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Predictors of Radio Frequency Identification Adoption for Medication Administration in Hospitals

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This is to certify that the doctoral dissertation by

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Walden University
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Abstract

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MPhil, Walden University, 2020

MS, The New School for Social Research, 1999

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of the Requirements for the Degree of

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Abstract

Medication administration challenges within the United States hospital system have led to adverse drug events from medication errors among patients, resulting in 1.3 million emergency room visits and 350,000 hospitalizations annually. Radio frequency identification (RFID) has been identified as a useful tool within hospital systems; however, this technology has been slow to be incorporated to manage medication administration processes, necessitating exploration of predicting factors of RFID adoption. This quantitative, cross-sectional study explored the contributing factors of United States hospital's adoption of RFID for medication administration using the technology-organization-environment framework as a foundation and secondary data from the Health Information Management Systems Society's survey of United States hospitals. A binary regression analysis was used to explore the relationships between technological (RFID interoperability, networked environment, and vendor selection), organizational (hospital size, financial status, and presence of a chief information officer), and environmental (presence of an Electronic Medical Record and the attainment of Health Information and Management Systems Society Stage 6) factors as predictors of RFID adoption for medication administration. The results of this study found an association between RFID interoperability and either no association or the inability to determine a relationship between the remaining variables and RFID adoption for medication administration. This research contributes and supports social change research as it provides information for hospital leaders exploring best practices for improving medication administration in hospitals via technological solutions.

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Dedication

The years of work dedicated to the completion of this dissertation and degree program could not have been done without the support of my dear family, specifically, my husband, Macio, my sons, Devin and Broderick, my parents, Charles and Frankie Greene, and my dear Godfather, Dr. Charles Rice. I appreciate all the acts of patience, kindness, love, and support you have given me through this time.

I would also like to dedicate this work to my extended family, friends, coworkers, and peers who have listened, consulted, and provided guidance and prayer. Your patience, support, and continued mental health check-ins meant more to me than you know. I thank you all.

I did it, Dad! I did it, Charles!

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Chapter 1: Introduction to the Study

Introduction

Patient safety continues to challenge the United States healthcare delivery system where adverse drug events (ADEs) or the results of medication errors (MEs) cause approximately 1.3 million emergency department visits and 350,000 hospitalizations each year (Centers for Disease Control and Prevention, 2018). Medication administration processes are continually assessed as these MEs and resulting ADEs occur when medications are processed, prepared, dispensed, and evaluated on their effectiveness (Baraki et al., 2018). The wrong drug, dose, rate, omission, and/or time may cause an error resulting in patient harm (U.S. Department of Health & Human Services, 2018).

Hospitals have recognized the need to increase patient safety measures in their facilities via improved medication administration activities that are in line with the five rights of safe medication practice (right patient, right medication, right time, right dose, and right route; U.S. Department of Health & Human Services, 2018). Health information technologies (HIT) have been increasingly used to support quality measures, including patient safety outcomes in hospitals; however, a large majority of the data has centered on the electronic medical record (EMR; Chen, 2018; McKenna et al., 2018). Recent research has shown that other types of HIT, such as automatic identification and data capture (AIDC) methods (i.e., biometric and barcode technologies), are increasingly effective in improving patient safety and has reported success with medication administration activities (Smith-Ditizio & Smith, 2019). Radio frequency identification (RFID) technologies, a form of AIDC, are increasingly considered for medication administration use where the research supporting its effectiveness has increased within several industries but has been slow to be adopted within the United States healthcare delivery system, including hospitals.

Hospitals have been touted as complex entities where medical care is provided in a dynamic interactive matrix structure with competing goals, priorities, agencies, and paradigms that translate into inefficiencies and ineffectiveness (Aboelmaged & Hashem, 2018). This complexity compounds the difficulty of incorporating technologies such as RFID as it requires significant contextual research, financial investment, and organizational buy-in to support the business need as well as an assessment from a technological, organizational, and environmental context as these are areas that are considered complex in a hospital setting and can constrain the adoption or implementation of innovations (Aboelmaged & Hashem, 2018).

The following research addressed contributing factors to a hospital's adoption of RFID for medication administration. This chapter provided a summary of the study, its significance to healthcare, as well as its significance to social change. Also included was a description of the selected methodology used to inform the study, the conceptual framework, selected research questions, as well as identified limitations, delimitations, and assumptions to support the identified research topic.

Background

Prescription drug usage has increased over the last 10 years in the United States where 48% of the United States population has reported using at least one prescription drug, a stark change from 1994 at 38% usage (Centers for Disease Control and

Prevention, 2017a). This dramatic change is also noted in the number of individuals reporting the use of three or more drugs at 23% and those reporting the use of five or more drugs at 12%, an increase since 1994 from 11% and 3.6% respectively (Centers for Disease Control and Prevention, 2017a). There is a recognized need for thorough initiatives to create efficiencies in medication administration, processes that facilitate the safe and effective use of medications. The safety concerns and public health risks are significant, oftentimes leading to ADEs or harms resulting from the use of medications and including allergic reactions, side effects, overmedication, and MEs (Centers for Disease Control and Prevention, 2018).

This recognized need to assist with medication administration initiatives was noted through the creation of federal legislation such as the Health Information Technology for Economic and Clinical Health Act (HITECH) Act of 2009 to support the advancement of HIT capabilities throughout the United States healthcare delivery system. The adoption of HIT has led to quality, safety, and efficiencies throughout the industry, thus providing the catalyst to further incorporate specific metrics of assessing technology-enabled medication administration within the eight stages of the Health Information Management & Systems Society (HIMSS) electronic medical record adoption model (EMRAM) requirement (HIMSS Analytics, 2017).

AIDC methods support these initiatives through their abilities to support real-time flow of materials and products to minimize costs and improve efficiencies (DeBusk et al., 2021). These technologies can support customer value by way of monitoring and controlling functions; data analytics; and information sharing and collaboration abilities to identify areas of improvement within business processes, and personalized care to support provider's opportunities to positively influence patient behavior (Smith-Ditizio & Smith, 2019; Thakur & Thakur, 2019).

Research has noted that the adoption of RFID technology has lagged due to its cost relevant to its return on investment, privacy concerns, and technical limitations, such as system errors, interference with medical equipment, and interoperability with other HIT such as EMR systems (Paaske et al., 2017). These factors have influenced the identification of organizational barriers limiting RFID adoption, which include ease of use, usefulness, security, credibility, relative advantage, cost, organizational readiness, and attitudes toward use (Pool et al., 2017). Other research studies have included characteristics of the organization's employees such as gender, age, level of education, and job level as part of their organizational analysis (Fosso Wamba et al., 2016). However, these studies have not identified factors of influence of RFID adoption in hospitals, specific to medication administration in support of patient safety, hence the identified need for this research via the gap in the literature.

Problem Statement

The use of technology to assist with medication safety practices has increasingly gained the attention of legislatures to identify, develop, and implement several policy initiatives, regulations, and tools as this issue is estimated to cost $3.5 million annually across all healthcare settings (Centers for Disease Control and Prevention, 2018). RFID has emerged as a cutting-edge technology in the growing forms of AIDC methods, which also include biometrics and barcodes. RFID can capture data automatically from remote distances and hands-free using Wi-Fi-enabled tags and labels to track the exact location of patients, providers, and medications in real-time throughout the hospital and at the point of care, streamlining the medication administration and reconciliation processes with reduced MEs (Paaske et al., 2017).

Despite the growing evidence supporting the use of RFID to reduce MEs and improve patient safety within healthcare organizations, RFID has been slow to be implemented in the hospital setting (Fosso Wamba et al., 2016). Understanding the technological, organizational, and environmental influences involved in the adoption of RFID in hospitals can provide insight into the ability of this technology to support hospitals' medication administration goals and its potential to support patient safety. For example, the technical consideration of an interoperable system to support performance and operational efforts is critical to the organization as there is significant evidence attesting to the usefulness that the exchange of information between the processes, services, and data provides (Holmgren & Ford, 2018; Leal et al., 2019). Conversely, from an organizational perspective, profit organizations are more likely to consider the financial performance of a technology whereas nonprofit organizations seek to minimize associated costs (Lee et al., 2017).

Additionally, as it relates to the hospital's management structure within the organization, top management has a significant impact on RFID adoption and is considered a critical component for an organization to move from considering RFID implementation to the implementation stage (Sulaiman & Wickramasinghe, 2018; Syahrir et al., 2018). From an environmental perspective, legislation such as the HITECH Act in

2009 spurred the increased use of HIT and the establishment of the HIMSS EMRAM stage model (Adler-Milstein & Jha, 2017; HIMSS Analytics, 2017; U.S. Department of Health & Human Services, 2017). It is necessary to further explore these, and other factors and their influence on the adoption of RFID in hospitals for medication administration and efforts towards patient safety. This study expanded the literature on RFID adoption factors for medication administration with a specific focus on the technological, organizational, and environmental factors of hospitals in the United States.

Purpose of the Study

The purpose of this nonexperimental, cross-sectional quantitative study was to explore the contributing factors of United States hospital's adoption of RFID for medication administration. These factors were assessed via technological (RFID interoperability, networked environment, and vendor selection), organizational (hospital size, financial status, and presence of a chief information officer [CIO]), and environmental contexts (EMR adoption and HIMSS stage 6 certification). This study was designed to contribute to the knowledge of RFID adoption by providing an integrated view of RFID adoption and to determine the key factors that influence key decision makers' intention to adopt RFID technologies. Understanding the relationship of these aspects of the organization will provide insight into the incorporation of RFID in hospitals to support medication administration activities, leading to improved patient safety outcomes and healthcare delivery.

Research Questions and Hypotheses

The following research questions were used to guide the study to understand the relationship between the identified technological, organizational, and environmental influences of United States hospital's adoption of RFID for medication administration:

Research Question 1 (RQ1): Is there an association between hospitals' technical influences (RFID interoperability, networked environment, and vendor selection) and the adoption of RFID for medication administration?

$H_0$1: There is no association between hospitals' technical influences (RFID interoperability, networked environment, and vendor selection) and the adoption of RFID for medication administration.

H_a1: There is an association between hospitals' technical influences (RFID interoperability, networked environment, and vendor selection) and the adoption of RFID for medication administration.

Research Question 2 (RQ2): Is there an association between hospitals' organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration?

$H_0$2: There is no association between hospitals' organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration.

H_a2: There is an association between hospitals' organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration.

Research Question 3 (RQ3): Is there an association between hospitals' environmental influences (presence of an EMR and the attainment of HIMSS stage 6) and the adoption of RFID for medication administration?

$H_0$3: There is no association between hospitals' environmental influences (presence of an EMR and the attainment of HIMSS stage 6) and the adoption of RFID for medication administration.

H_a3: There is an association between hospitals' environmental influences (presence of an EMR and the attainment of HIMSS stage 6) and the adoption of RFID for medication administration.

Research Question 4 (RQ4): Is there an association between hospitals' technological (RFID interoperability, networked environment, and vendor selection), organizational (hospital size, financial status, and presence of a CIO), and environmental (presence of an EMR and the attainment of HIMSS stage 6) influences and the adoption of RFID for medication administration?

$H_0$4: There is no association between hospitals' technological (RFID interoperability, networked environment, and vendor selection), organizational (hospital size, financial status, and presence of a CIO), and environmental (presence of an EMR and the attainment of HIMSS stage 6) influences and the adoption of RFID for medication administration.

H_a4: There is an association between hospitals' technological (RFID interoperability, networked environment, and vendor selection), organizational influences (hospital size, financial status, and presence of a CIO), and environmental (presence of an EMR and the attainment of HIMSS stage 6) influences and the adoption of RFID for medication administration.

Conceptual Framework

The conceptual framework used for this study was the technology-organization-environment (TOE) theory. Originally documented in 1990 (Tornatzky, Fleischer, & Chakrabarti, 1990), this theory describes three specific contexts that influence a firm's likeliness to adopt technical innovations. The TOE is an organization-based theory that spans the process of innovation within an organization from development through to the implementation and incorporation of said innovations within the organization. It proposes three specific enterprise contexts that influence adoption and/or the implementation of innovations to include technological, organizational, and environmental, which interact with each other and influence technology decision making.

The technological context refers to those technologies currently used, those available for use, their complexities and associated learning curve, usefulness, and organizational compatibility. These technologies may include supporting hardware, software, and processes that identify the maturity level of the organization (Tornatzky et al., 1990). Based on this context, hospitals can make the decision to adopt RFID within their organizations using their current technological landscape as a gauge to identify the most appropriate RFID solutions from the marketplace of vendors. Successful implementation of RFID depends on the technological competence of the organization or its ability to use the appropriate knowledge, skill sets, and analytics to analyze the functional and technical issues within the organization, including the product's interoperability and the networked environment as well as the selection of a vendor that may support decision making (David & Jahnke, 2018; Ng & Kee, 2018).

The concept of organization is defined as the resources and the manpower available to support the innovation and refers to descriptive characteristics of the firm, such as size, structure, resources, and communication channels (Bhuyan et al., 2018; Olutoyin & Flowerday, 2016). Top management play a crucial role in HIT strategy and decision making for the organization as well as the identification of technical resources to support implementations (Bhuyan et al., 2018). The size of the hospital has shown to be an important variable to use as it has been found to have a moderating effect on RFID use and an economic benefit to the hospital (Hossain & Ahmad, 2018).

The environmental context of this theory relates to the market elements, competitors, and government regulations that are all likely to influence an organization's propensity to adopt innovation (Tornatzky et al., 1990). Hospitals are impacted by these factors where they encourage quality improvement measures that will encourage providers to improve the quality of care provided, leading to an increased quality of service and the attraction of more customers (Short & Ho, 2019).

The TOE has been used in varying types of organizations and industries as well as the social sciences to assess information technology (IT) adoption where it continues to inform the research (Kim et al., 2017). Additionally, TOE has been used to understand RFID investments leading to recommendations to improve efficiencies in healthcare, hence the reliability in applying this framework to this study (Bhattacharya & Wamba, 2018; Hossain & Ahmad, 2018). This conceptual framework informed the RQs and helped identify research design decisions.

Nature of the Study

The nature of this study was quantitative, nonexperimental, and cross-sectional in research and design. According to Queirós et al. (2017), quantitative research is highly utilized in human services as the preferred methodology where the statistical analysis is leveraged not only to investigate existing problems and future trends but also to inform policy. Additionally, the statistical nature of quantitative research allows for the study to be repeated, using the same formula or methods with different samples for comparison (Queirós et al., 2017). Different from qualitative research designs, quantitative research does not allow for interpretation from the researcher via an understanding of participant perspectives but allows generalization of the findings to a population using numerical data and measurable variables (Park & Park, 2016). The findings from this study on RFID adoption for medication safety was generalized to the total population of United States hospitals.

The use of a cross-sectional design allows for the focus or measurement on existing differences between selected phenomena at a certain point in time, the use of existing and large data sets of data, and secondary data sets, which all allow for inferences based on the findings (Setia, 2016). This study leveraged secondary data from the HIMSS Analytics Database and focused on hospital data as they related to RFID adoption in United States hospitals. Additionally, as this study was non-experimental, I did not manipulate the data, which allowed for conclusions to be drawn from the data provided.

Definitions

The following are definitions of terms and phrases used throughout this study:

Adverse drug events (ADEs): Harms resulting from the use of medication and include allergic reactions, side effects, overmedication, and MEs (Centers for Disease Control and Prevention, 2018).

American Recovery and Reinvestment Act of 2009: An economic stimulus package that provides appropriations for employment, infrastructure investment, energy efficiency, and fiscal stabilization purposes (Congress, n.d.).

Automatic identification and data capture (AIDC): Category of technologies used to collect data from individuals, objects, or images with little to no human intervention and entered directly into computer systems that are used to track inventory, assets, delivery, security, and documents (Patil & Patil, 2018)

Electronic health record (EHR): An electronic database that stores records of patient health information that focuses on the overall health of the individual (i.e., patient demographics, progress notes, medications, past medical history, immunizations) using the patient encounter to support its evidence-based decision support, quality management, and outcomes reporting (HIMSS, 2018a).

Electronic medical record (EMR): A digital database that stores patient information collected during a medical visit by clinicians in that office, clinic, or hospital for the purpose of diagnosis and treatment (HealthIT.gov, 2019).

Electronic medical record adoption model (EMRAM): Algorithm depicting stages of EMR adoption and system capabilities to automatically score hospitals' progression to a near paperless state (HIMSS Analytics, 2017).

The Health Information Technology for Economic and Clinical Health (HITECH) Act: Law enacted in 2009 as part of the American Recovery and Reinvestment Act that promotes the use of information technology adoption and meaningful use of health information technology as well as increased identification and criminal enforcement of the Health Information Portability and Accountability Act privacy and security concerns associated with the electronic transmission of medical records (U.S. Department of Health & Human Services, 2017).

Healthcare information and management systems society (HIMSS): A nonprofit organization dedicated to the support of health through information and technology, leveraging industry experts, predictive data modeling, and best practices for improved healthcare outcomes (HIMSS, 2018).

Medication Error (ME): "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 health care professional, patient, or consumer" (National Coordinating Council for Medication Error Reporting and Prevention, 2020, para. 1).

Networked environment: A communications system that ties multiple users together (The Free Dictionary, n.d.). This network is comprised of computers that are linked to share resources and an exchange of data via an electronic connection.

Radio frequency identification (RFID): A technology that uses radio waves to automatically identify people or objects, using transponders to relay identification information to a reader where it is stored in a digital format that can be passed on to computers for analysis (RFID Journal, 2020a).

Assumptions

The assumptions identified in this study were consistent with those associated to quantitative research methods and the use of secondary data (Clarke & Cossette, 2016). It was assumed that the HIMSS data set used was indeed a comprehensive compilation of the use, implementation, and planning status of HIT, inclusive of more than 90% of United States hospitals and that the information provided from these organizations of their use or planned use of RFID technology was a true representation of their organization at the time of data collection. According to Fulton (2018), key leaders have the most access to proprietary data and have the most historical knowledge of the organization's history and activities but are the least likely to respond to organizational studies. Per the requirements of the HIMSS research team, the data submitted should be from an authorized leader of the organization who could attest to its validity.

Scope and Delimitations

The scope of this study included an analysis of the technical, organization, and environmental factors on RFID adoption in United States hospitals for medication administration and safety practices. The scope was limited to the data contained in the secondary data set as it was comprehensive of the United States hospitals surveyed and was inclusive of the technical, organization, and environmental factors that were used in the analysis. The secondary data used contained information solely pertinent to hospital units and did not include any personal health identifiers or patient level information. Additionally, the data did not include information for federal hospitals. The delimitations of the study were the selected independent variables, which represented the underpinnings of United States hospitals and represented a reasonable cross-section of the concept.

Limitations

Limitations are those influences for which the researcher has no control. A limitation identified for this study included the validity and reliability of the data collected in response to the HIMSS survey, which could not be verified and were assumed to be truthful accounts of the hospitals' use, implementation, and planning status of HIT hardware, software, and infrastructure (see Jordan, 2018). Additionally, responses to the nonmandated HIMSS survey were received from 90% of nonfederal United States hospitals, which may call into question the representativeness of the sample to draw conclusions; however, it is considered the most comprehensive database for hospital information technology.

Significance

Technological change introduces a level of uncertainty within an organization where it is difficult to predict future outcomes. The outcomes of this research may influence the adoption trends of specific HIT-related technologies such as RFID, affording decision makers with the necessary data to allocate funds and incorporate these technologies throughout their organizations based on the evidence-based research provided. This evidence-based research can advance the knowledge gained through social sciences research, contributing to the research on RFID and its adoption in healthcare organizations.

Technology has an instrumental effect on social change where, according to Ogburn (as cited in Mutekwe, 2012), as technology changes, the culture makes a shift to adapt its systems and processes to meet the need. The social change significance of this research relates to its support of the American Recovery and Reinvestment Act of 2009, specifically the Title XIII statute establishing the HITECH Act, which supports the improvement of healthcare quality, safety, and efficiency through the use of IT whereby this research may provide a means toward reducing MEs, increasing patient safety measures and medication administration practices in United States hospitals (Text - H.R.1 - 111th Congress [2009-2010]).

Summary

The purpose of this study was to explore the factors of RFID adoption in United States hospitals for medication administration. This chapter provided an overview of the research to include a background of the study, its purpose, and its significance to the discipline as well as its significance to social change. I identified opportunities for RFID as a technological tool to support healthcare policy and regulations associated to medication safety initiatives. The exploration of RFID as a technological opportunity to improve medication administration practices may not only lead to improvements in patient safety in hospitals but may also pose an opportunity for larger adoption and application in other areas of the United States healthcare delivery system, promoting a culture of patient safety.

Chapter 2 provided a review of the literature and was organized to provide a summary of related evidence-based literature and supporting synthesis. I also identified gaps in the literature that this research helped to fill.

Chapter 2: Literature Review

Introduction

Patient safety is a serious public health issue in the United States healthcare industry and the value of incorporating advanced EMRAM levels of EMR certification and HIT-enabled technologies for medication administration may aid in the prevention of ADEs though the use of technology remains high (HIMSS Analytics, 2018). As hospitals are increasingly seeking full compliance with these regulations, many are incorporating additional HIT-enabled technologies to aid in medication administration processes; however, they often struggle with incorporating technologies within such complex organizational structures. As RFID continues to make gains in its usefulness within the industry, it would prove useful to assess the contributing factors of RFID adoption within United States hospitals for medication administration. Using a nonexperimental, cross-sectional quantitative study research design, I focused on specific technological, organizational, and environmental factors. This study was designed to contribute to the knowledge of RFID adoption by providing an integrated view of RFID adoption and to determine the key factors that influence decision makers' intention to adopt RFID technologies. Understanding the relationship of these aspects of the organization can provide insight into the incorporation of RFID in hospitals to support medication administration activities, leading to patient safety outcomes and improved healthcare delivery.

This chapter focused on a review of the literature supporting the need to conduct the study. It included the search strategy used to identify pertinent research, a discussion of the theoretical foundation used to guide the study, and a literature review related to key variables and concepts that were identified through a gap in the literature related to RFID adoption for medication administration.

Literature Search Strategy

The literature search strategy was developed to produce the most optimal results of relevant research information related to the area of RFID adoption and concepts supporting this research. It included an identification of the search engines, terms, and a description of the databases used as well as the scope of the literature review to include years searched and types of literature and sources searched.

Search Engines, Databases, and Search Terms

The search for relevant research began with an identification of search terms to be used to gather and retrieve a broad, yet relevant body of scholarly literature. Terms used included *RFID, RFID adoption, hospital technology adoption, medication administration,* and *healthcare technology legislation and policy to include EMRAM* and *HITECH*. Additionally, the variables selected for use in this study as they related to technology adoption including *RFID interoperability, networked environment, vendor selection, hospital organization size, financial status, presence of a CIO, presence of an EMR,* and *HIMSS EMRAM certification* were included in the search terms. These terms were used independently as well as in combination to maximize results.

Google and Google Scholar were the primary search engines used for their accessibility, convenience, and far-reaching ability to retrieve related literature using their search algorithms. Health Science databases including CINAHL, MEDLINE, ProQuest, and PubMed as well as Information Systems and Technology Databases including the Association for Computing Machinery Digital Library, Computers and Applied Science Complete, and ProQuest Computing were selected for their relevance to the search terms and content. These databases maintain up-to-date peer-reviewed data related to clinical research, healthcare systems, new technologies, and technology management in social and professional contexts. In addition to these resources, peer-reviewed journal articles, official government websites, and conference materials related to medication administration and patient safety, legislative support for this technology in healthcare, and RFID adoption were also referenced where the time period used for the inclusion of relevant literature was between 2016 to present, with outliers related to the theoretical foundation used and the evolution of RFID technology in the healthcare sector.

Theoretical Foundation

Technology-Organization-Environment Theory

The conceptual framework used for this study was the TOE theory. Originally documented in 1990 (Tornatzky et al., 1990), this theory was developed to explain an organization's adoption of technical innovation in which the authors theorized that innovation adoption takes place at the organizational level and may be influenced by factors associated to the theory's concepts (Yoon & George, 2013). It proposed three specific enterprise contexts that influence adoption and/or the implementation of innovations to include technology (currently used and those available for use), organization (descriptive characteristics of the firm such as size, structure, resources, and communication channels), and environment (market elements, competitors, and government regulations; Awa et al., 2016; Thomas et al., 2016).

The technological context of this theory included all the technology related to the organization, including those that are currently in use and those that are available for use in the market. According to Tornatzky et al. (1990), the technologies currently in use within the organization have an impact on business processes, procedures, and needs where the technological landscape is considered when assessing the incorporation of any new technologies, hence influencing technology adoption decisions. The same influence can be applied from technologies being considered and/or available in the marketplace for use where they are limited to showcase their functioning abilities to assist the organization evolve and adapt in their respective field. The TOE theory purports that the descriptive characteristics of organization such as its size, structure, resources, and communication channels have a propensity to influence innovation adoption. Per Tornatzky et al. (1990), these characteristics comprise the theory’s organizational context where the presence or lack of the inner workings of these factors also influence technology decisions. The environmental context of this theory is related to the market elements, competitors, and government regulations that are all likely to influence an organization's propensity to adopt innovation (Tornatzky et al., 1990).

Alternative theories were assessed for applicability to this study; however, they did not meet the scope of the research from an organizational perspective and/or were geared towards human behaviors, hence additional support for the use of the TOE theory. The diffusion of innovations (DOI) was among the initial theories developed to assess innovation acceptance and adoption of technological innovations where the theory posits that members of a social system communicate or diffuse information regarding an innovation, which then goes through several stages, including understanding, persuasion, decision, implementation, and confirmation, leading to the adoption of said technologies (Rogers, Singhal, & Quinlan, 2014). According to this theory, innovation is an idea, process, or technology that is new to individuals within the social system, which is then communicated throughout the organization via various communication channels (i.e., mass media and interpersonal communication; Lambert, 2019).

This theory has demonstrated its usefulness in research related to the study of individuals' adoption of new healthcare information technologies, assisting in the explanation of the social processes that occur (Davidson et al., 2018; Dearing & Cox, 2018; Dearing et al., 2017; Lambert, 2019). However, critics of the DOI theory have contended that using behavioral-based models to assess innovation acceptance and adoption weakens the argument as there are cultural and economic differences between individuals that may influence decision making, an undetermined link between the innovation properties and a proper expected attitude, and conflicting information available regarding the innovation (Daim et al., 2016). The power of this theory to explain the adoption of technology is limited to its focus on system characteristics, organizational attributes, and environmental aspects (Taherdoost, 2018). Due to these criticisms and the theory's focus on the individual and social networks of the organization, this theory would not have been helpful to assess the factors affecting RFID adoption in hospitals for medication administration as this was not a focus of the research.

The technology acceptance model is used to assess technology innovation acceptance and adoption via behavioral-based reasoning on how users leverage personal reasoning towards the adoption of technology (Davis, 1989). Included and assessed in this model are two specific beliefs: perceived usefulness and perceived ease of use,) which defines the potential user's likelihood of the system to improve their action and for the system to be effortless in its use (Davis, 1989; Lai, 2017).

This theory has also proved its usefulness in explaining RFID adoption-related research results; however, it does not consider external barriers and factors on technology adoption (Werber et al., 2018). Additionally, it is limited by its inability to explain some of its results and its effect of social, individual, and cultural influences on the acceptance of technology, and it lacks full measures that prove its validity, which led to later revisions of the theory (Dwivedi et al., 2019; Zhang et al., 2019). These limitations also deem this theory non useful to assess factors affecting RFID adoption in hospitals for medication administration.

Venkatesh et al. (2003) identified other factors as relevant in the assessment of technology innovation acceptance and adoption using four predictors of users' behavioral intention (performance expectancy, effort expectancy, social influence, and facilitating conditions), a combination of constructs used in the technology acceptance model and other theories (Lai, 2017). Similar to the DOI theory and the technology acceptance model, the unified theory of acceptance and use of technology theory is largely used in assessing an individual's behavior as it relates to the adoption of technology. Specific to this theory, it is unclear as to whether actual usage or behavioral intention is measured as well as the quantitative benefits of adopting a technology (Rautiainen, 2017; Shachak et al., 2019). As the methodology selected for this research was quantitative, the unified theory of acceptance and use of technology theory was not applicable to this research.

TOE and RFID Adoption

The TOE has been used in varying types of organizations to assess IT adoption and has been increasingly used in the healthcare industry and other areas of social sciences research where it continues to prove effective (Kim et al., 2017). Additionally, TOE has been used to assess RFID investments leading to recommendations to improve efficiencies in healthcare, hence the reliability in applying this framework to this study to inform the RQs and help identify research design decisions (see Bhattacharya & Wamba, 2018). Abugabah (2017) developed an incorporated view of a theoretical framework examining the factors of RFID adoption using the contexts of technology adoption theories including TOE, as many of the contexts contain similar characteristics. In a survey to employees of six government hospitals in varying cities of the United Arab Emirates, this quantitative study extended the TOE theory to include economic and human factor contexts to determine RFID adoption where the results identified that all of these factors have a significant effect on the adoption of RFID within the hospital setting, with the most significant factors being the technological context followed by the human factor, and environmental and organizational contexts such as upper management buy-in (Abugabah, 2017). The author summarized the need to explore these factors prior to the adoption of RFID as these factors have varying levels of influence and therefore implications to a successful implementation.

A review of technological factors was considered for an RFID proof-of-concept system developed by Álvarez López et al. (2018) to track medical items and medications in a Spain-based hospital where the proposed architecture was integrated within the medical systems and network infrastructures of hospitals. Once integrated within the hospital, testing of the proposed application showed positive results where the tags were able to read and identify medications accordingly (identifying tagged items correctly if within or out of the service areas); and update readings once items were moved to another location outfitted with RFID capabilities (Álvarez López et al., 2018). The authors contended that the value-add for this research lied in the technological considerations of the software such as an understanding of its hardware, the advantages and limitations of different kinds of RFID technology, and its coverage and effects (intended and unintended) on specified services as well as its ability to connect and adapt to the existing network infrastructure or wireless networks, and a review of the product offerings to include low-cost, disposable sensors that can be tagged. These studies provided support for the applicability and use of the TOE framework for assessing RFID via an understanding of how the technological variables influenced RFID adoption and may provide the same insight on this research of RFID using similar variables.

Literature Review Related to Key Variables and/or Concepts

About RFID

RFID is a form of AIDC technology that is used to identify and collect data about objects electronically, transferring and storing the data into computer systems, without human involvement. RFID does not require line-of-sight readers from its tags yet uses three specific components to capture data: a transponder (tag), a transponder reader, and a database software application (Paaske et al., 2017). RFID tags have microchips and an antenna that are attached to the item or individual for tracking/data collection and can be classified as active (battery-powered), passive (the reader signal is used for activation) or semi passive (battery assisted, activated by a signal from the reader; Turcu, 2017). The reader is responsible for communicating with the tag using the antenna and radiofrequency signals to identify the data within the tag as well as the location of the item (Paaske et al., 2017). This information is stored within the organization's database using an RFID-enabled network and software for information processing and retrieval by users (Duroc & Tedjini, 2018).

RFID vs Barcode Technology

There are other forms of AIDC, including biometrics, optical scanner recognition, magnetic stripes, and barcodes technologies, which have been more widely used in healthcare settings including hospitals to automate processes and improve operations management (Jain et al., 2017). Barcode technologies have been more widely associated in its functionality to RFID as they both work well for tracking purposes, collecting data, and their data storage and retrieval functions; however, RFID has several advantages over barcode technology. Barcode labels are printed, placed on an item, and are susceptible to wrinkle and/or fade over time, making it more likely that the barcode will error upon matching the correct patient with the correct medications, which is a large issue within medication administration processes (Lotlikar et al., 2013). RFID tags are less sensitive to adverse conditions, creating a near flawless read rate where medical and human errors caused by patient misidentification are reduced as they are made using bonded in-lay components, affixing three different substrate layers of components (Haddara & Staaby, 2018; Smith et al., 2018).

Barcodes are designed to be read one item at a time using human interaction with a scanner device to be in proximity of the barcoded label. The scanner devices require line-of-sight access to each label for the accurate recording of the data associated to the label. Barcode technologies require manual tracking, the identification of a type of item, and can only read data within a range of several inches to feet (Lotlikar et al., 2013).

Conversely, RFID tags do not require human intervention, thereby reducing human resource costs and errors during data collection (Khattab et al., 2017). RFID tags have a longer range than barcodes (30 feet to 100s of feet, depending on active vs passive tags) to identify data due to its reliance on radio waves and antennas for its basic functioning (Lotlikar at al., 2013). RFID tags can also store larger amounts of data than barcodes, which is a very distinct difference between the two as RFID can store 2,000 bytes of data where barcodes can store up to 85 characters (Nilsson & Elmar Merkle, 2018). Additionally, as noted in Table 1, RFID systems have read/write functionalities to process more than one tag simultaneously and more flexibility to be attached to items as they are small in stature and do not require line of sight readers (Ishtiaq et al., 2019).

These benefits are a realistic challenge for hospitals implementing RFID as their hospital IT systems may require a level of sophistication, including interoperability and integration capabilities (Haddara & Staaby, 2018; Kumar & Ting, 2019). Further, if these IT systems are not in place, this may pose a challenge to many hospitals as the costs associated to adopting RFID begins ~$0.07- $25 for tags ($200- $2,000 for readers) versus $0.01-$0.05 for barcodes (RFID Journal, 2020b).

Table 1

Comparison: Barcode and RFID

Characteristic	Barcode	RFID
Design	Printed; susceptible to wrinkling and fading over time.	Bonded in-lay components on different substrate.
Usage requirements	Requires human intervention using a line-of-sight reader to scan each item individually.	Does not require human intervention; uses radio frequency waves to identify objects.
Read rate	Line of sight required; identifies items individually but not uniquely.	Uses radio waves to identify multiple items uniquely.
Reach	Inches to several feet	30 feet to 100’s of feet
Data storage	~85 characters	2,000 bytes of data storage
Cost	$0.01-$0.05	~$0.07 and up (depending on passive or active)

Technological Contexts for HIT Adoption

The use of technology as a variable in assessing HIT adoption is considered key as its contexts have been found to influence decision-making. The technology context of the TOE framework relates to all the technology related to the organization, including those that are currently in use and those that are available for use in the market (Evwiekpaefe et al., 2018; Tornatzky et al., 1990). Specific to the technological contexts for HIT adoption, the technological factors selected to assess RFID adoption will include interoperability, networked environment, and vendor selection.

Interoperability

The interoperability of a platform is a commonly utilized characteristic of a technology that is assessed. Interoperability refers to the ability of two or more systems to integrate between all shared information services, taking into consideration its scalability, flexibility, portability, and security as well as its ability to ensure continuity of data, process, and context (Oyeyemi & Scott, 2018; Azarm et al., 2017). The challenge confronted with the interoperability of many platforms are the limits placed on its architecture where the standards and heterogeneity among each may differ, causing increased challenges for industries, especially within healthcare delivery as its clinical, medical, and administrative systems exhibit these limitations (Satti et al, 2019). The heterogeneity of these platforms includes the lack in plug and play integration, infrastructure functionality including physical location and positioning, security and privacy, data management as well as the identification of application areas prudent for the technology (Rajkumar et al., 2018).

RFID is a technology that has not matured in the marketplace as there isn't a 'one size fits all' with this technology that allows for the ease of integration within the current technological landscape of an organization, causing the technology to function improperly and increase its risk of interference if considerable effort is not spent on integrating RFID properly into an organization's existing business processes (Gillenson et al., 2019).

A significant characteristic of RFID technology is its hardware (tags and readers) and software (database application) components, needed to fully function within any environment, including healthcare organizations (Abugabah et al., 2020). According to Almanaseer (2019), the technological make-up of RFID systems has been known to cause interference in hospitals with medical/surgical equipment and other HIT, increasing the read failure rate of RFID tags and other system errors. Further, standardization across software and vendors as well as the lack of international RFID standards have further impeded the incorporation of this software into hospital systems (Almanaseer, 2019). This standardization would call for a unified language and operating mechanism that is easily understood by all systems in a global environment as well as the interoperability and communication between them, lending to further research in this area (Hadjer et al., 2019; Tu et al, 2019).

Although there are no standards between various applications and vendors supporting healthcare services within the hospitals, there are technical standards that support applications using a wireless connection. 802.11 and 802.11X, originally created in 1997 and revised in 1999, are a family of specifications for wireless local access network (WLAN) technology which establishes the speed of data transmission between the router and devices connected to it wirelessly as well as ensures that devices maintain their connectivity to the router where they coordinate the distribution of data between the router and devices (IEEE Standards Association, 2020). The use of WLAN that meets 802.11 and 802.11X specifications assists with the interoperability challenges of RFID and other wireless-related technologies within the hospital setting (Tamai et al., 2019; Deepika & Usha, 2017). This research assesses interoperability as a technological factor in adopting RFID for medication administration by the identification of these specifications with the hospital setting.

Networked Environment

A networked environment is a communications system that ties multiple users together (The Free Dictionary, n.d.). This is achieved via a group of computers, servers, mainframes, and other devices supporting the organization’s infrastructure that allow the sharing of data, is also a key characteristic of a technology that is assessed. To compound the challenges that networking presents for connection, technology has continued to transform in this area from a wired network (connected devices via cables) to a wireless network; however, the hospitals in the United States are challenged to incorporate these technologies due to power efficiencies of sensors; standards and protocols; network mobility; and scalability, hence its inclusion in the assessment of HIT for adoption (Dantu et al., 2019).

RFID systems are generally tied to the internet and the network of systems supporting these connections are a key consideration for its adoption. The use of complimentary hardware and software networks and systems are a challenge as uniformity amongst RFID manufacturers and standards does not exist. The networking of an embedded system integrating all these parts is critical to the safety and reliability of a connected system within a clinical environment (Misser et al, 2020; Nursuwars & Rahmatulloh, 2019). For example, Song et al. (2020) discussed how the use of internet of things such as RFID could improve medical conditions such as severe acute respiratory infections and recommend an enhancement of the distributed network where sensors must communicate with services such as the Internet and wireless networks such that information can be relayed to remote health workers. This recommendation can be furthered by this research where the networked environment to support RFID adoption in hospitals for medication administration was included as an assessment variable.

Vendor Selection

The identification of technology vendors is also considered a characteristic highly used for HIT adoption as the technological offerings of products may vary from vendor to vendor. Patri and Suresh (2018) identify the vendor selection process as a key factor in influencing technology implementations in healthcare organizations, as this process must be strategically aligned, planned, and agreed upon within the organization to prevent future implementation and functionality changes. According to Norton et al. (2019) vendors develop a wide variety of software capabilities to facilitate patient engagement and performance measurement, causing an increased digital divide among healthcare organizations. Additionally, the authors refer to the resources available to support new HIT systems where it was found that larger healthcare systems that allocate resources and purchase software centrally have more bargaining power with vendors, allowing increased adoption capabilities (Norton et al., 2019).

Vendor selection is also seen as a challenging factor to hospital's adoption of HIT as healthcare organizations are unique and bring a myriad of considerations to the decision-making process. Stillwell et al. (2018) identified a lack of research in the vendor selection process as it relates to EHRs in targeted areas such as time management; patient, provider, and other medical team collaboration, and access to data including physician notes and test results.

Vendor selection challenges were also identified among healthcare practitioners via a qualitative study of their perceptions in the adoption and implementation of HIT where a main descriptive outcome of these challenges was the lack of vendor understanding of the organizational environment and the specific workflows supporting patient care, contributing to user frustration (Mukono & Tokosi, 2019). This data led to the recommendation to use in-house IT staff or local vendors to develop the IT as this will increase the engagement and involvement of key users of HIT to improve ownership and acceptance of the system (Mukono & Tokosi, 2019).

Makhni et al. (2017) explored the results of HIT innovation at healthcare institutions throughout the United States as the level of innovation was much lower as compared to well-established drug and device industries. In comparison of the two industries through the HIT processes of discovery, proof of concept, regulatory review, and post-market monitoring and distribution, the process of HIT innovations were not held to the same standards where there is a breakdown in several areas including the lack of review expertise and capabilities where the reliance on vendors is high and often does not meet the claims made (Makhni et al., 2017). Additionally, the authors cite a lack of post-market transparency where vendors lack incentives to provide unfavorable data and are unable to identify or articulate clear financial savings (Makhni et al, 2017). This data led to the recommendations for regulatory and third-party monitoring, institutional alignment of relevant bodies to create visibility for decision-makers to fully evaluate the innovation (Makhni et al, 2017).

The identification of characteristics leading to the variability among health systems in the adoption of advanced HIT such as predictive analytics and patients access to records was conducted by the National Survey of Healthcare Organizations and Systems (NSHOS) which found 78.9% of health systems reported conducting vendor selection at the system level which indicates that the people, organizations, and actions of these systems are integral to the decision-making process (Norton et al., 2019). These findings lead to the recommendation of standardization and uniformity of technology across systems including the consideration among HIT vendors of ways to standardize products across systems to ensure greater adoption (Norton et al., 2019).

RFID products are not exempt from the heterogeneity found amongst RFID vendors as, common to other technologies, the number of companies developing and marketing RFID products are vast, increasing the heterogeneity of products and vendor-supported services. Aboelmaged and Hashem (2018) discussed the application of RFID in patient and medical asset operations management where the technical complexities of health care organizations impede the adoption of RFID systems in managing patients and asset operations. Vendors of RFID services were identified as playing a crucial role to better understand RFID implementation issues, increase its technology fit into service operations, and accelerate its implementation (Aboelmaged & Hashem, 2018). Thus, vendor selection as a key variable to assess RFID adoption in the hospital environment for medication administration.

Organizational Context for HIT Adoption

The organizational context of this theory in assessing HIT adoption is also considered key as its factors have been found to influence decision-making. The organizational context of the TOE framework relates to all the descriptive characteristics of the firm such as size, structure, resources, and communication channels (Evwiekpaefe et al., 2018; Tornatzky et al., 1990). Specific to the organizational contexts for HIT adoption, the organizational factors selected to assess RFID adoption will include hospital size, financial status, and presence of a CIO.

Hospital Size

Hospital size is oftentimes viewed by the number of functional units or areas of the hospital such as clinical laboratories, imaging, emergency rooms, and surgery; hospitality functions, such as food service and housekeeping; and the fundamental inpatient care or bed-related functions which can have competing priorities and influence technological opportunities (National Institute of Building Science, 2019). However, hospital size is derived by the number of beds that can be used for patient care services and medical treatment (Centers for Medicare and Medicaid Services, 2019-a).

Hospital size (specifically the number of beds) is a driver of HIT adoption as noted by Almeida et al. (2017). A 10-year literature review during the period 2004-2014 for a proposed theoretical framework on the organizational drivers of technology adoption supported the inclusion of organizational size, structure, and innovativeness of senior executives are key drivers of technology adoption and are recommended for inclusion in the development of theoretical frameworks conducting research pertaining to this subject area (Almeida et al., 2017).

These findings were also supported by Feibert and Jacobsen (2019), in their study on factors impacting technology adoption in hospital bed logistics, hospital size and staffing levels were significant indicators of hospital quality which should be assessed prior to adopting technology. The authors state that the bed logistics process involves several different organizational units including general cleaning staff and nurses where the number of staff involved in the bed logistics process increases the fragmentation of services and requires collaboration between several staff and groups (Feibert & Jacobsen, 2019).

Hospital Financial Status

The identification of the hospital's financial status may exhibit differences in the use of HIT; however, this research was not able to draw a supporting conclusion on this characteristic (Williams et al., 2016). Conversely, HIT adoption among for-profit hospitals was significantly higher than nonprofit hospitals when hospital characteristics associated with complete and partial implementation of EHRs were assessed (Bhounsule & Peterson, 2016). In a retrospective cross-sectional study using the 2012 American

Hospital Association Annual Survey Database, the authors assessed several organizational factors including size, ownership, staffing, and services where larger-sized hospitals were associated with increased instances of EHR adoption and hospitals with higher staffing, a function of larger size, have the financial means to invest in progressive strategies such as HIT adoption (Bhounsule & Peterson, 2016).

Presence of a CIO

Traditionally, the role of the Chief Information Officer within the hospital is a non-medical professional with expertise in managing all things IT including the people, processes, policy, and financial aspects of IT within the hospital environment (Sridharan et al., 2018). The role of the CIO has shown to foster innovation within hospitals through strategic visioning, guidance, and implementation of technology where the resulting process innovations lead to improved organizational outcomes (Esdar et al., 2017). Substantiating the role of CIOs is challenging as there is no scientific evidence supporting the innovation capabilities of CIOs in healthcare including the hospital setting (Esdar et al., 2017). An empirical assessment of the innovation capabilities of hospital CIOs was conducted via an online survey of 1,284 German-based CIOs where the data identified that the hospital organizational environment, specifically the financial promotion and strategic support from top management, is aligned to HIT innovation (Esdar et al., 2017). Additionally, the data supported an entrepreneurship personality (personal motivation and self-determination) and the openness towards users (i.e., their participation and involvement, Esdar et al., 2017).

Liebe et al. (2017) furthered these empirical findings on the innovative capability of hospital CIOs via research on the antecedent or pre-existing origin of CIOs' innovation capability utilizing a regression analysis on the same dataset to measure the perceived innovation capability of CIOs. Using the results of the previous study to build a composite score tool along with attributes of the variables resulting in valid relationships (innovative organizational culture, intrapreneurial personality and openness towards users), the data found that CIOs' innovation capability can be significantly explained by a formalized, intense, professional and strategic cooperation between the CIO and the hospital board and a function of management conditions, lending the role to be a lead on IT initiatives (Liebe et al., 2017).

The innovativeness of hospital CIOs was also a key factor of research in identifying innovation criteria of Information Security (IS) technology adoption in organizations (Kosasi et al., 2018). Data was obtained via an online survey of managing IT directors in southeast Asia along with in-depth follow-up interviews of the respondents analyzed through the combined use of the TOE Framework and the HOT-Fit model where the resulting data identified several criteria as related to the adoption success of IS security including CIO innovativeness as relevant to the strategic decision-making process of innovation adoption (Kosasi et al., 2018).

Environmental Context for HIT Adoption

The environmental context of this theory in assessing HIT adoption is also considered key as its factors have been found to influence decision-making. This context relates to the market elements, competitors and government regulations that are all likely to influence an organization's propensity to adopt innovation (Evwiekpaefe et al., 2018; Tornatzky et al., 1990). In this study, the environmental context of RFID adoption for medication administration was assessed via the presence of an EMR and HIMSS EMRAM Certification.

Presence of an EMR and HIMSS EMRAM Certification

The use of HIT in hospitals to assist in medication administration processes is usually centered on the EMR, which is a database tool used to store patient information collected during a medical visit by clinicians in that office, clinic, or hospital for the purpose of diagnosis and treatment (HealthIT.gov, 2019). EMRs have assisted the management of patient medical data, outcomes, quality, and overall cost savings via federal guidelines on their use and function such as Meaningful Use (MU), which incentivizes organizations to implement EHRs and EMRs as a means towards efficiencies within the industry (Centers for Medicare & Medicaid Services, 2019-b)**.**

HIMSS supported these efforts with the introduction of EMRAM certification which identifies the level (Stages 0-7) of EMR capabilities implemented by the hospital with Stage 7 indicating that the hospital no longer uses paper charts to manage patient medical care (HIMSS Analytics, 2017). Of specific relevance to this research, Stage 6 identifies the level where technology is used to achieve a closed-loop process for administering medications or an administration system that seamlessly integrates electronic medication management automation and administrative processes (Burkoski et al, 2019). This closed-loop process also allows for improved patient safety by removing errors common in the medication administration process (Furniss et al., 2019).

This stage also calls for a more advanced level of clinical decision support to provide for the “five rights” of medication administration, systems which provide timely patient care information leading to improved outcomes and increased quality healthcare (Agency for Healthcare Research and Quality, 2019). These systems can also provide alerts at the time of ordering as well as reduce MEs and ADEs via the integration within an EMR (Anker et al., 2017).

RFID technology has been increasingly utilized to support the improved technical capabilities of closed-loop and clinical decision support processes when integrated with an EMR system. According to Vankipuram et al. (2018), RFID systems complement human actions and can identify potential areas of concern via its technical capabilities.

Historical Perspective of Medication Administration

Challenges within the medication administration process have been identified as a key threat to patient safety and remains a significant public health threat in the United States where ADEs result in 1 in 3 of all hospital adverse events, affect about two million hospital stays each year, and prolong hospital stays by 1.7 to 4.6 days (Office of Disease Prevention and Health Promotion, 2019). MEs contribute to the large number of ADEs in hospitals who struggle with the overall medication administration process where, according to HIMSS (2018), 56% of healthcare professionals surveyed indicated that the medication administration processes within the hospital facility failed to capture 20% or more of MEs with 6% of these individuals claiming the number is at least at a 75% failure rate. The following provides a discussion of the challenges within medication administration processes as it relates to the hospital settings and clinical resources involved in those processes leading to a discussion of interventions used to reduce these issues.

Medication Administration Challenges in the Hospital Setting

Research has made great strides to further understand the challenges of medication administration and the depth of its impact on patient safety. Nanji et al. (2016) assessed the rates of MEs and ADEs in an inpatient setting as percentages of medication administrations, to evaluate their root causes and target solutions to prevent them. In their prospective observational study of a United States-based academic medical center, a retrospective abstraction and review of charts with medication administrations where 277 operations were observed of which 193 cases involved a ME (153 or 79.3%) and/or ADE (91 or 64.7%). The authors concluded that 1 in 20 of perioperative medication administrations involved a ME and/or ADE with the potential harm to the patient as being significant and life-threatening and suggest assessments of technology-based solutions to address the root causes of the errors to reduce their incidence, hence, increase patient safety (Nanji et al., 2016).

Inpatient medication administration patterns were also of interest to Loresto et al. (2019) who utilized medication administration event data from a level I trauma safety-net hospital in Colorado from April 2013-March 2015 where the resulting outcome of the linear regression test found time differences between medication schedule and administration (Loresto, et al., 2019). Medications were delayed by an average of 12 minutes, Spanish-speaking patients had a significant 2.3-4.2-minute delay, and certified nurses routinely gave medications earlier than the scheduled time as compared to noncertified nurses by 1.6 minutes (Loresto, et al., 2019). These outcomes lend to the observation that medication administration patterns in a clinical setting is a multifactorial process involving clinical staff, the consideration of patient demographics and conditions as well as culture and unit-level layout (Loresto, et., 2019).

Medication administration and patient safety in hospitals has also been studied from a patient population lens to identify impacts among specific patient groups. For example, neonates were the target population of research for Krzyzaniak and Bajorek (2016), who utilized a literature review study to examine the medication safety of this population compared to other age groups in a hospital setting as this age group is particularly vulnerable to harm due to their physiological inability to buffer MEs. In review of fifty-eight articles related to hospitalized pediatric, adult, and elderly patients versus neonatal patients, the study found that although medication administration errors were found across each age population, that patient misidentification and overdosing were particularly prevalent in neonates, where 46% of the errors were ten times the number of overdoses in the compared groups (Krzyzaniak & Bajorek, 2016). Additionally, the study found that specific medications were prevalent amongst all groups, however, these medications (heparin, antibiotics, insulin, morphine, and parenteral nutrition) are complex in use for neonates and hence, greater consequences (Krzyzaniak & Bajorek, 2016).

Pediatric patients cared for in hospital emergency departments were identified as a high-risk group for associated MEs where a multidisciplinary team of healthcare providers including emergency care providers, EHR representatives, pharmacists, patient safety leaders and parents of children who experienced ADEs, sought to review the systematic research and recommend strategies for improvements to address the issue (Benjamin et al., 2018). The research gathered found several factors that attributed to the prevalence of MEs including the medical complexity of patients with multiple medications, challenges with weight-based dosing, lack of standards in pediatric drug dosing and formulations, lack of information technology systems, lack of emergency department staff and numerous transitions in care where the majority of pediatric patients are treated in non-dedicated pediatric emergency departments (EDs) which may not have the experience as dedicated Eds (Benjamin et al., 2018). The error rates in pediatric patients identified up to one-third of medication dosing errors of commonly used medications among 8 Michigan emergency medical service agencies, an error rate of 10-31% among hospitals with dedicated pediatric Eds, and an error rate of 39% in children at 4 rural EDs in California, with 16% of these errors having the potential to cause serious harm (Benjamin et al., 2018). Based on this data, the team recommends a multidisciplinary approach to medication safety specific to pediatric care across all services prior to, during and after emergency care to include standardized medication dosing guidelines, better integration and use of information technology and increased education efforts for healthcare providers (Benjamin et al., 2018).

Ni et al. (2018) conducted a prospective observational study to timely identify medication administration errors in a neonatal intensive care unit via automated real-time medication usage data and messaging summary data from the EHR system at Cincinnati Children's Hospital Medical Center. Using logic-based rules and electronic processing techniques for targeted medications/infusions built within the EHR to analyze the real-time messages delivered to physicians, 116 out of 10,104 or 1.15% of MAEs were identified during the study period in comparison to the baseline system which found 111 MAEs, indicating good decision-making capabilities within the automated system and the potential to reduce patient exposure to harm from 256 minutes to 35 minutes per patient as well as guarding against alert fatigue amongst medical providers (Ni, 2018).

Pediatric and adult patients were the object of study for Ruano et al. (2016), who further explored how the strategy implementations of new technologies have impacted MEs in children and adults. Similar to Krzyzaniak and Bajorek (2016), the authors also found through a review of the available research, significant incidences of MEs in neonates as part of the pediatric group but also among the adult population, with a rate of 74% for both groups due to dosage errors (28%), prescriptions (13.2%), and drug administration (19.6%) (Ruano et al., 2016). Their research also found that the implementation of new technologies such as computerized physician order entry (CPOE), AIDC, and others have improved the incidence of MEs in both populations and proven effective for inpatient safety. Further, the authors recognize that the implementation of such technologies are not easy but highly recommend these strategies for improved patient safety (Ruano et al., 2016).

Medication Administration Challenges in the Hospital Setting and the Clinical Resource

Several studies have extensively researched medication administration and its effect on patient safety through the lens of clinical resources involved in the processes.

Farzi et al. (2017) conducted an exploratory qualitative study involving nineteen members of the healthcare team (physicians, nurses, and clinical pharmacists) across 16 Intensive Care Units (ICUs). The data was categorized into four areas: low attention of healthcare professionals to medication safety, lack of professional communication and collaboration, environmental determinants, and management determinants (Farzi et al., 2017). Among the common themes included unsafe drug administration, incorrect prescribing among physicians, lack of pharmaceutical knowledge of the healthcare team, and weak professional collaboration leading to MEs (Farzi et al., 2017). As a result of the analyzed data, the authors recommend increased interactions with patients and their families, interprofessional collaboration, the use of information technologies such as EHRs and computerized prescription order entry (CPOE) (Farzi et al., 2017).

Specific to nurses as they administer most medications and are deemed accountable, Johnson et al. (2018) conducted a qualitative study aimed of nurses of varying levels within a hospital environment to examine the nature of interruptions during medication administration. The findings from the semi-structured focus group indicated common sources of interruptions including nurse initiated, other health professionals, support staff, patients, relatives or self-initiated, all of which could be considered predictable (could be managed by other team members) or unpredictable (requiring immediate attention by the nurse) (Johnson et al., 2018). The authors lend to recommended behavioral strategies such as prevent, block, engage, mediate, multitask, engage, and mediate to address these interruptions which will lead to decreased medication administration errors among the nursing staff and increased patient safety

(Johnson et al., 2018).

Härkänen et al. (2018) analyzed inpatient MEs via incidence reports related to wrong-patient classification among two specialized care hospitals in Finland where nurses have the responsibility to administer medications to patients. Of the 1,102 incidence reports related to medication administration at the two hospitals, 103 were classified as wrong patient-related where drugs were administered to neighboring patients or other patients within the same room; patients were similar to one another; nurses took the wrong patient's drugs from the medication tray; and other explanations of the incidents were given (Härkänen et al., 2018). The identification of the wrong-patient issue was found immediately during or just after medication administration; patient or relative noticed; and other methods were contributing factors of unsafe acts and omissions and other error provoking conditions. The authors contend that each individual has responsibilities in patient identification processes to reduce the onset of MEs and recommend additional system support including technology to improve the accuracy of limiting these errors (Härkänen et al., 2018).

Rasheed et al. (2018) also examined medication administration errors across teaching hospitals across Erbil, Iraq among 250 nurses working in acute, subacute, and general wards with direct contact to medication administration processes. In an attempt to determine the most common types of MEs present among these hospitals and across this sample group as well as the identifying factors that lead to the medication administration errors, the authors utilized a cross-sectional research method which found that the highest amount of errors occurred where the administration of the drugs occurred at the wrong time, allergies were not noted until after administration, medication orders from the physician were not legible, lack of adequate staffing and high workload, leading to the conclusion that there are various causes and types of medication administration errors and a recommendation for an interventional program designed to treat each of these factors (Rasheed et al., 2018).

Utilizing a mixed methods study design to analyze the medication administration procedures among the nursing staff of 3 inpatient units of teaching hospitals in Brazil between January 2014 and March 2015, Magalhães et al. (2019) found there are organizational weaknesses that attribute to these errors to humanistic reasons (distractions, disruptions, lack of attention, fatigue, stress) but also to systemic challenges such as the diversity of types and routes of drug administration and an increasing work demand caused by patients with increasing clinical conditions warranting an increase of prescribed medications. The authors contend that detailing the care process in the management of drug administration is needed and that measures to prevent errors using the ‘five rights’ when preparing and administering medications is necessary.

Medication administration-related errors have also been reviewed from the lens of the physician where Murray et al. (2017) examined MEs among attending physicians of an academic medical center-based emergency department for discharged patients where 13.4% of the 1,000 prescriptions written contained errors with the most common error being incomplete or inadequate prescription (Murray et al., 2017). The authors recommend dedicated emergency department pharmacists as resources to improve the error rates and decreasing unintended medications, training, and a dedicated discharge prescription review policy (Murray et al., 2017). The authors do not mention HIT as an intervention; however, this is another opportunity where the value of RFID can be realized via its incorporation into these discharge processes.

Westbrook et al. (2018) examined the medication prescribing errors of twenty-eight emergency physicians in an observational study where out of 239 prescriptions ordered, 209 consisted of errors that were associated to interruptions (9.4 times /hour), multi-tasking and lack of sleep. Given these findings, the authors raise evidence-based questions on the rates of multitasking and interruption in clinical environments and the issue is of increasing importance as the opportunities to multitask increase with technology (Westbrook et al., 2018). To combat these issues, targeted recommendations are suggested including the introduction of information technology which can provide cues to allow more effective recovery from interruptions (Westbrook et al., 2018). Based on the recommendation for the introduction of information technology, this would be opportune for RFID use as it could be used to alert clinicians prior to the error occurrence.

Medication Administration

RFID has been increasingly regarded in healthcare organizations for its positive impact on managing medication processes. Aldeer et al. (2018), in their review of medication monitoring technologies, assessed the usefulness of RFID as a proximity-sensing tool to assist in medication processes. When RFID tags and readers are attached to medication drawers, bottles and platforms, the technology may notify the patient to take the medication and/or informs healthcare providers of the location and inventory of the medication inside RFID-enabled bottles and dosing instructions (Aldeer et al., 2018).

To further exhibit how RFID can automate medication dispensing solutions in an inpatient setting, Chen et al. (2016) created a prototype automatic medication dispensing machine (AMDM) equipped with RFID tags and readers to create an effective inpatient medication management safety system using RFID. Upon analysis, the authors identified significant results upon review of the key performance indicators for the application where it was shown that the use of human resources to manage the AMDM for corrections was reduced by 50%, the cost of these associated resources were reduced by 50% and MEs were reduced by 70%, hence the proposal of a novel system to improve medication safety measures within the inpatient setting (Chen et al., 2016).

RFID has also proved useful in the tracking and storage of emergency medications for use in the hospital setting (Martínez-Pérez et al., 2016; Pérez et al., 2017). Hamm et al. (2018) introduced an RFID web-based program at the Cleveland clinic that replaced the emergency medication kit restocking/inventory and location tracking paper process. This web-based program allowed for the identification of kits nearing expiration or containing recalled medications where 119 days post implementation, there was a 74% decrease in the amount of time pharmacists spent on approving these tasks as opposed to the prior paper-based process which decreased pharmacist review, minimized compliance risk, and increased access to real-time data (Hamm et al., 2018).

The use of RFID to aid in medication administration activities in hospitals are increasingly found in the literature. Dey et al. (2016), conducted an exploratory investigation of RFID adoption in United States hospitals utilizing the TOE framework. The survey responses from identified contacts of United States hospitals was small, resulting in a sample size of n=85 where the study found that a high percentage of respondents have adopted or are considering adopting RFID where organizational and technological factors have a positive influence on the decision-making, yet the environmental factor did not have a significant impact. Hence, the recommendation to replicate the study with a larger sample size as the technology matures. This current research will utilize a similar approach; however, the database includes a larger sample size from which to draw conclusions, specifically to how this technology can be leveraged to support medication administration processes to improve patient safety.

These efforts to further explore RFID technology are not only an indicator of industry interest but are also an indication of an industry increasingly moving towards AIDC technological solutions to support business needs.

Operational Benefits

Research is continuing to expand as it relates to RFID technology in healthcare settings, particularly its application in hospitals for its perceived benefits to improving efficiency and effectiveness of business operations, customer service, and strategic plans. Hossain and Ahmad (2018) examined the determinants of RFID use and benefits within hospitals where resulting survey data of 142 hospitals showed that RFID use in hospitals is influenced by TOE factors. The TOE factors utilized in this study included information privacy (technology), absorptive capacity and resource readiness (organization), and coercive pressure (environment) and hospital size as a control variable. A further analysis of the combined effect of hospital size and RFID use on perceived benefits showed a significant relationship between RFID use and economic benefits but not between RFID use and operational benefits (Hossain & Ahmad, 2018).

The efficiency and effectiveness of RFID on business operations was supported via the research of Aboelmaged (2017) where a voluntary survey of healthcare workers (technicians, managers, nurses, and physicians) in charge of asset and patient management within public and private hospitals in the United Arab Emirates. 311 total individuals responded to questions pertaining to their assessment, knowledge, and/or experience of RFID’s ability to improve asset management processes, to monitor patients’ whereabouts and their medical status throughout the facility, to increase efficiencies in inventory management, service quality and security (Aboelmaged, 2017). Resulting data found strong effects of RFID from the factors supporting technical advantages and organizational capacity on both asset and patient management with environmental competitiveness having an effect only on patient management operations, supporting the implications for healthcare managers to better understand RFID implementation issues and increase its technological fit within the various operational services offered throughout the organization (Aboelmaged, 2017).

Landry et al. (2016), via a longitudinal case study of two Canadian hospitals with differing approaches, examined the logistical strategic deployment of an RFID-enabled solution to improve their materials management systems. Utilizing step-by-step deployment practices, strategic planning tools incorporating leadership and departmental involvement, and logistics planning incorporating the unique characteristics and complexity of hospitals, interviews of logistics personnel and resources key to the implementations were gathered via a semi-structured framework (Landry et al., 2016). With the common aim of relieving the clinical staff of logistical tasks and hiring a manager to lead the materials management practice, the resulting data found that the utilization of strategic logistical methods to implement an RFID-enabled solution to improve efficiencies in materials management, proved that RFID solutions can be implemented within the hospitals when there is a concerted effort among resources and the time to incorporate these innovations given the complex nature of the hospital environment (Landry et al., 2016).

Dey et al. (2016), in their exploratory investigation of technology adoption of RFID in US hospitals, utilized the TOE framework to demonstrate how United States hospitals are adopting RFID. Utilizing an online survey targeting Chief Information Officers and top information technology executives of United States acute care hospitals, the respondents (n=86) have adopted or are considering adoption of RFID technology where organizational and technical factors have a strong influence on the decision-making, whereas the environmental factors do not play a significant role in the adoption of RFID (Dey et al., 2016). Additionally, the respondents indicated the main reasons for implementing this technology was improved hospital operations including inventory management, asset control, workflow and patient flow with concerns related to the cost of the tags and implementation, data that can be utilized to further inform healthcare managers on the challenges and opportunities presented by RFID adoption (Dey et al., 2016).

Summary and Conclusion

This literature review provided further support to explore the relationship between technological, organizational, and environmental factors and the adoption of RFID for medication administration. The theoretical concept as well as alternative theories was reviewed to demonstrate the usefulness of the TOE theory for this research as opposed to the other identified theories. Additionally, the importance of examining the key concepts related to the adoption of RFID for medication administration was provided via a review of the challenges of medication administration and patient safety within the inpatient setting; among differing patient populations; and from a clinical lens as well as legislation supporting improvements to medication administration practices; and the adoption of RFID for medication administration.

Chapter 3 of the proposal delved further into the methodology utilized, offering insight into the study’s research design, data collection, supporting analysis and the rationale for conducting the study.

Chapter 3: Research Method

Introduction

The purpose of this research study was to explore contributing factors to RFID adoption in United States hospitals for medication administration. These factors are identified as technological, organizational, or environmental-related aspects of the hospital. This study was designed to contribute to the knowledge of RFID adoption by providing an integrated view of RFID adoption and to determine the key factors that influence key decision makers' intention to adopt RFID technologies. Understanding the relationship of these aspects of the organization can provide insight into the incorporation of RFID in hospitals to support medication administration activities, leading to patient safety outcomes and improved healthcare delivery.

Chapter 3 of this research study expanded upon the research design and the research rationale for conducting the study. It also included a methodology section that identified the population selected, sampling and sampling procedures, data collection, and instrumentation and operationalization of constructs. Threats to validity and ethical procedures were included prior to a summarization of the chapter and transition to Chapter 4.

Research Design and Rationale

Variables

The variables selected for this research study were used to determine the relationship between the characteristics of the hospitals and RFID adoption to determine whether the relationships affect medication administration practices. There were eight independent variables for this study, which included specific technological, organizational, and environmental constructs related to hospital facilities that attribute to their complexity and the adoption of HIT. Specific variables and associated constructs from the database were identified further in the discussion.

Technological Variables

Technology within hospitals is complex and refers not only to the amount and use of multiple technological innovations and their interrelated parts to support business processes and services but also to the relative measure of difficulty for programmatic and technical risk that those innovations may have on an organization (see Cresswell et al., 2016). Hospitals, considered complex adaptive systems due to their multiple processes and subsystems, have invested in a myriad of technologies and technical systems to support patient care, including medication administration efforts (Reale et al., 2016).

To manage the complex landscape that the incorporation of technical innovations may present, the consideration of RFID interoperability within the technical landscape of systems within the hospital is necessary. This technical landscape, comprised of numerous competing and complimentary systems, poses challenges needing considerate evaluation prior to the integration of any new technologies. It is important that the hospital uses 802.11 or 802.11X standard WLAN to support the functionality and interoperability of RFID and other wireless technologies. This technological construct, RFID interoperability, was defined by the presence of an 802.11 or 802.11X standard WLAN.

The networked environment within the organization and the introduction of new technology is also pertinent for further analysis. RFID requires solid network connections including reliable WLAN capabilities to perform at optimal capacities; however, an increased number of access points to a WLAN system is considered complex and less technically secure and can be addressed via the deployment of access points between buildings and clinical areas with the capacity to handle users moving throughout the coverage area using varying mobile devices (Khan & Sarfaraz, 2018). This technological construct was defined by the location of a WLAN within the hospital, specifically in areas that support medication administration processes.

The use of a RFID vendor for assistance into the integration of this technology into the technical landscape is also pertinent for further analysis. Vendors of RFID services were identified as playing a crucial role to better understand RFID implementation issues, increase its technology fit into service operations, and accelerate its implementation (Aboelmaged & Hashem, 2018). Thus, vendor selection as a key variable to assess RFID adoption in the hospital environment for medication administration. This technological construct was defined by vendor ID and type.

Organizational Variables

Hospitals as organizational entities are also complex due to the dynamic nature of its organizational components and their interactions as part of a whole system (Mosadeghrad & Mojbafan, 2019). Hospitals are considered organizationally complex due to their large size, financial status, greater differentiation in personnel such as multiple levels of clinical staff, and distributed systems or functional services as major providers of healthcare services where these factors have impacted technological adoption (Thune & Mina, 2016). Operationalization of this construct was indicated by hospital size (measured by the number of beds in the hospital), financial status (measured by profit/nonprofit status), and the registered identification and presence of a CIO.

Environmental Variables

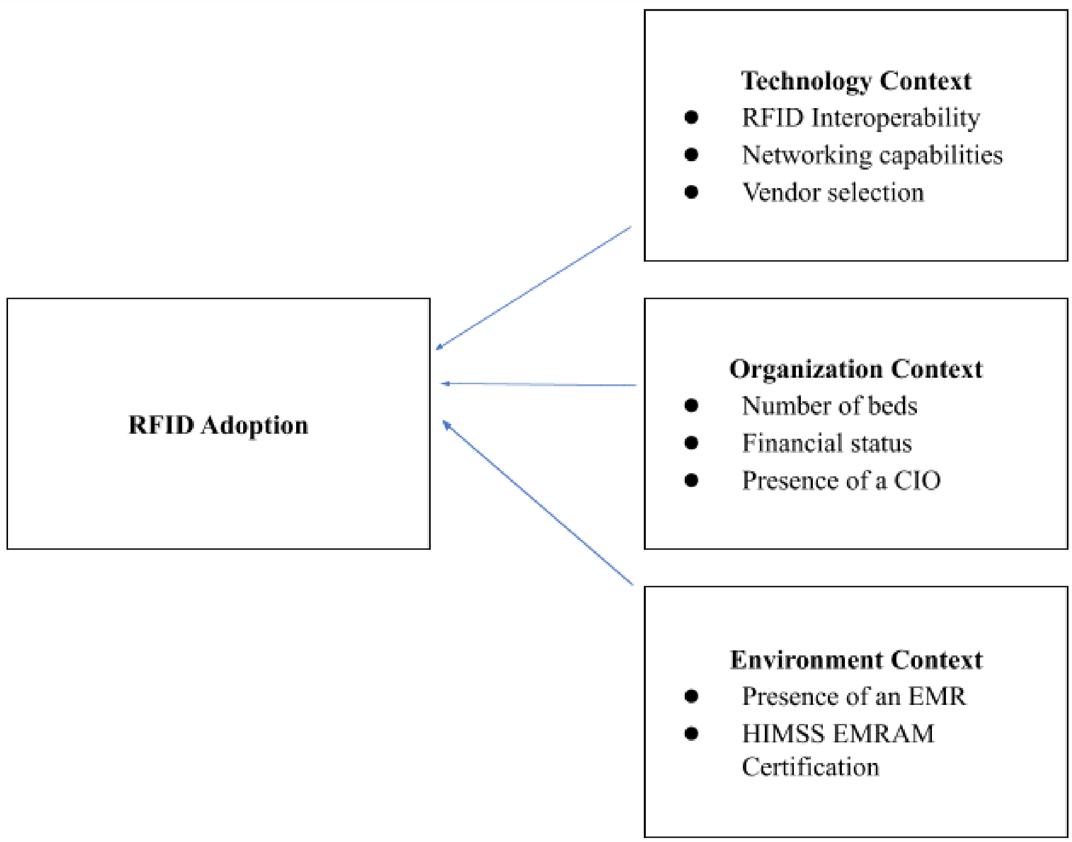
Environmental factors play an increasing role on the complex nature of hospitals due to legislative and political changes and have a direct impact on healthcare. Legislation such as the HITECH Act in 2009 spurred the increased use of HIT and the establishment of HIMSS EMRAM stage model (Adler-Milstein, & Jha, 2017; HIMSS Analytics, 2018; U.S. Department of Health & Human Services, 2017). The presence of an EMR in tandem with the attainment of stage 6 HIMSS certification was used to assess the impact of this environmental factor on RFID adoption within the hospital.

RFID Adoption for Medication Administration

RFID adoption for medication administration is the dependent variable in this study. Through the review of the literature, it was shown that the decision to adopt RFID within the hospital setting is a complex process influenced by varied inputs throughout the hospital organization. This organizational complexity further challenges the ability of hospitals to adopt RFID technology for medication administration practices. Attainment of stage 6 of the HIMSS EMRAM EMR certification status indicates that the hospital has achieved an advanced certification level via the incorporation of an EMR-enabled closed loop system that supports medication administration, supports the five rights of medication administration (the right patient, the right drug, the right dose, the right route, and the right time), and allows for the integration of an advanced technology such as RFID to integrate within medication processes, thus leading to patient safety within the hospital (HIMSS, 2017). Figure 1 shows the conceptual model for the adoption of RFID.

Figure 1

Conceptual Model for the Adoption of RFID



Research Design

A quantitative research design was used for this study to explore the contributing factors of United States hospital's adoption of RFID for medication administration. The selection of the quantitative design allowed for the relationships between the independent and dependent variables to be measured numerically. It is also intended for this research to be repeated (using the same or different variables), a process that is allowable via the choice of the research design, using the same formula or methods with different samples for comparison (see Queirós et al., 2017). Additionally, quantitative research allows generalization of the findings to a population using numerical data and measurable variables (Park & Park, 2016). The findings from this study on RFID adoption for medication administration was generalized to the total population of United States hospitals.

The use of a cross-sectional design allowed for the focus or measurement of existing differences between selected phenomena at a certain point in time as well as the use of existing and large data sets of data and secondary data sets, which all allowed for inferences based on the findings (see Setia, 2016). This study leveraged secondary data from the HIMSS Analytics Database and focused on hospital data as they related to RFID adoption for medication administration in United States hospitals (HIMSS Foundation, 2020). The use of secondary data was advantageous for this research as it significantly reduced the time and resources available to me, allowing a more efficient timeframe for completion (see Johnston, 2017). Additionally, as this study was nonexperimental, the data were not manipulated, and conclusions were drawn from the data provided.

Methodology

The methodology section of this chapter provided information on how the research was conducted to answer the RQs. It included a description of the study’s population, sampling and sampling procedures, procedures for archival/secondary data, processes for instrumentation, and the operationalization of constructs.

Population

The population for this study included published data of the information technology status of nonfederal United States hospitals from the HIMSS Analytics Database (see HIMSS Foundation, 2020). Hospitals are provided with an opportunity to submit input into this survey, which is touted as the largest healthcare IT database in the industry, a motivator for hospital representatives to respond accurately to the questionnaire (Park et al., 2019). HIMSS Analytics used structured processes to identify, collect, and analyze the data received from the organizations and provided each participating organization with a copy of the detailed report (HIMSS Foundation, 2020).

Sampling and Sampling Procedures

This study used data from the 2017 HIMSS Analytics Database, which offers data on hospitals and their information technology use (see HIMSS Foundation, 2020). Market segmentation and size statistics, IT purchase plans for healthcare organizations, and the software, hardware, and infrastructure installed throughout all facilities are examples of the information included in this dataset. The demographic and IT information provided in this dataset includes nearly 40,000 facilities, specifically 5,527 hospitals, 2,317 subacute care facilities, 35,132 ambulatory facilities, 1,375 home health care facilities, and 180 free standing data centers.

The sample size for this research was derived using a recommended approach for binary logistic regression analysis. According to Bujang et al. (2018), the use of events per variable (EPV) in the formula (n = 100 + xi) is highly effective in determining sample size for binary logistic regression analyses where 100 is a fixed value as determined for logistic regression, x equals the EPV or a multiplication factor of 10 to 50, and i represents the number of independent variables in the research study (Bujang et al., 2018).

To determine the EPV to use for this calculation, a review of the research on the recommended values for EPV was conducted. An EPV value of 10 is widely used in the literature and is considered the rule of thumb where 10 events per variable is desired to maintain validity of the research (Peduzzi et al., 1996). The literature on EPV also advises of the potential bias in the statistics using an EPV of 10, which oftentimes exhibit poor performance in large-scale simulations, leading to the recommended use of EPV > 50 to reduce these challenges in large populations (Riley et al., 2019; van Smeden, et al., 2019).

A review of the literature was also conducted to determine potential use cases within the dataset as it related to this research study. A review of a previous study on the use of RFID for medication administration in hospitals leveraging the 2015 release of the HIMSS dataset of 5,400 U.S. hospitals indicated that approximately 100 hospitals surveyed used RFID for medication administration, with an increase of 4% from 2012 to 2015 (Uy et al., 2015). This finding was relevant in determining the appropriate EPV value to use as the sample size itself should generally reflect the number of cases in the selected population. Although the current number of hospitals using RFID for medication administration purposes is unknown in the current 2017 dataset being used for this study, it contains approximately 100 additional participating hospitals, potentially reflecting an increase of hospitals using RFID for medication administration. Based on this information, an EPV of 10 was used. Applying this value within the formula for this research study where there were eight predictor variables selected to assess the adoption of RFID in hospitals for medication administration, it was determined that 180 was the minimum sample size needed [n = 100 + 10 (8) = 180].

Archival Secondary Data

The data was obtained from the HIMSS Analytics Database, which is currently managed and updated yearly by the HIMSS Foundation’s Dorenfest Institute (see HIMSS Foundation, 2020). This database is a comprehensive compilation of the use, implementation, and planning status of HIT, which includes more than 90% of all United States hospitals (Jordan, 2018). According to Sun and Lipsitz (2018), the use of secondary data is an efficient use of data collected to address new RQs, whereby existing data may be leveraged for additional means of study. Additionally, it is advantageous due to its low cost, accessibility, documentation of the data, and data collection processes made available to potential users of the data by the original team (Sun & Lipsitz, 2018).

This database is free to academic researchers interested in contributing to the knowledge of HIT in the United States and is made available for a year from the provisioning date, extensions granted by request. Represented in the database is self-reported data from over 5,000 nonfederal hospitals whose designated representatives responded to specific questions regarding the facilities’ IT use and planned usage as well as other demographic, personnel, and organizational characteristics, including those identified as variables in this study (i.e., bed size, financial status, and wireless connectivity). There were no human subjects used in this research study as only historical data using this database were obtained.

Operationalization of Constructs

This section further defined or operationalized the concepts utilized in this study into quantifiable factors. Included were the descriptions of each construct along with research-accepted variable scale measurements for each. There were three identified constructs for analysis (Technology, Organization and Environment) which included eight independent or predictor variables as well as one dependent or outcome variable which was RFID adoption, all of which are described below and identified in Table 2.

Table 2

Operationalization of Constructs

Type of variable	Construct	Variable	Description	Database field name	SPSS field name	Categorization
Independent Variables	Technological	RFID interoperability	802.11 or 802.11X WLAN availability	Version	Version	Nominal
		Networked environment	Location of WLANs in the facility	Location	Location	Nominal
		Vendor selection	Vendor used?	VendorID	VendorID	Interval
				Type	Type	Nominal
	Organizational	Hospital size	Number of Beds	NofBeds	NofBeds	Interval
		Financial status	Financial Status	ProfitStatus	ProfitStatus	Nominal
		Presence of a CIO	Presence of a CIO	Name	Name	Nominal
		Presence of an EMR	EMR Adoption	Function	Function	Nominal
	Environmental	Attainment of HIMSS stage 6	EMRAM Adoption Level	Stage	Stage	Nominal
Dependent Variable	RFID for Medication Administration	RFID for medication administration	RFID in use at the hospital?	InUseFlag	InUseFlag	Nominal
				Type	Type	Nominal
				DepartmentName	Department Name	Nominal

Technological Factors

This construct was operationalized via three area fields from the database.

RFID interoperability: RFID interoperability was defined by the presence of an 802.11 or 802.11X standard WLAN supporting hospital operations and was categorized as a nominal variable: “yes” or “no”. The database field is ‘Version’, and the variable was named as such in SPSS.

Networked environment: Networked environment was defined by the location of Wireless Local Access Networks within the hospital. “Location” was the identified field from the database and was assessed by the areas which support medication administration processes. There was a total count for each medication administration-supported area identified to include Cardiology, Emergency Department, Laboratory, Operating Room, Pharmacy, and Radiology departments. The areas identified as supporting medication administrative processes was displayed in a comma delimited string format and totaled per hospital where the number of hospitals with WLANs (0-6) was displayed. The variable was named “Location” in SPSS.

Vendor selection: Vendor selection was defined by the database variables “Vendor ID and Type”. “Vendor ID” was categorized as a nominal variable: “yes” or “no”. “Type” was categorized as a nominal variable: “yes” or “no”. The variable was named as such in SPSS.

Organizational Factors

This construct was operationalized via three area fields from the database.

Hospital size: Hospital size was defined as the number of beds. It was identified using the database field "NofBeds" and was categorized via an interval: 1= small (<100 beds); 2= medium (100-499 beds); and 3= large (500+ beds). The variable was named and coded as such in SPSS.

Financial status: Financial status was defined using the financial status of the hospital and was identified by the database field "ProfitStatus". It is a dichotomous or nominal variable and was categorized as 'profit' or 'not for profit'. The variable was named and coded as such in SPSS.

The presence of a CIO: The presence of a CIO was defined by the identification of a CIO as part of the organization. It was identified in the database as "Name" and was categorized as a nominal variable: "yes" or "no". The variable was named and coded as such in SPSS.

Environmental Factors

This construct was operationalized via two area fields from the database.

Presence of an EMR: The presence of an EMR was defined by the indication of a certified EMR within the hospital. "FunctionName" was the database field used and was categorized as a nominal variable: "yes" or "no". The variable was named and entered as such in SPSS.

The attainment of HIMSS Stage 6: The attainment of HIMSS stage 6 was identified using the database field "Stage". It is a dichotomous or nominal variable and was categorized on a nominal level with no calculated relationship assumed. The variable was named and entered as such in SPSS.

RFID Adoption for Medication Administration

The indication that the hospital has adopted RFID for medication administration was identified via three database fields: “InUseFlag” (categorized as a nominal variable: “yes” or “no”), coded at the nominal level with no calculated relationship assumed. “Yes” value indicates that the hospital utilizes bar coding, RFID, or bar coding/RFID. “Type” was the second field needed which will specifically identify the auto identification type. It was categorized as a nominal variable and coded as such in SPSS. “DepartmentName” was the third field needed to identify this dependent variable and the department where bar coding, RFID, or bar coding/RFID is being used. It was categorized as a nominal variable and coded as such in SPSS.

Data Analysis Plan

The data for this study was analyzed using Statistical Package for the Social Sciences (SPSS) v28 software program which provides researchers with varying types of statistical analyses (IBM, n.d.). Using SPSS, regression analysis was the process whereby the relationship between the dependent variable (RFID adoption for medication administration) and the eight independent variables (RFID interoperability, networked environment, vendor selection, hospital size, financial status, the presence of a CIO, the presence of an EMR, and HIMSS stage 6 attainment) as categorized as a specific Technological, Organizational, or Environmental construct is determined via inferential statistics. Specifically, a binary logistic regression analysis was conducted to assess the relationship between the dependent variable and the multiple independent variables. This analysis is commonly used when there is one nominal dependent variable and two or more nominal (measurement) independent variables taken into consideration simultaneously to predict an effect. Additionally, regression analyses assume the observations are independent of each other, that the dependent variable is coded accordingly, and the sample size is large to maximize likely estimates (Statistics Solutions, 2022). The utilization of the HIMSS data set met the independent nature of responses as each hospital organization responded based on their individual hospital characteristics at the time of response. Also, the associated coding for the variables was unique within the data set, furthering the independent nature of the data. And finally, the size of the data set was large, allowing for the maximization of likely estimates between variables. This analysis was used to assess the following RQs:

RQ1: Is there an association between hospitals' technical influences (RFID interoperability, networked environment, and vendor selection) and the adoption of RFID for medication administration?

$H_0$1: There is no association between hospitals' technical influences (RFID interoperability, networked environment, and vendor selection) and the adoption of RFID for medication administration.

H_a1: There is an association between hospitals' technical influences (RFID interoperability, networked environment, and vendor selection) and the adoption of RFID for medication administration.

RQ2: Is there an association between hospitals' organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration?

$H_0$2: There is no association between hospitals’ organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration.

H_a2: There is an association between hospitals’ organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration.

RQ3: Is there an association between hospitals’ environmental influences (presence of an EMR and the attainment of HIMSS stage 6) and the adoption of RFID for medication administration?

$H_0$3: There is no association between hospitals’ environmental influences (presence of an EMR and the attainment of HIMSS stage 6) and the adoption of RFID for medication administration.

H_a3: There is an association between hospitals’ environmental influences (presence of an EMR and the attainment of HIMSS stage 6) and the adoption of RFID for medication administration.

RQ4: Is there an association between hospitals’ technological (RFID interoperability, networked environment, and vendor selection), organizational (hospital size, financial status, and presence of a CIO), and environmental (presence of an EMR and the attainment of HIMSS stage 6) influences and the adoption of RFID for medication administration?

$H_0$4: There is no association between hospitals’ technological (RFID interoperability, networked environment, and vendor selection), organizational (hospital size, financial status, and presence of a CIO), and environmental (presence of an EMR and the attainment of HIMSS stage 6) influences and the adoption of RFID for medication administration.

H_a4: There is an association between hospitals' technological (RFID interoperability, networked environment, and vendor selection), organizational influences (hospital size, financial status, and presence of a CIO), and environmental (presence of an EMR and the attainment of HIMSS stage 6) influences and the adoption of RFID for medication administration.

Threats to Validity

The validity of a study referenced the extent to which the researcher answers the RQs whereas the validity of the measurement can influence the conclusions drawn because of hypothesis testing (Andrade, 2018). Threats to the validity of a study are related to the internal validity (changes in the independent variable are indeed a direct result of changes in the dependent variable) or external validity (research findings are generalized to a larger population) of a study (Frankfort-Nachmias & Nachmias, 2008).

Threats to the internal validity of this study were controlled by the nature of the research design which minimizes the potential for alternative explanations of results and increases the resulting confidence of the independent variable (s) having an effect on the dependent variable. As secondary data was used, there were no changes to the history or maturation of the variables utilized, measurement of the instrumentation, or design of the study which reduces the possibility of threats to internal validity. Additionally, the use of secondary data in this study was further reduced as human subjects were not used in the gathering of the data; therefore, threats such as differential selection; attrition/withdrawals/dropouts; or any other human subject-related threats (compensation, experimenter bias) were not problematic for this research.

Threats to external validity were also minimalized for this research study. Large datasets that are collected and funded by agencies such as the HIMSS dataset utilized for this study contain substantial breadth and are said to be more representative of the target population which allows for greater validity and generalizability of the findings (Johnston, 2017). Also, as it relates to the voluntary nature of the HIMSS data, the potential threat to validity was noted for voluntary surveys as they are subject to bias and the misreporting of data may affect validity (Gallagher, 2016). Using multiple independent technological, organizational, and environmental variables to assess the dependent variable (RFID for Medication Administration), the threat is minimalized.

Ethical Procedures

Ethical procedures in research are necessary and required to protect the rights of participants and compliance standards (Johnston, 2017). This research study utilized secondary data obtained from HIMSS Analytics, a large-scale survey, where hospitals voluntarily provided data specific to their organization and was not inclusive of any personnel-related information or personal identifiable data (HIMSS Foundation, 2020). The surveys were administered online and compiled into a database for public research access for which permissions via a user agreement was secured by the researcher. The agreement to gain access to the database identifies the roles and responsibilities of the researcher, scope of data use, and timelines for data access and retrieval. Additionally, Walden University's Institutional Review Board (IRB) was consulted to review the research study for compliance with federal research standards and ethical procedures, resulting in an approval (12-09-20-0346444) to conduct the research.

Summary

The purpose of this research study was to explore the relationships between RFID adoption in United States hospitals for medication administration and associated technological, organizational, and environmental independent factors. This chapter provided a detailed understanding of this study's research, highlighting three specific areas: research design, methodology, and threats to validity. The research design selected for the study was quantitative, non-experimental, and cross-sectional in nature and was chosen due to the kind of RQs selected to guide the study. Included was the identification of the independent and dependent variables utilized as the measurement of their characteristics were key to the outcome of the research and ability to answer the RQs.

The methodology section of this chapter focused on the study's population, sampling and sampling procedures, procedures for archival/secondary data, processes for instrumentation and the operationalization of constructs. The utilization of the HIMSS dataset and its role within the study was a crucial aspect of the methodology as the use of secondary data is a flexible and viable tool to exercise systematic evaluation processes (Johnson, 2017). Threats to validity were identified and controlled via the use of a secondary dataset. Additionally, ethical procedures were in line with the use of procedures governing standard scientific research including the use of Walden University's IRB process and the maintenance of the integrity of the Dataset.

Chapter 4 of the proposal provided a review of the data collection, techniques, analysis, and results.

Chapter 4: Results

Introduction

The purpose of this nonexperimental, cross-sectional quantitative study was to explore the contributing factors of United States hospital's adoption of RFID for medication administration. These factors were assessed via technological (RFID interoperability, networked environment, and vendor use for RFID), organizational (hospital size, financial status, and presence of a CIO), and environmental (EMR adoption and HIMSS stage 6 certification) contexts. This research study was designed to contribute to the knowledge of RFID adoption for medication administration by providing an integrated view of RFID adoption and understanding the key factors that influence key decision makers' intention to adopt RFID technologies. Understanding the relationship of these aspects of the organization provided insight into the implementation of RFID in hospitals to support medication administration activities.

Research Questions and Hypotheses

The following RQs were used to guide the study to understand the relationship between the identified technological, organizational, and environmental influences of United States hospital's adoption of RFID for medication administration.

RQ1: What is the association between hospitals' technological influences (RFID interoperability, networked environment, and vendor used for RFID) and the adoption of RFID for medication administration?

$H_0$1: There is no association between hospitals' technological influences (RFID interoperability, networked environment, and vendor used for RFID) and the adoption of RFID for medication administration.

H_a1: There is an association between hospitals' technological influences (RFID interoperability, networked environment, and vendor used for RFID) and the adoption of RFID for medication administration.

RQ2: What is the association between hospitals' organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration?

$H_0$2: There is no association between hospitals' organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration.

H_a2: There is an association between hospitals' organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration.

RQ3: What is the association between hospitals' environmental influences (presence of an EMR and the attainment of HIMSS stage 6) and the adoption of RFID for medication administration?

$H_0$3: There is no association between hospitals' environmental influences (presence of an EMR and the attainment of HIMSS stage 6) and the adoption of RFID for medication administration.

H_a3: There is an association between hospitals' environmental influences (presence of an EMR and the attainment of HIMSS stage 6) and the adoption of RFID for medication administration.

RQ4: What is the association between hospitals' technological (RFID interoperability, networked environment, and vendor used for RFID), organizational (hospital size, financial status, and presence of a CIO), and environmental (presence of an EMR and the attainment of HIMSS stage 6) influences and the adoption of RFID for medication administration?

H_04: There is no association between hospitals' technological (RFID interoperability, networked environment, and vendor used for RFID), organizational (hospital size, financial status, and presence of a CIO), and environmental (presence of an EMR and the attainment of HIMSS stage 6) influences and the adoption of RFID for medication administration.

H_a4: There is an association between hospitals' technological (RFID interoperability, networked environment, and vendor used for RFID), organizational influences (hospital size, financial status, and presence of a CIO), and environmental (presence of an EMR and the attainment of HIMSS stage 6) influences and the adoption of RFID for medication administration.

The following chapter provided a detailed review of the data analysis used to address the RQs. It began with the data collection process, an explanation of the data cleaning procedures, and a description of the resulting data. It also included an analysis of associations identified between the variables via the binary logistic regression analysis and a statistical presentation of the results and findings summarizing the analysis conducted.

Data Collection

Data Collection and Cleansing

Secondary data from the 2015 HIMSS Analytics Database was used for this study, which publishes data of the information technology status of nonfederal United States hospitals (see HIMSS Foundation, 2020). The demographic and IT information provided in this dataset included nearly 40,000 facilities, specifically 5,527 hospitals; 2,317 subacute care facilities, 35,132 ambulatory facilities, 1,375 home health care facilities, and 180 free standing data centers in the United States.

The database contained several tables that included survey data responses collected from these organizations. The specific tables used for this research study were identified using the data dictionary provided by the HIMSS organization where each variable (dependent and independent) was mapped to a specific element(s) in a table based on its descriptive characteristic. MS Access was then used to analyze the variables related to the specific RQs, linking individual tables via the field HAEntityID, which is the identification number associated to each surveyed entity. This field and its associated facility type was also used to identify hospital-only facilities (N=5,527) to include in this research, allowing focus on these specific facilities.

It is important to note that there were independent variables identified for analysis that did not return any data from any hospital during the query process, or for those variables that did return data, there were hospitals that did not include data for one or more variables as responses for each question on the survey were not mandated for participation and submission. The remaining variables (independent and dependent) included within this research study and their associated constructs can be summarized in Table 3.

Table 3

Frequency Distribution of Constructs and Independent Variables

Construct	Independent variable (table name)	Variable type	Categorization (if applicable)	DV = 0 (where IV = 0)	DV = 0 (where IV = 1)	DV = 1 (where IV = 0)	DV = 1 (where IV = 1)
Technological *n*= 1,088	RFID interoperability (version)	Continuous	N/a	744	282	53	9
	networking capabilities (location)	Continuous	N/a	115	911	5	57
	vendor selection (vendor_type)	Continuous	N/a	984	42	58	4
Organizational *n* = 3,748	number of beds	Categorical	Small (<100 Beds)	0	0	0	1,691
			Med (100-499 Beds)	0	0	0	1,799
			Large (500+ Beds)	0	0	0	258
	financial status	Continuous	N/a	0	0	0	0
	presence of CIO	Continuous	N/a	0	0	0	3,748
Environmental *n* = 5,527	presence of an EMR (function)	Continuous	N/a	0	0	0	0
	HIMSS EMRAM certification (stage)	Continuous	N/a	5,416	0	0	111

Each table was exported from MS Access and saved as separate MS Excel data files where additional coding occurred, including the renaming of the variables according to the crosswalk table as well as coding for variable conditions where 1 was entered for yes (meeting the true condition) and 0 was entered for no (not meeting the true condition). Once completed, each file was imported individually into SPSS v28 using the DataImport function.

A binary logistic regression analysis was conducted to determine the relationship of the selected technological, organizational, and environmental variables on the adoption of RFID for medication administration in hospitals and was used for each RQ. This analysis is commonly used when there is one nominal or categorical dependent variable with two categories and two or more nominal (measurement) independent variables taken into consideration simultaneously to predict an effect. Additionally, regression analyses assume the observations are independent of each other, the dependent variable is coded accordingly, and the sample size is large to maximize likely estimates (Statistics Solutions, 2022, para. 3-7). The use of the HIMSS data set meets the independent nature of responses as each hospital organization responded based on their individual hospital characteristics at the time of response. Also, the associated coding for the variables was unique within the data set, furthering validating the independent nature of the data. Finally, an adequately calculated sample size reflecting the size of the dataset, allowing for the maximization of likely estimates between variables, should equate to an EPV of 50 or formula of $n = 100 + 50$ (I or the number of independent variables; Bujang et al., 2018). This would equate to a minimum sample of 250 for RQs 1 and 2, 200 for RQ3, and 500 for RQ4. The sample size for each RQ resulted in 1,088; 3,748; 5,527; and 779 records for RQs 1 to 4 respectively, exceeding the minimum sample required for each question.

The cases returned for each analysis represented the unweighted sample used, increasing the statistical significance of associations, and limiting assumptions made by weighing data via calculated methods to create a nonrepresentative sample (see Black et. Al, 2019). To determine the relationship between the variables, the resulting *p*-values of the analysis was used as the indicator of a statistically significant relationship where $p \leq .05$ (Di Leo & Sardanelli, 2020).

RQ1: What is the association between hospitals' technological influences (RFID interoperability, networked environment, and vendor used for RFID) and the adoption of RFID for medication administration?

> $H_0 1$: There is no association between hospitals' technological influences (RFID interoperability, networked environment, and vendor used for RFID) and the adoption of RFID for medication administration.
>
> $H_a 1$: There is an association between hospitals' technological influences (RFID interoperability, networked environment, and vendor used for RFID) and the adoption of RFID for medication administration.

To determine the association between hospitals' technological influences (RFID interoperability, networked environment, and vendor used for RFID) and the adoption of RFID for medication administration, the identified variables were combined for analysis, resulting in 1,088 records. A binary logistic regression analysis was conducted, which resulted in a 1-Step output, displaying the predictor or independent variables, and associated data in its model (see Table 4).

RFID interoperability (as defined with the variable name version) was the only technological variable related to RFID for medication administration at a statistically significant level ($p = < .05$) at 0.027. This finding is supported by CI values of 0.215 for the lower limit and 0.91 for the upper limit, where values less than 1 for both limits indicates that if the study is conducted multiple times (multiple sampling from the same population) with corresponding 95% CI for the mean constructed, it is expected that 95% of the data will contain the true population mean (Tan & Tan, 2010). The *OR* (0.443) and probability (31%) of a hospital adopting RFID for medication administration has a predicted change (*Beta* (*B*)) of -0.815, a value < 1, which is the predicted change in the logistic odds where every 1 change in the version predictor, there is a change of the *OR* or the probability of the outcome, a change that has a negative risk factor present. The *OR,* which is a measure of association and its associated strength, does not suggest a strong relationship between RFID interoperability and RFID adoption for medication administration as the value is < 1, and although a significant relationship exists, it is not a strong relationship or causal in nature.

Conversely, networked environment (location) and vendor used for RFID (vendor_type) were not significant predictors of RFID for medication administration. They reflect an *OR* > 1, indicating that hospitals are 47% and 60% more likely, respectively, to adopt RFID for medication administration ($p > 0.05$). However, the effects of these variables are not significant, which is confirmed as the range of the CI includes 1 or the crossing of the mean of the interval. Based on these results, the conclusion is to fail to reject the null hypothesis as there is only one variable within this construct that is statistically significant.

Table 4

Binary Logistic Regression—Technological Construct

Variables in the equation	*B*	S.E.	Wald	*df*	Sig.	*OR*	95% CI for *OR*	
							Lower	Upper
RFID Interoperability	0.815	0.368	4.913	1	0.027	0.443	0.215	0.91
Location	0.385	0.478	0.649	1	0.421	1.47	0.576	3.754
Vendor_type	0.467	0.543	0.739	1	0.39	1.595	0.55	4.627
Constant	3.012	0.46	42.945	1	<.001	0.049		

a Variable(s) entered on Step 1: version, location, vendor_type.

RQ2: What is the association between hospitals' organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration?

$H_0$2: There is no association between hospitals' organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration.

H_a2: There is an association between hospitals' organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration.

To determine the association between hospitals' organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration, the identified variables were combined for analysis, resulting in 3,748 records. It is important to note that the independent variable financial status did not return any results for any hospital entity upon initial query of the HIMSS database and was, therefore, not included in this research. Using the remaining variables, a binary logistic regression analysis was conducted where the resulting data for the independent variable presence of a CIO terminated at iteration number 6 as parameter estimates changed by less than .001.

The independent variable hospital size (as defined with the variable name *'NofBeds')* was the only organizational variable that produced results in the analysis. Identified as a categorical variable, the three categories of hospital size (Small<100 beds; Medium: 100-499 beds; Large: +500) were assessed as predictors in the model where NofBeds (100-499) and NofBeds (500+), when compared to the comparison outcome of NofBeds (0-99), the Odds Ratio for these predictors are <1 (0.952 and 0.993 respectively). This indicates that the comparison outcome becomes less likely relative to the reference outcome when the categorical predictor changes from the reference level to the comparison level or changes from one category of bed size to the next will be less relative to each level. The results also indicate 49% and 50% more likely to adopt RFID for medication administration in medium (100-499 beds) and large (500+)-sized hospitals than small-sized ones (0-99 beds), respectively. Medium- and large-sized hospitals are associated to a lower odds of adopting RFID for medication administration. As it relates to the significance values, each of the predictors indicated significance values higher than the threshold (*p*=<.05) with values of 0.961, 0.783, and 0.983 respectively and is confirmed as the range of the CI includes 1 or the crossing of the mean of the interval (Table 5), resulting in a failure to reject the null hypothesis for this construct as there are no variables that indicate a statistically significant association to the adoption of RFID for medication administration.

Table 5

Binary Logistic Regression--Organizational Construct

Variables in the equation	*B*	S.E.	Wald	*df*	Sig.	*OR*	95% CI for *OR*	
							Lower	Upper
NofBeds (0-99)			0.079	2	0.961			
NofBeds (100-499)	-0.049	0.177	0.076	1	0.783	0.952	0.673	1.347
NofBeds (500+)	-0.007	0.346	0	1	0.983	0.993	0.504	1.956
Constant	-3.204	0.126	650.9	1	<.001	0.041		

a Variable(s) entered on step 1: NofBeds.

RQ3: What is the association between hospitals' environmental influences (presence of an EMR and the attainment of HIMSS stage 6) and the adoption of RFID for medication administration?

$H_0$3: There is no association between hospitals' environmental influences (presence of an EMR and the attainment of HIMSS stage 6) and the adoption of RFID for medication administration.

H_a3: There is an association between hospitals' environmental influences (presence of an EMR and the attainment of HIMSS stage 6) and the adoption of RFID for medication administration.

The independent variable *'presence of an EMR',* did not return any data from the original HIMSS database and was, therefore, not included in the analysis for this RQ. The remaining independent variable attainment of HIMSS stage 6, was used to determine the association of this environmental construct and the adoption of RFID for medication administration among hospitals and resulted in 5,527 cases for analysis. The data analysis indicated that this solution was not unique because a perfect fit was detected among the compared variables. This can occur when the predictor variable (attainment of HIMSS stage 6) perfectly predicts the outcome or the dependent variable (RFID for medication administration) where there is no variability and an association could not be determined; often caused by coding errors, the use of several categorical variables whose categories are coded by indicators, and/or a small sample size (UCLA, 2022).

RQ4: What is the association between hospitals' technological (RFID interoperability, networked environment, and vendor used for RFID), organizational (hospital size, financial status, and presence of a CIO), and environmental (presence of an EMR and the attainment of HIMSS stage 6) influences and the adoption of RFID for medication administration?

H_04: There is no association between hospitals' technological (RFID interoperability, networked environment, and vendor used for RFID), organizational (hospital size, financial status, and presence of a CIO), and environmental (presence of an EMR and the attainment of HIMSS stage 6) influences and the adoption of RFID for medication administration.

H_a4: There is an association between hospitals' technological (RFID interoperability, networked environment, and vendor used for RFID), organizational influences (hospital size, financial status, and presence of a CIO), and environmental (presence of an EMR and the attainment of HIMSS stage 6) influences and the adoption of RFID for medication administration.

To determine the association between hospitals' technological (RFID interoperability, networked environment, and vendor used for RFID), organizational (hospital size, financial status, and presence of a CIO), and environmental (presence of an EMR and the attainment of HIMSS stage 6) influences and the adoption of RFID for medication administration, the identified variables were combined for analysis, resulting in 779 records. A binary logistic regression analysis was conducted where the independent variables RFID interoperability and attainment of HIMSS stage 6 (as identified here with the variable names *'Version'* and *'Stage'* respectively) were the only 2 variables related to RFID for medication administration at a statistically significant level (p=<.05) with values of 0.038 and <.001, respectively (Table 6). This association is confirmed with the resulting CI range of values for each which do not indicate the value of '1'. Additionally, several of the odds ratio values for the predictor variables indicated negative relationships (values <1) where for every one increase in unit, the odds of RFID for medication administration experienced a decrease by that factor. Positive relationships were noted by the odds ratio values for vendor_type (1.5) and stage (9.9) indicated by the odds ratio values >1. These results also indicated 60% and 91% likeliness to adopt RFID for medication administration, for these variables, respectively. The utilization of a vendor for RFID may not have been significant in this study but the odds ratio does note that the odds of adopting RFID for medication administration increases by a factor of 1.5. Based on these results, the conclusion is to fail to reject the null hypothesis as there are only two variables within this combined construct that are statistically significant.

Table 6

Binary Logistic Regression--Technological, Organizational, Environmental Constructs

Variables in the equation	*B*	S.E.	Wald	d*f*	Sig.	*OR*	95% CI for *OR*	
							Lower	Upper
RFID interoperability	-0.962	0.463	4.31	1	0.038	0.382	0.154	0.948
Location	-0.02	0.629	0.001	1	0.975	0.98	0.286	3.367
VendorType	0.422	0.786	0.288	1	0.592	1.525	0.326	7.122
NofBeds (0-99)			0.661	2	0.719			
NofBeds (100-499)	-0.17	0.402	0.178	1	0.673	0.844	0.384	1.856
NofBeds (500+)	-0.564	0.699	0.651	1	0.42	0.569	0.145	2.238
Stage	2.29	0.617	13.77	1	<.001	9.874	2.946	33.098
Constant	-4.411	0.828	28.35	1	<.001	0.012		

a Variable(s) entered on Step 1: version, location, vendortype, *N*ofbeds, stage.

Discussion

The statistical analysis and resulting outcomes were presented where a multiple logistic regression analysis was conducted to identify associations between independent variables (categorized as either a technological, organizational, or environmental construct) and the adoption of RFID for medication administration. The results of this analysis indicated that there were no significant relationships identified for any of the constructs, however, the individual variables RFID interoperability and Attainment of HIMSS stage 6 (as defined with the variable names version and stage respectively) did indicate a significant relationship when combined with all the other variables ($p=<.05$). Version also indicated a significant relationship within its Technological construct whereas stage presented with not enough variability to determine an association to the adoption of RFID for medication administration.

Summary

This chapter provided a review of the data presented to address the RQs. It began with the data collection process, an explanation of the data cleaning procedures and an analysis of each of the RQs via a binary regression analysis. Chapter 5 expanded on these findings including limitations to the study, recommendations for further research and implications for social change.

Chapter 5: Discussion, Conclusions, and Recommendations

Introduction

Patient safety continues to challenge the United States healthcare delivery system where ADEs or the results of MEs cause approximately 1.3 million emergency department visits and 350,000 hospitalizations each year (Centers for Disease Control and Prevention, 2018). Hospitals have recognized the need to increase patient safety measures in their facilities via improved medication administration activities that are in line with the five rights of safe medication practice (right patient, right medication, right time, right dose, and right route; U.S. Department of Health & Human Services, 2018). HIT have been increasingly used to support quality measures, including patient safety outcomes in hospitals; however, a large majority of the data has centered on the EMR (Chen, 2018; McKenna et al., 2018). Recent research has shown that other types of HIT such as AIDC methods (i.e., biometric and barcode technologies) are increasingly effective in improving patient safety and has reported success with medication administration activities (Smith-Ditizio & Smith, 2019). RFID technologies, a form of AIDC, are increasingly considered for medication administration use where the research supporting its effectiveness has increased within several industries but has been slow to be adopted within the United States healthcare delivery system, including hospitals. This study explored select technological, organizational, and environmental factors to gauge the adoption of RFID in hospitals for medication administration where it was found that select factors were influential in adoption, but others did not show an association or did not have enough data to determine an association.

Interpretation of the Findings

This study explored the predictors of RFID adoption for medication administration in U.S. hospitals using a quantitative methodological approach, secondary data, and TOE -related constructs. Conducting a preliminary analysis in MS Access to gauge the potential statistical findings in SPSS provided insight into the potential relationship among the variables pertaining to this research. Both analyses indicated a limited amount of data for several of the select variables as reported by the hospital participants, yet it provided some insight on those variables with presenting data.

Technological Context

The technological context of this study referred to those technologies currently used, those available for use, their complexities and associated learning curve, usefulness, and organizational compatibility. Successful implementation of RFID depends largely on the technological competence of the organization or its ability to use the appropriate knowledge, skill sets, and analytics to analyze the functional and technical issues within the organization, including the product's interoperability and the networked environment as well as the selection of a vendor that may support decision making (David & Jahnke, 2018; Ng & Kee, 2018).

The technological context of this research was addressed in the first RQ, which asked whether there was a relationship between hospitals' technical influences (RFID interoperability, networked environment, and vendor presence) and the adoption of RFID for medication administration. RFID interoperability (identified here as the independent variable wireless version), was significantly associated with hospitals adopting RFID for medication administration, with a .4 times greater chance of adopting this technology over the other technological variables. This finding supports research that hospitals are equipped to meet the interoperability challenges presented by the incorporation of RFID as WLAN specifications are adequately in place. These specifications (802.11 and 802.11X) establish the speed of connectivity to the router and coordinate the distribution of data between the router and connected devices, thereby assisting with the challenges of RFID integration and other wireless-related technologies in the hospital setting. It supports the literature that indicates that hospitals are leveraging this type of WLAN or this type of Wi-Fi to add on or make use of already incorporated Wi-Fi in their buildings for new technological opportunities (see Thewan et al., 2019).

Conversely, networked environment (identified here as location of wireless) and vendor used for RFID (identified as vendor_type) did not indicate an association to the adoption of RFID for medication administration by hospitals, however indicated 1.5 times greater chance of adopting this technology over the other technological variables. Hospitals in the United States are challenged by their organizational infrastructure to incorporate fully networked systems due to power efficiencies of sensors, standards and protocols, network mobility, and scalability (Dantu et al., 2019). The challenges of fully incorporating networked systems in the hospital due to organizational infrastructure issues is supported by the results of this research where the location of wireless capabilities within specific hospital areas where medication administration is performed were not associated to the adoption of RFID. Improving these capabilities may improve leadership's willingness to support technological solutions such as RFID to assist with their medication administration challenges.

Additionally, vendor used for RFID (identified as vendor_type) did not indicate an association to the adoption of RFID for medication administration by hospitals. These results did not support Patri and Suresh (2018), who identified the vendor selection process as a key factor in influencing technology implementations in healthcare organizations, as this process must be strategically aligned, planned, and agreed upon within the organization to prevent future implementation and functionality changes. Angeles (2022) also indicated that the use of an RFID vendor is a contributing factor to the successful deployment and implementation of an RFID-enabled system,; hence, leveraging a vendor to support RFID implementations may lead to increased use of this technology and improvement in medication administration processes. The results of this research did not support the literature assertions of an association between the presence and use of RFID vendors and RFID adoption for medication administration.

Successful implementation of RFID depends largely on the technological competence of the organization or its ability to use the appropriate knowledge, skill sets, and analytics to analyze the functional and technical issues within the organization, including the product's interoperability and the networked environment as well as the selection of a vendor that may support decision making (David & Jahnke, 2018; Ng & Kee, 2018). Overall, in review of the three independent variables used for the technological construct, the analysis supported the acceptance of the null hypothesis, where there is no association between all the combined technological variables of this

RQ. This analysis showed that in combination, the data did not support hospitals' ability to incorporate RFID technology with the necessary interoperability (wireless capabilities), networked environment (location of wireless in pertinent areas where medication is administered), or the use of a vendor to support RFID implementation within the hospital system to support improved medication administration processes, leading to improved patient safety outcomes.

Organizational Context

The organizational context of this study referred to the descriptive characteristics of the firm such as size, structure, resources, and communication channels (Evwiekpaefe et al., 2018; Tornatzky et al., 1990). Successful implementation of RFID is dependent upon human, technology, environment, and organization, which are significant factors of adoption within the different sizes of hospitals (Ahmadi et al., 2018). The organizational characteristics were addressed in the second RQ, which asked whether there was a relationship between hospitals' organizational influences (hospital size, financial status, and presence of a CIO) and the adoption of RFID for medication administration. The analysis did not return any values for the independent variable financial status and was not included in the results. As noted, responses to the HIMSS survey were completely optional, and there is a risk of not having completed data in this instance, which is cited as a common barrier to open data (Schöpfel et. al, 2015). As these responses were not mandated for completion, these data were necessary to understand the relationship between financial status and RFID adoption for medication administration in U.S. hospitals. However, as the literature noted, the identification of the hospital's financial status may exhibit differences in the use of HIT and hospitals with higher staffing, a function of larger size, and the financial means to invest in progressive strategies such as HIT adoption (Bhounsule & Peterson, 2016; Williams et al., 2016). This finding could not be supported with this research study.

The organizational influence indicated by the independent variable presence of CIO did not show an association to the adoption of RFID for medication administration by hospitals. This finding does not support the literature presented where it was found that the role of the CIO has been shown to foster innovation within hospitals through strategic visioning, guidance, and implementation of technology, where the resulting process innovations lead to improved organizational outcomes. Also, the CIO leadership role is needed to effect change with technological integration with hospital systems (Tanniru et al., 2018). However, substantiating the role of CIOs is challenging as there is no scientific evidence supporting the innovation capabilities of CIOs in healthcare, including the hospital setting (Esdar et al., 2017).

The independent variable hospital size (no. of beds) also showed no association to the adoption of RFID for medication administration by hospitals. Hospital size is derived by the number of beds that can be used for patient care services and medical treatment and was analyzed categorically according to these commonly used size measurements (small [<100 beds], medium [100-499 beds], large [500+ beds]) (Centers for Medicare and Medicaid Services, 2019a). This result does not support the literature, which showed that hospital size is a driver of HIT adoption. Overall, in review of the independent variables used for the organizational construct, the analysis supported the acceptance of the null hypothesis where there is no association between all the combined organizational variables of this RQ and the adoption of RFID for medication administration in hospitals.

Environmental Context

The environmental context of this research relates to the market elements, competitors and government regulations that are all likely to influence an organization's propensity to adopt innovation (see Tornatzky et al., 1990). Successful implementation of RFID from an environmental context would rely on hospital organizations managing and incorporating necessary changes within their organizations to align with the impact of these influences. The environmental context was addressed in the third RQ, which asked whether there was a relationship between hospitals' environmental influences (presence of an EMR and the attainment of HIMSS stage 6) and the adoption of RFID for medication administration. The analysis did not return any values for the independent variable presence of an EMR and, hence, was not included in the analysis. Although there were no data available for this variable to determine any relationship to RFID adoption for medication administration, prior research studies did purport an association of RFID adoption where an EMR was already in place. This finding could not be supported with this research study.

The environmental influence indicated by independent variables attainment of HIMSS stage 6 suggested that the solution was not unique because a perfect fit among the compared variables was detected as there was no variability and an association could not be determined. The inability to determine a relationship is an unfortunate finding as RFID technology has been increasingly used to support the improved technical capabilities of closed-loop and clinical decision support processes when integrated with an EMR system. The EMRAM certification identifies the level (stages 0-7) of EMR capabilities implemented by the hospital, with stage 7 indicating that the hospital no longer uses paper charts to manage patient medical care (HIMSS Analytics, 2017). Stage 6 identifies the level where technology is used to achieve a closed-loop process for administering medications or an administration system that seamlessly integrates electronic medication management automation and administrative processes (Burkoski et al, 2019). This stage also calls for a more advanced level of clinical decision support to provide for the five rights of medication administration, systems that provide timely patient care information, leading to improved outcomes and increased quality healthcare (Agency for Healthcare Research and Quality, 2019). These systems also can provide alerts at the time of ordering and can reduce MEs and ADEs via the integration within an EMR (Ancker et al., 2017).

Limitations of the Study

There were several limitations of this study that contributed to its findings. The use of secondary data, although flexible in their use as they can be affordable and easily accessible and can reduce time spent on behalf of the researcher on data collection, may not always provide the data needed for a specified study. This study was limited to the completeness of the responses provided by its participants. Hospital participation in the data collection effort was voluntary, and those hospitals who chose to participate were not required to complete all areas of the questionnaire, leading to missing data for the selected variables needed for analysis in this research study and, hence, the inability to find a meaningful relationship amongst them.

Also associated with the data set, the exclusion of federal hospitals may have limited the amount of data potentially collected for these variables. Participants are often excluded when they meet the inclusion criteria but may present with characteristics that may interfere with potential study results (Patino & Ferreira, 2018). It is unclear as to the reason these hospitals were not invited to participate, a potential challenge to generalize findings to the general population or external validity of the study.

There is also a limitation imposed by the use of secondary data which is the accuracy of responses from the surveyed participants. I am hopeful that the participants responding to the HIMSS hospital survey have answered truthfully to the questions but do note this as a limitation as the use of secondary data or data collection efforts in general.

Recommendations

Further research is needed to fully explore contributing factors to the adoption of RFID in U.S. hospitals for medication administration use. It is recommended to identify a dataset that is more robust in data on RFID from responding participants or for the researcher to conduct a primary data collection effort to potentially maximize participation and data for analysis. Alternatively, researchers may choose to reassess and/or expand upon the framework used in this research study using different technological, organizational, and/or environmental factors that may provide insight into the adoption of RFID within hospitals.

Reviewing each of the variables independently and not as a group for each context may provide insight as to which variables have an impact on the adoption of RFID for medication administration.

Also, as this research study was a cross-sectional approach, allowing the research to take a snapshot of data at a specific time, without manipulating data and reviewing multiple characteristics at a time to review the targeted characteristics of the population, a potential change to a longitudinal approach where one could assess hospital's adoption of RFID over a period may provide further insight into this phenomenon.

Future research in this area may also benefit from a mixed methods research model to allow for the qualitative responses to inform the results of the quantitative aspect of the research. This model may have proved useful in this research, potentially assisting in understanding why there were so many missing data fields and why the data analysis returned a limited number of case studies. A qualitative analysis may have also helped to understand the extent of RFID knowledge as a useful technology to assist in the reduction of MEs and as a tool in medication administration processes.

Implications and Social Impact

The results of this study contribute to our understanding of the key factors which influence decision makers' intention to adopt RFID technologies to support medication administration activities, using a quantitative methodological approach, secondary data, and TOE-related constructs. It provided an understanding of RFID technology and the benefits of its use in other industries where the data suggests high benefits of its use within the health care industry as well. Hospital leaders looking to identify improved patient safety and healthcare delivery outcomes may leverage this study as a starting point in the recognition of RFID to assist in these efforts.

Conclusions

The use of technology to assist with medication safety practices has increasingly gained the attention of legislatures to identify, develop, and implement several policy initiatives, regulations and tools as this issue is estimated to cost $3.5 million annually across all healthcare settings (Centers for Disease Control and Prevention, 2018). RFID has emerged as a cutting-edge technology as it can capture data automatically from remote distances and hands-free using Wi-Fi-enabled tags and labels to track the exact location of patients, providers, and medications in real-time throughout the hospital and at the point of care streamlining the medication administration and reconciliation processes with reduced MEs (Paaske et al., 2017).

Despite the growing evidence supporting the use of RFID to reduce MEs and improve patient safety within healthcare organizations, RFID has been slow to be implemented in the hospital setting (Fosso Wamba et al., 2016). This study expanded on the literature on RFID adoption factors for medication administration with specific focus on the technological, organizational, and environmental factors of hospitals in the United States using a quantitative methodological approach and secondary data. Although the analysis resulted in a limited number of cases to identify relationships among the identified variables, this study has supported the additional need for further research on RFID and its adoption in hospitals. The identification and use of technological advances that prevent life-threatening medical errors will have long-lasting social implications, enhancing the health and safety of those served by U.S. hospitals.

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