) was the most important of the five criteria (Table V), with the highest priority weight of 43%. This was followed by process (P), which received a competitive priority of 23%, and was slightly higher than education (E) (21%). The lowest two elements were quality and safety (QS) at 9% and technology (T) at 5%; these criteria were ranked the fourth and fifth priority factors affecting the implementation of BCMA. Overall, the CR for the main criteria was below 0.10, which indicates that the matrix was sufficiently consistent.

Table V

The Geometric Means of Pair-Wise Comparisons of the Main Criteria

Competitive priority	(L)	(T)	(P)	(E)	(QS)	Priority weight
(L)	1.00	7.60	2.83	2.82	3.12	**0.43**
(T)	0.13	1.00	0.12	0.43	0.53	**0.05**
(P)	0.35	8.33	1.00	1.30	1.76	**0.23**
(E)	0.35	2.33	0.57	1.00	5.68	**0.21**
(QS)	0.32	1.89	0.57	0.18	1.00	**0.09**
						CR= 0.00 <0.10 (acceptable)

The geometric means for the pairwise comparisons of the six leadership sub-criteria were also measured Table VI. Environmental factors (EF) had the highest priority ranking at 35%, whereas multidisciplinary teams and committees (MTA) had the lowest priority with a weight of 5%. Management of change (MC) was ranked as the second leadership priority (22%), with staff satisfaction (SS) at 20%, assessing bar-coding readiness (ABCR) at 10%, and costs assessment (CA) at 8% ranked fourth, fifth, and sixth, respectively. The CR was below 0.10, which indicated that the matrix was sufficiently consistent.

Table VI

The Geometric Means of Pair-Wise Comparisons of The Leadership Criteria

Competitive priority	(EF)	(MC)	(ABCR)	(SS)	(CA)	(MTA)	Priority weight
(EF)	1.00	4.11	5.18	2.48	3.22	3.13	**0.35**
(MC)	0.24	1.00	6.45	1.84	2.63	3.41	**0.22**
(ABCR)	0.19	0.16	1.00	1.36	2.43	1.50	**0.10**
(SS)	0.40	0.54	0.74	1.00	5.81	6.90	**0.20**
(CA)	0.31	0.38	0.41	0.17	1.00	2.95	**0.08**
(MTA)	0.32	0.29	0.67	0.14	0.34	1.00	**0.05**
							CR= 0.00 <0.10 (acceptable)

There were four geometric means calculated for pairwise comparisons of the technology (T) sub-criteria Table VII. Usefulness (U) was highest ranked (priority weight of 42%), followed by technology specifications (TS) at 29%, and ease of use (EU) at 22%. User support (US) was the ranked fourth at a priority weight of 7%. The matrix was sufficiently consistent with a CR equal to 0.00, which was below 0.10.

Table VII

The Geometric Means of Pair-Wise Comparisons of The Technology Criteria

Competitive priority	(TS)	(U)	(EU)	(US)	Priority weight
(TS)	1.00	1.21	1.33	2.59	**0.29**
(U)	0.83	1.00	4.16	5.72	**0.42**
(EU)	0.75	0.24	1.00	5.57	**0.22**
(US)	0.39	0.17	0.18	1.00	**0.07**
					CR= 0.00 <0.10 (acceptable)

Table VIII presents the analysis of the process (P) sub-criteria, with the geometric means for pairwise comparisons of three elements. Workflow medication administration (WMA) had the highest priority weight of 71%, drug labeling and packaging (DLP) was ranked second (23%), and task characteristics (TC) had the lowest priority weight of 7%. The CR was again below 0.10, showing the matrix was sufficiently consistent

Table VIII

The Geometric Means of Pair-Wise Comparisons of The Process Criteria

Competitive priority	(WMA)	(DLP)	(TC)	Priority weight
(WMA)	1.00	5.23	7.65	**0.71**
(DLP)	0.19	1.00	5.38	**0.23**
(TC)	0.13	0.19	1.00	**0.07**
				CR= 0.00 <0.10 (acceptable)

Table IX shows the geometric means for the pairwise comparisons of the five education (E) sub-criteria. Documentation (D) was ranked the highest-ranked priority at 31%, followed by clinical information and alert system (CIAS) and staff training (ST) (each with 25%). Patient education (PE) was ranked fourth at 12%, and awareness (A) was lowest at 7%. The CR was below 0.10, indicating the matrix was sufficiently consistent.

Table IX

The Geometric Means of Pair-Wise Comparisons of The Education Criteria

Competitive priority	(D)	(CIAS)	(ST)	(PE)	(A)	Priority weight
(D)	1.00	3.9	1.4	1.5	2.5	**0.31**
(CIAS)	0.26	1.00	2.88	3.76	2.09	**0.25**
(ST)	0.71	0.35	1.00	4.70	4.51	**0.25**
(PE)	0.66	0.27	0.22	1.00	2.76	**0.12**
(A)	0.39	0.48	0.22	0.36	1.00	**0.07**
						CR= 0.00 <0.10 (acceptable)

Four quality and safety (QS) sub-criteria were identified. Table X shows that quality process risk management (QPRM) was classified as the highest priority (51%), with culture (C) ranked second at 29%, using data to improve medication safety (UD) ranked third at 12%, and

Table X

The Geometric Means of Pair-Wise Comparisons of The Quality Safety Criteria

	(QPRM)	(C)	(UD)	(PI)	Priority weight
(QPRM)	1.00	4.01	5.58	3.32	**0.51**
(C)	0.25	1.00	5.47	4.55	**0.29**
(UD)	0.18	0.18	1.00	3.18	**0.12**
(PI)	0.30	0.22	0.31	1.00	**0.08**
					CR= 0.00 <0.10 (acceptable)

performance improvement (PI) ranked fourth at a priority weight of 8%. The CR was below 0.10,

indicating that the matrix was sufficiently consistent. The final step in the AHP model is

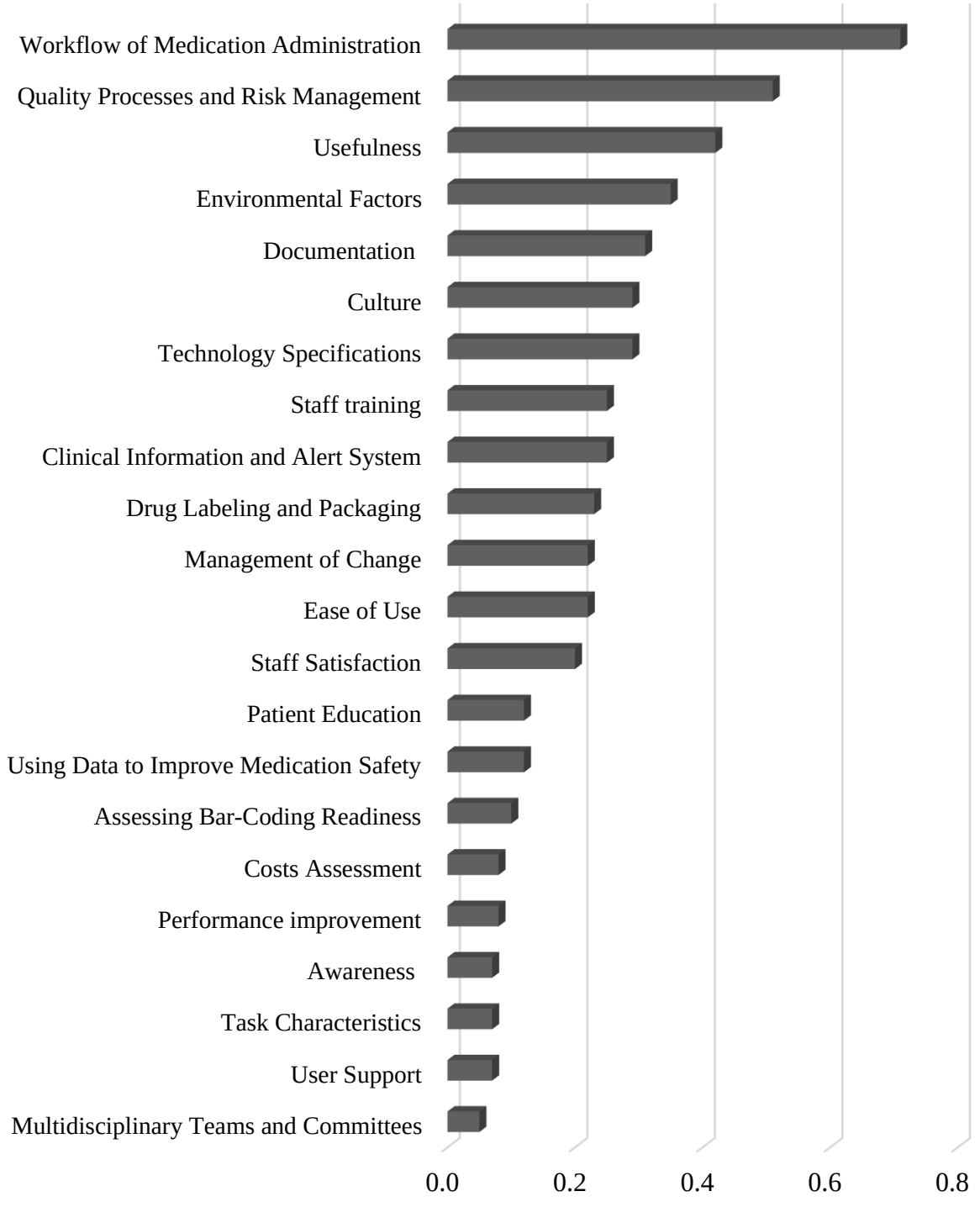

Figure 6: *The Overall Ranking of the 22 Sub-Criteria*

establishing the overall priority ranking for the 22 sub-criteria by multiplying the sub-criteria ranking by the main criteria priority matrix figure 6. For example, workflow of medication administration (WMA) at 71% was the highest-ranked sub-criterion. Quality process risk management (QPRM) had the second highest overall priority ranking of 51%, followed by usefulness (U) at 42%, and environmental factors at 35%. The relative overall ranking of all sub-criteria in figure 6 is within a close range, because of the difference in overall priority between the highest ranked (workflow of medication administration (WMA) at 71%) and the lowest ranked (multidisciplinary teams and committees (MTA) at 5%).

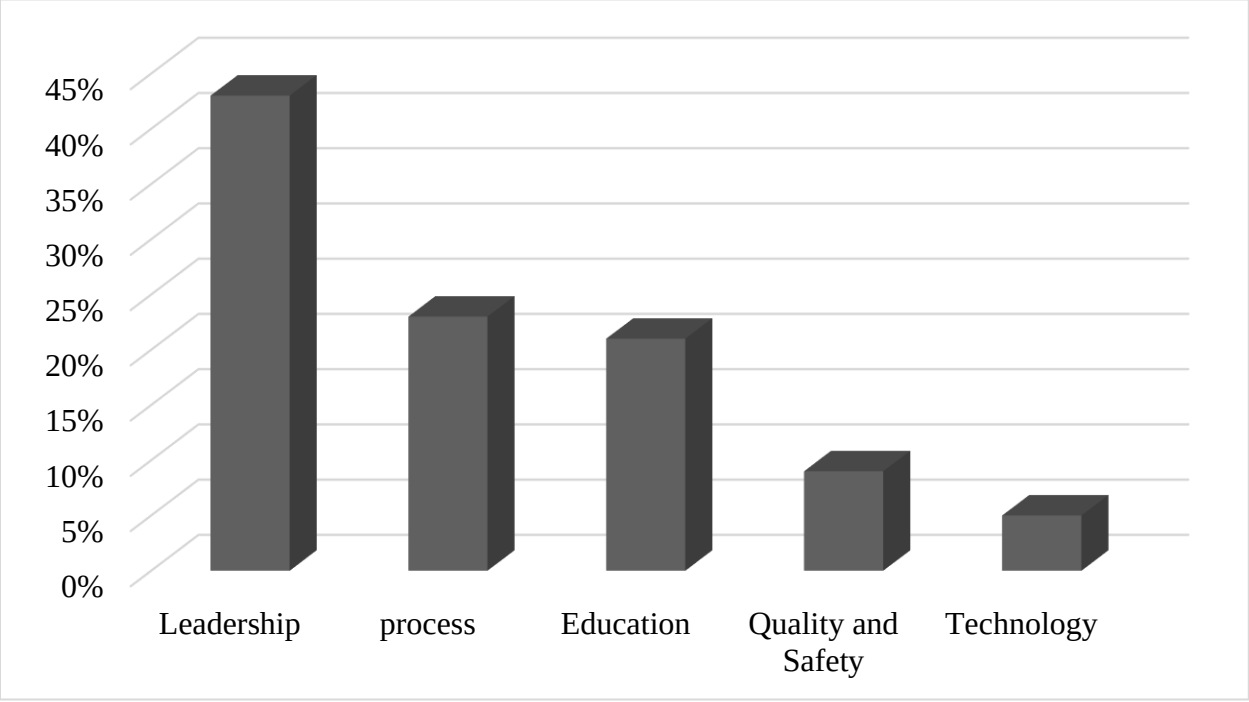

Figure 7: *Main Criteria Priority Weight*

6.3 Chapter Summary

This chapter presents the analysis of the results for the respondent groups. After building the AHP hierarchy, the next phase was measurement and data collection. Data were collected from 20 nursing staff recruited from participating medical units. Interviews with these respondents

aimed to explore factors affecting implementation of BCMA in the medical units, confirm the findings of the literature review, and verify the criteria identified through the two selected theories (DIT and GST). Five major domains/criteria were confirmed through these interviews.

The hierarchical framework was divided into five goals (criteria), and 22 sub-criteria. Then, each respondent group performed pairwise comparisons for the five primary criteria relating to implementing the new BCMA system in the healthcare environment to support prevention of patient harm. Priority weights were then generated for all criteria and sub-criteria, the group results were analyzed, and a combined analysis was performed. Figure 7 shows that the highest priority of these five criteria was leadership (L) (45%); however, workflow of medication administration (WMA) at 71% was the highest ranked of the 22 sub-criteria figure 6.

Chapter VII: Discussion

7.1 Introduction

This dissertation aimed to study the main factors that affect the process of implementing BCMA and measure the priority weight for each factor to allow comparison and prioritization of implementation domains in terms of the greatest impact on successful application in the health sector. This study was conducted across four specialized medical units in a tertiary hospital in Abu Dhabi. Five dimensions (leadership, technology, process, education, and quality and safety) were identified from a literature review and aligned with two theories. Twenty-two sub-criteria were identified for these five domains, and a nine-point scale was used to rank all criteria and associated sub-criteria. Overall, the CR was below 0.10, which indicates that all related matrices for the main criteria and sub-criteria were sufficiently consistent.

Expert opinion is valuable in the decision-making process, especially when dealing with MCDM problems. This means that the sample size did not necessarily have to be large (Morgan, 2014). The present study used a sample of 20 experts from participating medical units. These experts shared their opinions and experience about the implementation process related to a new healthcare technology (BCMA system). This approach enhanced knowledge concerning the analysis of factors that affect the BCMA implementation process. The 20 participating experts were expert clinicians from the nursing profession. This reflected the present study's focus on medication errors related to the medication administration process, which is a key role of nursing staff. Participating nurses included expertise across different levels, from managers to front-line staff nurses. Unit managers recruited as their opinions will be helpful in addressing the staffing, budgeting, and operational part of the implementation process, and they will support the new initiative as hospital leaders. This group will also be helpful in determining the staff satisfaction

part of the process. Nurse educators have a major role in staff education and can measure and evaluate the level of staff awareness and act as good observers throughout the implementation process. Charge nurses are on-site leaders of nursing practices; they monitor daily practices and report any shortfalls and needs to their managers. An essential part of the study sample was staff nurses, who are the front-line staff that actually implement the new technology. Their opinion was particularly valuable as they will experience the whole process of BCMA implementation and will deal with this technology on a daily basis. Each expert interview lasted 30 minutes, during which the questionnaire items were carefully explained to each expert (please see Appendix III for further details). The results of the AHP analysis indicated that support from leaders should be given the highest priority during the BCMA implementation stage; leadership (L) was weighted at 43% compared with technology (T), which had the lowest priority weight of 5% (Figure 7). Moreover, process (P) was the second most important factor at a weight of 23%; this suggests that with a combined weight of 66%, leadership support and a clear process will help ensure successful BCMA implementation. However, we should keep in mind that the AHP methodology was not used to exclude any criteria/sub-criteria, as all identified criteria/sub-criteria were regarded as important elements. This methodology will help to prepare the health sector for the launch of the new BCMA system, as implementation should be carefully planned based on AHP results.

Leadership is a significant variable in DIT, and influences people's behavior on whether to adopt and accept a new technology as an innovation. Technology such as BCMA is increasingly used in healthcare organizations, and hospital leadership must be aware of the safety risks and preventable adverse events that implementation of such innovations may create or maintain. As stated in the literature review, new technologies do not always work in the best interests of patient safety, as technology sometimes complicates patient care. However, undesirable outcomes can be

eliminated if the focus remains on quality of patient care and safety. All electronic systems depend on human users; for effective and safe practice, we must prioritize support from leaders and establish a clear process.

This study also showed that appropriate planning is a major leadership role. The literature indicates that inadequate technology planning can result in poor product selection, solutions that do not adapt well to the local clinical environment, or insufficient testing or training. Inadequacies include failing to: include front-line clinicians in the planning process, consider best practices, consider the costs and resources needed for ongoing maintenance, and consult product safety reviews/alerts or the previous experience of others. This study showed similar findings in that implementing a new clinical information system can expose hidden problems or faulty processes within existing manual systems; any problems should be identified and resolved before implementing the new system. Unless carefully planned and integrated into established workflow processes, the change in practice required by new technology systems can trigger uncertainty or other emotions that may affect a worker's ability to perform complex physical and cognitive tasks. Poorly-planned change may negatively impact on the new technology, affect the documentation process, and complicate workflow. Moreover, in the beginning, this change will be time consuming for staff to learn and understand the consequences. These are key points that leadership should consider when implementing the new BCMA system, as reflected by the staff surveys conducted for this study. At the same time, such constraints may lead to much-needed role standardization that reduces unnecessary clinical practice overlap, and may also redistribute work in unexpected ways, causing confusion or frustration.

This study confirmed the role of leadership in the process of implementing BCMA, which was consistent with the literature. Leaders in healthcare should direct attention to planning the

management of information, and must also plan for disaster recovery, downtime of information systems, and the periodic testing of the plan to ensure effectiveness and alignment with current practices. Leaders should also address the need to design new processes and establish safety programs.

In summary, this study confirmed the JCI recommended actions (Number, 2008) to help preventing patient harm related to implementation and use of Health Information Technology: 1). Assessing the workflow and the process should be revised prior to any technology implementation. This should include a multidisciplinary teamwork to examine and resolve any issue. Engaging the front line and clinician's expert, IT and others will play a big role during the planning, selecting, designing, reassessing and implementing any new technology related to medications. The reassessing stage and the involvement of the stockholders is required beforehand to support the infrastructure, communication of admission, discharge and transfer. 2). Investigating how best to meet these needs by requiring IT staff to interact with users outside their own facility and learn about the real-world capabilities of potential systems, including those of various vendors. 3). It was suggested for any introduction of new technology, continuously monitoring for problems and address any issues as quickly as possible, particularly problems obscured by workarounds or incomplete error reporting. 4). Leaders support is important and should be considered during the implementation phase to direct and help in rapidly resolving critical problems. 5). Launching and starting a training program for all clinicians and operations staff who will use the technology is vital during the implementation stage. 6). Before a technology "goes live," the organization should make sure that all standardized order sets and guidelines are developed, tested on paper, and approved by the Pharmacy and Therapeutics Committee. 7). Developing and communicating policies, a graduated system of safety alerts in the new technology to help clinicians determine

urgency and relevancy. 8). Developing a system that mitigates potential harmful Computerized Physician Order Entry (CPOE) drug orders by requiring departmental or pharmacy review and sign off on orders created outside the usual parameters. 9). For any safety improvement while implementing new technology it is important to have a a safe environment to protect the staff during data entry practice. 10). After implementation, continually reassessing and enhancing safety effectiveness and error detection capability. Moreover, a continuous monitoring and reporting errors and near misses caused by technology through manual or automated surveillance techniques (Number, 2008).

The geometric mean approach was used to combine the individual pairwise comparison judgment matrices to obtain consensus pairwise comparison judgment matrices for all evaluators (Saaty, 2012). The geometric means of the pairwise comparisons of the criteria (Table V) showed that leadership (L) was considered most important with highest priority weight of 43%, while technology (T) was the least important at 5%. The process (P) criterion was ranked second at 23%, which was slightly higher than education (E) (ranked third at 21%), which in turn was higher than quality and safety (QS) (ranked fourth at 9%). Overall, the CR for the main criteria was below 0.10, which indicated the matrix was sufficiently consistent.

These findings are consistent with previous literature, which highlighted that leadership buy-in and involvement is the most important factor to consider when implementing change. Leadership is connected to decision-making and ultimate organizational accountability. Among the six leadership sub-criteria (Table VI) environmental factors (EF) had the highest priority ranking at 35%, whereas multidisciplinary teams and committees (MTA) had the lowest priority weight at 5%. The other leadership elements (in ranked order) were management of change (MC) (22%), staff satisfaction (SS) (20%), assessing bar-coding readiness (ABCR) (10%), and costs

assessment (CA) (8%). Those elements were supported by other studies and the present theoretical framework (GST and DIT). Management of change (MC) was the second priority, suggesting that having positive environmental factors and good management of change support through leadership will reflect on staff satisfaction (our third priority) by means of leadership encouragement.

In contrast, technology (T) was ranked the least important priority (5%). This indicates that if leadership sets standards and establishes the correct environment, technological advancement would follow automatically. The newness of BCMA technology suggests that the technology used will be the most current. In this domain, the most important factor and first priority on which to focus was usefulness (U) (42% of the priority weight), followed by technology specifications (TS) (29%), ease of use (EU) (22%), and user support (US) (7%). Technology Acceptance Model (TAM) theory indicates that an important factor for any new technology is how useful the equipment is in preventing medication errors and protecting patients from harm.

The implementation process (P) (23%) was the second-ranked priority after leadership. As highlighted in previous studies, process plays a major role during the implementation stage, and staff will struggle without a clearly defined process. This was considered an extremely important factor for successful implementation of BCMA and aligned with GST (Appendix II B). Therefore, the process workflow for the medication administration system (WMA) sub-criterion was considered most important, with the highest priority weight among the sub-criteria (71%).

Education (E) was considered third most important for successful system implementation, with a weight of 21% (Table IX). A previous study using DIT showed that implications for education include careful review and revision of training material to avoid conflicting statements about the capability of BCMA. Providing clinical information and staff education are of high importance for successful implementation. Therefore, without proper staff education and provision

of correct clinical information, this system cannot be implemented in a safe, sustainable manner. Documentation (D) had the highest rank among the education sub-criteria (priority weight of 31%), followed by a clinical information and alert system (CIAS) and staff training (ST) (both at 25%), patient education (PE) (12%), and awareness (A) (7%). Documentation is an important factor that should be followed in reporting any system issue. Staff should understand the importance of documentation, and be well trained in its application through the new technology so as to understand the consequences of this alert system.

Four quality and safety (QS) sub-criteria were identified. Quality process risk management (QPRM) was classified as the highest priority (51%); overall, this was the second highest/most important priority after (WMA). The quality and safety sub-criteria ranked as second, third, and fourth were culture (C) at 29%, using data to improve medication safety (UD) at 12% and performance improvement (PI) priority weight at 8%, respectively.

7.2 Chapter Summary

Bedside barcode medication verification is usually implemented in combination with an eMAR system. This allows experts to automatically document drug administration and simultaneous patient identification in a real-time manner, and has been identified as the safest method of medication administration. The system imports medication orders electronically from physician order entries or the pharmacy system. Implementation of such a system may reduce transcription errors. The key implementation dimensions of leadership, technology, process, education, and quality and safety were identified through a literature review and aligned within a relevant theoretical framework. Twenty-two sub-criteria were identified for these five domains, and a questionnaire was developed that used a nine-point scale to prioritize these criteria and sub-criteria.

The findings of this study were consistent with previous literature that highlighted leadership buy-in and involvement was the most important factor to consider when implementing change. Leadership is connected with decision-making and is essential for any organization. This reflects how setting the stage and planning are an important part of the implementation process, along with considering the project from the perspective of front-line staff. Environmental factors include the overall implementation environment as well as the physical hardware used and placement of the technology. Consistent with previous studies and the theoretical framework (GST and DIT), this study showed that having positive environmental factors and good management of change, supported by leadership as the first priority, would be reflected in staff satisfaction.

Future research may benefit from clarifying the workarounds and shortcuts taken by staff in UAE hospitals when implementing BCMA. This is a big area of shortfall in this system. There are many roadblocks that may push staff to take shortcuts and not implement the system as intended. However, no such studies have been conducted in the UAE healthcare environment. Another direction for future research may be clarifying the relationship between BCMA implementation and cost savings gained from reducing medication errors in the UAE. It is well-known internationally that implementation of BCMA will reduce costs resulting from medication errors. However, this type of research has not been conducted in the UAE, especially with regard to the cost of any healthcare errors and methods to overcome or reduce such costs.

Chapter VIII: Conclusion

8.1 Empirical Implications

The implication of introducing BCMA to patient care is strongly connected to patient safety. There are several potential sources of medical errors in hospitals, one of which is medication administration errors. Improving medication administration will have a positive impact on decreasing medical errors associated with medication administration specifically, and saving patients from harm in general. The BCMA system is intended to eliminate errors attributed to medication administered to a wrong patient, as well as allowing the system to detect such errors. In addition, the system will be able to detect if the wrong medication is administered to a patient, including timing, dosage, route, and frequency of medication, (the most common sources of medication administration errors). The BCMA system will help to eliminate all of these errors provided the implementation go smoothly and correctly. By eliminating these errors, BCMA will improve patient safety, increase the reliability of the organization, and decrease potential compensable events and patient claims. The BCMA is an innovative technology that can be used in any healthcare organization with suitable infrastructure. A future-proof technology will add value to the quality of patient care, improve safe practices, and mitigate medication errors in the UAE and wider gulf region.

8.2 Managerial Implications

This research illuminates the importance of using technology in healthcare. The 21st century is technology dependent, with exponential increases in technologies that are being developed and incorporated in practice. Healthcare is no different from any other profession that should use technology for better outcomes. The ultimate outcome of healthcare is safe and efficient patient care. BCMA is intended to help achieve this goal. Moreover, this study will support senior

management in reliable healthcare organizations to identify factors that lead to best approaches in implementing this system. Highly reliable organizations are built on valid, solid bases that lead to sound decision-making. Using scientific and clinically proven decision-making approaches will enable organization management to drive safer care. The driving factors identified in this research will enable healthcare leaders to focus on areas that best help in delivering optimum results. This approach involving prioritizing factors will, at the same time, enable leadership in healthcare organizations to expend less resources and effort on ineffectual factors.

This study should be used as a roadmap when implementing the BCMA system. It represents several different internal and external components that leaders should consider. Once an organization has determined it is ready to move forward with a BCMA system, there are many implications that must be considered. The first consideration is the presence of a strong leadership team to guide the organization through an effective implementation process, followed by obtaining the right resources and education to support successful implementation. This study is the first of its kind in a UAE hospital setting. All reviewed literature discussed BCMA implementation in other care settings in different countries. Use of the AHP model provided a scientific method of choosing among identified factors that impact on BCMA implementation.

8.3 Limitations

Despite the fact that this study makes an important contribution that may support the UAE government's 2030 vision of "World Class" care and adoption of advanced technology, it has some limitations. Although the study involved four different medical units, the sample was drawn from one specialty (medical), and the sample size may be considered insufficient to reflect the UAE context. Furthermore, data were collected from employees working in different positions. Therefore, the participants' behaviors and interactions might have been influenced by their

positions and the organizational context, which might have affected the accuracy and generalizability of the present findings. Second, future empirical studies on BCMA implementation will benefit from attempting to develop and measure relationships among the variables identified in this study. While the theoretical support for these constructs appeared to be adequate, they have yet to be empirically tested and verified.

8.4 Recommendation

A recommendation from this study is that the UAE healthcare sector should consider using BCMA as the main method of medication administration. An in-depth study and analysis of an organization's capability and capacity should be performed before implementing a BCMA system. Resource management must be in place to facilitate system implementation. Proper staff and patient education must be conducted before and during BCMA implementation. A continuous improvement process must also be in place to overcome workarounds and shortfalls of system implementation.

Likewise, nurses are primarily involved in the administration of medications across settings. However, they involved in both the dispensing and preparation of medications, such as crushing pills and drawing up a measured amount for injections. Early research on medication administration errors (MAEs) reported an error rate of 60%, mainly in the form of wrong time, wrong rate, or wrong dose (Raju et al., 1989). So, the future studies can emphasize on additional factors that have an impact in medication errors In addition, future studies can address and highlight additional factors to the five criteria that been identified earlier and expand the number of expert by involving other caregivers who deal with medication throughout the four stages of medication procedures (Ordering, transcribing, despising and administering). One more

recommendation is study other practices and procedures that can benefit from advanced technology that deal with health care to improve patient safety.

8.5 Chapter Summary

BCMA has many benefits; it reduces medication errors and enhances patient safety, and the associated leadership support will promote and endorse a positive safety culture during the implementation phase. Once implemented in medical units, the BCMA system will have a positive effect on patient safety. This influence can extend throughout the healthcare system in the Emirate of Abu Dhabi and the UAE in general. Specific factors affect implementation of the BCMA system, and these factors vary by the importance of their effect. The most important positive effect will be higher levels of safety and quality in patient care through fewer medication administration errors and adverse events.

The implication of introducing BCMA to patient care is strongly connected to patient safety. Medication administration errors are a major source of medical errors in hospitals. Improving medication administration will have a positive impact on decreasing medical errors and saving patient lives. The BCMA system is intended to eliminate errors attributed to medication administered to a wrong patient, as the system will detect such errors.

This research demonstrates the importance of using technology in healthcare, particularly as the 21st century is experiencing exponential increases in technologies that are developed and incorporated into practice. Therefore, this study may provide a roadmap for implementing the BCMA system. It represents different internal and external components that leaders should consider. This study is the first of its kind in a UAE hospital setting. Although it makes an important contribution to supporting “World Class” care and adoption of advanced technology in the UAE, there are some limitations. First, the sample was drawn from one organization in Abu Dhabi, and

the sample size may be considered insufficient to reflect the UAE context. Furthermore, data were collected from one professional group (medical). The results may be strengthened by involving different groups of employees and stakeholders from other specialties to support the improvement of patient safety across the UAE.

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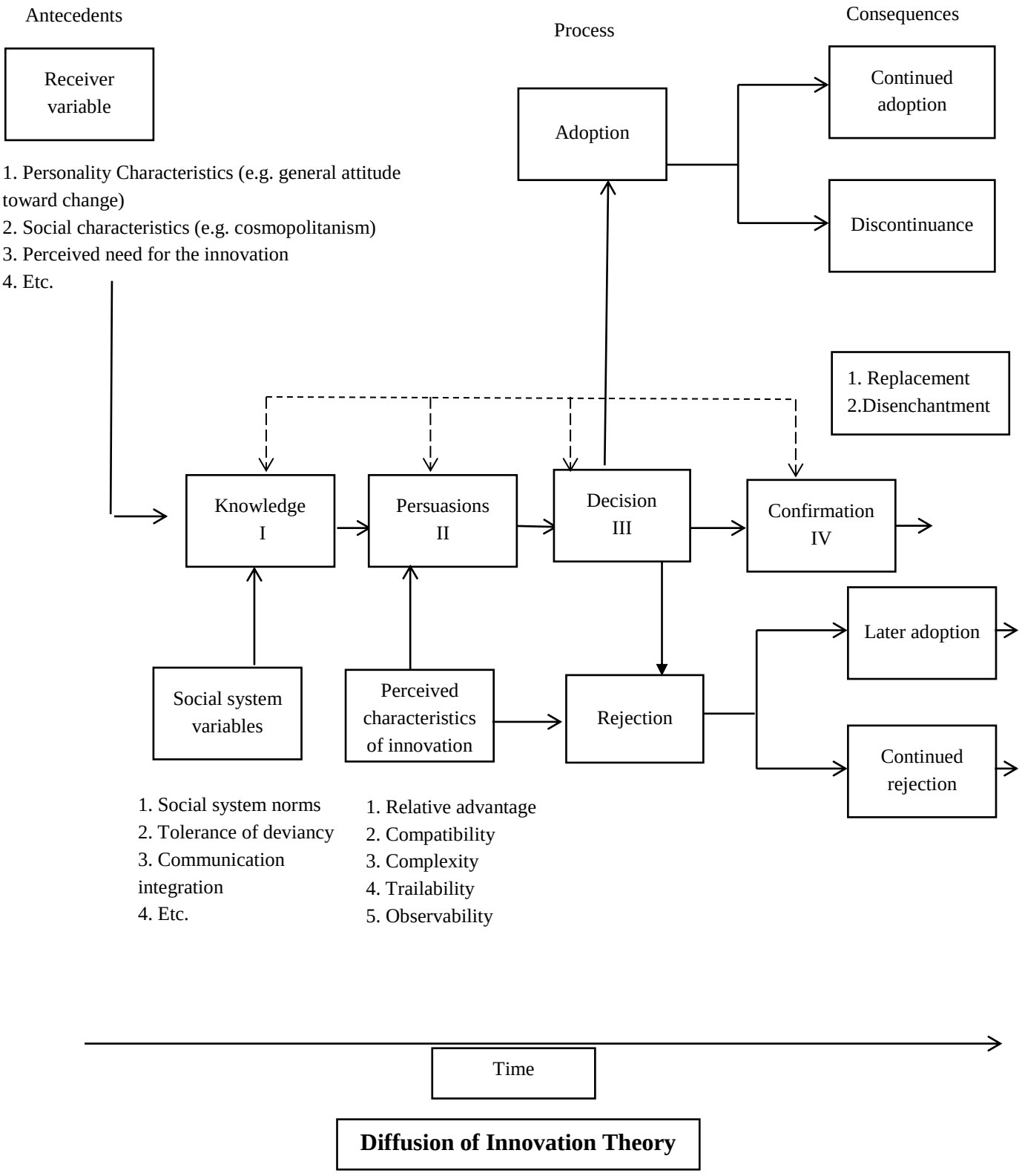
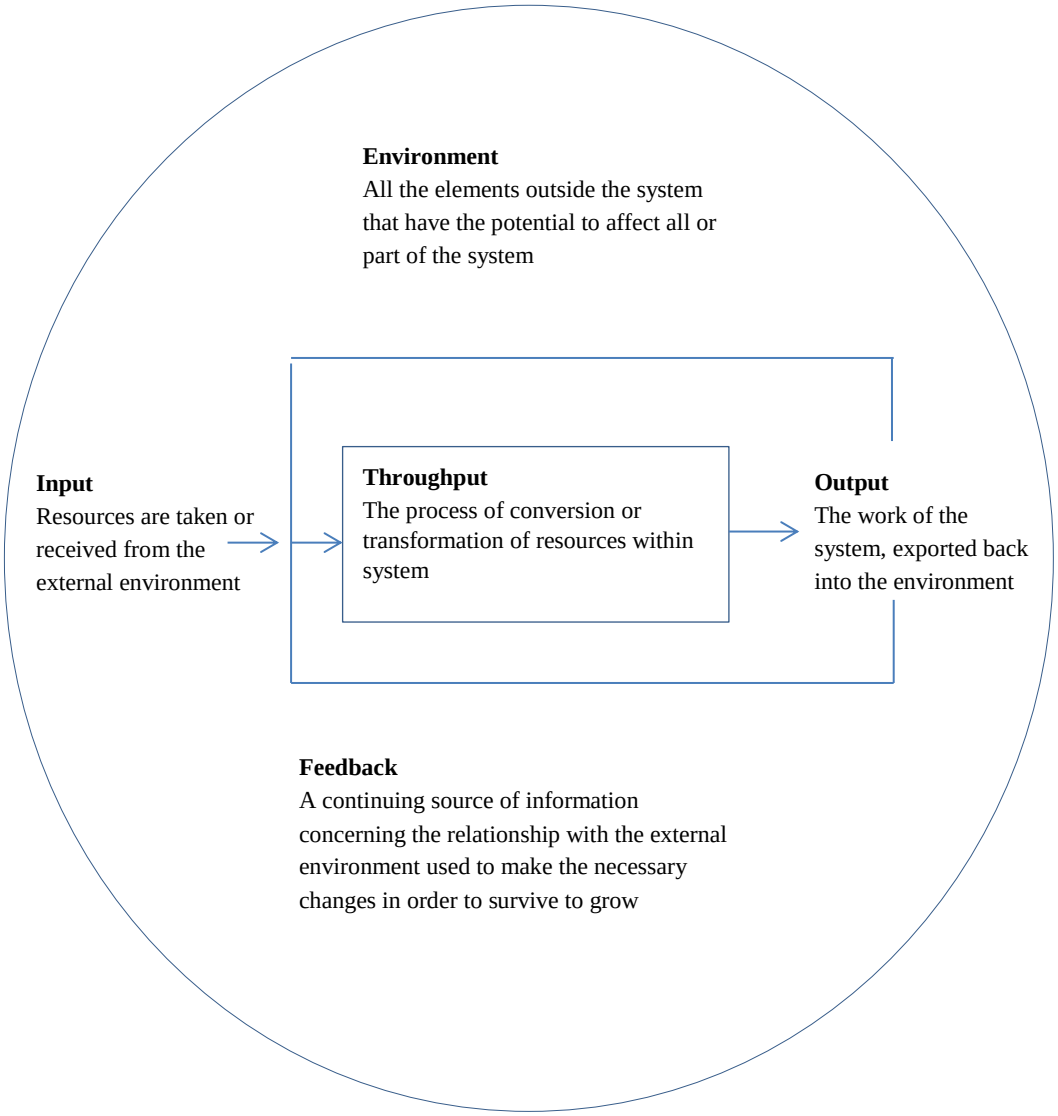
Appendix I



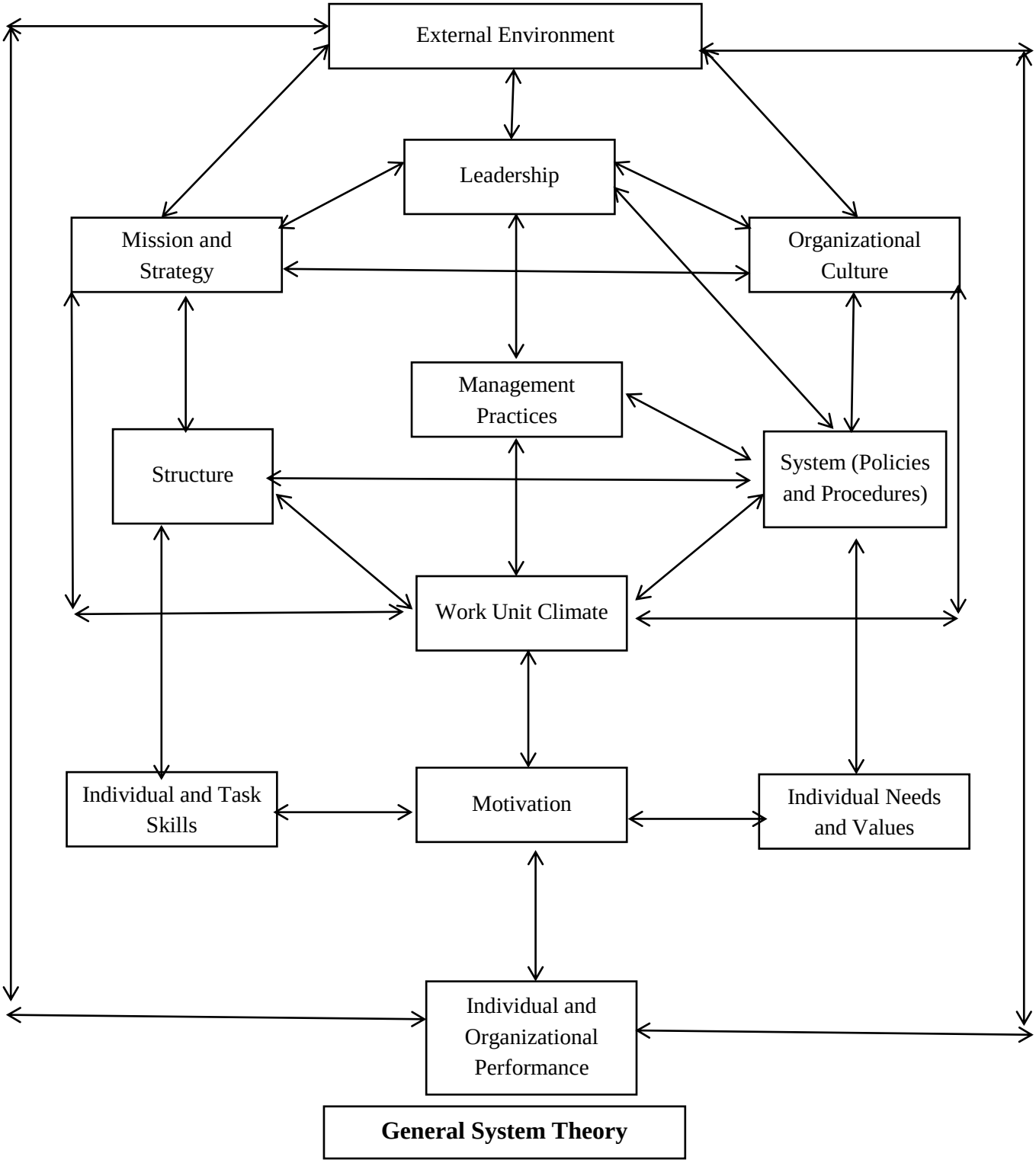
Diffusion of Innovation Theory

Appendix II (A)



General System Theory

Appendix II (B)



Appendix III

AHP Study		
	Whole Number	eg: 9
	Fraction	eg. 1/9

Section 1: Main criteria of Implementing Barcode Medication Administration System

	Equal importance 1	Between equal and moderate importance 2	Moderate importance 3	Between moderate and strong importance 4	Strong importance 5	Between strong and very strong importance 6	Very strong importance 7	Between very strong and extreme importance 8	Extreme importance 9	
Leadership										**Technology**
Leadership										**process**
Leadership										**Education**
Leadership										**Quality and Safety**
Technology										**process**
Technology										**Education**
Technology										**Quality and Safety**
process										**Education**
process										**Quality and Safety**
Education										**Quality and Safety**

Section 2: Leadership Sub Criteria										
	Equal importance 1	Between equal and moderate importance 2	Moderate importance 3	Between moderate and strong importance 4	Strong importance 5	Between strong and very strong importance 6	Very strong importance 7	Between very strong and extreme importance 8	Extreme importance 9	
Environmental Factors										Management of Change
Environmental Factors										Assessing Bar-Coding Readiness
Environmental Factors										Staff Satisfaction
Environmental Factors										Costs Assessment
Environmental Factors										Multidisciplinary Teams and Committees
Management of Change										Assessing Bar-Coding Readiness
Management of Change										Staff Satisfaction
Management of Change										Costs Assessment
Management of Change										Multidisciplinary Teams and Committees
Assessing Bar-Coding Readiness										Staff Satisfaction
Assessing Bar-Coding Readiness										Costs Assessment
Assessing Bar-Coding Readiness										Multidisciplinary Teams and Committees
Staff Satisfaction										Costs Assessment
Staff Satisfaction										Multidisciplinary Teams and Committees
Costs Assessment										Multidisciplinary Teams and Committees

Section 3: Technology Sub Criteria										
	Equal importance 1	Between equal and moderate importance 2	Moderate importance 3	Between moderate and strong importance 4	Strong importance 5	Between strong and very strong importance 6	Very strong importance 7	Between very strong and extreme importance 8	Extreme importance 9	
Technology Specifications										Usefulness
Technology Specifications										Ease of Use
Technology Specifications										User Support
Usefulness										Ease of Use
Usefulness										User Support
Ease of Use										User Support

Section 4: Process Sub Criteria										
	Equal importance 1	Between equal and moderate importance 2	Moderate importance 3	Between moderate and strong importance 4	Strong importance 5	Between strong and very strong importance 6	Very strong importance 7	Between very strong and extreme importance 8	Extreme importance 9	
Workflow of Medication Administration										Drug Labeling and Packaging
Workflow of Medication Administration										Task Characteristics
Drug Labeling and Packaging										Task Characteristics

Section 5: Education Sub Criteria										
	Equal importance 1	Between equal and moderate importance 2	Moderate importance 3	Between moderate and strong importance 4	Strong importance 5	Between strong and very strong importance 6	Very strong importance 7	Between very strong and extreme importance 8	Extreme importance 9	
Documentation										**Clinical Information and Alert System**
Documentation										**staff training**
Documentation										**Patient Education**
Documentation										**awareness**
Clinical Information and Alert System										**staff training**
Clinical Information and Alert System										**Patient Education**
Clinical Information and Alert System										**awareness**
staff training										**Patient Education**
staff training										**awareness**
Patient Education										**awareness**

Section 6: Quality and Safety Sub Criteria										
	Equal importance 1	Between equal and moderate importance 2	Moderate importance 3	Between moderate and strong importance 4	Strong importance 5	Between strong and very strong importance 6	Very strong importance 7	Between very strong and extreme importance 8	Extreme importance 9	
Quality Processes and Risk Management										Culture
Quality Processes and Risk Management										Using Data to Improve Medication Safety
Quality Processes and Risk Management										performance improvement
Culture										Using Data to Improve Medication Safety
Culture										performance improvement
Using Data to Improve Medication Safety										performance improvement