EVALUATING THE RELATIONSHIP BETWEEN PATIENT SAFETY CULTURE AND THE BEHAVIORAL INTENTION TO USE BAR CODE MEDICATION ADMINISTRATION AMONG REGISTERED NURSES IN HOSPITALS

by

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by

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DEDICATION

This is dedicated to my parents Samuel and Chong Song who have always instilled that learning is a life long journey and that we must do our best contribute to society. Forty years ago they came to the United States of America to provide a better life for my brother and me and because of their sacrifices, I am extremely grateful.

This is also dedicated to my wonderful husband Ian Crumbley for providing much needed support and encouragement.

Also, I'd like to dedicate this to Sam, Kimberly, Spencer, Evan, and Henry Song for ensuring that I have fun by cheering for Spencer at his bowling tournaments and cheering for Evan when he's running with the football.

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LIST OF ABBREVIATIONS

Agency for Healthcare Research and Quality .... AHRQ
Bar Code Medication Administration .... BCMA
Behavioral Intention to Use .... BI
Communication Openness .... CO
Computerized Provider Order Entry .... CPOE
Emergency Department .... ED
Electronic Medication Administration Record .... eMAR
Feedback and Communication about Errors .... FCE
Hospital Management Support for Patient Safety .... HMSPS
Hospital Survey on Patient Safety Culture .... HSOPSC
Institute of Electrical and Electronics Engineers .... IEEE
Institute of Medicine .... IOM
Intensive Care Unit .... ICU
National Coordinating Council for Medication Error Reporting & Prevention NCC MERP
Operating Room .... OR
Perceived Ease of Use .... PEOU
Perceived Usefulness .... PU
Registered Nurse .... RN
Teamwork within Hospital Units .... TWHU
Technology Acceptance Model .... TAM

ABSTRACT

EVALUATING THE RELATIONSHIP BETWEEN PATIENT SAFETY CULTURE AND THE BEHAVIORAL INTENTION TO USE BAR CODE MEDICATION ADMINISTRATION AMONG REGISTERED NURSES IN HOSPITALS

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Background: Serious medication errors continue to exist in hospitals even though there is technology that could potentially eliminate them such as bar code medication administration (BCMA). Little is known about the degree to which the culture of patient safety is associated with the behavioral intention to use BCMA. The purpose of this study was to evaluate the relationship between patient safety culture and BCMA perceived usefulness and perceived ease of use among registered nurses in hospitals to determine the behavioral intention to use BCMA technology based on the Technology Acceptance Model.

Methods: A correlational design using quantitative surveys with a convenience sample of 163 registered nurses at rehabilitation and acute care hospitals using bar code medication administration was used in this study. The primary outcome variable of interest is BCMA behavioral intention to use. As independent variables, demographics and work characteristics and patient safety culture composites including teamwork within hospital units, communication openness, and feedback and communication about errors, and hospital management support for patient safety were included.

Results: There were significant relationships of BCMA perceived usefulness (PU) ($r = .432$, $p<0.001$), BCMA perceived ease of use (PEOU) ($r = .333$, $p<0.001$) with BCMA behavioral intention to use (BI) in the bivariate analyses. However, BCMA PEOU was not significantly related to BCMA BI in the multivariate relationship after controlling for demographics, work characteristics, and patient safety culture. In the multivariate regression model of BCMA BI, age had a statistically significant negative impact ($\beta = -.17$, $p<0.05$), teamwork within hospital units ($\beta = .20$, $p<0.05$) and BCMA PU ($\beta = .35$, $p<0.01$) both had a statistically significant positive impact. The overall BCMA BI model explained 24% ($p<0.001$) of variance.

Conclusion: Identified factors influencing the behavioral intention to use BCMA can help inform hospitals to develop a tailored intervention for registered nurses to promote the use of BCMA. Adherence to BCMA could decrease medication administration errors.

CHAPTER ONE

According to the Institute of Medicine, each year medication errors result in more than 7000 deaths (IOM, 2000) and harm at least 1.5 million people, at a cost of $3.5 billion (IOM, 2007). Indeed, one of every five medication administrations reportedly involves an error of some sort (Barker, Flynn, Pepper, Bates, & Mikeal, 2002). Additionally, registered nurses contributed to 54% of medication errors, with 30% of errors occurring at the medication administration phase (Pham et al., 2008).

Many studies have attempted to dissect the medication process to determine where these errors occur (Antonow, Smith, & Silver, 2000; Bates et al., 1995; Carayon et al., 2007; Leape et al., 1995; McDowell, Ferner, & Ferner, 2009) and what factors contribute to their occurrence (Carayon et al., 2007; Pape et al., 2005; Tang, Sheu, Yu, Wei, & Chen, 2007). Questions still remain, however. For example, it is unclear precisely why medication errors continue to occur, despite application of technology that could potentially eliminate them (Cochran, Jones, Brockman, Skinner, & Hicks, 2007). One such technology is bar code medication administration (BCMA). During the medication process, nurses are generally the last healthcare professional with the opportunity to correct medication errors before the mediation reaches the patient. BCMA could potentially assist nurses in preventing medication errors, but for a variety of reasons compliance with this technology is often lacking (Cochran, Jones, Brockman, Skinner & Hicks, 2007; van Onzenoort, van de Plas, Kessels, Veldhorst-Janssen, van der Kuy, & Neef, 2008). It is therefore imperative that the issue of medication errors be addressed with the aim of preventing further harm to people and eliminating their associated costs. The aim of the proposed study is to determine whether a relationship exists among the patient safety culture in hospitals, registered nurses' demographic and work characteristics, and the behavioral intention to use BCMA.

Statement of the Problem

There have been many studies examining the efficacy of using BCMA to reduce the frequency of medication errors (DeYoung, VanderKooi, & Barletta, 2009; Franklin, O'Grady, Donyai, Jacklin, & Barber, 2007; Poon, et al., 2010). There have also been studies of BCMA workarounds, such as not scanning the patient or the medication (Koppel, Wetterneck, Telles, & Karsh, 2008; Patterson, Rogers, Chapman, Render, 2006; Rack, Dudjak, & Wolf, 2012). Nonetheless, little is known about the degree to which the culture of patient safety is associated with the behavioral intention to use BCMA. Determining whether such a relationship exists is essential, as medication administration errors continue to occur, despite the introduction of bar code technology to the medication administration process. Numerous barriers to BCMA have been described in the literature, as have ways to work around the procedure (Patterson, Rogers, Chapman, & Render, 2006; Rack, Dudjak, & Wolf, 2012). By understanding the relationship between patient safety culture and the behavioral intention to use BCMA, healthcare organizations could facilitate adoption of BCMA to further minimize medication errors by promoting the proper usage of bar code technology in the medication administration process.

Research conducted by Koppel, Wetterneck, Telles, and Karsh (2008), and Carayon et al. (2007) has documented the ways in which nurses work around BCMA. The research provides a basic understanding of observed workarounds and their potential causes. Additionally, both studies also reported the environmental factors and the task sequences associated with BCMA. The “automation surprises” encountered by nurses included network disconnection, freezing of the BCMA device, screen misalignment, short time out settings, and an incidence of not recognizing the nurse’s ID (Carayon et al. (2007). Other technical issues encountered were software related, such as numerous screens needed to perform a task, multiple scanning attempts, and beeping for both acceptable and incorrect scans (Koppel, Wetterneck, Talles, & Karsh, 2008). Understanding the interactions among these obstacles, the potential workarounds, and the lack of education may shed light on why nurses deviate from established BCMA procedures. This non-adherence to BCMA procedures can negatively impact patient safety and allow significant medication errors to occur (Carayon et al., 2007; Poon et al., 2010; Rack, Dudjak, & Wolf, 2012). At present, however, there are no studies in the literature focusing on the culture of patient safety as it relates to BCMA workarounds. Although it is acknowledged that patient safety is affected by BCMA workarounds, the role of the culture of patient safety has not been addressed.

Evidence suggests that the frequency of medication errors is reduced upon implementation of BCMA systems (Cochran, et al., 2007; DeYoung, Wanderkooi &

Barletta, 2009; Helmons, Wargel, & Daniels, 2009; Paoletti et al., 2007; Sarkowski, Newman, & Dozier, 2008 & Yates, 2007). It has not been claimed that BCMA can prevent all medication errors, it cannot, but it must be acknowledged that BCMA can significantly reduce the frequency of medication errors (Poon et al., 2010). It should also be recognized that in instances where components of the technology fail, it is the nurse's response to that failure that is important for the prevention of medication errors (Hanuscak, Szeinbach, Seoane-Vazquez, Reichert, McCluskey, 2009). This is because the decision by a nurse to comply with a delineated medication administration procedure in the absence of reliable technology or presence of environmental barriers also can promote medication errors.

Medication errors continue to occur at healthcare organizations employing BCMA when there is not a full understanding of the patient safety culture. Furthermore, these organizations may not have the information they need to address these medication errors. Ultimately, an understanding of the factors contributing to the behavioral intention to use BCMA will be essential for promoting adherence to the BCMA. Reducing the frequency of medication errors requires cultural indoctrination of the BCMA process as part of a healthcare organization's patient safety culture.

To understand the impact of patient safety culture on BCMA, it is necessary to evaluate the behavioral intention to use BCMA technology. 'The behavioral intention to use' is a construct that is a strong determinate of usage behavior, which is influenced by perceived usefulness and perceived ease of use (Davis, 1989). By incorporating the behavioral intention to use BCMA technology, this study can assist healthcare organizations to understand the influence of patient safety culture and the impact of BCMA usage behavior.

Background of the Study

Medication Errors Defined

Medication errors have been defined in many different ways. For example, Morriss et al. (2009) define a medication error as “an error in ordering, transcribing, dispensing, administering, or monitoring a medication.” On the other hand, in physician-focused studies, medication errors have been defined as a deviation for an order that a physician has written (Mark & Burleson, 1995). To standardize the definition of a medication error, the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP, 2010) has provided a specific definition to be used in its entirety. The NCC MERP (2010) defines a medication error as:

> “A medication error is any preventable event that may cause or lead to inappropriate medication use of patient harm while the medication is in the control of the healthcare professional, patient, or consumer. Such events may be related to professional practice, healthcare products, procedures, and systems, including prescribing; order communication; product labeling, packaging, and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use.”

The Council encourages the consistent use of this definition to identify medication errors in research.

Medication Administration Process and Errors

The Medication Administration process is interdisciplinary and includes the "prescribing, transcribing, manufacturing or compounding, dispensing, and administration of a drug, and monitoring therapy" (McDowell, Ferner, & Ferner, 2009, p.606). In their description of what they call the "pathophysiology of medication errors," McDowell et al. (2009) characterizes the medication process as separate actions performed by different disciplines with each step or action at risk for a medication error. The interdisciplinary team participating in the medication process consists of licensed independent providers such as physicians, residents and nurse practitioners, who prescribe medications, and pharmacists/pharmacy technicians, who compound and dispense the drug, and registered nurses, who typically administer and monitor the drug therapy (Antonow, Smith, Silver, 2000; McDowell et al., 2009). With multiple disciplines involved in the multistep medication administration process, there are numerous opportunities of the process to fail (McDowell et al., 2009).

It is well documented that medication administration is a fallible process, and no areas administering medications or the type of mediations administered are immune. Extensive research conducted in medical-surgical units, intensive care units (ICU), emergency departments (ED), pediatric departments and operating rooms (OR) have all reported medication errors (Helmons, Wargel, & Daniels, 2009). Additionally, certain medications such as opioids (Morriss, Abramowitz, Newlson, Milavetz, Michael, & Gordon, 2011), warfarin (FitzHenry, Doran, Lobo, Sullivan, Potts, Feldott, Matheny, McCulloch, Deppen, & Doulis, 2011) and intravenous medications (McDowell et al., 2009) are prone to errors. Not only do certain levels of care have medication errors, but the experience of the interdisciplinary team can also have an effect on the overall error rate of medications (McDowell et al., 2009).

Medication Errors by Stage

Medication administration is a multistep process, and each step has a potential for failure resulting in a medication error (Leape et al., 1995; McDowell, Ferner, & Ferner, 2009; Pham et al. 2008;). Research studies have identified errors occurring at various phases or stages of the medication process, which includes prescribing, transcribing, dispensing and administering medications (Antonow, Smith, & Silver, 2000; Leape et al., 1995; Pham et al., 2008). These studies have reported rate of physician-initiated error at the prescribing stage in medical and surgical units at 39% (N = 334) (Leape et al., 1995), pediatric units at 30% (N = 177) (Antonow, Smith, & Silver, 2000) and emergency departments at 24% (N = 13,392) (Pham et al., 2008). The rate of medication administration errors by nurses is similar at 38% in medical and surgical units (Leape et al., 1995), 24.3% in pediatric units (Antonow, Smith, & Silver, 2000) and 36% in emergency departments (Pham et al., 2008). The reported dispensing errors by pharmacies were reported at 11%, 24.9% and 4%, respectively.

The study conducted by Leape et al. (1995) was notable in that evaluated the systems failures contributing to the potential for adverse drug events. The authors acknowledge that individuals make errors; however, it is the systems in place that promotes errors (Leape et al., 1995). Of the errors reported, 78% were due to these systems failures involving drug knowledge, dose and patient identification, patient information, order transcription, allergy checking, medication order tracking and interdisciplinary communication (Leape et al., 1995).

Despite the number of medication errors in the adult admissions at two hospitals over a 6-month period, investigators found that nurses were able to intercept 86% of physician prescribing errors, with the pharmacy intercepting only 12% of medication errors (Leape et al., 1995). Additionally, Antonow, Smith, and Silver (2000) reported that 62.1% medication errors were prevented before reaching the patient, and that medication error prevention decreases as the medication process gets closer to medication administration. Case in point, 70% of dosing errors were intercepted in the prescribing phase, while only 6% were intercepted in the administration phase (Leape et al., 1995).

While medication errors were prevented from reaching the patient, errors still occurred (Antonow, Smith, & Silver, 2000; Leape et al., 1995; Pham et al., 2008). The most common medication errors were dosing errors (28%), occurring primarily in the prescribing phase (Leape et al., 1995). Among the pediatric population, dosing errors are the most common medication error; this is related to the fact that weight is essential for calculating medication dose in children (Wong, Ghaleb, Franklin, & Barber, 2004). Sheu, Wei, Chen, Yu, and Tang (2008) reported results that show wrong medication dosage and wrong medications to account for 60% of medication errors.

Of the medication errors reported by Pham et al. (2008), improper dose/quantity accounted for 18%, giving a drug not ordered accounted for 11%, and an ordered drug not administered accounted for 11%. Among the reasons for medication errors, protocol violation (17%) and poor communication (11%) were the largest contributing factors

(Pham et al., 2008). Other factors such as abbreviations, transcription, calculation errors, and contraindicated medications also contributed (Pham et al., 2008).

Pham et al. (2008) used the MEDMAREX medication error reporting system containing more than 1.2 million medication errors and found supporting results focusing on emergency department medication errors. Of the reported errors by 496 emergency departments between the years 2000 to 2004, there was a total of 13,392 medication errors, or a rate of 78 medication errors per 100,000 administrations (Pham el al., 2008). Of the three medication error-related deaths reported in the Pham et al. (2008) study, the causes were 1) administration of an incorrect drug that appeared similar to another drug, 2) an inappropriate order for a blood pressure medication for a patient with end-stage cardiac disease, and 3) a 10-fold dosing error. These fatal errors can be categorized with the system failures of drug knowledge and dosing errors described by Leape et al. (1995).

Medication Error Reporting by Nurses

A common theme surrounding the number of reported medication errors in research is the underreporting of medication incidents (Antonow, Smith, & Silver, 2000; Sheu, Wei, Chen, Yu, & Tang, 2008; Ulanimo, O'Leary-Kelly, & Connolly, 2007). Antonow, Smith, & Silver (2000) investigated 51 incident reports for medication errors, and noted that only 30% of the medication errors described in their study resulted in incident reports. Similarly, nurses reported only 28.9% of medication errors by completing an incident report (Ulanimo, O'Leary-Kelley, & Connolly, 2006). On the contrary, Sheu et al. (2008) presented higher rates of reporting medication errors, with 62.5% actual errors and 50.7% near misses being reported. Overall, near miss errors were less likely to be reported (Antonow, Smith, & Silver, 2000). This could possibly be related to the hospitals' patient safety culture of reporting all errors. Still, the literature shows a lack of incident reporting for medication errors.

When investigating the barriers on reporting medication errors, per Ulanimo, O'Leary-Kelley, and Connolly (2007), 60% of nurses (N = 27) believed that nurses don't report medication errors because of manager reaction, and 64% believe errors aren't reported because of peer reaction. Additionally, when asked if they failed to report a medication error, 16% of the nurses responded in the affirmative and gave fear of disciplinary action or job loss as a reason (Ulanimo et al., 2007). Other authors have reached the same conclusions regarding the underreporting of medications errors (Antonow, Smith, & Silver, 2000; Sheu et al., 2008). These findings are noteworthy as feedback and communication about errors is essential for creation of an open environment that can improve the medication administration process by reporting all errors or potential errors.

Medication Error Causes

Since prevention of medication errors decreases as the medication reaches the medication administration phase (Antonow, Smith, & Silver, 2000), studies have included nurses when investigating errors surrounding medication administration errors. In an attempt to better understand the role of demographic and work characteristics in this phase, Sheu, Wei, Chen, Yu, and Tang (2008) used a snowball sampling method to recruit 85 nurse participants for their study. Using a semi-structured questionnaire to obtain information about the type of medication error, hospital and nurse demographics, patient outcomes, error reporting rates, Sheu et al. (2008) collected information on 328 medication administration errors from local hospitals. They also reported 48 instances of a medication being administered to the wrong patient. The authors reported that medication errors were more prevalent on the day shift due to greater numbers of distractions occurring during the day, among nurses working less than 2 years due to their lack of pharmacology education, and on medical/surgical units at teaching hospitals due to the complexity of the medication regimens.

Besides the demographic and work characteristics identified by Sheu et al. (2008), nurses responded that medication errors occur when nurses do not check the patient's armband against the medication administration record (45.8%) followed by fatigue (33%) (N = 27) (Ulanimo et al., 2007).

Referencing Sheu et al. (2008) findings that day shift nurses had more medication errors due the amount of interruptions, Elganzouri, Standish, and Androwich (2009) was able to quantify the number of interruptions during the process of medication administration. They observed 151 nurses on medical/surgical units distributing 980 medications to patients in three hospitals on all shifts. Notably, Elangzouri et al. (2009) reported 1,052 interruptions during the distribution of medication. That is an average of 1.21 interruptions during each medication pass, each of which could potentially cause an error.

BCMA in the Medication Process

Health information technology has assisted in reducing medication errors. Computerized provider order entry (CPOE), electronic medication administration records (eMAR), bedside automated medication dispensing machines, BCMA, decision support systems and other technology-influenced systems have all contributed to reducing medication errors by altering staff and preventing errors at their onset. Technology also standardizes the medication administration process, thereby reducing the frequency of human error in the medication process (Chang & Mark, 2009), and technological interventions have demonstrated that streamlining processes is important for reducing errors in the medication administration. Among the various technologies currently in use, the focus is specifically on BCMA in the proposed study.

BCMA technology incorporates a bar code scanner into the medication administration process. This assists in the prevention of medication administration errors by integrating the medication administration record, validating the 5 rights, and following medication administration protocols (Koppel et al., 2008). After a physician writes or enters the medication order, the order is processed by the pharmacy, and the patient's medication is then listed on the electronic medication administration record (eMAR) (Poon et al., 2010). Prior to administering the medication, the nurse verifies the physician's order against the eMAR. During the medication administration process, the nurse, with the assistance of BCMA technology, verifies the 6 rights – i.e., the right patient, right medication, right dose, right route, right time, and right documentation – for each medication scanned. Currently, there are 8 rights of medication administration, which also includes the right reason for giving the medication and the patient's response to the drug (Nursing2012 Drug Handbook, 2012, p.14). In this study, the focus will be on the 6 rights of medication administration, since the last 2 rights rely on the nurse to make this assessment.

The available evidence suggests that use of BCMA has enabled errors to be detected that previously would have gone undetected (Young, Slebodnik, & Sands, 2010). Errors such as order expiration or no order for the medication (DeYoung, VanderKooi, & Barletta, 2009; Paoletti et al., 2007; Sakowski et al., 2008), incorrect dosage (Franklin et al., 2007; Morriss et al., 2009; Poon et al., 2010; Sakowski et al., 2008), extra dose (Franklin et al., 2007), omitted dose (DeYoung et al., 2009; Helmons et al., 2009), wrong time (DeYoung, VanderKooi, & Barletta, 2009; Sakowski et al., 2008), and wrong route (Sakowski et al., 2008) have all been identified by BCMA. However, Sakowski et al. (2008), reported that errors caught by BCMA accounts for less than 10% of moderate or severe adverse effects. Although small, this error rate still contributes to patient safety issues.

Not only does BCMA identify errors that were not previously detected, the overall impact on medication error rates after the implementation of BCMA is positive. Poon et al. (2010) reported a 50.8% reduction in potential adverse drug events, an 80.3% reduction in medication administration documentation errors and a 33.0% reduction in wrong dose errors. DeYoung et al. (2009) reported a 56% reduction in medication error rates after the implementation of BCMA (N = 775 pre-implementation, N = 690 post implementation), which contributed to a reduction in wrong administration time from 19.7% to 8.7%. Franklin et al. (2007) reported a 39% decrease in medication error rates for non-IV medications resulting from reductions in wrong dosage and omission errors

(N = 1644 pre-implementation, N = 1178 post implementation). Additionally, Franklin et al. (2007) reported an increase of checking the patient's identity prior to administration of medication from 17.4% pre-BCMA implementation to 81.1% post-implementation. Paoletti et al. (2007) reported a 54% decrease of medical administration errors on a medical-surgical unit (N = 320 pre-implementation, N = 310 post implementation). The implementation of BCMA has not only enabled detection of errors not previously reported, it has decreased the incidence of medication administration errors.

There are mixed reports that BCMA does not impact medication administration errors in all hospital units or have an effect on all medication severity ratings. Helmons, Wargel, and Daniels (2009) reported that there was no change in the overall medication error rate in ICUs, where the pre-implementation rate was 12.6% and post-implementation rate was 13.5%. On medical surgical units, the pre-implementation rate was 10.7% and post implementation rate was 9.9%; however, when wrong time errors were excluded, the medication error rate decreased by 58% (Helmons et al., 2009). Both significant (48.5%) and serious (54.1) potential adverse drug events were reduced; however, life threatening potential adverse drug events didn't change (Poon et al., 2010). The premise of BCMA is the same, although the user interface and devices differ depending on the BCMA software and hardware vendor, all of which may contribute to the mixed impact of BCMA. Still there are safety advantages provided by BCMA, though the descriptions of the BCMA systems are lacking.

BCMA Workarounds

BCMA workarounds have been defined as “the use of BCMA in ways that circumvent its safety advantages” (Cochran et al., 2007, p.297). Although BCMA is an intended safety layer in the medication administration process, nurses are not always compliant with its intended use. Patterson, Rogers, Chapman, and Render (2006) noted that nurses create BCMA workarounds, which in turn create new avenues to adverse medication events, and reduce the system’s effectiveness. In an observational study, Carayon et al. (2007) documented unsafe medication practices that included administering medication without scanning the patient, administering medication before scanning the patient, documenting medication administration with the medication was not given, scanning the patient’s chart instead of the patient, administration of a dose of medication higher then ordered, and overriding the BCMA alarms. In addition, the study conducted by Koppel et al. (2008) identified 15 related BCMA workarounds with possible errors involving the wrong medication, wrong dose, wrong route, wrong time, and wrong patient, as well as, omission of a medication or failure to document a medication given. They classify these errors as omission of process steps, steps performed out of sequence and unauthorized BCMA process steps, all of which were to work around BCMA.

A few studies provide probable causes for BCMA workarounds. Carayon et al. (2007) described technology issues encountered by nurses using BCMA, including unresponsive devices, lack of wireless connectivity, application timed out, improper screen alignment, and failure to recognize the nurse’s identification badge. Koppel et al. (2008) also identified several types of possible causes for BCMA workarounds related to technology, organization, task, patient, and environment. Technology-related workarounds included: BCMA device times out prior to the nurse completing medication administration, multiple screens, multiple bar code scans, device peeping, BCMA device bulky, lack of wireless connectivity, battery life, slow application response, scanning failures, and reliance on technology. Probable organization-related causes included: unit dose of medication larger or smaller than the dose ordered, non-formulary medication, medication order not on the eMAR, bar code not readable, patient without armband, inadequate staffing, untrained users, and lack of awareness of hospital policies. Other probable causes include: bar code-related errors consisting of task-related, patient-related, and environment-related factors such as multiple bar codes, inaccessible bar code, patient refusing scanning, loss of wireless connectivity, and inability to hear scanner due to environmental noise. Development of approaches to minimize the use of BCMA workarounds is essential for improving patient safety by reducing the frequency of medication administration errors. These procedures may also reduce costs, as medication errors cost up to $8.4 million per year in a 700-bed hospital, not including patient injury and malpractice costs (Bates et al., 1997).

The common theme regarding the majority of BCMA workarounds comes down to the nurses' compliance with BCMA use in complying with procedure. The most common failure was not scanning the medication barcode (72%, N = 220), not scanning the patient's armband (63%), scanning the medication after medication administration (40%), and scanning the patient's ID band on another object other than the patient's wrist band (23%) (Rack, 2012). Other studies have reported the rate of not scanning the medication bar code at 44.7% (N = 15,162) (Van Onzenoort et al., 2008). Even though these are nursing deviations from the established BCMA protocol, this does not discount the real issues surrounding the barriers of BCMA, as outlined by Koppel et al. (2008).

BCMA Re-Education

Early, Riha, Martin, Lowdon, and Harvey (2011) conducted a study after a near miss involving an override of the BCMA system to identify the reasons why overrides occur and to prevent them in the future. The study highlighted that this is a common workaround practice among nurses and focused on changing the cultural environment by stressing that overrides are not acceptable. In this study, an override was defined as the improper scanning of a patient identifier (e.g., patient label on a form) other than a patient's scanned attached armband. After the re-education, a wireless upgrade, replacement scanners, bar-code printers, and a second person witnessing the override, there was a 79% reduction in "overrides" from 1512 to 427. After mandatory Web-based education and direct management feedback and follow up with "overrides," practice behaviors changed.

Knowledge Gap

Medication errors still persist even though there have been technological improvements to assist in the reduction of errors in the medication process, such as BCMA technology. The literature has shown the benefits of BCMA for reducing medication administration errors (Poon et al., 2010; DeYoung et al., 2009; Franklin et al., 2007; Morriss et al., 2009; Paoletti et al., 2007) as well as other benefits, like detecting errors not previously detected (Young et al. 2010). Yet there is still non-adherence to the

BCMA process (Carayon et al., 2007; Cochran et al., 2007; Koppel et al., 2008; Patterson et al., 2006).

Technology alone cannot solve the problem of medication administration errors. This study hopes to bridge the knowledge gap between BCMA technology and the lack of adherence to BCMA procedures by exploring its relationship to patient safety culture in hospitals. Perhaps by understanding the patient safety culture within our hospitals we can focus on the patient safety culture dimensions to encourage the proper use of BCMA to reduce medication administration errors.

Purpose of the Study

The purpose of this study was to evaluate the relationship between patient safety culture and BCMA perceived usefulness and perceived ease of use among registered nurses in hospitals to determine the behavioral intention to use BCMA technology. The patient safety culture composites used in this study include teamwork within hospital units, communication openness, and feedback and communication about errors, and hospital management support for patient safety. The BCMA device used at the hospitals in this study is the Motorola MC70 Enterprise Digital Assistant (Figure 1).

Figure 1 Morotola's MC70 Enterprise Digital Assistant image retrieved on September 04, 2012 from http://www.motorola.com/web/Business/Products/Mobile%20Computers/Handheld%20Computers/MC70/_Documents/Static%20Files/MC70_SS_1208.pdf.

Research Questions

1. What is the relationship between BCMA perceived usefulness (PU) and teamwork within hospital units (TWHU) among registered nurses in hospitals?
2. What is the relationship between BCMA perceived usefulness (PU) and communication openness (CO) among registered nurses in hospitals?
3. What is the relationship between BCMA perceived usefulness (PU) and feedback and communication about errors (FCE) among registered nurses in hospitals?
4. What is the relationship between BCMA perceived usefulness (PU) and hospital management support for patient safety (HMSPS) among registered nurses in hospitals?
5. Do teamwork within hospital units (TWHU), communication openness (CO), and feedback and communication about errors (FCE), hospital management support for patient safety (HMSPS) better predict BCMA perceived usefulness (PU) than any single dimension of patient safety culture alone, after controlling for demographic and work characteristics among registered nurses in hospitals?
6. What is the relationship between BCMA perceived ease of use (PEOU) and teamwork within hospital units (TWHU) among registered nurses in hospitals?
7. What is the relationship between BCMA perceived ease of use (PEOU) and communication openness (CO) among registered nurses in hospitals?

8. What is the relationship between BCMA perceived ease of use (PEOU) and feedback and communication about errors (FCE) among registered nurses in hospitals?
9. What is the relationship between BCMA perceived ease of use (PEOU) and hospital management support for patient safety (HMSPS) among registered nurses in hospitals?
10. Do teamwork within hospital units (TWHU), communication openness (CO), and feedback and communication about errors (FCE), and hospital management support for patient safety (HMSPS) better predict BCMA perceived ease of use (PEOU) than any single dimension of patient safety culture alone, after controlling for demographic and work characteristics among registered nurses in hospitals?
11. What is the relationship between BCMA perceived ease of use (PEOU) and behavioral intention to use (BI) BCMA among registered nurses in hospitals?
12. What is the relationship between BCMA perceived usefulness (PU) and the behavioral intention to use (BI) BCMA among registered nurses in hospitals?
13. Do both BMCA perceived ease of use (PEOU) and BCMA perceived usefulness (PU) better predict the behavioral intention to use (BI) BCMA then either one alone, after controlling for demographic and work characteristics among registered nurses in hospitals?

Conceptual Underpinnings for the Study

The Technology Acceptance Model (TAM) was developed by Fred Davis (1986) specifically to examine computer usage behavior as it relates to user acceptance of information systems. Davis (1986) developed the Tam by adapting the Theory of Planned Behavior developed by Ajzen and Fishbein (1975), which takes a general approach to explaining behavior (Ajzed & Fishbein, 1980). The TAM also takes the approach to explaining behavior; more specifically the TAM focuses on computer usage behavior. This enables the TAM to be applied generally to al technology-related usage behavior and user populations (Davis, Bagozzi, & Warshaw, 1989). For that reason, the TAM was purposely selected as the conceptual model for this study.

The basic function of the TAM is to explain technology usage behavior. Perceived usefulness and perceived ease of use are the two main components that drive the behavioral intention to use technology that ultimately explains the usage behavior or adoption of technology. Perceived usefulness is defined by Davis (1989) as "the degree to which a person believes that using a particular system would enhance his or her job performance" (p.320). Davis (1989) defines perceived ease of use as "the degree to which a person believes that using a particular system would be free from effort" (p.320). These two constructs are the basis for individual perceptions influencing the behavioral intention to use technology and ultimately determine acceptance of information technology.

The TAM has been widely validated and used as a research-based model for user acceptance of computer technology, The purpose of the proposed study is not to revalidate the TAM by applying it to BCMA technology or to extend the TAM, Rather, the purpose is to evaluate the relationship between patient safety culture and the perceived usefulness and perceived ease of use of BCMA that drive the behavioral intention to use BCMA (Figure 2). Per Davis (1989), perceive ease of use reflects physical effort, mental effort, and ease of learning, and has the theoretical basis supported by the Bandura's Self-Efficacy theory. Davis (1989) states that, "self-efficacy beliefs are theorized to function as proximal determinants of behavior" (p.321). By evaluating the relationship between BCMA perceived usefulness, perceived ease of use and a set of dimensions, including teamwork within hospital units, communication openness, feedback and communication about errors, and hospital management support for patient safety, perhaps healthcare organizations can promote a patient safety culture and positively influence the adoption of technology.

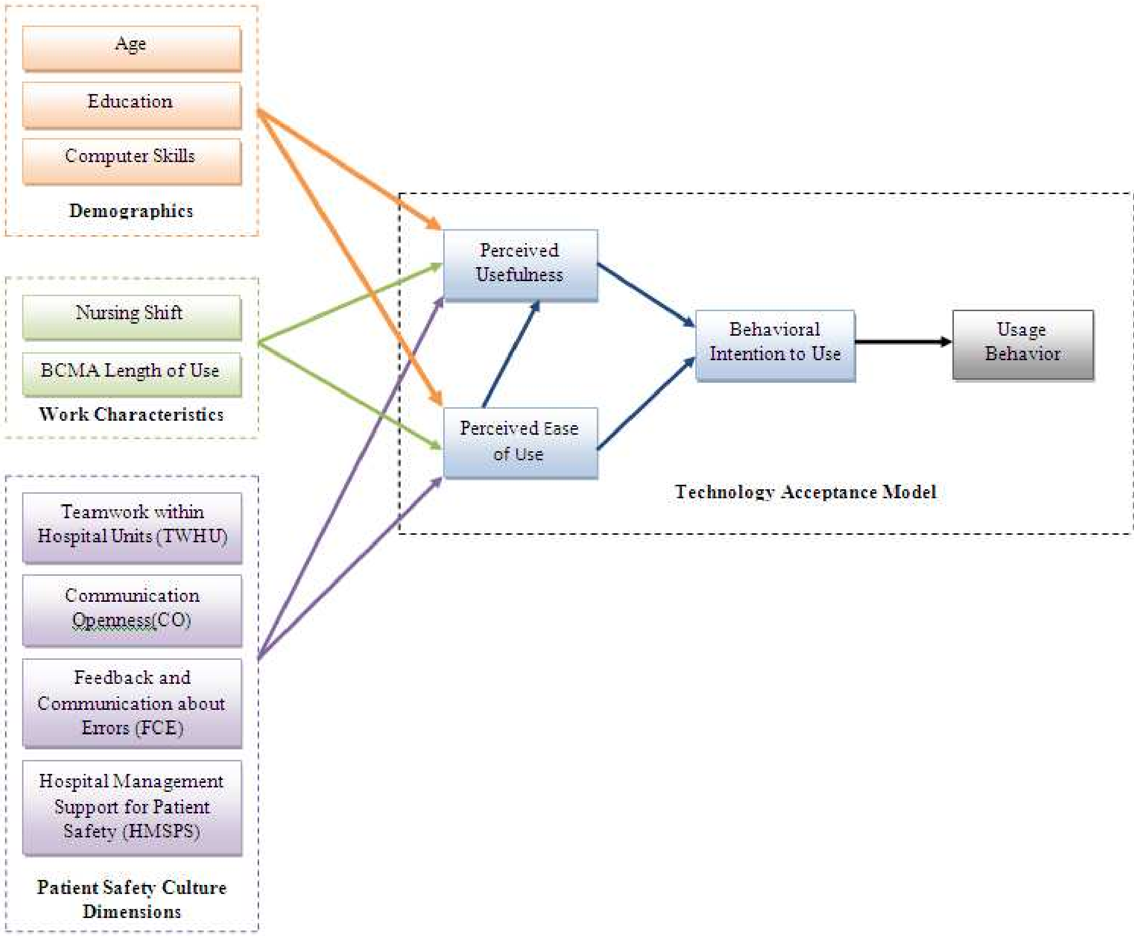

Figure 2 This study's adaptation of the selected Patient Safety Culture Dimensions (Sorra & Nieva, 2004) to the Technology Acceptance Model (Davis, 1989).

Definition of Terms

The conceptual and operational definitions are noted for the following terms in this study (table 1).

Table 1 Conceptual and Operational Definitions

Term	Definition

Bar Code Medication Administration (BCMA)	In this study, BCMA is conceptually defined as “a point-of-care software solution that addresses the serious issue of inpatient medication errors by electronically validating and documenting medications for inpatients. It ensues that the patient receives the correct medication in the correct dose, at the correct time, and visually alerts staff when the proper parameters are not met” (Department of Veterans Affairs). http://www.innovations.va.gov/page.cfm?pg=13 This concept is operationally defined as a point-of-care device incorporating a bar code scanner used in the administration of medications by scanning the patient’s armband and the patient’s medications to ensure the patient, medication, medication dosage, medication route, and time are all correct, and notifies the user of the point-of-care device when any of these parameters are not correct. The BCMA also documents the administration of the medication.
Patient Safety Culture	AHRQ defines the Patient Safety Culture as “the safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization’s health and safety management. Organizations with a positive safety culture are characterized by communications founded on mutual trust,

	by shared perceptions of the importance of safety, and by confidence in the efficacy of preventive measures." Organising for Safety: Third Report of the ACSNI (Advisory Committee on the Safety of Nuclear Installations) Study Group on Human Factors. Health and Safety Commission (of Great Britain). Sudbury, England: HSE Books, 1993. For the purpose of this study, patient safety culture is defined as having the following components: teamwork within hospital units, hospital management support for patient safety, communication openness, and feedback and communication about errors.
Teamwork Within Hospital Units (TWHU)	The Patient Safety Culture survey defines teamwork within hospital units as "staff support one another, treat one another with respect, and work together as a team" (AHRQ, 2010, p.14). In this study, teamwork within hospital units is defined as nurses working within the same hospital unit assisting one another to care for patients. It is operationally defined by the following questions from Section A of the instrument: People support one another in this unit. When a lot of work needs to be done quickly, we work together as a team to get the work done. In this unit, people treat each other with respect.

	When one area in this unit gets really busy, others help out.
Communication Openness (CO)	The Patient Safety Culture survey defines communication openness as "staff freely speaking up if they see something that may negatively affect a patient and feel free to question those with more authority" (AHRQ, 2010 p.15). Communication Openness is defined as fluid and unhindered discussions with persons of authority as it impacts patient care. It is operationally defined by the following questions from Section B of the instrument: Staff will freely speak up if they see something that may negatively affect patient care. Staff feel free to question the decisions or actions of those with more authority. Staff are afraid to ask questions when something does not seem right.
Feedback and Communication about Errors (FCE)	The Patient Safety Culture survey defines feedback and communication about error as "staff are informed about errors that happen, are given feedback about changes implemented, and discuss ways to prevent errors." (AHRQ, 2010, p.15) Feedback and communication about errors is defined as the exchange of information regarding errors, and the discussion of error prevention.

	It is operationally defined by the following questions from Section C of the instrument: We are given feedback about changes put into place based on event reports. We are informed about errors that happen on this unit. In this unit, we discuss ways to prevent errors from happening again.
Hospital Management Support for Patient Safety (HMSPS)	The Patient Safety Culture survey defines management support for patient safety as "hospital management provides a work climate that promotes patient safety and shows that patient safety is a top priority" (AHRQ, 2010, p.15). The concept of hospital management support for patient safety is defined as the hospital management promoting an environment that identifies patient safety as a top priority. It is operationally defined by the following questions from Section D of the instrument: Hospital management provides a work climate that promotes patient safety. The actions of hospital management show that patient safety is a top priority. Hospital management seems interested in patient safety only after an adverse event happens.
Perceived	Davis originally defined perceived usefulness as "the degree to which

Usefulness (PU)	a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p.320). In this study, perceived usefulness is defined as the nurse's belief that BCMA technology would enhance his or her job performance. It is operationally defined by the following questions from Section E questions 1 - 4 of the instrument: Using the bar code medication system improves my performance in my job. Using the bar code medication administration system increased by productivity Using the bar code medication administration system to be useful in my job.
Perceived Ease of Use (PEOU)	Davis originally defined perceived ease of use as "the degree to which a person believes that using a particular system would be free from effort" (Davis, 1989, p.320). In this study, perceived ease of use is defined as the nurse's belief that BCMA technology is free from effort. It is operationally defined by the following questions from Section F of the instrument: Using the bar code medication system is clear and understandable. Using the bar code medication administration system does not require

	a lot of my mental effort. I find the bar code medication administration system to be easy to use. I find it way to get the bar code medication administration system to do what I want it to do. I find that there are minimal complications in using the bar code medication administration system.
Behavioral Intention to Use (BI)	Behavioral intention to use is "a measure of the strength of one's intention to perform a specified behavior" (Davis, Bagozzi & Warshaw, 1989, p.984). In this study, behavioral intention to use is defined as the nurse's intention to use BCMA technology. It is operationally defined by the following questions from Section E, questions 5 & 6 of the instrument: Assuming I have access to the bar code medication administration system, I intend to use it. Given that I have access to the bar code medication administration system, I predict that I would use it.

Assumptions

In this study, it is assumed that BCMA assists in the verification of the 6 rights, and that bar code medication assists to prevent medication errors. Additionally, it is assumed that decreasing medication errors positively impacts patient safety. In the TAM, perceived ease of use influences perceived usefulness because when a technology is ease to use, it becomes more useful (Venkatesh, 2000). Per Venkatesh (2000), “TAM suggests that the two specifics beliefs – perceived ease of use and perceived usefulness – determine one’s behavior intention to use a technology, which as been linked to subsequent behavior” (p. 343). It is hoped that by focusing on the constructs perceived usefulness and perceived ease of use, the proposed study can identify the impact of patient safety culture components on the behavioral intention to use BCMA linking it to the BCMA actual system use.

Significance of the Study

The proposed study evaluates the relationship between the patient safety culture dimensions and BCMA perceived usefulness and perceived ease of use that drives the behavioral intention to use BCMA technology among registered nurses in hospitals. The results of this study could assist hospitals to reevaluate and improve their patient safety culture, which could lead to better use of BCMA technology and significantly reduce the frequency of medication errors. Not only could the findings in this study improve the patient safety culture by reducing the use of BCMA workarounds by nurses, it could also impact other healthcare disciplines by encouraging them to adopt various other technologies, as well as, to improve patient care safety and outcomes.

Identification of the relationship between the patient safety culture and BCMA perceived usefulness and perceived ease of use in the proposed study could enable nurses to more appropriately evaluate their own values and behaviors regarding the decision to use BCMA, taking into account the influences of their healthcare organization’s patient safety culture. Nurses are the final safety check in the medication process, and non-adherence to BCMA procedures/policies can negatively impact medication error rates and ultimately jeopardize patient safety. Providing a culture of patient safety could improve nurse's adherence to BCMA and further reduce frequency of medication errors, perhaps even making them a thing of the past.

In an effort to provide a culture of patient safety, hospitals could improve: teamwork within hospital units, communication openness, feedback and communication about errors, and management support for patient safety. Such an effort could provide nurses with a voice to better contribute to a discussion of technology that impacts nursing and patient care safety. For example, the nurse's decision-making process in the presence of obstacles to BCMA could be discussed so that action could be taken to reduce the variance in the patterns of BCMA use. This open communication could also improve the current technology utilization and enhance future technology implementations by fostering a continuing dialog within nursing.

The proposed study supports the continued efforts of the Joint Commission to improve the quality and safety of healthcare organizations by focusing on bar code technology in medication administration. Each year the Joint Commission revises its National Patient Safety Goals, and the improvement of medication administration continues to be included as a priority. For example, the Joint Commission has identified commonly used abbreviations that should not longer be used when ordering or documenting medications, when medications sound or look similar, when labeling medications in unlabeled containers, or when reconciling medications. Positive patient identification is another Joint Commission National Patient Safety Goal that is essential for administration of the proper medications to the correct patient. In short, the medication process continues to be a focus for the Joint Commission.

The processes involved in medication administration will continue to be of global interest until the process is infallible, or at least until medication errors are rare events in healthcare. As we incorporate technology to assist us in realizing that goal, research is needed to ensure that practicality of technology in promoting patient safety and a patient safety culture.

The proposed study will contribute to the body of knowledge by shedding new light on the relationship between the patient safety culture dimensions and the behavioral intention to use BCMA. Additionally, this study can assist in the development of an intervention to promote the appropriate use of BCMA to reduce medication errors in hospitals. Lastly, the information from this study could guide hospital administrations toward an understanding that technology cannot be implemented without appropriate buy in from the front line clinical stakeholders.

Summary

Medication errors persist today even though there is technology that could potentially prevent them. Research has shown that BCMA technology has reduced the frequency of medication errors and provided additional information on errors not previously captured. Although there are positive outcomes using BCMA technology, compliance is often lacking among registered nurses who use this technology as part of their workflow when administering medications to patients. Interestingly, even with the advantages of BCMA technology, there is a lack of adherence to established procedures for BCMA among registered nurses. This must be explored. What isn't discussed in the literature is the impact of patient safety dimensions on the perceived usefulness and perceived ease of use that drives the behavioral intention to use BCMA. This study will investigate whether a relationship exists among patient safety culture in hospitals, work and demographic characteristics and the behavioral intention to use BCMA.

CHAPTER TWO

This literature review focuses on research involving the nursing population, he TAM's perceived ease of use and perceived usefulness constructs, and the Hospital Survey on Patient Safety Culture. The results of Medline®, CINAHL®, and the Institute of Electrical and Electronics Engineers (IEEE) searches were used to determine the scope of the available research and its applicability to nursing, the TAM and the Hospital Survey on Patient Safety Culture. The literature review describes the research conducted on the TAM and the enhancements to that model made to address the variance in technology acceptance. Because the dissertation focuses on perceived ease of use and perceived usefulness, studies relating these constructs to nurses as a population were also reviewed.

Published research on the Hospital Survey on Patient Safety Culture was also reviewed. Studies employing the dimensions teamwork within units, communication openness, feedback and communication about errors, and hospital management support were selected for review.

Technology Acceptance Model

Since the initial introduction of the TAM by Davis in 1986, it has been widely accepted in the technology sector as predictive of user acceptance and usage of technology. Variations of the TAM have been used extensively in social networking

(Guo, Skim, & Otondo, 2010), internet (Pan & Jordan-Marsh, 2010; Shin, 2009), software (Shih & Huang, 2009; Venkatesh & Davis, 1996), mobile technology (Jaradat & Twaissi, 2010; Kim & Garrison, 2009; Shin, 2009; Singh, Singh, Singh & Singh, 2010; Wang, Lo & Fang, 2008), and education (Park, 2009; Teo, 2010). These studies have used varied populations, including students (Guo et al., 2010; Venkatesh & Davis, 1996), professionals (Jaradat & Twaissi, 2010; Kim & Garrison, 2009; Shih et al., 2010; Venkatesh & Davis, 1996), teachers (Teo, 2010) and the general public (Pan & Jordan-Marsh, 2010; Shin, 2009).

To explain additional behavioral variances, many research studies have extended the TAM, leading to the development of the Technology Acceptance Model 2 (TAM2) (Venkatesh & Davis, 2000), Combined Technology Acceptance Model and Theory of Planned Behavior (C-TAM-TPB), Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003), Mobile Wireless Technology Acceptance Model (MWTAM) (Kim & Garrison, 2008), and the Information and Communication Technology Acceptance Model (ICTAM) (An, Hayman, Panniers, & Carty, 2007).

There is limited research on the application of the TAM in healthcare. Most of the studies have focused on personal digital assistant (PDA) usage by Emergency Medical Services personnel (Chang et al., 2004), pharmacists (Dasgupta, Sansagiry, Shere, Wallace, & Sikri, 2009) and nurses (Zhang, Cocosila & Archer, 2010). Other studies of the application of the TAM to healthcare include examination of physician acceptance of telemedicine (Hu, Chau, Sheng & Tam, 1999), smart phone use by physicians and nurses (Park & Chen, 2007), and electronic health records (de Veer & Francke, 2010; Hyun, Johnson, Stetson, & Bakken, 2009; Morton & Wiedenbeck, 2010).

There have been a few studies entailing the use of the TAM to examine the acceptance and/or use of technology by nurses in clinical settings. Searching the Medline® and CINAHL® databases using the keywords "Technology Acceptance Model" and "nursing" returned 18 results. Dissertations, non-nursing study populations, nursing students, and studies not using the perceived ease of use construct were eliminated from the literature review, leaving nine research studies to review. Of those, studies that did not clearly state the research methodology were eliminated from the review, leaving six articles.

Of the research studies focused on adoption of technology by nurses, the following technologies were studied: personal digital assistant (PDA) use (Zhang et al., 2010), web based learning (Chen, Yang, Tang, Huang & Yu, 2008; Tung & Chang, 2008), adverse event reporting systems (Wu, Chen, Lin, Greenes, & Bates, 2008), electronic patient records (de Veer & Francke, 2010; Hyun et al., 2009), general technology implementation in healthcare (Aggelidis & Chatzoglou, 2009), nursing portal usage (Welsh & Houston, 2010), and logistics information systems (Tung, Chang & Chou, 2008). There were no studies that applied the TAM to BCMA.

Because only a limited number of studies were returned using the Medline® and CINAHL® databases, an additional literature search was performed using the IEEE database. When using the "Technology Acceptance Model" as the key phrase, 1,621 results returned. When adding another key word, "nurse," 120 results returned.

However, when searching for “Hospital Survey on Patient Safety Culture,” no results were returned.

Of the 120 results from IEEE, 7 of the studies were from the category Journal & Magazines, and 113 were from Conference Publications. Of the 7 Journal & Magazine results, 5 of the articles were excluded because nurses were not the study population, or the Technology Acceptance Model or its derivatives were not the conceptual model in use. The articles varied from an opinion paper regarding telemedicine (Meso, Mbarika, & Sood, 2009), university students self referral for mental health screening (Kim, Coumar, Lober, & Kim, 2011), electrocardiography (ECG) for detection of abnormal cardiac activity in elderly patients at home (Shih, Chiang, Lin, & Lin, 2010), information seeking by patients using offline services and online TV information at a large health care provider (Lankton & Wilson, 2007), and comparing Chief Information Officer characteristics with information technology innovation (Li, Tan, Teo, & Tan, 2006).

Two studies included nursing among other disciplines in the study, but not as the study population. These studies did use the Technology Acceptance Model as the conceptual model. In an observational study, Mejia, Favela, and Moran (2010) evaluated informal communication via a remote method (SOLAR) that notes the location of the health providers and shared patient care tasks and information. This study focused on the perceived usefulness construct from the TAM to determine the behavioral intention to use SOLAR; however, the authors did not indicate why perceived ease of use was not used. Additionally, physicians and not nurses were the participants in the study. The authors of this study are also the developers of SOLAR, and the results could potentially be biased.

The sharing of information is instantaneous when using SOLAR, as the information is displayed on the device and recorded conversations are available for replay, so that patient care could be facilitated. However, the potential negative impact that the physician interruptions could have on patient care were not addressed, nor were issues related to the technology or connectivity. More studies with a larger sample size that is not supported by the authors are advised.

The second study from the literature search was conducted by Favela, Rodriguez, Preciado, and Gonzalez (2004). These authors studied the integration of public displays, such as tracking boards, that changes in context based on the local proximity of the health care provider with their hand held device.

Perceived Usefulness

Perceived usefulness is also a major construct in the TAM that drives the user's intention to use technology. Davis originally defined perceived usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p.320) and several studies have incorporated that definition (Hyun et al., 2009; Tung & Chang, 2008; Wu et al., 2008).

Perceived Ease of Use

Perceived ease of use is a major construct in the TAM that drives perceived usefulness and the user's intention to use technology. Perceived ease of use was originally defined by Davis as, "the degree to which a person believes that using a particular system would be free from effort" (Davis, 1989, p. 320), and several studies have incorporated that definition (Hyun et al., 2009; Tung & Chang, 2008; Wu et al., 2008).

Studies adapting the Technology Acceptance Model

Adaptations to the TAM in health care studies were explored to investigate the relationship among the researcher's external variables and the TAM constructs. In a study on the adoption of an electronic logistics information system used in healthcare, the Tung et al. (2008) study added two external variables: trust and perceived financial cost. Another study introduced trust and management support to nurses' intention to use an adverse-event reporting system (Wu et al., 2008). Tung et al. (2008) found that higher perceived ease of use resulted in higher trust in the system; conversely, Wu et al. (2008) found that trust had a positive effect on behavioral intention to use the technology. The results of Tung et al. (2008) and Wu et al. (2008) revealed that perceived ease of use had a direct positive effect on both the perceived usefulness and the behavioral intention to use technology.

The aforementioned studies by Wu et al., (2008) and Tung et al., (2008) used the TAM2 as the conceptual model. Yu, Li & Gagnon (2009) also employed the TAM2 to investigate adoption of health information technology by nurses, in this case at long-term care facilities. The authors used social influence (subjective norm and image) and demographic variables (computer skills, age, job level and experience) to measure technology acceptance by nurses. Yu et al. (2009) found computer skills had a significant positive impact, whereas image had a significant negative impact, on the intention to use technology. The perceived usefulness construct was influenced by perceived ease of use, job level and subjective norm, while the perceived ease of use was influenced by image, subjective norm and computer skills (Yu et al., 2009). Interestingly, age and work experience did not have an effect on the acceptance of technology. Overall, the author's model explained 34% of the intention to use the technology before its implementation. This approach differs from other researchers who studied the use of a specific technology after its implementation (Tung et al., 2008; Tung & Chang, 2008; Wu et al., 2008). No follow-up study to Yu et al. (2009) after implementation of the technology has yet been published.

In the nursing studies summarized above, the relationship of variables enhancing Davis' original TAM to fit technology were explored. For example, structural equation modeling (SEM) was used to analyze the causal relationship between the study variables (Aggelidis & Chatzoglou, 2009; Tung et al., 2008; Tung & Chang, 2008; Wu et al., 2008; Yu et al., 2009). Other statistical methods used were correlation, explanatory factor analysis (Aggelidis & Chatzoglou, 2009), and confirmation factor analysis (Aggelidis & Chatzoglou, 2009; Tung et al., 2008; Tung & Chang, 2008; Wu et al., 2008).

Hospital Survey on Patient Safety Culture

Development of the Hospital Survey on Patient Safety Culture

In 2004, the Hospital Survey on Patient Safety Culture was sponsored by the Agency for Healthcare Research and Quality (AHRQ) to assess the safety culture of hospitals from the employee perspective. The Hospital Survey on Patient Safety Culture was influenced by technical reports derived from two existing surveys: Westat's Medical Event Reporting System for Transfusion Medicine and the Veterans Health

Administration's Patient Safety Questionnaire (Sorra & Nieva, 2004). Since its initial development, there have been four comparative database reports published between 2007, when 108,621 hospital staff from 382 participating hospitals responded, and 2010, when 338,607 hospital staff from 885 hospitals responded.

The 2004 pilot study was administered at 21 hospitals in 6 states. There were 1,437 respondents from among a total of 4,983 administered surveys (Sorra & Nieva, 2004). The response rate was 29% (Sorra & Nieva, 2004). Data analysis using confirmatory factor analysis, correlations among the patient safety dimensions, and analysis of variance provided evidence supporting the final survey (Sorra & Nieva, 2004). After the data analysis, the draft survey was refined until it consisted of 10 identified safety culture dimensions (teamwork within units, supervisor/manager expectations and actions promoting patient safety, management support for patient safety, organizational learning-continuous improvement, feedback and communication about error, communication openness, teamwork across units, staffing, handoffs and transitions, and non-punitive response to error) and two patient safety outcome scales (overall perceptions of safety and frequency of event reporting).

Psychometric Properties

The Hospital Survey on Patient Safety Culture tool was selected for this study based on its strong psychometric properties (Blegen, Gearhart, O'Brien, Sehgal, & Alldredge, 2009; Smits, Wagner, Spreeuwenberg, van der Wal, & Groenewegen, 2010; Sorra and Dyer, 2010). In a systematic literature review of patient safety climate scales, Colla, Bracked, Kinney, and Weeks (2005) compared nine published surveys, including the Hospital Survey on Patient Safety Culture. Compared were setting, general characteristics, patient safety dimensions, psychometrics, and study utilization (Colla et al., 2005). Per Colla et al. (2005), eight studies used a 5-point Likert scale with varying general characteristics of individual completion, numbers of items, and measurement of action implementation. The reliability coefficients for the Veteran's Administration Patient Safety Culture Questionnaire ranged from .45 to .90, however, reliability coefficients for the Strategies for Leadership: An Organizational Approach to Patient Safety nor the Patient Safety Cultures in Healthcare Organizations published reliability results per Colla et al., 2005. The Culture of Safety Survey was deemed to be poor. The Hospital Survey on Patient Safety Culture reliability (.63-.83) was better, overall, than other patient safety climate scales comparing similar settings appropriate for survey use.

Flin, Burns, Mearns, Yule, & Robertson (2006) reviewed 12 studies measuring safety climate and safety culture in healthcare using psychometric criteria for content validity, criterion validity and factor analysis. Flin et al. (2006) identified three core dimensions, "management/supervisory commitment to safety, safety system, and work pressure" (p.110), from studies only incorporating one or two of these core dimensions. They reported that the Hospital Survey on Patient Safety Culture did not include safety system perceptions, but did have good α-coefficients, and no specific information was provided for the criterion validity. The Veteran's Administration Patient Safety Culture Questionnaire was not included in that study, which focused primarily on the Safety Climate Scale. Flin et al. (2006) concluded that the Hospital Survey on Patient Safety Culture was more psychometrically sound than the other surveys. However, in the interval since Flin et al. (2006) and Colla et al. (2005) published their reviews, there has been little comparison with other surveys.

With its strong psychometric properties, the Hospital Survey on Patient Safety Culture has been adapted and translated into a number of languages. The survey has been implemented and adopted in hospitals in Lebanon (El-Jardali, Jaafar, Dimassi, Jamal, & Hamdan, 2010), the Netherlands (Smits, Christiaans-Dingelhoff, Wagner, van der Wal, & Groenewegan, 2008; Smits, Wagner, Spreeuwenberg, van der Wal & Groenewegan, 2010), Belgian (Hellings, Schrooten, Klazinga, & Vleugels, 2010), Turkey (Bodur & Filiz, 2010) and Taiwan (Chen & Li, 2010). In addition, a few studies have been conducted in the United States focusing on validation of the survey (Blegen et al., 2009), its use with neonatal intensive care units (Snijders, Kollen, van Lingen, Fetter, & Molendijk, 2009), and the use of the AHRQ's data set (Sorra & Dyer, 2010; Sorra, Famolaro, Dyer, Nelson, & Khanna, 2008).

For the proposed study, the Hospital Survey on Patient Safety Culture was adapted to include the following unit-level aspects of safety culture: Teamwork within Hospital Unit, Communication Openness, and Feedback and Communication about Errors. In addition, a hospital-level aspect of patient safety culture, Hospital Management Support for Patient Safety, was also included. These composites were selected based on their potential effect on BCMA adoption. Using MEDLINE® and CINAHL® to search for hospital surveys on patient safety culture, 36 results were returned. Articles that were not in English or were focused on long-term care facilities or dealt with the oil industry were eliminated, as were items returned from SBAR, which left 10 articles for review.

Teamwork within Hospital Unit

Teamwork within Hospital Unit was initially defined by AHRQ as "staff support one another, treat one another with respect, and work together as a team" (AHRQ, 2010, p.16). In its 2010 Patient Safety Culture: 2010 User Comparative Database Report (2010), the AHRQ reported that Teamwork within Units had an average positive response rate of 80%. Teamwork within Units was assessed using the following four teamwork items were 1) people support one another in this unit; 2) when a lot of work needs to be done quickly, we work together as a team to get the work done; 3) in this unit, people treat each other with respect; and 4) when one area in this unit gets really busy, others help out (AHRQ, 2004; AHRQ, 2010).

International researchers who replicated the Hospital Survey on Patient Safety Culture by translating the survey reported varying positive response rates for Teamwork within Unit. In Taiwan, the reported positive response rate for Teamwork within Units was 94% (N = 788) for non-supervisors and 93% for supervisory staff, which was significant ($p<0.01$) (Chen & Li, 2010). These Teamwork within Unit scores, which were higher than the reported US response rate of 80%, may reflect cultural differences (Chen & Li, 2010).

In an Arabic translation of the study conducted in Lebanon, El-Jardali et al. (2010) the reported positive response for Teamwork within Units was 82.3% (N = 6807, $p<0.01$), which is similar to the reported US response rate. A Turkish version of the study was conducted by Bodur and Filiz (2010), who reported the positive response rate for Teamwork within Units was 70% (N = 309) with no significant findings for this dimension. The lowest score for Teamwork within Units was 65% for people support one another between units (Bodur & Filiz, 2010). The survey items differed slightly from the original AHRQ (2010) survey, which used "between units" instead of "in this unit," when describing the first Teamwork within Units survey item. Additionally, the third survey item used "all" instead of "this" when describing people treat each other with respect.

Communication Openness

Communication Openness was initially defined by the AHRQ as "staff freely speak up if they see something that may negatively affect a patient and feel free to question those with more authority" (AHRQ, 2010, p.15). In its 2010 Patient Safety Culture: 2010 User Comparative Database Report (2010), the AHRQ reported that Communication Openness had an average positive response rate of 62%. Communication Openness was assessed using the following 3 items: 1) staff will freely speak up if they see something that may negatively affect patient care; 2) staff feel free to question the decisions or actions of those with more authority; and 3) staff are afraid to ask questions when something does not seem right (AHQR, 2004; AHRQ, 2010).

According to Chen and Li (2010), assessment of the Communication Openness of Taiwanese hospital staff gave a positive response rate of 59% for supervisors and 57% for non-supervisors, which was found not to be significant. This score for Taiwanese hospitals may reflect cultural differences from the US, as the authors report the Chinese people have a "strong social conformity in opinion or behavior" (Chen & Li, 2010, p. 8).

El-Jardali et al. (2010) reported Communication Openness with a positive rate of 57.3% ($p<0.001$). The rates were 61.1% for staff will freely speak up if they see something that may negatively affect patient care; 53.8% for staff feel free to question the decisions or actions of those with more authority; and 56.9% for staff are afraid to ask questions when something does not feel right (El-Jardali et al., 2010). For the Turkish version, Bodur & Filiz (2010) combined Communication Openness with Feedback and Communication about Errors based on an exploratory factor analysis, which resulted in a combined positive response rate of 38% ($p<0.05$). The reported Communication Openness rates were 43% for staff will freely speak up if they see something that may negatively affect resident care; 19% for staff feel free to question the decisions or actions of those with more authority; and 47% for staff are afraid to ask questions when something does not seem right (Bodur & Filiz, 2010). The findings for Feedback and Communication about Errors were found significant ($p<0.05$). Note that there was one minor change in the Turkish survey: "patient" in the original AHRQ questions was replaced with "resident."

Feedback and Communication about Errors

Feedback and Communication about Errors was initially defined by AHRQ as "staff are informed about errors that happen, are given feedback about changes implemented, and discuss ways to prevent errors" (AHRQ, 2010, p.15). In its 2010 Patient Safety Culture: the 2010 User Comparative Database Report (2010) reported that Feedback and Communication about Errors had an average positive response rate of 63%, and was assessed using the following three items: 1) we are given feedback about changes put into place based on event reports; 2) we are informed about errors that happen in this unit; and 3) in this unit, we discuss ways to prevent errors from happening again (AHQR, 2004; AHRQ, 2010).

For Feedback and Communication about Errors at Taiwanese hospitals, Chen and Li (2010) reported a positive response rate of 61% for supervisors and 58% for non-supervisors which was not significant. With positive Feedback and Communication about Error documented at 68.1%, El-Jardali et al. (2010) reported a rate 58.2% for we are given feedback about changes put into place based on event reports; 71.3% for we are informed about errors that happen in this unit; and 74.5% for in this unit, we discuss ways to prevent errors from happening again. The findings were not significant among hospitals mean sizes of small, medium, and large (El-Jardali et al., 2010).

Hospital Management Support for Patient Safety

Hospital Management Support for Patient Safety was initially defined by AHRQ as "Hospital management provides a work climate that promotes patient safety and shows that patient safety is a top priority" (AHRQ, 2010, p.15). In its 2010 Patient Safety Culture: 2010 User Comparative Database Report (2010), the AHRQ stated that Management Support for Patient Safety had an average positive response rate of 72% and was assessed using the following three items: 1) hospital management provides a work climate that promotes patient safety; 2) the actions of hospital management show that patient safety is a top priority; and 3) hospital management seems interested in patient safety only after an adverse event happens (AHQR, 2004; AHRQ, 2010)

For Hospital Management Support for Patient Safety, Chen and Li (2010) reported a positive response rate of 60% for supervisory staff and 64% for non-supervisory staff with non significant findings reported. The Lebanese study composite of Hospital Management Support for Patient Safety reported a positive response rate of 78.4% (El-Jardali et al., 2010) which was significant among the different hospital sizes. The reported rate was 79.3% for hospital management provides a work climate that promotes patient safety; 80.3% for the actions of hospital management show that patient safety is a top priority; and 75.6% for hospital management seems interested in patient safety only after an adverse event happens (El-Jardali et al., 2010). Bodur and Filiz (2010) also combined Teamwork across Units and Management Support for Resident Safety from the exploratory factor analysis with a positive response rate of 40% ($p<0.05$). Rates for individual survey items for Management Support for Resident Safety were 40% for management provides a work climate that promotes resident safety; 37% for the actions of management show that resident safety is a top priority; and 32% for management seems interested in resident safety only after an adverse event happens at (Bodur and Filiz, 2010).

Of the few studies that applied management support to the TAM, Wu et al. (2008) defined management support as “the perceived level of general support offered by top management” (p.124) and stated that “management support plays a vital role in promoting open discussion of errors in the hospital” (p.125). Without management support, changing the culture is not possible. Management support had a direct effect on the TAM2 constructs, including perceived ease of use of an adverse event reporting system.

Relationship between BCMA and Patient Safety Culture

As mentioned above, there are currently no published reports associating patient safety culture with BCMA technology. Without using any parameters for publication date, searching MEDLINE® and CINAHL® for "bar code medication administration" and "patient safety culture" did not return any results. Using the terms "patient safety culture" and "bar code" also did not yield any results. Another search containing only "bar code medication administration" without any date parameters returned 59 studies, which were reviewed and found not to address the concept of patient safety culture.

Studies of Other Variables

The demographic and work characteristic variables in this study include: age in years, education level, computer skills, nursing shift, and BCMA length of use in years. For descriptive purposes only, the following background variables were included in the study: gender, race/ethnic background, and years worked as a registered nurse.

The demographic characteristics age, education and computer skills were included in some studies enhancing the TAM. To determine public health nurses intention toward web-based learning, the authors included age, education and computer skills with no significant findings on perceived usefulness or perceived ease of use (Chen et al., 2008). Additionally, de Veer and Francke (2010) reported that educational level was not statistically significant for education level on perceived usefulness. In contrast Yu, Li, and Gagnon (2009) found the impact of age and computer skills to be weak with a significantly negative correlation ($r^2 = -0.23$, $p<0.01$). Subsequently, age was removed from the model, since it did not have any impact on the acceptance of technology (Yu, Li, & Gagnon, 2009).

The self-rating of computer skills enables the user to indicate how comfortable they are with computer use, in general, which helps to identify their overall level of skill with computer technology. Yu et al. (2009) reported the following self-identified ranking of the participants' computer skills: poor (11.1%), below average (22.4%), average (32.1%), above average (5.2%), good (21.6%) and excellent (7.5%). Computer skills on the other hand had a significant positive impact on perceived ease of use ($p<0.001$) and the behavioral intention to use ($p<0.05$) (Yu, Li, & Gagnon, 2009).

In the reviewed studies, work characteristics of nursing shift and BCMA length of use were not included in any TAM studies, since there are no studies using the TAM with BCMA use.

Summary

The TAM is a widely accepted model for predicting users' acceptance of technology and was selected as the conceptual model for this study. The core concepts are perceived usefulness, perceived ease of use, which drives the behavioral intention to use the technology that predicts usage behavior (Davis, 1989). The TAM was enhanced to extend the instrument with additional validation while leaving its core intact. Studies using perceived usefulness and perceived ease of use constructs that were focused on the nursing population were reviewed. In addition, literature on the Hospital Survey on Patient Safety Culture was reviewed, including studies carried out in other countries using translated versions of the survey.

CHAPTER THREE

In this chapter, the methodology of the study is described. An overview of the study is presented, and the research questions to be addressed, the research design, study population and sample, the instruments used, data collection procedures, data analysis, ethical considerations and study limitations are discussed.

Problem and Purposes Overview

Medication errors reportedly persist in healthcare organizations, even after introduction of technology designed to eliminate such errors (*e.g.*, BCMA technology) (DeYoung et al., 2009; Franklin et al., 2007; Morriss et al., 2009; Paoletti et al., 2007). In the literature available today are generic studies of patient safety culture (Bodur & Filiz, 2010; Chen & Li, 2010; El-Jardali et al., 2010; Smits et al., 2008; Sorra & Nieva, 2004), comparisons of various patient safety culture instruments (Colla et al., 2005; Etchegaray & Thomas, 2012; Flin et al., 2006) and evaluations of the relationship between patient safety culture dimensions, such as management safety commitment (Feng, Acord, Cheng, Zeng, & Song, 2011), and the structural empowerment with patient safety culture (Armellino, Quinn Griffin, & Fitzpatrick, 2010). However, the relationship between technology, more specifically BCMA, and patient safety culture has yet to be explored. This gap in our knowledge must be explored, because while there is an assumption that BCMA technology can enhance patient safety by reducing the frequency of medication errors (DeYoung et al., 2009; Franklin et al., 2007; Morriss et al., 2009; Paoletti et al., 2007), it remains unknown whether the use of technology can, in fact, influence patient safety culture. In that context, the purpose of the proposed study was to evaluate the relationship between patient safety culture and the perceived ease of use and the perceived usefulness of BCMA, which drives the behavioral intention to use BCMA among registered nurses in hospitals. This study evaluated whether such a relationship exists and assessed whether improving the patient safety culture can lead to more effective use of BCMA and, ultimately, reduction of the frequency of medication errors. These research questions were explored:

Research Questions

1. What is the relationship between BCMA perceived usefulness (PU) and teamwork within hospital units (TWHU) among registered nurses in hospitals?
2. What is the relationship between BCMA perceived usefulness (PU) and communication openness (CO) among registered nurses in hospitals?
3. What is the relationship between BCMA perceived usefulness (PU) and feedback and communication about errors (FCE) among registered nurses in hospitals?
4. What is the relationship between BCMA perceived usefulness (PU) and hospital management support for patient safety (HMSPS) among registered nurses in hospitals?
5. Does the combination of teamwork within hospitals units (TWHU), hospital management support for patient safety (HMSPS), communication openness (CO), and feedback and communication about errors (FCE) better predict BCMA

perceived usefulness (PU) than any single dimension of patient safety culture alone, after controlling for demographic and work characteristics among registered nurses in hospitals?

6. What is the relationship between BCMA perceived ease of use (PEOU) and teamwork within hospital units (TWHU) among registered nurses in hospitals?
7. What is the relationship between BCMA perceived ease of use (PEOU) and communication openness (CO) among registered nurses in hospitals?
8. What is the relationship between BCMA perceived ease of use (PEOU) and feedback and communication about errors (FCE) among registered nurses in hospitals?
9. What is the relationship between BCMA perceived ease of use (PEOU) and hospital management support for patient safety (HMSPS) among registered nurses in hospitals?
10. Does the combination of teamwork within hospital units (TWHU), communication openness (CO), and feedback and communication about errors (FCE), hospital management support for patient safety (HMSPS) better predict BCMA perceived ease of use (PEOU) than any single dimension of patient safety culture alone, after controlling for demographic and work characteristics among registered nurses in hospitals?
11. What is the relationship between BCMA perceived ease of use (PEOU) and behavioral intention to use (BI) BCMA among registered nurses in hospitals?

12. What is the relationship between BCMA perceived usefulness (PU) and the behavioral intention to use (BI) BCMA among registered nurses in hospitals?
13. Does combined BMCA perceived ease of use (PEOU) and BCMA perceived usefulness (PU) better predict the behavioral intention to use (BI) BCMA then either one alone, after controlling for demographic and work characteristics among registered nurses in hospitals?

Hypotheses 1:

H_0: There is no correlation between BCMA perceived usefulness (PU) and teamwork within hospital units (TWHU).

H_a: There is a correlation between BCMA perceived usefulness (PU) and teamwork within hospital units (TWHU).

Hypotheses 2:

H_0: There is no correlation between BCMA perceived usefulness (PU) and communication openness (CO).

H_a: There is a correlation between BCMA perceived usefulness (PU) and communication openness (CO).

Hypotheses 3:

H_0: There is no correlation between BCMA perceived usefulness (PU) and feedback and communication about errors (FCE).

H_a: There is a correlation between BCMA perceived usefulness (PU) and feedback and communication about errors (FCE).

Hypotheses 4:

H_0: There is no correlation between BCMA perceived usefulness (PU) and hospital management support for patient safety (HMSPS).

H_a: There is a correlation between BCMA perceived usefulness (PU) and hospital management support for patient safety (HMSPS).

Hypotheses 5:

H_0: The combined teamwork within hospital units (TWHU), hospital management support for patient safety (HMSPS), communication openness (CO), and feedback and communication about errors (FCE) does not better predict BCMA perceived usefulness (PU) than any single dimension of patient safety culture alone, after controlling for demographic and work characteristics.

H_a: The combined teamwork within hospital units (TWHU), hospital management support for patient safety (HMSPS), communication openness (CO), and feedback and communication about errors (FCE) better predicts BCMA perceived usefulness (PU) than any single dimension of patient safety culture alone.

Hypotheses 6:

H_0: There is no correlation between BCMA perceived ease of use (PEOU) and teamwork within hospital units (TWHU).

H_a: There is a correlation between BCMA perceived ease of use (PEOU) and teamwork within hospital units (TWHU).

Hypotheses 7:

H_0: There is no correlation between BCMA perceived ease of use (PEOU) and communication openness (CO).

H_a: There is a correlation between BCMA perceived ease of use (PEOU) and communication openness (CO).

Hypotheses 8:

H_0: There is no correlation between BCMA perceived ease of use (PEOU) and feedback and communication about errors (FCE).

H_a: There is a correlation between BCMA perceived ease of use (PEOU) and feedback and communication about errors (FCE).

Hypotheses 9:

H_0: There is no correlation between BCMA perceived ease of use (PEOU) and hospital management support for patient safety (HMSPS).

H_a: There is a correlation between BCMA perceived ease of use (PEOU) and hospital management support for patient safety (HMSPS).

Hypotheses 10:

H_0: The combined teamwork within hospital units (TWHU), hospital management support for patient safety (HMSPS), communication openness (CO), and feedback and communication about errors (FCE) does not better predict BCMA perceived ease of use (PEOU) than any single dimension of patient safety culture alone, after controlling for demographic and work characteristics.

H_a: The combined teamwork within hospital units (TWHU), hospital management support for patient safety (HMSPS), communication openness (CO), and feedback and communication about errors (FCE) better predicts BCMA perceived ease of use (PEOU) than any single dimension of patient safety culture alone.

Hypotheses 11:

H_0: There is no correlation between BCMA perceived ease of use (PEOU) and behavioral intention to use (BI) BCMA.

H_a: There is a correlation between BCMA perceived ease of use (PEOU) and behavioral intention to use (BI) BCMA.

Hypotheses 12:

H_0: There is no correlation between BCMA perceived usefulness (PU) and behavioral intention to use (BI) BCMA.

H_a: There is a correlation between BCMA perceived usefulness (PU) and behavioral intention to use (BI) BCMA.

Hypotheses 13:

H_0: The combined BCMA perceived usefulness (PU) and BCMA perceived usefulness (PU) does not better predict BCMA behavioral intention to use (BI) than either construct alone, after controlling for demographic and work characteristics.

H_a: The combined BCMA perceived usefulness (PU) and BCMA perceived usefulness (PU) better predicts BCMA behavioral intention to use (BI) than either construct alone, after controlling for demographic and work characteristics.

Research Design

A cross-sectional, correlational design utilizing a quantitative survey was used in this study. Given the lack of precedent in the literature, an advantage of this design is that it allows discovery of a possible relationship between patient safety culture composites and the TAM constructs. Although a correlational design does not enable one to assert causation, it does provide a starting framework for determining whether an association exists. Moreover, the correlational design used answered the stated research questions, and enabled the study to be completed in reasonable manner with available resources.

Population and Sample

Population

The target population consisted of hospital-based registered nurses using BCMA in the United States. Under the umbrella of an integrated health delivery network, there are 8 acute care hospitals and 1 rehabilitation hospital that currently use BCMA. A convenience sample of nurses from one of the tertiary acute care hospitals and the rehabilitation hospital located on the same campus were included in this study. The inclusion criteria for participation were registered nurses working at the rehabilitation hospital or the tertiary acute care hospital administering medications to patients using BCMA technology. The exclusion criteria included nurses who do not administer medications and who do not work at one of these two hospitals. There are approximately 166 nurses in the target population at the rehabilitation hospital and 2300 nurses at the tertiary acute care hospital.

Sample Size

Hypotheses 1-4, 6-9 and 11-12 was tested using Pearson’s correlation coefficient. According to Cohen (1988), the small, medium and large effect sizes for hypothesis tests based on Pearson’s correlation coefficient (r) are: r = 0.1, r = 0.3 and r = 0.5, respectively

(p. 79-81). A sample size of 153 produces 80% power at the 0.05 level of significance and detects an effect size of 0.22, which is a medium effect size. This means, for example, that if the correlation between perceived ease of use and teamwork within a hospital unit is 0.22 or greater, this study has an 80% chance of detecting that correlation at the 0.05 level of statistical significance.

Hypotheses 5, 10 and 13 were tested using multiple linear regression analysis. Power analysis for multiple linear regression is based on determining the amount of change in R-squared that is attributable to the variables. According to Cohen (1988), the small, medium and large effect sizes for hypothesis tests using R-squared are R-squared = 0.0196, R-squared = 0.13 and R-squared = 0.26, respectively (p. 413-414). Using an F-Test with a significance level of 0.05, a sample size of 153 achieves 80% power to detect an R-squared of 0.067, which is a medium effect size attributable to the 4 predictor variables (teamwork within hospital units, communication openness, feedback and communication about errors, hospital management support for patient safety) when controlling for 8 demographic (age, education, computer skills), work (nursing shift, BCMA length of use), and TAM (perceived ease of use, perceived usefulness, behavioral intention to use) variables. A sample size of 153 is thus justifiable for detecting medium effect sizes for hypotheses 1-13. Data collection was continued when the required sample size was obtained.

Instrumentation

The Technology Acceptance Model and the Hospital Survey on Patient Safety Culture were adapted to collect data to evaluate the relationship between patient safety culture composites, perceived usefulness and perceived ease of use of BCMA. Additionally, the relationship between BCMA perceived usefulness, BCMA perceived ease of use, and the behavioral intention to use BCMA was evaluated. The Technology Acceptance Model and the Hospital Survey on Patient Safety Culture instruments have been widely accepted as valid for assessing technology acceptance and patient safety culture, respectively.

Technology Acceptance Model Psychometric Properties

The Technology Acceptance Model was originally developed by Davis (1986) to measure the user's acceptance of technology using 2 key determinants: perceived usefulness and perceived ease of use. These 2 determinants drive the behavioral intention to use technology in predicting the actual use of the technology. The original Technology Acceptance Model was refined by Davis by further refining the measurement scale of perceived usefulness and perceived ease of use from a 14 item scale to a 10 item scale (Cronbach α = .97 & .91) to a 6 item scale (Cronbach α = .97 & .93) (Davis, 1989). After additional item analysis of the key constructs, 4 items are now used for each construct with reliability coefficients of .95 and .92 for perceived usefulness and .91 and .90 for perceived ease of use at 2 points of time (Davis, Bagozzi, & Warshaw, 1989). Later Venkatesh and Davis (1996) further enhanced the Technology Acceptance Model by adding additional constructs with reliability coefficients of perceived usefulness ranging from .87-.98 and perceived ease of use ranging from .86-.98.

In the Venkatesh and Davis (1996) study, the Technology Acceptance Model consisted of 26 questions and 9 measurement scales, which included the 4 item scales of perceived usefulness and perceived ease of use. Using the model in 4 longitudinal field studies (2 voluntary & 2 mandatory technology use settings), the authors reported excellent reliability that exceeded .80 in all measurement scales. The survey was administered online and on paper at each of the 4 organizations, and the items were measured using a 7 point Likert scale from "Strongly Disagree" to "Strongly Agree."

Table 2 TAM2 Measurement Scales, Reliabilities, and Number of Items per Measurement

Measurement	Cronbach's Alpha	Number of Items
Intension to Use	.82-.97	2
Perceived Usefulness	.87-.98	4
Perceived Ease of Use	.86-.98	4
Subjective Norm	.81-.94	2
Voluntariness	.82-.91	3
Image	.80-.93	3
Job Relevance	.80-.95	2
Output Quality	.82-.98	2
Result Demonstrability	.80-.97	4

Note:
Venkatesh & Davis, 1996

Health care-based studies have replicated and extended the Technology Acceptance Model by adding additional external components. Tung, Chang, and Chou (2008) confirmed the perceived ease of use measurement scale with a reliability of .89 in their study to extend trust in the Technology Acceptance Model in the implementation of an electronic logistics information system. In a study of health information technology adoption in long-term care facilities in Australia, Yu, Li and Gagnon (2009) reported Cronbach's Alpha for perceived ease of use as .87, perceived usefulness as .93 and the behavioral intention as .63. Exploring the adoption of online nursing courses, Tung and Chang (2008) reported construct reliability for perceived ease of use as .85, perceive usefulness as .88, and the behavioral intention as .85 in evaluating the intention to use an adverse reporting system using the Technology Acceptance Model. These health care-based studies support the strong reliability of the perceived ease of use measurement scale. In the present study, the Technology Adoption Model was adapted by using the technology of bar code medication administration.

Hospital Survey on Patient Safety Culture Psychometric Properties

The Hospital Survey on Patient Safety Culture was sponsored by the Agency for Healthcare Research and Quality and focused on the safety culture of hospitals (Sorra & Nieva, 2004). The survey, which can be distributed by mail or electronically, consisted of 42 self-administered questions covering 12 dimensions of patient safety culture and background information (Sorra & Nieva, 2004). It uses a 5-point Likert scale from "Strongly disagree" to "Strongly agree" or from "Never" to "Always." Eighteen items were reverse coded. For each item, frequencies were calculated based on the overall response. Additionally, composite frequencies based on each patient safety dimension can be calculated for a particular dimension. The total score for the instrument ranges from 0 to 100%, with higher scores indicating a higher patient safety culture.

The statistical analyses conducted for the Hospital Survey on Patient Safety Culture included exploratory factor analysis, confirmatory factor analysis, reliability analysis, validity analysis and analysis of variance (Sorra & Nieva, 2004). For the purpose of evaluating the psychometric properties at the individual, unit and hospital levels, Sorra and Dyer (2010) repeated and confirmed the psychometric properties of the survey using the 2007 AHRQ Comparative Database. Using a dataset of 331 hospitals with 2,267 units and 50,513 respondents, they found the dimensions staffing and supervisor/manager expectations & actions promoting patient safety to be lower than the original AHRQ results; however, these dimensions were not included in the present study.

Other authors have also assessed the psychometric properties of the instrument. In a pre- and post-intervention study with nurses and physicians, Blegen et al. (2009) performed exploratory factor analysis confirming the dimensions teamwork within units, hospital management support for safety, communication openness, and feedback and communication about errors as reported by the AHRQ. To determine internal consistency, a coefficient (Cronbach α) was calculated for each group before and after the interventions; however, the dimension communication openness was .58 for RNs, which was less than the coefficient of .72 reported by the AHRQ. In addition, the dimensions teamwork within units was .79, hospital management support for safety was .71, and feedback and communication about errors was .77, all of which were less than the coefficients reported by the AHRQ (Blegen et al., 2009).

Additional psychometric properties were evaluated by researchers overseas who translated the AHRQ from English to Dutch (Smits et al., 2008), Turkish (Bodur & Filiz, 2010), Chinese (Chen & Li, 2010) and Arabic (El-Jardali et al., 2010). These translated versions demonstrated acceptable reliability and construct validity (Smits et al., 2008).

Confirmatory factor analysis (principal component analysis with Varimax rotation) and exploratory factor analysis were conducted to compare the factor structure of the original AHRQ survey with the translated versions. Smits et al. (2008) reported communication openness (0.72) to be the same as reported by the AHRQ. The other dimensions, teamwork within units (0.66), feedback and communication about error (0.75), and hospital management support for safety (0.68), were lower than the established confirmatory factor analysis by the AHRQ. Smits et al. (2008) then conducted an exploratory factor analysis and by combining organizational learning and feedback and communication about errors identified 11 factors that would better fit the Dutch data. Even with the minor changes, the Smits et al. (2009) survey exhibited acceptable reliability and construct validity and explained 57.1% of the variance in the responses.

Chen and Li (2010) also used confirmatory factor analysis (principal component analysis with Varimax rotation) to confirm construct validity, and were able to explain 61.57% of the variance. The Hospital Survey on Patient Safety Culture was therefore deemed to be a good fit for most of the dimensions. Positive scores for feedback and communication about error (59%), hospital management support for patient safety (62%), and communication openness (58%) were lower than the average positive responses reported by the AHRQ (62%, 62% and 61%, respectively). However, teamwork within units had a reported average positive response of 94%, which was greater than the 78% reported by the AHRQ. The authors speculated that the discrepancies may be due to the unique cultural values and personalities of the Taiwanese.

To test internal consistency and reliability in the Lebanese translated study, El-Jardali et al. (2010) calculated Cronbach's α for teamwork within units (0.684), hospital management support for patient safety (0.631), communication openness (0.460), and feedback and communication about error (0.645). These values were less than the reported AHRQ Cronbach's α, with communication openness being markedly less. Values of Cronbach's α were lower than the reported AHRQ values.

Several patient safety composites from the Hospital Survey on Patient Safety Culture were included in the proposed study. In a pilot study conducted by Sorra and Nieva (2004) to test the reliability and validity of the instrument, 21 selected hospitals participated. A total of 4,983 surveys were distributed, and 1,437 responses were obtained. The authors reported that the reliability values among the dimensions ranged from .63 to .84 (Sorra & Nieva, 2004, p. 59). The 12 composites and their reliabilities (Cronbach's α) include 2 outcome dimensions and 10 safety culture dimensions as displayed in the table below. Higher scores within the patient safety culture composites indicate a higher patient safety culture. In the proposed study, 4 of the safety culture dimensions were analyzed with BCMA perceived ease of use and with BCMA perceived usefulness.

Table 3 Hospital Survey on Patient Safety Culture Dimensions, Reliability, and Number of Items per Composite

Category	Composite	Cronbach's Alpha	Number of Items
Outcome	Overall perceptions of safety*	.74	4
	Frequency of event reporting*	.84	3

Safety Culture	Supervisor/manager expectations and actions promoting patient safety*	.75	4
	Organizational learning-continuous improvement*	.76	3
	Teamwork within unit	.83	4
	Communication openness	.72	3
	Feedback and communication about error	.78	3
	Nonpunitive response to error*	.79	3
	Staffing*	.63	4
	Hospital management support for patient safety	.83	3
	Teamwork across hospital units*	.80	4
	Hospital handoffs and transitions*	.80	4

Notes:
Sorra & Nieva, 2004
*Patient safety culture dimensions not included in this study

Table 4 Results of Translated Studies using Confirmatory Factor Analysis

	Cronbach's Alpha				
Composite	**AHRQ**	**Dutch**	**Lebanese**	**Taiwan**	**Turkish**
Teamwork within unit	.83	.66	.68	.78	.83
Communication openness	.72	.72	.46	.51	.81
Feedback and communication about error	.78	.75	.65	.36	.81
Hospital management support for patient safety	.83	.68	.63	.70	.80*

Notes:
*Combined with Teamwork across Units

Table 5 Average Positive Response Rate

Composite	AHRQ	Dutch	Lebanese	Taiwan	Turkish
Teamwork within unit	78%	N/A	82.3%	94%	70%
Communication openness	61%	N/A	57.3%	58%	38%
Feedback and communication about error	62%	N/A	68.1%	59%	38%
Hospital management support	69%	N/A	78.4%	62%	40%*

for patient safety

Notes:
*Combined with Teamwork

Questionnaire and Study Variables

For the purposes of this study, the following key composites from the Hospital Survey on Patient Safety Culture were included: teamwork within hospital units (TWHU), communication openness (CO), feedback and communication about errors (FCE), and hospital management support for patient safety (HMSPS). Additionally, the TAM constructs of perceived ease of use (PEOU), perceived usefulness (PU), and the behavioral intention to use (BI) were included in the survey questionnaire, as well as several demographic and work characteristic variables. The operational definitions of the instrument were previously described in chapter 1, table 1: Conceptual and operational definitions (see p. 23).

Independent Variables

Teamwork Within Hospital Unit (TWHU): This was measured on a continuous scale with a range of 1 to 5. The scores were determined by calculating the sum of questions 1, 2, 3 and 4 from section A: Teamwork. Response choices on the questionnaire were coded as: 1 = Strongly Disagree; 2 = Disagree; 3 = Neither; 4 = Agree; and 5 = Strongly Agree. Lower scores indicated a perception that teamwork within hospital units was of poorer quality, while higher scores indicated a perception that teamwork within hospital units was of better quality.

Communication Openness (CO): This was measured on a continuous scale with a range of 1 to 5. The scores were determined by calculating the sum of questions 1, 2 and 3 from section B: Communication Openness. Response choices on the questionnaire were coded as: 1 = Strongly Disagree; 2 = Disagree; 3 = Neither; 4 = Agree; and 5 = Strongly Agree. Question 3 was reverse coded prior to calculating the score. Lower scores indicated a perception that communication openness was of poorer quality, while higher scores indicated a perception that communication openness was of better quality.

Feedback and Communication about Errors (FCE): This was measured on a continuous scale with a range of 1 to 5. The scores were determined by calculating the sum of questions 1, 2 and 3 from section C: Feedback & Communication about Errors. Response choices on the questionnaire were coded as: 1 = Strongly Disagree; 2 = Disagree; 3 = Neither; 4 = Agree; and 5 = Strongly Agree. Lower scores indicated a perception that feedback and communication about errors was of poorer quality, while higher scores indicated a perception that feedback and communication about errors was of better quality.

Hospital Management Support for Patient Safety (HMSPS): This was measured on a continuous scale with a range of 1 to 5. The score was derived by calculating the sum of questions 1, 2 and 3 from section D: Your Hospital. Response choices on the questionnaire were coded as: 1 = Strongly Disagree; 2 = Disagree; 3 = Neither; 4 = Agree; and 5 = Strongly Agree. Question 3 was reverse coded prior to calculating the score. Lower scores indicated a perception that hospital management support for patient safety was of poorer quality, while higher scores indicated a perception that hospital management support for patient safety was of better quality.

Dependent Variables

Perceived Usefulness (PU): This was measured on a continuous scale with a range of 1 to 5. The scores were determined by calculating the sum of questions 1, 2, 3, 4 and 5 from section F: Bar Code Medication Administration Ease of Use. Response choices on the questionnaire were coded as: 1 = Strongly Disagree; 2 = Disagree; 3 = Neither; 4 = Agree; and 5 = Strongly Agree. Lower scores indicated a perception that BCMA was less useful, while higher scores indicated a perception that BCMA was more useful.

Perceived Ease of Use (PEOU): This was measured on a continuous scale with a range of 1 to 5. The scores were determined by calculating the sum of questions 1, 2, 3 and 4 from section E: Bar Code Medication Administration Usefulness. Response choices on the questionnaire were coded as: 1 = Strongly Disagree; 2 = Disagree; 3 = Neither; 4 = Agree; and 5 = Strongly Agree. Lower scores indicated a perception that BCMA was more difficult to use, while higher scores indicated a perception that BCMA was easier to use.

Behavioral Intention to Use (BI): This was measured on a continuous scale with a range of 1 to 5. The scores were determined by calculating the sum of questions 5 and 6 from section E: Bar Code Medication Administration Usefulness. Response choices on the questionnaire were coded as: 1 = Strongly Disagree; 2 = Disagree; 3 = Neither; 4 = Agree; and 5 = Strongly Agree. Lower scores indicated a perception that the intention to use BCMA was less, while higher scores indicated a perception that the behavioral intention to use BCMA was greater.

Human Subjects Protection

This study was reviewed by the integrated health delivery network's Office of Research Integrity's Institutional Review Board (IRB) and received an exempt status, since the questionnaires were not completed in the presence of the researcher and anonymously placed in a designated envelope or box for later collection. Because of these factors, the consent was waived for this study. Additionally, the George Mason University Human Subjects Review Board (HSRB) also approved an exempt status for this study.

Data Collection Procedures

After obtaining IRB approvals, permission to survey the nurses at the 2 hospitals was granted by each of the hospital's Chief Nursing Officers. For this study, there were separate data collection procedures, depending on the hospital site. At the rehabilitation facility, the nursing manager approved leaving paper questionnaires and a survey collection box in a designated place on each nursing unit. Completed questionnaires were collected weekly from each unit from the designated boxes. Data from the questionnaires were entered into Microsoft Excel®.

Per a request from the second hospital's Director of Nursing Research and Evidence Based Practice, and with approval from the Vice President of Quality and Outcomes Management, two methods were used to collect data at the acute care hospital. The primary data collection method was to distribute the surveys prior to Culture of

Safety classes, where nurses would be present among other hospital employees. A brief introduction regarding the survey was presented before 29 Culture of Safety classes. The surveys were then distributed to the nurses in the classroom. Additional surveys were available at the registration table for late arrivals. An envelope was placed on the registration table for participants to place their surveys. After the class, the envelope containing the questionnaires was collected, and the data was entered into Microsoft Excel®. To identify surveys from the acute care hospital, the survey was copied on blue paper.

To obtain additional respondents, a second data collection method was also used. Since the Culture of Safety classes were ongoing prior to the start of this study, at the recommendation of the Director of Nursing Research and Evidence Based Practice, the surveys were distributed at 2 key nursing meetings. The surveys were distributed prior to the start of the meetings, and an envelope was left for collection of the surveys.

Because the Hospital Survey on Patient Safety Culture and the Technology Acceptance Model are two well tested instruments used in many studies, a pilot study was not conducted.

Data Analysis

Missing Data

Data from the survey were initially entered into Microsoft Excel® to maximize data integrity by limiting data input errors. Data from Microsoft Excel® were then imported into IBM SPSS for Windows® version 19.0, which was used for the data analysis. All statistical analyses was two-sided with an α of 5%. The evaluation procedure for missing data was conducted by evaluating the number of missing questions within a subscale. If more than 1 question was not answered for the subscale, the survey was removed from the dataset. If data were missing for a single question for a subscale, the missing data were replaced with the mean score of the subscale. Demographic data were described using the mean, standard deviation and range for continuous variables, and frequency and percent for categorical variables. Cronbach's α was used to measure the internal consistency and reliability for BCMA perceived usefulness, BCMA perceived ease of use, behavioral intention to use BCMA, teamwork within hospital units, communication openness, feedback and communication about errors, and management support for patient safety.

Assumptions in Multiple Regression

Outliers: Data outliers can be identified by calculating Mahalanobis distance (Mertler & Vannatta, 2005). After reviewing the data input, there were no data entry errors. The decision was made to keep all the data since the data was within the range of acceptable values.

Multicollinearity: In this study, tolerance statistics and variance inflation factor for each predictor were measured and found not to violate multicollinearity. When independent variables are highly correlated then these variables are essentially measuring the same concept (Mertler & Vannatta, 2005). A tolerance value close to zero and/or a variance inflation factor greater than 10 indicates multicollinearity (Mertler & Vannatta, 2005). The data did not violate multicollinearity.

Violation of Assumptions: Per Polit (2010), multivariate normality is assumed that all variables and combinations of variables are normally distributed, assume linearity, and homoscedasticity. Residual scatterplots and p-p plots regression standardized residual were assessed for multivariate normality and linearity.

Data Analysis Plan

Hypothesis 1 was tested using Pearson's correlation coefficient. The null hypothesis was rejected if the Pearson correlation coefficient was statistically different from zero, indicating that there is a correlation between perceived usefulness and teamwork within hospital units among nurses using BCMA in hospitals. The strength and direction are reported and interpreted.

Hypothesis 2 was tested using Pearson's correlation coefficient. The null hypothesis was rejected if the Pearson correlation coefficient was statistically different than zero, indicating that there is a correlation between perceived usefulness and hospital management support for patient safety among nurses using BCMA in hospitals. The strength and direction are reported and interpreted.

Hypothesis 3 was tested using Pearson's correlation coefficient. The null hypothesis was rejected if the Pearson correlation coefficient was statistically different than zero, indicating that there is a correlation between perceived usefulness and communication openness among nurses using BCMA in hospitals. The strength and direction are reported and interpreted.

Hypothesis 4 was tested using Pearson's correlation coefficient. The null hypothesis was rejected if the Pearson correlation coefficient was statistically different than zero, indicating that there is a correlation between perceived usefulness and feedback and communication about errors among nurses using BCMA in hospitals. The strength and direction are reported and interpreted.

Hypothesis 5 was tested using hierarchical multiple linear regression analysis. The dependent variable in the regression model was BCMA perceived usefulness. The independent variables were teamwork within hospital units, hospital management support for patient safety, communication openness, and feedback and communication about errors. The independent variables were entered into the hierarchical regression model as the 3rd step. If the regression coefficients for all four independent variables were statistically significant, then the null hypothesis was rejected. This would indicate that teamwork within hospital units, hospital management support for patient safety, communication openness, and feedback and communication about errors better predict BCMA perceived usefulness than any single dimension of patient safety culture alone, after controlling for demographic and work characteristics. The equation for the model and the R-square are reported and interpreted.

For exploratory purposes to determine which demographic and work variables needed to be included in testing hypothesis 10, a one-way analysis of variance (ANOVA) was conducted to determine whether there is a statistically significant relationship between BCMA perceived usefulness and education level. A second ANOVA was performed to determine whether there is a statistically significant relationship between BCMA perceived usefulness and computer skills. A third ANOVA was performed to determine whether there is a statistically significant relationship between BCMA perceived usefulness and nursing shift. Person's correlation statistic was used to determine whether there is a statistically significant relationship between BCMA perceived usefulness and age. A second Pearson's correlation statistic was used to determine whether there is a statistically significant relationship between BCMA perceived usefulness and BCMA length of use. If there was a statistically significant association between education, computer skills, nursing shift, age, or BCMA length of use and BCMA perceived usefulness, then a multiple linear regression analysis was performed to control for these variables. The dependent variable in the regression model was BCMA perceived usefulness. The demographic control variables were whichever age, education, and/or computer skills were statistically significantly associated with BCMA perceived usefulness. The work characteristics control variables were whichever nursing shift and/or BCMA length of use was statistically significantly associated with BCMA perceived usefulness. The independent variables were teamwork within hospital units, hospital management support for patient safety, communication openness, and feedback and communication about errors. Demographic and work characteristics control variables that correlate with the criterion variable at $p<0.2$ were considered for entry into the regression model. The statistically significant demographic control variables were entered into the model as the first step of the model building process. The second step entailed entering the work characteristic control variables into the regression model, and the third step entailed simultaneously entering the independent variables into the regression model. Statistically significant regression coefficients were interpreted. In addition, the equation for the model and the R-square are reported and interpreted.

Hypothesis 6 was tested using Pearson's correlation coefficient. The null hypothesis was rejected if the Pearson correlation coefficient was statistically different from zero, indicating there is a correlation between perceived ease of use and teamwork within hospital units among nurses using BCMA in hospitals. The strength and direction are reported and interpreted.

Hypothesis 7 was tested using Pearson's correlation coefficient. The null hypothesis was rejected if the Pearson correlation coefficient was statistically different than zero, indicating there is a correlation between perceived ease of use and hospital management support for patient safety among nurses using BCMA in hospitals. The strength and direction are reported and interpreted.

Hypothesis 8 was tested using Pearson's correlation coefficient. The null hypothesis was rejected if the Pearson correlation coefficient was statistically different than zero, indicating there is a correlation between perceived ease of use and communication openness among nurses using BCMA in hospitals. The strength and direction are reported and interpreted.

Hypothesis 9 was tested using Pearson's correlation coefficient. The null hypothesis was rejected if the Pearson correlation coefficient was statistically different than zero, indicating there is a correlation between perceived ease of use and feedback and communication about errors among nurses using BCMA in hospitals. The strength and direction are reported and interpreted.

Hypothesis 10 was tested using hierarchical multiple linear regression analysis. The dependent variable in the regression model was BCMA perceived ease of use. The independent variables were teamwork within hospital units, hospital management support for patient safety, communication openness, and feedback and communication about errors. The independent variables were entered into the hierarchical regression model as the 3rd step. If the regression coefficients for all four independent variables were statistically significant, then the null hypothesis was rejected. This would indicate that teamwork within hospital units, hospital management support for patient safety, communication openness, and feedback and communication about errors better predict BCMA perceived ease of use than any single dimension of patient safety culture alone, after controlling for demographic and work characteristics. The equation for the model and the R-square are reported and interpreted.

For exploratory purposes to determine which demographic and work variables needed to be included to test hypothesis 5, a one-way ANOVA was conducted to determine whether there is a statistically significant relationship between BCMA perceived ease of use and education level. A second ANOVA was performed to determine whether there is a statistically significant relationship between BCMA perceived ease of use and computer skills. A third ANOVA was performed to determine whether there is a statistically significant relationship between BCMA perceived ease of use and nursing shift. Person's correlation statistic was used to determine whether there is a statistically significant relationship between BCMA perceived ease of use and age. A second Pearson's correlation statistic was used to determine whether there is a statistically significant relationship between BCMA perceived ease of use and BCMA length of use. If education, computer skills, nursing shift, age, and/or BCMA length of use were statistically significantly associated with BCMA perceived ease of use, then a multiple linear regression analysis was performed to control for these variables. The dependent variable in the regression model was the BCMA perceived ease of use. The demographic control variables were whichever age, education, and computer skills were statistically significantly associated with BCMA perceived ease of use. The work characteristic control variables were nursing shift and BCMA length of use, which were statistically significantly associated with BCMA perceived ease of use. The independent variables were teamwork within hospital units, hospital management support for patient safety, communication openness, and feedback and communication about errors. Demographic and work characteristics control variables that correlated with the criterion variable at $p<0.2$ were considered for entry into the regression model. The statistically significant demographic control variables were entered into the model as the first step of the model building process. The second step entailed entering the work characteristic control variables into the regression model, and the third step entailed simultaneously entering the independent variables into the regression model. Statistically significant regression coefficients were interpreted. In addition, the equation for the model and the R-square are reported and interpreted.

Hypothesis 11 was tested using Pearson's correlation coefficient. The null hypothesis was rejected if the Pearson correlation coefficient was statistically different from zero, indicating there is a correlation between perceived ease of use and the behavioral intention to use BCMA in hospitals. The strength and direction are reported and interpreted.

Hypothesis 12 was tested using Pearson's correlation coefficient. The null hypothesis was rejected if the Pearson correlation coefficient was statistically different from zero, indicating there is a correlation between perceived usefulness and the behavioral intention to use BCMA in hospitals. The strength and direction are reported and interpreted.

Hypothesis 13 was tested using hierarchical multiple linear regression analysis. The dependent variable in the regression model was BCMA behavioral intention to use. Demographic and work characteristics control variables that correlated with the criterion variable at $p<0.2$ were considered for entry into the regression model. The statistically significant demographic control variables were entered into the regression model as the first step. The second step entailed entering the statistically significant work characteristic control variables into the model. The third step of the regression model included the patient safety culture dimensions. The independent variables were BCMA perceived ease of use and BCMA perceived usefulness, and these variables were entered into the regression model as the last step. If the regression coefficients for the 2 independent variables was statistically significant, then the null hypothesis was rejected. This would indicate that BCMA perceived ease of use and BCMA perceived usefulness better predict BCMA behavioral intention to use than any single construct alone, after controlling for demographic and work characteristics. The equation for the model and the R-square are reported and interpreted.

Ethical Considerations

Prior to data collection, approval was obtained from the George Mason University Human Subjects Review Board and the integrated health delivery network's Institute Office of Research Integrity's Institutional Review Board. The purpose of this study was fully disclosed to the participants in a cover letter on the survey instrument. Participation in this study was voluntary, and no harm was expected from completing the survey. Anonymous numbers were placed on the survey after the surveys were returned, making it impossible to identify individual respondents.

Summary

The purpose of this study was to evaluate the relationship between patient safety culture and the perceived usefulness and perceived ease of use of BCMA, which drive the behavioral intention to use BCMA. In addition, demographic and work characteristics were assessed to determine whether these variables have a relationship with perceived usefulness, perceived ease of use, and/or the behavioral intention to use BCMA.

To answer the research questions in this study, a cross-sectional, correlational design using a quantitative survey was used to evaluate the relationship between patient safety culture and the behavioral intention to use BCMA. In particular, hierarchical regression analysis was used to evaluate the regression model.

CHAPTER FOUR

This chapter describes the data used to evaluate the relationship between patient safety culture and the behavioral intention to use bar code medication administration among registered nurses in hospitals. This chapter also discusses the data quality, demographics, and quantitative analysis using SPSS® addressing the research questions.

Data Collection

The target population included 166 nurses at the rehabilitation facility. All 166 registered nurses were invited to participate in the study, and the response rate was 45.7%. At the acute care facility, the there is an estimated total of 2300 registered nurses; however, only those nurses using BCMA and who attended the Culture of Safety class or the key nursing meetings were invited to participate. The survey response rate could not be calculated for the acute care facility. A total of 173 nurses completed the survey. Among the 173 respondents, 10 respondents skipped more than 1 survey question making up a given subscale (independent and/or dependent variable), and they were omitted from the analysis. A total of 10 respondents skipped only 1 question making up a given subscale. Means substitution was used to replace missing values for these 10 respondents. The final sample size for the study was 163.

Demographic Variables

Among the 163 study participants, 137 (84%) were female, 23 (14%) were male, and 3 (1.8%) failed to report their gender. A total of 22 (13.5%) study participants reported their ethnicity as Asian, 68 (41.7%) as African American, 7 (4.3%) as Hispanic or Latino, 56 (34.4%) as White, and 10 (6.1%) failed to report their ethnicity. The education distribution was 32 (19.6%) Diploma/Associates degrees, 105 (64.4%) Bachelor's degrees, and 26 (16%) Master's/Terminal degrees. A Total of 106 (65.6%) reported working day shift, 19 (11.7%) evening shift, 32 (19.6%) night shift, and 5 (3.1%) failed to report their shift worked. The distribution of computer skills was 15 (9.2%) beginners and 148 (90.8%) advanced users. The average (SD) age was 39.8 (11.6) years and the range was 22 to 67 years. The average (SD) years of experience as an RN was 12.4 (11.4), and the range was less than 1 to 46. The average (SD) number of years of experience using BCMA was 2.6 (1.9), and the range was less than 1 to 10. See Appendix A for detailed frequency tables and descriptive statistics for all of the survey questions.

Table 6 Participant Characteristics

Variable		**N (%)**
Demographics		
Gender[a]	Male	23 (14.4%)
	Female	137 (85.6%)
Age[b]	20 -29	34 (23.6%)
	30-39	36 (25.0%)
	40-49	39 (27.1%)
	50-59	28 (19.4%)
	≥60	7 (4.9%)
Ethnicity[c]	White	56 (36.6%)

	Black	68 (44.4%)
	Hispanic or Latino	7 (4.6%)
	Asian	22 (14.4%)
Education[d]	Diploma	5 (3.2%)
	Associates	27 (17.1%)
	Bachelors	100 (63.3%)
	Masters	23 (14.6%)
	Terminal	3 (1.9%)
Computer Skills[e]	Beginner	15 (9.5%)
	Intermediate	86 (54.4%)
	Advanced	57 (36.1%)
RN Years of Experience[f]	0-5	64 (42.7%)
	5-10	17 (11.3%)
	11-20	33 (22.0%)
	21-30	22 (14.7%)
	≥31	14 (9.3)
Work Characteristics		
Facility	Rehabilitation	74 (45.4%)
	Acute Care	89 (54.6%)
Nursing Shift[g]	Day	107 (67.7%)
	Evening	19 (12.0%)
	Night	32 (20.3%)
BCMA Length of Use in Years[h]	<1	13 (8.5%)
	1-2	72 (47.1%)
	3-4	45 (29.4%)
	>5	23 (15.0%)

Notes:
Total N = 163
[a]Missing n = 3; [b]Missing n = 19; [c]Missing n = 10; [d]Missing n = 5; [e]Missing n = 5; [f]Missing n = 13; [g]Missing n = 5; [h]Missing n = 10

Descriptive Statistics for the Hospital Patient Safety Culture and Technology Acceptance Scores

Table 7 shows descriptive statistics for the hospital patient safety culture and technology acceptance scores. The smallest possible Teamwork score was 4 and the maximum possible score was 20. On average, the Teamwork score was rated well above the middle score of 12, with an average of 15.5 (SD = 3.18, range = 4 – 20). The smallest possible Communication Openness score was 3 and the maximum possible score was 15.

The average score in the sample was greater than the middle score of 9, with an average of 10.5 (SD = 2.13, range = 5 – 15). The smallest possible Feedback and Communication about Errors score was 3 and the maximum possible score was 15. The average score in the sample was greater than the middle score of 9, with an average of 11.5 (SD = 2.48, range = 3 – 15). The smallest possible Hospital Management Support for Patient Safety score was 3 and the maximum possible score was 15. The average score in the sample was greater than the middle score of 9, with an average of 10.9 (SD = 2.60, range = 3 – 15). The smallest possible Perceived Usefulness score was 5 and the maximum possible score was 25. The average score in the sample was only slightly above the middle score of 15, with an average of 15.4 (SD = 3.64, range = 5 – 20). The smallest possible Ease of Use score was 5 and the maximum possible score was 25. The average score in the sample was well above the middle score of 15, with an average of 17.9 (SD = 1.58, range = 6 – 25). The smallest possible Behavioral Intention to Use score was 2 and the maximum possible score was 10. The average score in the sample was well above the middle score of 6, with an average of 8.3 (SD = 4.19, range = 2 – 10).

Table 7 Descriptive Statistics for the Hospital Patient Safety Culture and Technology Acceptance Model Scores

	Range	Mean	Std. Deviation
Teamwork[a]	(4 – 20)	15.5036	3.17572
Communication Openness[b]	(3 – 15)	10.5436	2.12629
Feedback & Communication about Errors[c]	(3 – 15)	11.4996	2.47556
Hospital Management Support for Patient Safety[d]	(3 – 15)	10.9264	2.59844

BCMA Perceived Usefulness[e]	(5 – 20)	15.3804	3.63489
BCMA Perceive Ease of Use[f]	(6 – 25)	8.3139	1.58107
BCMA Behavioral Intention to Use[g]	(2 – 10)	17.9187	4.18917

Notes:
N = 163
[a]Missing n = 4; [b]Missing n = 2; [c]Missing n = 1; [d]Missing n = 3; [e]Missing n = 0; [f]Missing n = 3; [g]Missing n = 2

Cronbach's Alpha for the Hospital Patient Safety Culture and Technology Acceptance Model Scores

A Cronbach's alpha was calculated for each of the Hospital Patient Safety Culture and Technology Acceptance Model scores. Table 8 shows that with the exception of Communication Openness, all of the scores had an alpha above .70.

Table 8 Cronbach's Alpha Reliability for Hospital Patient Safety Culture and Technology Acceptance Model Scores

	Variable	Cronbach's Alpha	Number of Items
Patient Safety Culture Dimensions	**Teamwork**	0.92	4
	Communication Openness	0.61	3
	Feedback & Communication about Errors	0.84	3
	Hospital Management Support for Patient Safety	0.72	3
Technology Acceptance Model	**BCMA Perceived Usefulness**	0.83	4
	BCMA Perceive Ease of Use	0.90	2
	BCMA Behavioral Intention to Use	0.91	4

Note:
N = 163

Preliminary Analyses

Two-sample t-tests were performed to compare the average PU, PEOU and BI scores between males and females. Table 9 shows there was not a statistically significant difference between males and females for any of the three variables. Pearson's correlation statistic was used to assess the relation between age and PU, PEOU and BI. Table 9 shows there was a statistically significant, weak negative correlation between age and BI ($p<0.05$). This means that on average, older nurses tend to score lower on behavioral intention to use than younger nurses.

Analysis of variance (ANOVA) was used to compare the average PU, PEOU and BI scores among the four ethnic groups. Table 9 shows there were statistically significant differences at $p<0.001$ in PU and PEOU among the four ethnic groups. Post-hoc Bonferroni adjusted two-sample t-tests were then performed to determine which groups were different. The White ethnic group had a statistically significantly smaller average PU score than the Asian and Black ethnic groups. None of the other ethnic groups were statistically significantly different than each other with respect to PU. With respect to PEOU, the White ethnic group had a statistically significantly smaller score, on average, than the Asian and Black ethnic groups. None of the other ethnic groups differed significantly from any other with respect to PEOU. There was not a statistically significant difference in the average BI score among the four ethnic groups.

Analysis of variance (ANOVA) was used to compare the average PU, PEOU and BI scores among the three education groups. Table 9 shows there was no statistically significant differences in the PU, PEOU or BI scores among the three education groups.

Two-sample t-tests were performed to compare the average PU, PEOU and BI scores between nurses with beginner level computer skills and those with advanced computer skills. Table 9 shows there was not a statistically significant difference between the two groups for any of the three variables.

Two-sample t-tests were performed to compare the average PU, PEOU and BI scores between nurses who worked in the rehabilitation facility and those who worked in the acute care facility. Table 9 shows that, on average, nurses working in the acute care facility scored statistically significantly lower on all three measures of technology acceptance (PU $p<0.001$; PEOU $p<0.001$; BI $p<0.05$). Pearson's correlation statistic was used to assess the relation between years of experience as an RN and PU, PEOU, and BI. Table 9 shows there was a statistically significant, weak negative correlation between years of experience and BI ($p<0.05$). This means that, on average, nurses with more experience tend to score lower on behavioral intention to use than nurses with less experience. Pearson's correlation statistic was also used to assess the relation between years of experience using BCMA with PU, PEOU and BI. Table 9 shows there was a statistically significant, moderately strong positive correlation between years of experience with BCMA and both PU, and PEOU. This means that, on average, nurses with more experience with BCMA tend to score higher on PU and PEOU than nurses with less experience with BCMA. There was not a statistically significant correlation between years of experience and BCMA and BI.

Analysis of variance (ANOVA) was used to compare the average PU, PEOU and BI scores among the three nursing shifts. Table 9 shows there were statistically significant differences in the average PU score among the three groups. Post-hoc Bonferroni adjusted two-sample t-tests were performed to determine which groups were different. The Day group had a statistically significantly smaller average PU score than the Evening group. None of the other groups differed significantly from any other with respect to PU. There was not a statistically significant difference in the average PEOU or BI scores among the three nursing shifts.

Table 9 Descriptive Statistics for Demographic and Work Characteristic Variables in the Study

Variables		**BCMA**					
Demographics **Work Characteristics**		**Perceived Usefulness**		**Perceived Ease of Use**		**Behavioral Intention to Use**	
	Total Possible Range	(5 – 20)		(6 – 25)		(2 – 10)	
		Mean		Mean		Mean	
Gender	Male Female	15.04 (3.89) 15.48 (3.56)	t =.53 df = 158 p = .60	17.26 (4.97) 18.05 (4.05)	t = .84 df = 158 p = .41	8.61 (1.56) 8.29 (1.58)	t = -.89 df = 158 p = .38
Age	Range (22 – 67)		r = -.04 p = .61		r = -.02 p = .80		r = -.17 **p = .04***
Ethnicity	White Black Hispanic Asian	13.80 (3.71) 16.46 (3.47) 15.00 (1.73) 16.50 (2.39)	F = 7.17 df = 3,149 **p <0.001*** **	15.58 (3.88) 19.40 (3.95) 18.00 (2.31) 19.86 (2.82)	F = 12.88 df = 3, 149 **p<0.001*** **	8.30 (1.65) 8.49 (1.38) 7.71 (2.14) 8.27 (1.91)	F = .57 df = 3, 149 p = .64
Education	Diploma/Associates Bachelors Masters/Terminal	16.03 (3.90) 15.42 (3.54) 14.42 (3.65)	F = 1.43 df = 2, 160 p = .24	19.20 (3.94) 17.86 (4.06) 16.58 (4.68)	F = 2.90 df = 2, 160 p = .06	8.56 (1.16) 8.25 (1.64) 8.27 (1.80)	F = .49 df = 2, 160 p = .61
Computer Skills	Beginner Advanced	15.13 (3.20) 15.41 (3.69)	t =-.28 df = 161 p = .78	16.89 (3.20) 18.02 (4.27)	t =-1.00 df = 161 p = .32	7.95 (1.49) 8.35 (1.59)	t =-.95 df = 161 p = .34
Facility	Rehabilitation Acute Care	17.00 (2.71) 14.03 (3.77)	t =5.67 df = 161 **p <0.001*** **	19.53 (3.78) 16.58 (4.05)	t = 4.77 df = 161 **p <0.001*** **	8.62 (1.55) 8.06 (1.57)	t = 2.23 df = 161 **p = .02***
RN Years	Range (1 – 46)		r = -.06 p = .45		r = -.01 p = .88		r = -.18 **p = .03***
BCMA Length of Use	Range (0 – 10)		r = .27		r = .26		r = .03

			p <0.001* **		**p <0.001*** **		p = .73
Nursing Shift	Day Evening Night	14.89 (3.54) 17.00 (3.25) 16.06 (3.71)	F = 3.61 df = 2,155 **p =.029***	17.72 (4.06) 19.47 (4.03) 17.63 (4.52)	F = 1.53 df = 2, 155 p = .22	8.23 (1.62) 8.95 (1.18) 8.31 (1.60)	F = 1.71 df = 2, 155 p = .19

Notes:
N = 163

Independent t-tests were used to evaluate the relationships between Gender, Computer Skills, and Facility and Perceived Usefulness, Perceived Ease of use, and the Behavioral Intention to Use BCMA.

ANOVA was used to evaluate the relationships between Ethnicity, Education, and Nursing Shift and Perceived Usefulness, Perceived Ease of use, and the Behavioral Intention to Use BCMA.

Pearson's Correlation was used to evaluate the relationships between Age, RN Years of Experience, and BCMA Length of use and Perceived Usefulness, Perceived Ease of use, and the Behavioral Intention to Use BCMA.

* p<0.05; ** p<0.01; and *** p<0.001

Hypothesis Results

Hypotheses 1-4

Table 10 is a correlation matrix showing the Pearson correlation statistics used to test hypotheses 1 through 4. There were statistically significant ($p<0.001$) moderately strong positive correlations between PU and Feedback and Communication About Errors, and Hospital Management Support. The null hypotheses 3 and 4 were rejected and it was concluded that, on average, nurses who perceive better feedback and communication about errors, and better hospital management support, tend to perceive BCMA to be useful.

Table 10 Correlation matrix for Patient Safety Culture Dimensions versus BCMA Perceived Usefulness for Testing Hypotheses 1 through 4 and 6 through 9

		Teamwork	Communication Openness	Feedback & Communication about Errors	Hospital Management Support for Patient Safety	BCMA Perceived Usefulness	BCMA Perceived Ease of Use
Teamwork	Pearson Correlation	1	.300	.209	.220	.109	.103
	Sig. (2-tailed)		**<0.001*** **	**.007** **	**.005** **	.166	.189
	N	163	163	163	163	163	163
Communication Openness	Pearson Correlation	.300	1	.439	.353	.059	.088
	Sig. (2-tailed)	**<0.001*** **		**<0.001*** **	**<0.001*** **	.454	.264
	N	163	163	163	163	163	163
Feedback & Communication about Errors	Pearson Correlation	.209	.44	1	.517	.324	.273
	Sig. (2-tailed)	**.007** **	**<0.001*** **		**<0.001*** **	**<0.001*** **	**<0.001*** **
	N	163	163	163	163	163	163
Hospital Management Support for Patient Safety	Pearson Correlation	.220	.353	.517	1	.306	.298
	Sig. (2-tailed)	**.005** **	**<0.001*** **	**<0.001*** **		**<0.001*** **	**<0.001*** **
	N	163	163	163	163	163	163
BCMA Perceived Usefulness	Pearson Correlation	.109	.059	.324	.306	1	.71
	Sig. (2-tailed)	.166	.454	**<0.001*** **	**<0.001*** **		**<0.001*** **
	N	163	163	163	163	163	163
BCMA Perceived Ease of Use	Pearson Correlation	.103	.088	.273	.298	.71	1
	Sig. (2-tailed)	.189	.264	**<0.001*** **	**<0.001*** **	**<0.001*** **	
	N	163	163	163	163	163	163

Notes:
N = 163
** p<0.01; and *** p<0.001

Hypotheses 5

Hypothesis 5 was tested using hierarchical linear regression analysis. The dependent variable was the BCMA perceived usefulness (PU) score. In the first step of the model building process, age, education and level of computer skills were reviewed to determine whether these demographic control variables correlate with the criterion variable at $p<0.2$. The demographic variables age, education and computer skills were not significant and were not entered into the first step.

Since the demographic variables did not meet the criterion in the first step, work characteristic variables were then reviewed to determine if nursing shift and BCMA years of use met the criterion variable of $p<0.2$. Table 11 shows years of experience with BCMA was statistically significant at $p<0.05$. Since nursing shift ($p<0.03$) and years of experience with BCMA ($p<0.001$) met the criterion variable of $p<0.2$, these work characteristic variables were entered into the first step of the model building process. The R^2 attributed to nursing shift and years of experience with BCMA was .10. The overall model was significant at $p<0.001$. This means that when controlling for nursing shift and years of experience with BCMA, the model explains 10% of the total variance in PU. The standardized regression coefficient for years of experience with BCMA was .20. The interpretation of this coefficient is, when controlling for nursing shift, the average PU score is expected to increase by .20 points for every 1-year increase in experience with BCMA.

In the second step of the model building process, the four measures of hospital patient safety culture were entered into the model. Table 11 shows that only "Feedback and Communication about Errors" was statistically significant ($p<0.01$). The overall model was statistically significant at $p<0.001$. The R^2 attributed to the four hospital patient safety culture scores was .11. This means that when controlling for nursing shift and years of experience with BCMA, the four measures of patient safety culture explain 11% of the total variance in PU. The standardized regression coefficient for "Feedback and Communication about Errors" was .26. This means that when controlling for nursing shift, years of experience with BCMA, Teamwork, Communication Openness, and Hospital Management Support, the average PU score is expected to increase by .26 points for every 1-point increase in the "Feedback and Communication about Errors" score. The cumulative R^2 attributed to the full model was .21, which was statistically significant at $p<0.001$. This means that, nursing shift, years of experience with BCMA, Teamwork, Communication Openness, Feedback and Communication about Errors, and Hospital Management Support, collectively explain 21% of the total variance in PU scores.

Table 11 Hierarchical Multiple Regression of BCMA Perceived Usefulness, BCMA Perceived Ease of Use, and the Behavioral Intention to Use BCMA among Registered Nurses

		BCMA					
		Perceived Usefulness		**Perceived Ease of Use**		**Behavioral Intention to Use**	
Step	**Predictor**	Beta [a]	R^2 Change	Beta [a]	R^2 Change	Beta [a]	R^2 Change
1	***Demographics***				.04		**.03***
	Age	n/a		n/a		**-.17***	
	Education – Bachelors	n/a		-.11		n/a	
	Education – Advanced	n/a		**-.24***		n/a	
	Computer Skills	n/a		n/a		n/a	
2	***Work Characteristics***		**.10*****		**.05****		.02
	Shift – 1	.09		n/a		.08	
	Shift – 2	.12		n/a		-.02	
	BCMA Use in Years	**.20***		**.18***		n/a	
3	***Patient Safety Culture Dimensions***		**.11*****		**.11*****		**.07***
	Teamwork within Hospital Units	.03		.08		**.20***	
	Communication Openness	-.11		-.05		.04	
	Feedback & Communication about Errors	**.26****		**.22***		.01	
	Hospital Management Support for Patient Safety	.16		.149		-.09	
4	***Technology Acceptance Dimensions***						**.12*****
	Perceived Usefulness	n/a		n/a		**.35****	
	Perceived Ease of Use	n/a		n/a		.06	
	Cumulative R^2		**.21*****		**.20*****		**.24*****

Notes:
N = 163
[a] Betas shown are for the last step
Model Summary was used for R^2 Change
Standardized Coefficients was used for Betas

* $p<0.05$; ** $p<0.01$; and *** $p<0.001$

Hypotheses 6 – 9

Table 10 is a correlation matrix showing the Pearson correlation statistics used to test hypotheses 6 through 9. There were statistically significant ($p>0.001$), moderately strong positive correlations between BCMA perceived ease of use (PEOU) and Feedback and Communication about Errors, and Hospital Management Support. The null hypotheses 8 and 9 were rejected and it was concluded that, on average, nurses who perceive better feedback and communication about errors and better hospital management support tend to perceive BCMA to be easier to use.

Hypothesis 10

Hypothesis 10 was tested using hierarchical linear regression analysis. The dependent variable was the BCMA perceived ease of use (PEOU) score. Education was recoded into dummy variables such that the referent group was Diploma/Associates; Education - Bachelors = 0 if the highest level of education was not a Bachelor's degree, or 1 if it was a Bachelor's degree; Education - Advanced = 0 if the highest level of education was not a Masters/Terminal degree, or 1 if it was a Masters/Terminal degree. Table 11 shows that only advanced education was statistically significant. In the first step of the model building process, age, education and level of computer skills were reviewed to determine whether these demographic control variables correlate with the criterion variable at $p<0.2$. The demographic variables age and computer skills were not significant; however, education met the criterion variable at $p<0.058$ and so education was entered into Step 1 of the model building process. The R^2 attributed to education was .04 which was not significant. This means that education explains 4% of the total variance in BCMA perceived ease of use. The standardized regression coefficient for advanced education was -.24. The interpretation of this coefficient is that the average BCMA PEOU score is expected to be .24 points lower for nurses with a Masters/Terminal degree than for those without a Masters/Terminal degree.

Nursing shift was recoded into dummy variables such that the referent group was "Day;" Shift - 1 = 0 if nursing shift was not "Evening," or 1 if it was "Evening;" Shift - 2 = 0 if nursing shift was not "Night," or 1 if it was "Night." Table 11 shows that only years of experience with BCMA was statistically significant ($p<0.05$). To determine which work characteristic variables should be entered in the second step of the model building process, nursing shift and years of experience with BCMA were reviewed to determine whether these demographic control variables correlate with the criterion variable at $p<0.2$. BCMA years of use met the criterion variable value of $p<0.2$ and was entered into the second step of the model building process. The R^2 attributed to years of experience with BCMA was .05, which was significant at $p<0.01$. This means that when controlling for education and years of experience with BCMA, the model explains 5% of the total variance in PEOU. The standardized regression coefficient for years of experience with BCMA was .18. The interpretation of this coefficient is that when controlling for education, the average PEOU score is expected to increase by .18 points for every 1-year increase in experience with BCMA.

In the third step of the model building process, the four measures of hospital patient safety culture were entered into the model. Table 10 shows that among the hospital patient safety culture measures, feedback and communication about errors were statistically significant at $p<0.05$. The overall R^2 attributed to the four hospital patient safety culture scores was .11, which was statistically significant at $p<0.001$. This means that when controlling for education and years of experience with BCMA, the four measures of patient safety culture explain 11% of the total variance in PEOU. The cumulative R^2 attributed to the full model was .20 which was statistically significant at $p<0.001$. This means that education, years of experience with BCMA, Teamwork, Communication Openness, Feedback and Communication about Errors, and Hospital Management Support, collectively explain 20% of the total variance in PEOU scores.

Hypotheses 11 and 12

Table 12 is a correlation matrix showing the Pearson correlation statistics used to test hypotheses 11 and 12. There was a statistically significant, moderately strong positive correlation between PEOU and BI ($p<0.001$). In addition, there was a statistically significant, strong positive correlation between PU and BI ($p<0.001$). Null hypotheses 11 and 12 were rejected and it was concluded that, on average, nurses who perceive BCMA to be easier to use and more useful, tend to have greater intention to use BCMA.

Table 12 Correlation Matrix for BCMA Perceived Usefulness and Ease of Use versus BCMA Behavioral Intention to Use Hypotheses 11 and 12.

		BCMA Perceived Usefulness	**BCMA Perceived Ease of Use**	**BCMA Behavioral Intention to Use**
BCMA Perceived Usefulness	Pearson Correlation	1	.709	.432
	Sig. (2-tailed)		**<0.001*** **	**<0.001*** **
	N	163	163	163

BCMA Perceived Ease of Use	Pearson Correlation	.709	1	.333
	Sig. (2-tailed)	**<0.001*****		**<0.001*****
	N	163	163	163
BCMA Behavioral Intention to Use	Pearson Correlation	.432	.333	1
	Sig.(2-tailed)	**<0.001*****	**<0.001*****	
	N	163	163	163

Notes:
N = 163
* p<0.05; ** p<0.01; and *** p<0.001

Hypothesis 13

Hypothesis 13 was tested using hierarchical linear regression analysis. The dependent variable was the Behavioral Intention to Use (BI) score. In the first step of the model building process, age, education and level of computer skills were reviewed to determine whether these demographic control variables correlate with the criterion variable for placement into the model. The demographic variables education and computer skills were not significant and were not entered into the first step; however, age did meet the criterion variable. Table 11 shows that age was statistically significant at $p<0.05$. The R^2 attributed to age was .03 and was statistically significant at $p<0.05$. This means age explains 3% of the total variance in behavioral intention to use BCMA (BI).

In the second step of the model building process, nursing shift met the criterion variable and was entered into the model. Table 11 shows that neither nursing shift nor years of experience with BCMA were statistically significant. The R^2 attributed to nursing shift and years of experience with BCMA was .02. This means that when controlling for age and nursing shift, the model explains 2% of the total variance in BI.

In the third step of the model building process, the four measures of hospital patient safety culture were entered into the model. Table 5 shows that only "Teamwork" was statistically significant at $p<0.05$, and the overall model was significant at $p<0.05$. The R^2 attributed to the four measures of hospital patient safety culture was .07. This means that when controlling for age, nursing shift and the four measures of patient safety culture, the model explains 7% of the total variance in BI. The regression coefficient for "Teamwork" was .20. This means that when controlling for age, nursing shift, Communication Openness, Feedback and Communication about Errors, and Hospital Management Support, the average BI score is expected to increase by .20 points for every 1-point increase in the "Teamwork" score.

In the fourth step of the model building process, PU and PEOU were entered into the model. Table 11 shows that only PU was statistically significant at $p<0.01$. The overall model was significant at $p<0.001$ with an R^2 attributed to PU and PEOU of .12. This means that when controlling for age, nursing shift, and the four measures of patient safety culture, PU and PEOU explain 12% of the total variance in BI. The regression coefficient for PU was .35. This means that when controlling for age, nursing shift, the four measures of patient safety culture, and PEOU, the average BI score is expected to increase by .35 points for every 1-point increase in the PU score. The cumulative R^2 attributed to the full model was .24 which was statistically significant at $p<0.001$. This means that age, nursing shift, Teamwork, Communication Openness, Feedback and Communication about Errors, Hospital Management Support, and PEOU collectively explain 24% of the total variance in BI scores.

Summary

A cross sectional correlational design using a quantitative instrument was used in this study. A convenience sample of 163 registered nurses at rehabilitation and acute care hospitals using bar code medication administration was obtained. Descriptive statistics, bivariate, and multivariate analyses were conducted on demographic and work characteristics, patient safety culture dimensions, and TAM constructs.

Bivariate statistics on demographic variables revealed that older nurses and nurses with more experience tend to score lower on the behavioral intention to use BCMA than younger and less experienced nurses. Among the ethnic groups, white nurses were found to have a smaller average BCMA perceived usefulness and BCMA perceived ease of use scores than other ethnic groups. Among the work characteristics, the more experience nurses had with BCMA use in years, there was a strong positive correlation with BCMA perceived usefulness and BCMA perceived ease of use. RNs working the day shift had a lower BCMA perceived usefulness score than nurses working on the evening or night shifts. Interestingly, the acute care hospital nurses scored lower on all three technology acceptance scores.

Multivariate regression analyses were conducted using demographic and work characteristics, patient safety culture dimensions, and the TAM constructs. In the BCMA perceived usefulness model, BCMA use in years was statistically significant ($\beta = .20$, $p<0.05$) and contributed to 10% of the total variance. Feedback & communication about errors was statistically significant ($\beta = .26$, $p<0.01$) and contributed to 11% of the total variance. The overall R^2 in predicting BCMA perceive usefulness was successful ($R^2 = .21$) overall and statistically significant beyond $p<0.001$level.

In the BCMA perceived ease of use model, advanced education had a statistically negative impact ($\beta = -.24$, $p<0.05$) minimally contributing to the model ($R^2 = .04$). BCMA use in years had a statistically significant impact ($\beta = .18$, $p<0.01$) although had modest, but significant contributions ($R^2 = .05$, $p<0.01$) to the overall explained variance. Feedback & communication about errors was more successful in predicting BCMA perceive ease of use ($\beta = .22$, $p<0.05$) contributing to more than half of the explained variance ($R^2 = .11$, $p<0.001$). The total explained variance of the BCMA perceived ease of use model was successful ($R^2 = .20$) and was statistically significant beyond $p<0.001$ level.

There were significant relationships of BCMA perceived usefulness ($r = .432$, $p<0.001$), BCMA perceived ease of use ($r = .333$, $p<0.001$) with BCMA behavioral intention to use in the bivariate analyses. However, BCMA perceived ease of use was not significantly related to BCMA behavioral intention to use in the multivariate relationship after controlling for demographics, work characteristics, and patient safety culture. In the multivariate regression model of BCMA behavioral intention to use, age had a statistically significant negative impact ($\beta = -.17$, $p<0.05$), teamwork within hospital units ($\beta = .20$, $p<0.05$) and BCMA PU ($\beta = .35$, $p<0.01$) both had a statistically significant positive impact. The overall BCMA behavioral intention to use model explained 24% ($p<0.001$) of variance.

The inclusion of the patient safety culture dimensions greatly improved the multivariate analyses in the three models. The single most powerful predictor was feedback & communication about errors in the BCMA perceived usefulness and BCMA perceived ease of use models. BCMA perceived usefulness was the most powerful predictor in the BCMA behavioral intention to use.

CHAPTER FIVE

Current research focuses on BCMA and its impact on medication errors (DeYoung, VanerKooi, & Barletta, 2009; Franklin et al., 2007; Poon et al., 2010), as well as workarounds with BCMA (Koppel et al., 2008, Patterson et al., 2006; Rack, Dudjak, & Wolf, 2012); however, the role played by technology acceptance in patient safety culture is an unexplored area. By elucidating the relationship between patient safety culture and the behavioral intention to use BCMA, the present study fills a knowledge gap that could reduce medication errors through its impact on patient safety culture. Once they understand the relationship between patient safety dimensions, hospitals could enhance their patient safety culture to promote better adherence to BCMA technology as well as other technologies that could help reduce medical errors. Indeed, with greater awareness of the impact patient safety culture has on errors, hospitals could take the lead in an effort to improve patient safety through adherence to BCMA technology.

Demographics and Technology Adoption

The demographic characteristics of the respondents were evaluated against the technology acceptance model constructs BCMA perceived usefulness, BCMA perceived ease of use, and the behavioral intention to use BCMA. Between male and female nurses, among educational groups, and between nurses with beginner or advanced computer skills, there were no statistically significant differences with regard to BCMA perceived usefulness, perceived ease of use, or the behavioral intention to use BCMA. Other studies have found computer skills to have a significant impact on the perceived ease of use of technology (Tung & Chang, 2008; Venkatesh, 2000; Wu, Wang, Lin, 2007; Yu, Li, & Gagnon, 2009). In the present study, however, there were no significant findings regarding the relation between a nurse's computer skills and the acceptance of technology. A possible reason for this could be the implementation of computerized documentation along with BCMA at both hospital facilities.

It is noteworthy that older nurses were slightly less likely to have the behavioral intention to use BCMA than younger nurses. Additionally, nurses with more experience scored lower on the behavioral intention to use BCMA than nurses with less experience. This may indicate that nurses who are older and have more experience are less inclined to use the BCMA technology than younger and less experienced nurses. Because BCMA technology assists in the 6 rights of medication administration, younger and less experienced nurses are more likely to rely on the BCMA technology to ensure correct administration of medication to compensate for their lack of experience and/or as a confirmation of correctly administered medication. Younger and less experienced nurses may opt to adhere to established organizational procedures than more experienced nurses. The findings in this study are contradictory to previous findings by Chen et al. (2008) and Yu, Li, & Gagnon (2009) who found that age, and nursing job experience in years was not statistically significant on the measures of technology adoption.

Among ethnic groups, white nurses were less likely to view BCMA as useful and easy to use than Asian or African American nurses. Plausible reasons are unknown for this difference in the white group with the exception that white nurses may be in positions that use BCMA less and thus may not see BCMA as useful. There was no difference between the ethnic groups with respect to BCMA intention to use. Regardless of the perceived BCMA usefulness and ease of use among white nurses the behavioral intention to use BCMA is the same as the other ethnic groups. Other nursing studies using the TAM did not use ethnic groups to describe their sample (Chen et al., 2008; Tung, Chang, & Chou, 2008; Wu et al, 2008; Yu, Li, & Gagnon, 2009). A future qualitative study could explore the technology adoption practices of white nurses or perhaps more refined measures could evaluate the differences of this ethnic group. Additionally, a larger sample or different hospital setting could shed light on this interesting finding.

Work Characteristics and Technology Adoption

Of the two facilities studied, nurses working at the acute care facility scored statistically significantly lower on the three measures of technology adoption than nurses working at the rehabilitation facility. These differences may be explained by the difference in hospital types; i.e., a large acute care hospital with 926 licensed beds versus a specialty hospital with 137 licensed beds divided into 4 distinct units. This may suggest that the large acute care hospital should exert more effort to communicate its patient safety culture message or to communicate the usefulness of BCMA technology for the prevention of medication errors.

Nurses with more work experience scored lower on the behavioral intention to use BCMA than nurses with less work experience, as noted above. Nurses with more experience with BCMA scored higher on BCMA perceived usefulness and ease of use. However, there was no correlation between years of experience with BCMA and the behavioral intention to use BCMA directly. This suggests that even though nurses with more years of experience using BCMA may not have the behavioral intention to use BCMA technology directly, nurses have a perception that BCMA is useful and is easy to use asserted the behavioral intention to use BCMA. This concept supports the TAM model in previous findings (Davis 1989; Davis et al., 1989; Wu et al., 2008; Yu et al., 2009).

There were statistically significant differences in the average perception of BCMA usefulness among the 3 nursing shifts. The day shift had a smaller average BCMA perceived usefulness than the evening shift. This may suggest that the greater numbers of distractions and interruptions that occur during the day shift could impact the perceived usefulness by day shift nurses (Sheu et al., 2008). There were no differences in the technology adoption with BCMA perceived ease of use and the behavioral intention to use BCMA among the 3 nursing shifts.

BCMA Perceived Usefulness Model

Among the work characteristics, BCMA use in years was significant when controlling for nursing shift and contributed to half of the variance ($R^2 = .10$) in predicting BCMA perceived usefulness. This suggests that nurses who continue to use BCMA find that BCMA is useful for medication administration. The nursing shift worked did not have any significant impact on BCMA perceived usefulness. Of the four patient safety culture dimensions, only Feedback and Communication about Errors was statistically significant and also contributed to half of the variance ($R^2 = .11$) in predicting BCMA perceived usefulness. From this we can conclude that providing nurses feedback and communication about errors increases the perceived usefulness of BCMA, which suggests that when errors are communicated to nurses, it reinforces the notion that BCMA is useful in the prevention of medication errors.

The regression successfully predicted the overall BCMA perceived usefulness model ($R^2 = .21$), with each step being statistically significant beyond $p<0.001$ level. BCMA use in years and feedback & communication about errors were powerful predictors of BCMA perceived usefulness.

BCMA Perceived Ease of Use Model

Education accounted for a small portion of the explained variance ($R^2 = .05$) for BCMA perceived ease of use with advanced education having a negative but significant impact. This finding is contradictory to Chen et al. (2008) who reported that educational level was not statistically significant to perceived ease of use. The statistical significance of advanced education status means that nurses with Master's/terminal degrees had a lower perception of BCMA ease of use than nurses with Bachelor's and Diploma/Associates degrees. A possible reason for nurses with advanced degrees having a lower perception of BCMA ease of use is that they may not administer medications with BCMA as often as nurses with Bachelor's and Diploma/Associates degrees. To address this issue, nurses with advanced degrees should routinely administer medications using BCMA technology so that BCMA becomes easier to use.

The work characteristic, BCMA use in years, was included in the second step and accounted for slightly more of the proportion of the explained variance of BCMA perceived ease of use (R^2 = .05). BCMA use in years was significantly associated with BCMA perceived ease of use when controlling for education ($p<0.05$), which suggests that as nurses acquire more experience with BCMA, they perceive BCMA as easier to use. Targeting nurses with advanced degrees to use BCMA more often would address the negative perception that BCMA is not easy to use.

Of the four patient safety culture dimensions, again only Feedback and Communication about Errors was statistically significant at the $p<0.05$ level. From this we can conclude that providing nurses with feedback and communication about errors increases BCMA ease of use. This suggests that as errors are communicated to nurses, it reinforces the notion that BCMA is easy to use in light of its prevention of medication errors.

The multivariate regression was statistically significant ($p<0.000$) for predicting the overall BCMA perceived ease of use model (R^2 = .20), with steps 2 and 3 being statistically significant beyond the .01 and .001 level, respectively. The R^2 change was higher in the 3rd step of the regression contributing to more than half of the total variance of BCMA perceived ease of use.

Behavioral Intention to Use BCMA Model

The demographic characteristic of age accounted for a small, but statistically significant, portion of the explained variance for BCMA behavioral intention to use (R^2 = .03). The statistical significance of age means that nurses with advanced age have less behavioral intention to use BCMA than younger nurses. This could indicate that nurses with advanced age may also have more experience in medication administration without using BCMA technology. Thus, nurses with advanced age may not have the behavioral intention to use BCMA. This finding is also contradictory to the Chen et al. (2008) results where age did not have a significant impact on the behavioral intention to use.

Of the four patient safety culture dimensions, this time teamwork within hospital units was statistically significant at $p<0.05$ contributing to a modest R^2 change. From this we can conclude that teamwork within hospital units contributes to a behavioral intention in using BCMA. As teamwork within hospital units increases, overall behavior promoting the use of BCMA increases.

BCMA perceived usefulness was statistically significant at $p<0.01$ level, and as nurses come to perceive that the technology is useful, they have a behavioral tendency to use BCMA. This finding is supported by other studies (Davis, Bagozzi, & Warshaw, 1989; Tung, Chang, & Chou, 2008; Venkatesh & Davis, 2000; Yu, Li, & Gagnon, 2008). However, BCMA perceived ease of use did not have a significant effect on the behavioral intention to use BCMA which other studies have also demonstrated (Chen et al., 2008; Venkatesh, Morris, Davis, & Davis, 2003).

The overall regression model was statistically significant for predicting the BCMA behavioral intention to use score ($R^2 = .24$), with steps 1, 3 and 4 being statistically significant beyond the $p<0.01$, $p<0.01$ and $p<0.001$ levels, respectively. This means that the full model explains 24% of the variance in explaining the behavioral intention to use BCMA with BCMA perceived usefulness contributing a large portion of the explained variance.

Limitations

A limitation of this study is that actual usage behavior was not investigated. However it would be difficult to obtain IRB approval and the necessary resources for an observational study, and recruitment would also be a challenge. Moreover, studies have shown that the behavioral intention to use technology drives the actual usage behavior (Davis, 1989; Davis, Bagozzi, & Wasshaw, 1989; Venkatesh & Davis, 2000).

The participants were polled at 2 different hospital types: a large acute care hospital and a smaller specialty rehabilitation hospital. The nurses at the acute care hospital were from many different units using BCMA, and not all nurses at the acute care hospital were given the opportunity to participate in the study, since they were being asked to participate in other research studies at the time of data collection. Nurses at the rehabilitation hospital were from 4 distinct patient care units using BCMA. This study did not collect data on the nurse's primary unit to promote anonymity. Of note, the nurses at the rehabilitation hospital began using BCMA 1 month earlier than the nurses at the acute care facility. This study could be generalized to RNs using BCMA technology in acute care and rehabilitation hospitals.

Only 4 patient safety culture dimensions were examined in this study. In future studies, the inclusion of all the patient safety culture dimensions is recommended to determine whether they too have a relationship with the TAM. In addition, other studies incorporating new technologies into the nurses' workflow should be included.

Although there are some limitations to this study, the findings were consistent with the literature, overall. The patient safety culture dimensions, teamwork within hospital units and feedback and communication about errors, were predictive of BCMA perceived usefulness, BCMA perceived ease of use, and the BCMA behavioral intention to use.

Implications

Targeted Interventions

Using the results from the study, targeted interventions towards nurses could increase the behavioral intention to use BCMA. For example, older and more experienced nurses scored lower on the behavioral intention to use BCMA than younger and less experienced nurses. Reinforcement of the benefits of BCMA integration within the medication administration process should be focused towards older and more experienced nurses. This could assist in promoting BCMA usefulness and ease of use among these groups at risk for medication errors.

Interestingly, nurses with advanced education had a significant but negative impact on the BCMA perceived ease of use. Also, white nurses found BCMA less useful and not easy to use. If white nurses and nurses with advanced degrees use BCMA less than other nurses, hospitals could intervene with these groups to provide more opportunities for BCMA education.

Additionally work characteristics also impacted technology adoption among nurses. The acute care facility scored statistically significantly lower on all three measures of technology adoption. The acute care hospital should communicate its patient safety culture message and continue to publically reinforce the benefits of BCMA in the medication administration process. Of note, day shift nurses had a smaller average BCMA perceived usefulness than the evening shift. The amount of interruptions and distractions occurring on the day shift accounts for this difference. Perhaps hospitals could reduce the interruptions during medication passes. Interruptions during the medication pass can contribute to medication errors (Elganzouri, Standish, & Androwich, 2009; Sheu et al., 2008) and by reducing interruptions with the implementation of BCMA technology could decrease medication errors.

Patient Safety Culture and TAM

The results of this study suggest that the patient safety culture dimensions of teamwork within hospital units and feedback and communication about errors, significantly impacts technology adoption. Feedback & communication about errors explained a little more than half in predicting BCMA perceived usefulness and BCMA perceived ease of use. Teamwork within hospital units also had a large impact on BCMA behavioral intention to use; however, BCMA perceived usefulness accounted for half of the total variance in predicting BCMA behavioral intention to use.

To improve adherence to BCMA use, hospitals could re-evaluate and improve their patient safety culture, while nurses could evaluate their own values and behaviors regarding technology and how it impacts patient safety culture. If hospital organizations focused on building teamwork within hospital units and providing open feedback and communication about errors, hospitals could improve their patient safety culture, thereby fostering adherence to BCMA procedures and reducing medication errors. Building teamwork within hospital units is an important concept that not only drives the behavioral intention to use BCMA, it also promotes better overall performance and nurse and patient satisfaction. Nurses could assist one another when technology fails or when there is difficulty using the technology. If nurses adhere to the BCMA procedure and proactively engage the technology, the technology will function more like a beneficial tool than an impairment to workflow.

Technology Literacy

As computer technology continues to be integrated into nursing practice, it is imperative that nurses are technologically literate, so they can effectively use the provided technology meant to improve patient care and reduce human errors. Not surprisingly, the majority of the nurses in this study identified themselves as more than a beginner when describing their computer skills (90.8%). Nurses should acknowledge that technological literacy is now an integral part of their professional practice.

In their practice, nurses use technology such as computers, bar code medication administration hand held devices, biomedical devices and voice over communication tools, all of which must work properly to be effective. Without these technology tools, patient care becomes more difficult and less efficient. Nurses must not set these tools aside for someone else to use; instead, nurses must lead the effort to ensure these tools meet their needs by facilitating patient care, and they must not work around the process. Nurses need to be at the forefront of technology to improve that technology and to enhance workflow, patient care and outcomes.

Implementation of Technology

Prior to implementing a new technology affecting the hospital workforce, hospitals should reach out to the likely users of the technology to determine if there is a need for the technology, and they should include the users in the selection process. If the assessment is made that a technology is useful, additional effort should be made to ensure that the technology is easy to use. This will foster the behavioral intention to use the technology. The identified users of a system, not hospital administrators, should be the primary decision makers. Too often technology implementations fail due to a lack of user acceptance and adoption. Nurses should work alongside the technology vendors to streamline processes and enhance the software/hardware to make it easier to use.

Conclusion

This study uniquely fills the knowledge gap between BCMA technology and the lack of adherence to BCMA procedures by exploring the patient safety culture in hospitals. Identifying and addressing the factors influencing the behavioral intention to use BCMA could promote the proper use of BCMA by registered nurses, ultimately reducing medication administration errors. Understanding the relationship of patient safety culture within hospitals, we can develop targeted change and tailored interventions focusing on patient safety initiatives, including decreasing medication administration errors.

APPENDICES

Appendix A: Frequency Tables and Descriptive Statistics for all Survey Questions

Table 13 Section A: Teamwork. People support one another in this unit

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	3	1.8	1.8	1.8
	Disagree	8	4.9	4.9	6.7
	Neither	16	9.8	9.8	16.6
	Agree	92	56.4	56.4	73.0
	Strongly Agree	44	27.0	27.0	100.0
	Total	163	100.0	100.0	

Table 14 Section A: Teamwork. When a lot of work needs to be done quickly, we work together as a team to get the work done

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	4	2.5	2.5	2.5
	Disagree	10	6.1	6.1	8.6
	Neither	19	11.7	11.7	20.2
	Agree	90	55.2	55.2	75.5
	Strongly Agree	40	24.5	24.5	100.0
	Total	163	100.0	100.0	

Table 15 Section A: Teamwork. In this unit, people treat each other with respect

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	3	1.8	1.8	1.8
	Disagree	8	4.9	4.9	6.7
	Neither	29	17.8	17.8	24.5
	Agree	91	55.8	55.8	80.4
	Strongly Agree	32	19.6	19.6	100.0
	Total	163	100.0	100.0	

Table 16 Section A: Teamwork. When one area in this unit gets really busy, others help out

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	4	2.5	2.5	2.5
	Disagree	15	9.2	9.2	11.7
	Neither	34	20.9	20.9	32.5

	Agree	84	51.5	51.5	84.0
	Strongly Agree	26	16.0	16.0	100.0
	Total	163	100.0	100.0	

Table 17 Section B: Communication Openness. Staff will freely speak up if they see something that may negatively affect patient care

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	1	.6	.6	.6
	Rarely	4	2.5	2.5	3.1
	Sometimes	56	34.4	34.4	37.4
	Most of the Time	63	38.7	38.7	76.1
	Always	39	23.9	23.9	100.0
	Total	163	100.0	100.0	

Table 18 Section B: Communication Openness. Staff feels free to question the decisions or actions of those with more authority

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	4	2.5	2.5	2.5
	Rarely	25	15.3	15.3	17.8
	Sometimes	58	35.6	35.6	53.4
	Most of the Time	52	31.9	31.9	85.3
	Always	24	14.7	14.7	100.0
	Total	163	100.0	100.0	

Table 19 Section B: Communication Openness. Staff are afraid to ask questions when something does not seem right

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	16	9.8	9.8	9.8
	Rarely	56	34.4	34.4	44.2
	Sometimes	62	38.0	38.0	82.2
	Most of the Time	21	12.9	12.9	95.1
	Always	8	4.9	4.9	100.0
	Total	163	100.0	100.0	

Table 20 Section C: Feedback & Communication about Errors. We are given feedback about changes put into place based on event reports

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	4	2.5	2.5	2.5
	Rarely	14	8.6	8.6	11.0
	Sometimes	45	27.6	27.6	38.7
	Most of the Time	74	46.0	46.0	84.7
	Always	25	15.3	15.3	100.0
	Total	163	100.0	100.0	

Table 21 Section C: Feedback & Communication about Errors. We are informed about errors that happen in this unit

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	2	1.2	1.2	1.2
	Rarely	12	7.4	7.4	8.6
	Sometimes	28	17.2	17.2	25.8
	Most of the Time	72	44.2	44.2	69.9
	Always	49	30.1	30.1	100.0
	Total	163	100.0	100.0	

Table 22 Section C: Feedback & Communication about Errors. In this unit, we discuss ways to prevent errors from happening again

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	3	1.8	1.8	1.8
	Rarely	14	8.6	8.6	10.4
	Sometimes	23	14.1	14.1	24.5
	Most of the Time	75	46.0	46.0	70.6
	Always	48	29.4	29.4	100.0
	Total	163	100.0	100.0	

Table 23 Section D: Your Hospital. Hospital management provides a work climate that promotes patient safety

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	4	2.5	2.5	2.5
	Disagree	18	11.0	11.0	13.5
	Neither	13	8.0	8.0	21.5
	Agree	85	52.1	52.1	73.6

		Frequency	Percent	Valid Percent	Cumulative Percent
	Strongly Agree	43	26.4	26.4	100.0
	Total	163	100.0	100.0	

Table 24 Section D: Your Hospital. The actions of hospital management show that patient safety is a top priority

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	5	3.1	3.1	3.1
	Disagree	11	6.7	6.7	9.8
	Neither	28	17.2	17.2	27.0
	Agree	68	41.7	41.7	68.7
	Strongly Agree	51	31.3	31.3	100.0
	Total	163	100.0	100.0	

Table 25 Section D: Your Hospital. Hospital management seems interested in patient safety only after an adverse event happens

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	21	12.9	12.9	12.9
	Disagree	56	34.4	34.4	47.2
	Neither	22	13.5	13.5	60.7
	Agree	50	30.7	30.7	91.4
	Strongly Agree	14	8.6	8.6	100.0
	Total	163	100.0	100.0	

Table 26 Section E: Bar Code Medication Administration Usefulness. Using the bar code medication system improves my performance in my job

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	2	1.2	1.2	1.2
	Disagree	13	8.0	8.0	9.2
	Neither	20	12.3	12.3	21.5
	Agree	72	44.2	44.2	65.6
	Strongly Agree	56	34.4	34.4	100.0
	Total	163	100.0	100.0	

Table 27 Section E: Bar Code Medication Administration Usefulness. Using the bar code medication administration system increased my productivity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	13	8.0	8.0	8.0
	Disagree	25	15.3	15.3	23.3
	Neither	31	19.0	19.0	42.3
	Agree	57	35.0	35.0	77.3
	Strongly Agree	37	22.7	22.7	100.0
	Total	163	100.0	100.0	

Table 28 Section E: Bar Code Medication Administration Usefulness. Using the bar code medication administration system enhances my effectiveness in my job

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	5	3.1	3.1	3.1
	Disagree	17	10.4	10.4	13.5
	Neither	22	13.5	13.5	27.0
	Agree	79	48.5	48.5	75.5
	Strongly Agree	40	24.5	24.5	100.0
	Total	163	100.0	100.0	

Table 29 Section E: Bar Code Medication Administration Usefulness. I find the bar code medication administration system to be useful in my job

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	2	1.2	1.2	1.2
	Disagree	7	4.3	4.3	5.5
	Neither	24	14.7	14.7	20.2
	Agree	77	47.2	47.2	67.5
	Strongly Agree	53	32.5	32.5	100.0
	Total	163	100.0	100.0	

Table 30 Section E: Bar Code Medication Administration Usefulness. Assuming I have access to the bar code medication administration system, I intend to use it

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	2	1.2	1.2	1.2
	Disagree	5	3.1	3.1	4.3
	Neither	19	11.7	11.7	16.0
	Agree	79	48.5	48.5	64.4

	Strongly Agree	58	35.6	35.6	100.0
	Total	163	100.0	100.0	

Table 31 Section E: Bar Code Medication Administration Usefulness. Given that I have access to the bar code medication administration system, I predict that I would use it

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	.6	.6	.6
	Disagree	7	4.3	4.3	4.9
	Neither	17	10.4	10.4	15.3
	Agree	76	46.6	46.6	62.0
	Strongly Agree	62	38.0	38.0	100.0
	Total	163	100.0	100.0	

Table 32 Section E: Bar Code Medication Administration Ease of Use. Using the bar code medication administration system is clear and understandable

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	1	.6	.6	.6
	Disagree	7	4.3	4.3	4.9
	Neither	16	9.8	9.8	14.7
	Agree	88	54.0	54.0	68.7
	Strongly Agree	51	31.3	31.3	100.0
	Total	163	100.0	100.0	

Table 33 Section E: Bar Code Medication Administration Ease of Use. Using the bar code medication administration system does not require a lot of my mental effort

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	7	4.3	4.3	4.3
	Disagree	29	17.8	17.8	22.1
	Neither	22	13.5	13.5	35.6
	Agree	76	46.6	46.6	82.2
	Strongly Agree	29	17.8	17.8	100.0
	Total	163	100.0	100.0	

Table 34 Section E: Bar Code Medication Administration Ease of Use. I find the bar code medication administration system to be easy to use

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	6	3.7	3.7	3.7
	Disagree	17	10.4	10.4	14.1
	Neither	25	15.3	15.3	29.4
	Agree	83	50.9	50.9	80.4
	Strongly Agree	32	19.6	19.6	100.0
	Total	163	100.0	100.0	

Table 35 Section E: Bar Code Medication Administration Ease of Use. I find it easy to get the bar code medication administration system to do what I want it to do

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	12	7.4	7.4	7.4
	Disagree	36	22.1	22.1	29.4
	Neither	28	17.2	17.2	46.6
	Agree	66	40.5	40.5	87.1
	Strongly Agree	21	12.9	12.9	100.0
	Total	163	100.0	100.0	

Table 36 Section E: Bar Code Medication Administration Ease of Use. I find that there are minimal complications in using the bar code medication administration system

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly Disagree	19	11.7	11.7	11.7
	Disagree	35	21.5	21.5	33.1
	Neither	23	14.1	14.1	47.2
	Agree	61	37.4	37.4	84.7
	Strongly Agree	25	15.3	15.3	100.0
	Total	163	100.0	100.0	

Table 37 Section G: Background Information. Facility

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rehabilitation	74	45.4	45.4	45.4
	Acute Care	89	54.6	54.6	100.0
	Total	163	100.0	100.0	

Table 38 Section G: Background Information. Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	137	84.0	85.6	85.6
	Male	23	14.1	14.4	100.0
	Total	160	98.2	100.0	
Missing	System	3	1.8		
Total		163	100.0		

Table 39 Section G: Background Information. Ethnicity

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Asian	22	13.5	14.4	14.4
	African American	68	41.7	44.4	58.8
	Hispanic or Latino	7	4.3	4.6	63.4
	White	56	34.4	36.6	100.0
	Total	153	93.9	100.0	
Missing	System	10	6.1		
Total		163	100.0		

Table 40 Section G: Background Information. Age, RN Experience, BCMA Use Years

	Mean	Std. Deviation
Age	39.84	11.62
RN Experience	12.35	11.38
BCMA Use Years	2.62	1.91

Notes:
Age N = 144, RN Experience N = 150, BCMA Use Years N = 153

Table 41 Section G: Background Information. Education

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Associates	27	16.6	17.1	17.1
	Bachelors	100	61.3	63.3	80.4
	Diploma	5	3.1	3.2	83.5
	Masters	23	14.1	14.6	98.1
	Terminal	3	1.8	1.9	100.0
	Total	158	96.9	100.0	

Missing	System	5	3.1
Total		163	100.0

Table 42 Section G: Background Information. Education Consolidated

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Diploma/Associates	32	19.6	19.6	19.6
	Bachelors	105	64.4	64.4	84.0
	Masters/Terminal	26	16.0	16.0	100.0
	Total	163	100.0	100.0	

Table 43 Section G: Background Information. Nursing Shift

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Day	107	65.6	67.7	67.7
	Evening	19	11.7	12.0	79.7
	Night	32	19.6	20.3	100.0
	Total	158	96.9	100.0	
Missing	System	5	3.1		
Total		163	100.0		

Table 44 Section G: Background Information. Computer Skills

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Advanced	57	35.0	36.1	36.1
	Beginner	15	9.2	9.5	45.6
	Intermediate	86	52.8	54.4	100.0
	Total	158	96.9	100.0	
Missing	System	5	3.1		
Total		163	100.0		

Table 45 Section G: Background Information. Computer Skills Consolidated

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Beginner	15	9.2	9.2	9.2
	Advanced	148	90.8	90.8	100.0
	Total	163	100.0	100.0	

Table 46 Section G: Background Information. Education Consolidated

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Diploma/Associates	32	19.6	19.6	19.6
	Bachelors	105	64.4	64.4	84.0
	Masters/Terminal	26	16.0	16.0	100.0
	Total	163	100.0	100.0	

Appendix B: Recruitment Flyer

To All Registered Nurses

You are invited to complete a survey regarding patient safety culture and bar code medication administration.

For any questions, please don't hesitate to contact Lunar Song at 202-906-0565 or LSong1@gmu.edu

MedStar Health Research Institute
APPROVAL DATE FEB 13 2012
APPROVAL EXPIRES N/A
IRB APPROVED

Appendix C: Recruitment Letter

Dear Registered Nurses,

I am inviting you to participate in a study that will investigate the relationship between patient safety culture and the behavioral intention to use bar code medication administration among registered nurses. If you are a Registered Nurse and administer medications using bar code medication administration, please consider completing this 10 minute survey.

The purposes of the study:

- Evaluate if patient safety culture dimensions predicts bar code medication administration perceived ease of use
- Evaluate if patient safety culture dimensions predicts bar code medication administration perceived usefulness
- Evaluate the relationship between demographic, work characteristics, and patient safety culture dimensions with bar code medication administration perceived ease of use and perceived usefulness

The results of this study could assist hospitals to reevaluate and improve their patient safety culture, which could lead to better use of bar code medication administration technology and reduce the frequency of medication errors.

The completion of the survey is voluntary. If you choose to complete the survey, please place the completed survey in the provided envelope and insert the envelope in the box located on any nursing unit. Regardless if you choose to participate, if you would like to see a summary of the research findings or if you have any questions, please don't hesitate to contact me

Thank you!

Lunar Song, MS, BSN, RN
Doctoral Candidate, George Mason University
Phone: 202-906-0565
Email: lsong1@gmu.edu

Appendix D: Survey Instrument

Survey on Patient Safety Culture and Bar Code Medication Administration

This survey asks for your opinions about a few of the patient safety culture measurements and bar code medication administration system usability in your hospital. This survey will take about 10 minutes to complete.

- *An "event" is defined as any type of error, mistake, incident, accident, or deviation, regardless of whether or not it results in patient harm.*
- *"Patient safety" is defined as the avoidance and prevention of patient injuries or adverse events resulting from the processes of health care delivery.*

SECTION A: Teamwork

In this survey, think of your "unit" as the work area, department, or clinical area of the hospital where you spend *most* of your work time or provide *most* of your clinical services.

Please indicate your agreement or disagreement with the following statements about your work area/unit. Mark your answer by filling in the circle.

Think about your hospital work area/unit…	Strongly Disagree ▼	Disagree ▼	Neither ▼	Agree ▼	Strongly Agree ▼
1. People support one another in this unit	①	②	③	④	⑤
2. When a lot of work needs to be done quickly, we work together as a team to get the work done	①	②	③	④	⑤
3. In this unit, people treat each other with respect	①	②	③	④	⑤
4. When one area in this unit gets really busy, others help out	①	②	③	④	⑤

SECTION B: Communication Openness

How often do the following things happen in your work area/unit? Mark your answer by filling in the circle.

Think about your hospital work area/unit…	Never ▼	Rarely ▼	Some-times ▼	Most of the time ▼	Always ▼
1. Staff will freely speak up if they see something that may negatively affect patient care	①	②	③	④	⑤
2. Staff feel free to question the decisions or actions of those with more authority....................................	①	②	③	④	⑤
3. Staff are afraid to ask questions when something does not seem right	①	②	③	④	⑤

SECTION C: Feedback & Communication about Errors

How often do the following things happen in your work area/unit? Mark your answer by filling in the circle.

Think about your hospital work area/unit…	Never ▼	Rarely ▼	Some-times ▼	Most of the time ▼	Always ▼
1. We are given feedback about changes put into place based on event reports	①	②	③	④	⑤
2. We are informed about errors that happen in this unit	①	②	③	④	⑤
3. In this unit, we discuss ways to prevent errors from happening again	①	②	③	④	⑤

SECTION D: Your Hospital

Please indicate your agreement or disagreement with the following statements about your hospital. Mark your answer by filling in the circle.

Think about your hospital…	Strongly Disagree ▼	Disagree ▼	Neither ▼	Agree ▼	Strongly Agree ▼
1. Hospital management provides a work climate that promotes patient safety	①	②	③	④	⑤
2. The actions of hospital management show that patient safety is a top priority	①	②	③	④	⑤
3. Hospital management seems interested in patient safety only after an adverse event happens	①	②	③	④	⑤

SECTION E: Bar Code Medication Administration Usefulness

Please indicate your agreement or disagreement with the following statements about your hospital. Mark your answer by filling in the circle.

Think about your bar code medication administration system at your hospital…	Strongly Disagree ▼	Disagree ▼	Neither ▼	Agree ▼	Strongly Agree ▼
1. Using the bar code medication system improves my performance in my job	①	②	③	④	⑤
2. Using the bar code medication administration system increased my productivity...........................	①	②	③	④	⑤
3. Using the bar code medication administration system enhances my effectiveness in my job	①	②	③	④	⑤
4. I find the bar code medication administration system to be useful in my job	①	②	③	④	⑤
5.. Assuming I have access to the bar code medication administration system, I intend to use it	①	②	③	④	⑤

6. Given that I have access to the bar code medication administration system, I predict that I would use it.	①	②	③	④	⑤

SECTION F: Bar Code Medication Administration Ease of Use

Please indicate your agreement or disagreement with the following statements about your hospital. Mark your answer by filling in the circle.

Think about your bar code medication administration system at your hospital…	**Strongly Disagree** ▼	**Disagree** ▼	**Neither** ▼	**Agree** ▼	**Strongly Agree** ▼
1. Using the bar code medication system is clear and understandable	①	②	③	④	⑤
2. Using the bar code medication administration system does not require a lot of my mental effort	①	②	③	④	⑤
3. I find the bar code medication administration system to be easy to use	①	②	③	④	⑤
4. I find it easy to get the bar code medication administration system to do what I want it to do	①	②	③	④	⑤
5. I find that there are minimal complications in using the bar code medication administration system	①	②	③	④	⑤

SECTION G: Background Information

This information will help in the analysis of the survey results.

1. What is your gender?
   - ○ a. Female
   - ○ b. Male

2. What is your age in years?

   ________ Years

3. What is your race/ethnic background? Please choose only 1 option.
   - ○ a. White
   - ○ b. Black or African American
   - ○ c. Hispanic or Latino
   - ○ d. Asian
   - ○ e. Native Hawaiian or Other Pacific Islander
   - ○ f. American Indian or Alaska Native

4. What is your highest level of education completed? Please choose only 1 option.
   - ○ a. Diploma
   - ○ b. Associate's Degree
   - ○ c. Bachelor's Degree
   - ○ d. Master's Degree
   - ○ e. Terminal Degree (PhD, DNP, DSc, etc)

5. How many years have you worked as a registered nurse?

   ________ Years

6. What shift do you most often work? Please choose only 1 option
   - ○ a. Day (7a-7p OR 7a-3p)
   - ○ b. Evening (3p-11p)
   - ○ b. Night (7p-7a OR 11p-7a)

7. How would you classify yourself as a user of computer technology and/or software? Please choose only 1 option.
   - ○ a. Beginner
   - ○ b. Intermediate
   - ○ b. Advanced

8. How many years have you used the bar code medication system?

   ________ Years

Please feel free to write any comments about patient safety, error, or event reporting in your hospital.

THANK YOU FOR COMPLETING THIS SURVEY.

Notes:
In this survey, Sections A, B, C, D are from the Hospital Survey on Patient Safety Culture published by the Agency for Healthcare Research and Quality.

Section E and F is adapted from the Technology Acceptance Model 2 by Venkatesh and Davis. Question 5 is adapted from Hu, et al.

Race and ethnicity categories are from the Standards for Maintaining, Collecting, and Presenting Federal Data on Race and Ethnicity.

Appendix E: GMU IRB Approval Letter

GEORGE MASON UNIVERSITY

Office of Research Subject Protections
Research Hall
4400 University Drive, MS 6D5, Fairfax, Virginia 22030
Phone: 703-993-4121; Fax: 703-993-9590

TO: Kyeung Mi Oh, College of Health and Human Services

FROM: Aurali Dade
Assistant Vice President, Research Compliance

PROTOCOL NO.: 8028

PROPOSAL NO.: N/A

TITLE: Evaluating the Relationship between Patient Safety Culture and the Behavioral Intention to Use Bar Code Medication Administration among Registered Nurses in Hospitals

DATE: April 5, 2012

Cc: Lunar Song

Under George Mason University (GMU) procedures, this project was determined to be exempt by the Office of Research Subject Protections since it falls under DHHS Exempt Category 2, research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior.

A copy of the final approved consent document is attached. Please use this stamped copy for your research.

You may proceed with data collection. **Please note that all modifications in your protocol must be submitted to the Office of Research Subject Protections for review and approval prior to implementation**. Any unanticipated problems involving risks to participants or others, including problems regarding data confidentiality must be reported to the GMU Office of Research Subject Protections.

GMU is bound by the ethical principles and guidelines for the protection of human subjects in research contained in The Belmont Report. Even though your data collection procedures are exempt from review by the GMU HSRB, GMU expects you to conduct your research according to the professional standards in your discipline and the ethical guidelines mandated by federal regulations.

Thank you for cooperating with the University by submitting this protocol for review. Please call me at 703-993-5381 if you have any questions.

Appendix E: MedStar Health IRB Approval Letter

MedStar Health
Research Institute

Advancing Health Through Research

Exempt Determination Notice
Initial Review

15-Feb-2012

102 Irving Street, NW
Washington, DC 20010

Protocol Number:	**2012-021**
PI Name:	**Lunar Song MS, BSN, RN**
Protocol Title:	**Evaluating the Relationship between Patient Safety Culture and the Behavioral Intention to Use Bar Code Medication Administration among Registered Nurses in Hospitals**

Dear Lunar Song MS, BSN, RN,

The above-referenced **Initial Review** submission was reviewed by the Office of Research Integrity (ORI) on **13-Feb-2012**.

It has been determined that your study meets the criteria set forth in **[45 CFR 46.101(b), Category (2)]** and qualifies for exemption from the requirements of [45 CFR 46] federal regulations. In the event changes are made to the protocol, which may affect this determination, please submit documentation of this change for review prior to implementation.

Please refer to the Office of Research Integrity website to review the **Principal Investigator's Responsibilities** as a MedStar researcher on http://www. medstarresearch.org/Body.cfm?id=243.

If you have any questions, please contact me at 301-560-7339.

Thank you,

Jacqueline Steenbakker
Office of Research Integrity

Enclosure: Stamped Recruitment Flyer
Stamped Recruitment Letter
Stamped Participant Survey

6525 Belcrest Road, Suite 700, Hyattsville, MD 20782
phone: 301 560 7300 • *fax:* 301 560 7348

Appendix F: MedStar Health IRB Approval Letter Updated

MedStar Health
Research Institute

Advancing Health Through Research

04 April 2012

Lunar Song
National Rehabilitation Hospital
102 Irving Street NW
Washington DC 20010

RE: **DECLARATION OF EXEMPT STATUS OF RESEARCH**

Protocol Number: 2012-021

Protocol Title: Evaluating the Relationship between Patient Safety Culture and the Behavioral Intention to Use Bar Code Medication Administration among Registered Nurses in Hospitals

Study Location: National Rehabilitation Hospital & Washington Hospital Center

Dear Ms. Song,

The Office of Research Integrity has reviewed the submitted revision to the above referenced study, which had been previously determined to be exempt from he DHHS regulations at 45 CFR 46. It has been determined that the submitted revision (addition of Washington Hospital Center as a site), does not alter the study in such a way that the exemption criteria are no longer applicable.

As such this office's previous determination that this project meets the criteria set forth in 45 CFR 46.101(b), Category (2) and qualifies for exemption from regulation still stands. As such, an informed consent document is not required for this study.

Please refer to the Office of Research Integrity website at http://www.medstarresearch.org/body.cfm?id-31 to review the "Principal Investigator's Responsibilities" as a MedStar researcher.

If you have any questions, please contact the Office of Research Integrity at (301) 560-7339.

Sincerely,

Jacqueline Steenbakker
Research Management Specialist

6525 Belcrest Road, Suite 700, Hyattsville, MD 20782
phone: 301 560 7300 • *fax*: 301 560 7348

REFERENCES

REFERENCES

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CURRICULUM VITAE

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