Reducing Medication Errors in Inpatient Hospital Settings by Implementing the Barcode Medication Administration Technology: An Integrative Review

An Integrative Review for a Scholarly Project

Submitted to the

Faculty of Liberty University

In partial fulfillment of

The requirements for the degree

Of Doctor of Nursing Practice

By

Kali Brown

Liberty University

Lynchburg, VA

April 25, 2023

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Scholarly Project Chair Approval:

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Abstract

Medication administration errors adversely affect patient outcomes, satisfaction, safety, and quality of care. Barcode medication administration (BCMA) technology automates the verification process during medication administration by requiring that nurses scan the barcode on the medication and the patient identification wristband to confirm the five rights of medication administration. The BCMA thus helps to intercept medication errors that occur at the point of administration. A review of 32 articles published within the past six years was conducted to explore the impact of using BCMA technology on medication error rates in inpatient hospital settings. The review findings indicate that systemic and individual nurse factors cause medication errors. Individual nurse factors include constant disruptions during medication administration, a negative attitude toward medication safety practices, and incompetence. To eliminate these challenges and enhance the effectiveness of BCMA in preventing medical error rates, nurse involvement and comprehensive education and training during the implementation process are key. The implication of this integrative review on clinical practice is the increased need to embrace BCMA technology.

Keywords: medication errors, effectiveness, implementation, BCMA technology

Reducing Medication Errors in Inpatient Hospital Settings by Implementing the Barcode Medication Administration Technology: An Integrative Review

Dedication

This manuscript is dedicated to the loving memory of my brother, Marcellus A. Brown Sr.,

Forever in our hearts.

Acknowledgments

I take this opportunity to express my deepest gratitude to those who have helped make this project possible. Special thanks to my program chair, Dr. Sharon Kopis. Thank you for your encouragement, patience, and guidance while completing my project. I extend my heartfelt gratitude to my preceptor, Lee Bransky, MSN, RN, CNE, for your insight and encouragement throughout my project journey. I sincerely appreciate and admire your wisdom, knowledge, and expertise. I wish to thank Belmont Behavioral Hospital and Einstein Healthcare Network for allowing me to gain valuable practicum experience as my practicum site. I would also like to acknowledge my mother, Doris Brown. Thank you, mom, for your love, support, and encouragement. Without family, this achievement would have little meaning. Numbers 6: 24-26; The Lord bless you and keep you; the Lord make his face to shine upon you and be gracious to you; the Lord lift up his countenance upon you and give you peace.

Section One: Formulating the Review Question

Medication errors are among the costliest safety concerns affecting the healthcare system in the United States today. According to the U.S. Food and Drug Administration (FDA, 2019), over 100,000 reports of suspected medication errors are received annually. Additionally, medication errors rank as the eighth leading cause of death in the US, accounting for about 7,000–9,000 deaths annually (SingleCare Team, 2022). An additional 1.3 million individuals are injured yearly due to medication administration errors. Due to medication errors and their associated adverse effects, the US incurs an additional $40 billion in costs every year in addition to prolonged stays in hospital for the patients, high rates of patient dissatisfaction, and a negative effect on the safety and quality of care provided (SingleCare Team, 2022). The FDA (2019) indicates that medication errors can occur throughout the medication-use system, from when a doctor prescribes a drug to when the information is entered into the computer system, when the drug is dispensed or prepared, or when the drug is given to a patient.

Among nurses, some of the common causes of medication errors include poor communication among members of the nursing team or between the doctors and the nurses, interruptions when administering medication, drug names and medications that look or sound alike, and misunderstandings of medical abbreviations (Kiymaz & Koç, 2018). Despite the increased cost of care and adverse effect on the safety of care caused by medication errors, underreporting remains a common challenge. Some factors contributing to underreporting of these medication errors include a work climate/culture that does not prioritize patient safety, fear of consequences, and lack of feedback from the organizational administration or negative feedback(Aljabari & Kadhim, 2021). As such, it is important to develop a strategy that prevents medication errors and helps to create a culture that enhances patient safety.

Due to the need to enhance patient safety by reducing medication errors, the Joint Commission (2022) declared medication safety a National Patient Safety Goal for ambulatory clinics and hospitals. Per this pronouncement, numerous interventions have been adopted to help address the issue of medication errors, such as new smart infusion pumps, barcode scanning, protocols for medication administration, and computerized electronic medical records. This review seeks to explore how barcode medication administration (BCMA) technology can be used to prevent medication errors within inpatient hospital settings.

The BCMA technology automates the verification process during medication administration by requiring nurses to scan the medication's barcode and the patient identification wristband to confirm the five “rights” of medication administration (Mulac et al., 2021). The five rights are the right patient, the right medication, the right dose, the right route, and the right time (Mulac et al., 2021). As such, BCMA technology helps to intercept medication errors that occur at the point of administration to reduce the chance of harm to patients and promote the safety of care. This review will explore literature that addresses the use of BCMA technology and its impact on medication errors in inpatient hospital settings. Therefore, this review aims to contribute to existing knowledge on how BCMA technology can reduce medication administration errors within inpatient hospital settings.

Defining Concepts and Variables

For this integrative review, a medication error is defined as “a failure in the treatment process that leads to or has the potential to lead to, harm the patient” (Lisby et al., 2012, p.204). The error can occur at any stage of the medication process, such as during ordering, dispensing, or administering. This definition is based on existing taxonomy and a thoroughly modified Delphi-process consensus of definition and error types reached in a study by Lisby et al. (2012) seeking to develop and test the definition of medication errors. Operationally, *medication errors* refer to any unintentional error that occurs when prescribing, dispensing,

preparing, or administering a medicinal product while it is controlled by a healthcare professional or patient.

The BCMA is a hospital-based system used in the distribution of prescription medications. Operationally, BCMA pairs the implementation of an information technology solution called an *electronic medication administration record* with item-specific identification (bar-coding; Agency of Healthcare Research and Quality, n.d.). BCMA reduces medication errors by enhancing compliance with the five rights of medication administration: right patient, right dose, right route, right time, and right medication (Mulac et al., 2021). For this integrative review, patient safety is conceptually defined as a healthcare discipline that reduces the risk of harm in healthcare facilities (World Health Organization, 2019). Patient safety focuses on preventing and reducing risks while providing health care.

The Rationale for Conducting the Review

Medication errors add unnecessary costs to the healthcare system and negatively impact the safety of care provided to patients (FDA, 2019). The need for the U.S. health system to optimize its performance by improving patients' experience of care by focusing on quality and satisfaction, improving the health of populations, and reducing the per capita cost of health care is an area of priority (Institute for Healthcare Improvement, n.d.). Therefore, it is important to consider how medication errors can be reduced in inpatient settings to promote a culture of safety, reduce unnecessary care costs, and enhance patients' experience. The prevalence of medication errors within hospital settings and the likelihood of underreporting (Aljabari & Kadhim, 2021) make it necessary to identify studies that focus on implementing the BCMA technology to reduce medication errors and synthesize the findings to make recommendations on best practices for adopting the technology. The broad focus of this scholarly project is medication errors, their common causes, and the factors that hinder the successful implementation of interventions/efforts to reduce errors. As such, the

integrative review approach is suitable because it allows for the synthesis of broad literature to inform the findings of how the BCMA can be implemented successfully, specifically within inpatient hospital settings.

Purpose of the Integrative Review and Review Question

This integrative review aims to determine the impact of using BCMA technology to reduce medication errors in inpatient hospital settings. The anticipated outcome of this integrative review is the discovery of best practices for implementing BCMA technology within inpatient settings to prevent medication errors. To ensure that the BCMA technology protocol is sustained as standard, a systematic evaluation was conducted to evaluate its effectiveness in reducing medication errors and organizational needs that would need to be addressed to ensure that the change is sustained to create a culture that promotes patient safety. Specifically, the project leader reviewed the factors that enhance the effectiveness of the implementation of the BCMA technology, how the BCMA technology can address organizational and individual factors that contribute to medication errors, and methods to promote the acceptance of the BCMA technology within inpatient hospital settings. The review question is: Does implementing BCMA technology impact medication error rates in inpatient hospital settings?

Formulate Inclusion and Exclusion Criteria of the Literature

Whittemore and Knafl (2005) indicated that the data collection stage should be transparent and reproducible to enhance the validity of an integrative review. Per this recommendation, this integrative review used inclusion/exclusion criteria to guide the selection of articles from the records identified from the search. The electronic databases used for the search allowed the project leader to filter the search based on these eligibility criteria.

Table 1

Inclusion & Exclusion Criteria

Criterion	Rationale
Inclusion	
Peer-reviewed articles published in the last six years.	To ensure the use of current information.
Articles that focus on medication administration errors within inpatient settings.	To help answer the review question.
Articles that focus on the effectiveness of using BCMA technology to reduce medication errors.	To help answer the review question.
Articles provide recommendations on addressing the challenges of implementing BCMA technology in clinical settings.	To inform the recommendations and implications for practice.
Exclusion	
Articles that focus on implementing other EBP practices to address the challenge of medication administration errors.	To ensure that the study focuses on using the identified EBP to address the challenge of medication errors in inpatient settings.
Articles that are not peer-reviewed or do not have open access to the full text.	To enhance the validity and replicability of the review findings.
Articles that are not published originally in English.	This review is conducted within the American context, which uses English as a primary scientific language.

Conceptual Framework

This integrative review used the robust conceptual framework Harris Cooper (2001) and Whittemore and Knafl (2005) devised. To maintain the rigor of the review, decrease bias, and enhance accuracy, the processes suggested by Whittemore and Knafl (2005) were followed closely. The integrative review method was suitable because it helps the author to summarize past empirical and theoretical literature on the topic of interest (Whittemore & Knafl, 2005). An integrative literature review was conducted on using BCMA technology to reduce medication errors in inpatient hospital settings. Specifically, this integrative review seeks to summarize the findings of past literature and present a current state of knowledge on best practices for implementing the BCMA technology to address the issue of medication errors. Approval by the Institutional Review Board was not required because the integrative review method does not involve using human subjects or reviewing medical records. Nevertheless, the project leader completed Collaborative Institutional Training Initiative

(CITI) training to support the promotion of quality research within the integrative review. This scholarly project identifies best practices for implementing BCMA technology to reduce medication errors in inpatient healthcare settings.

Framework

Integrative reviews are defined as research of research, and they require a methodological rigor that is supported by a detailed framework. For this review, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) were used to underpin the search strategy and identification and selection of articles to review. The overarching framework, however, is the updated methodology of integrative reviews documented by Whittemore and Knafl (2005).

PRISMA Statement

PRISMA aims to support the reporting of a wide array of systematic reviews to assess the benefits and harms of a healthcare intervention (Page et al., 2021). The PRISMA flow diagram provides a visual summary of the screening process. The diagram indicates the number of articles identified, included, and excluded and the reasons for exclusion (Page et al., 2021). The rationale for using this framework is to make the selection process transparent by reporting on the decisions made at various stages of the integrative review (See Appendix A for the PRISMA flow diagram). The 27-item checklist and four-phase flow diagram support information reporting.

Whittemore and Knafl Framework

Whittemore and Knafl (2005) note that integrative reviews play a crucial role in evidence-based practice for nursing, as they allow for the inclusion of diverse methodologies to contribute to varied perspectives on the phenomenon of interest. This integrative review seeks to conclude best practices to adopt when implementing BCMA technology to reduce medication errors from separate investigations that address this topic of interest. This

integrative review synthesizes empirical and theoretical published literature to investigate the subject matter of interest. Specifically, this review identifies and clarifies the best practices for implementing BCMA technology within inpatient settings. This review raises awareness of medication errors within inpatient settings via a five-stage research synthesis comprising the following steps: problem formulation, data collection or literature search, data evaluation, data analysis, and interpretation and presentation of results.

Problem Formulation Stage

At the problem formulation stage, the integrative review identifies the problem and defines the variables of interest. This integrative review addresses the prevalence of medication errors in inpatient hospital settings. The variables of interest are patient safety, the effective implementation of the BCMA technology, and factors that enhance a culture of safety in inpatient hospital settings. Other variables of interest include the systemic and individual factors contributing to medication errors (Kiymaz & Koç, 2018) and how implementing BCMA technology can address them.

Data Collection

To enhance rigor and promote unbiased results, search strategies of the review process should be defined and documented clearly, a task that Whittemore and Knafl (2005) acknowledge can be challenging. The comprehensive literature search aims to obtain the maximum number of eligible sources to synthesize. The information sources for this review were electronic databases available through the university's library. The search was conducted through the CINAHL, Science Direct, ProQuest, and Cochrane databases. The information sources were mapped using keywords and phrases. Keywords and phrases searched included *medication errors, effectiveness, implementation,* and *BCMA technology.* The words were not used in any order. The inclusion and exclusion criteria listed in Table 1 were used to determine which articles would be included in this review.

Section Two: Comprehensive and Systematic Search

Search Organization Reporting Strategies

To increase the rigor of the integrative review, Toronto and Remington (2020) indicated that multiple databases should be searched for peer-reviewed articles and gray literature, including unpublished and theoretical literature. Per this recommendation, a search was conducted on the CINAHL, Science Direct, ProQuest, and Cochrane electronic databases. Limiters such as year of publication, language, access to full text, and publication status, as described in the eligibility criteria in Table 1, were utilized to narrow the search results to the most relevant literature. The PRISMA flow diagram (Appendix A) depicts the flow of information through the different phases of the systematic search.

Literature Search Results

The literature search identified 137 references published within the past six years. Fifty of the 137 references were duplicates and were removed from the review. After the duplicates were excluded, the titles and abstracts of the remaining 87 were reviewed, and 12 were excluded for not meeting the eligibility criteria (Table 1). Seventy-five articles were assessed further for eligibility and excluded based on the population of focus, an indication of adherence to ethical checklists, and lack of available full text. After those articles were eliminated, 32 articles were left to be reviewed. Therefore, the review focused on 32 articles identifying best practices for implementing BCMA technology to reduce errors in inpatient health settings.

Terminology

Toronto and Remington (2020) indicate that the database terminology can be confusing because this word may have different meanings in different disciplines. For this review, the term *database* is defined as an electronic, searchable collection of published

materials that includes a combination of journal articles, book chapters, reports, dissertations, and conference proceedings.

Section Three: Managing the Collected Data

According to the guidelines provided by Toronto and Remington (2020), managing the collected data involves screening by relevance, selecting by full text, and sorting by title. Per this recommendation, the project leader screened the relevant literature by considering titles and/or abstracts. All the irrelevant data were excluded. The remaining data were selected based on the eligibility criteria, and the articles chosen for this review were identified. A visual representation of the process is provided via the PRISMA flowchart (Appendix A).

Data Evaluation

The data sources were evaluated on methodological rigor and informational value. The requirements for a study to be included in the review include the most relevant sources because there is no gold standard for evaluating quality in research reviews (Whittemore & Knafl, 2005). The sources were also leveled per Melnyk's hierarchy of evidence rating system. The level of each study is identified in the literature review matrix (Appendix B).

Data Analysis

To identify the best practices for implementing BCMA technology to reduce medication errors in inpatient hospital settings, the data in the articles were coded, categorized, ordered, and summarized (Whittemore & Knafl, 2005). As part of the data analysis, the project leader read the identified articles to identify the commonly occurring themes. A summary of the findings was drafted into a matrix. From the conclusions, commonly occurring themes were coded using different colors to help visually identify the patterns and relationships across the information gathered (Whittemore & Knafl, 2005). The matrix is presented in Appendix C. The themes, patterns, and relationships informed the

thematic coding for this review's findings and recommendations regarding using BCMA technology to reduce medication errors within inpatient hospital settings.

Section Four: Quality Appraisal

Source of Bias

According to Toronto and Remington (2020), bias can occur at any research stage, affecting the findings' reliability and validity. For this scholarly project, the primary potential bias was in the selection of the studies. The inclusion/exclusion criteria listed in Table 1 were used to inform the studies selected for review to minimize the risk of this bias and enhance the findings' reliability and validity. Using the criteria ensured that only the most relevant studies were selected. Williams et al. (2020) noted that minimizing research bias enhances trustworthiness by ensuring the findings are transferable, credible, confirmable, and dependable. Similarly, eliminating selection bias by ensuring that the defined criteria were utilized and the process was described using the PRISMA flow chart (Appendix A) enhanced the trustworthiness of the findings of this scholarly project.

Internal Validity

Validity refers to how closely the results of a study approximate the truth (Toronto & Remington, 2020). According to Toronto and Remington (2020), validity is demonstrated when the results of a study are obtained using proper scientific methods. Internal validity refers explicitly to the degree to which the findings of a research are believable and free from bias (Toronto & Remington, 2020). To enhance the internal validity of this scholarly project, thematic analysis was used to determine the review results. As Whittemore and Knafl (2005) suggested, the thematic analysis process included identifying key themes in the selected studies and the patterns and relationships among them to inform the key findings of this scholarly project. As such, the findings of this scholarly project are supported by the key themes from existing literature.

Appraisal Tools (Literature Matrix)

The quality of the studies was appraised using the literature review matrix presented in Appendix B. The literature matrix identifies the title of the study, the purpose/objectives of the study, the characteristics of the sample population, the methods used to collect and analyze data, the results and limitations of the study, and whether the findings inform the review question. The literature review matrix (Appendix B) provides a detailed synopsis of each article reviewed in this scholarly project and how it informs the research question. The Melnyk framework was used to categorize the studies included in this review. The Melnyk framework categorizes evidence into seven levels, with Level 1 being the highest and Level 7 being the lowest (Melnyk & Fineout-Overholt, 2015). In Level 1 studies, evidence is derived from systematic reviews and meta-analyses of randomized controlled trials. In Level 2 articles, evidence is informed by one or more randomized controlled trials, and Level 3 comprises controlled trials without randomization. Evidence at Level 4 is informed by case-control or cohort studies. Level 5 is informed by systematic reviews of descriptive and qualitative studies, Level 6 by single descriptive or qualitative studies, and Level 7 by expert opinion (Melnyk & Fineout-Overholt, 2015). Of the 32 articles reviewed in this scholarly project, one was at Level 3, nine at Level 5, 19 at Level 6, and three at Level 7.

Applicability of Results

This scholarly project aimed to investigate the impact of implementing BCMA technology on medication error rates within inpatient health settings. The findings of this scholarly project can be applied within inpatient health settings to help organizations identify how implementing the BCMA technology helps reduce medication error rates. Moreover, from the findings of this scholarly project, organizations can determine how they can use comprehensive education and the involvement of nurses in the implementation process to deal with the challenges of nurses finding workarounds with scanning barcodes and policy

deviation associated with the implementation of BCMA in practice. This scholarly project did not involve the collection of data from human subjects. However, to ensure adherence to the ethical guidelines, the project leader sought permission from the university's Institutional Review Board (Appendix D). Moreover, the project leader ensured that all the primary studies in this review explicitly discussed adherence to specific ethical guidelines.

Reporting Guidelines

Reporting guidelines such as the PRISMA are used to minimize bias in the reporting of the final review (Whittemore & Knafl, 2005). According to Toronto and Remington (2020), the PRISMA guidelines were developed to enhance the quality and transparency of reporting systematic reviews by describing the characteristics that should be present in a review. Thus, for this scholarly project, the PRISMA guidelines (Appendix A) were used to enhance the transparency and quality of this review. As described in Appendix A, the articles reviewed in this study were identified after the irrelevant ones were excluded based on factors such as duplication, lack of full-text availability, and failure to specify the ethical guidelines adhered to. Repeating the process described in Appendix A would yield similar results, enhancing this scholarly project's transparency.

Section Five: Data Analysis and Synthesis

Data Analysis Methods: Thematic Analysis

This scholarly project, an integrative review of studies conducted in the past, sought to determine the impact of BCMA technology on medication error rates in inpatient health settings. Thematic analysis was conducted to identify the key themes, patterns, and relationships from the findings of research conducted in the past. The conclusions of the thematic analysis of past literature indicate that implementing BCMA technology within inpatient settings helps reduce medication error rates. Other key findings of this scholarly project include that challenges are often associated with implementing BCMA technology,

such as policy deviations and workarounds when using the barcode scanning technology, which can be solved through comprehensive education and nurse involvement in the implementation process.

Descriptive Results

Three key themes emerged from the review of the studies selected; these will be discussed in the following section. Thirty-two articles on BCMA implementation in various healthcare settings were reviewed for this scholarly project. A detailed description of the articles can be found in the literature review matrix (Appendix B).

Synthesis

Theme 1: Causes of Medication Errors in Inpatient Health Settings

One of the themes evident in the review was that systemic or individual factors cause errors. This theme helps answer the review question of whether implementing BCMA technology impacts medication error rates in inpatient hospital settings. Hammoudi et al. (2018) conducted a descriptive cross-sectional study to identify some of the key causes of medication errors from nurses' perspectives. From the perspective of the nurses, most medication errors are caused by systemic factors such as medication packaging, nurse-physician communication breakdown, inadequate nurse staffing, pharmacy processes, and transcribing issues. In a study focusing specifically on the nurse work environment in the United States, Wei et al. (2018) also identified that inadequate staffing, a systemic factor contributing to medication errors, is prevalent. According to Wei et al. (2018), inadequate staffing adversely affects performance, productivity, and satisfaction, contributing to an increased risk of accidents, including medication errors. The findings of Wei et al. (2018) support those of Hammoudi et al. (2018) that systemic factors, such as poor communication between pharmacists, physicians, and nurses, contribute to medication errors.

Further, Hammoudi et al. (2018), Rodziewicz et al. (2018), and Tawfik et al. (2018) identified that systemic issues also contribute to underreporting of medical errors, which further affects the quality and safety of care that patients receive. According to Hammoudi et al. (2018), nurses cited underreporting due to fear of disagreements concerning what caused a medication error and the fear of the administration's response. Rodziewicz et al. (2018) agreed that fear of the administration's response, especially fear of punishment, keeps nurses from reporting medication errors.

Tawfik et al. (2018) found that the fear of reported errors negatively impacting work unit safety grades discouraged nurses from reporting all medication errors. From Dyre et al.'s (2022) perspective, how systemic factors influence the reporting of errors depends on how they are conceptualized. Organizations seek to understand, avoid, or learn from mistakes. According to the findings of the research conducted by Dyre et al. (2022), organizations that seek to learn from errors have the lowest chance of repetitive mistakes compared to those that either avoid or seek to understand the errors.

On the other hand, some studies helped identify individual nurse-related factors contributing to medication errors. For example, Andersson et al. (2018) found that lack of competence was a key nurse-related factor contributing to medication errors in inpatient health settings. Lack of competence creates other problems, such as incomplete documentation, inadequate communication, and poor teamwork, all of which exacerbate medication errors within inpatient hospital settings (Andersson et al., 2018). In agreement, Rodziewicz (2018) indicated that the lack of competence among nurses contributes significantly to medication errors. For instance, Rodziewicz et al. (2018) highlighted that the failure of all front-line nurses to be familiar with all procedures creates the risk of medication errors. A negative attitude toward some safety practices is another nurse-related factor highlighted by Rodziewicz et al. (2018). For example, some nurses have a negative attitude

toward adequate documentation of the medication process. As Rodziewicz et al. (2018) explained, poor attitudes create communication gaps between nurses and other providers and negatively affect teamwork, eventually contributing to medication errors that could be avoided. Therefore, according to the findings of past literature, systemic and individual factors contribute to medication errors in inpatient hospital settings. These causes of errors, when viewed in conjunction with the factors that lead to underreporting, such as fear of punishment and fear of a hospital's administration response, help explain why medication errors continue to be prevalent in inpatient health settings.

From a slightly different perspective, Eid et al. (2022) indicated that nurses also create an unhealthy environment contributing to medication errors. In a study focusing on 28 nurses during medication rounds in different units within the inpatient environment, Eid et al. (2022) found that interruptions accounted for 90% of the total medication-related errors that occurred. Nurses often got interrupted by each other when administering medication, which Eid et al. (2022) attributed to a lack of a culture of respect and workplace etiquette. Johnson et al. (2017) and Thomas et al. (2017) agreed that nurse interruptions during medication administration cause distractions that contribute to the prevalence of medication errors within inpatient settings. Johnson et al. (2017) indicated that interruptions cause substantial additional workload during medication tasks, which Thomas et al. (2017) described as cognitive load contributing to procedure and medication errors.

Theme 2: The Impact of Implementing the BCMA Technology

Most of the studies included in this integrative review discussed the effectiveness of implementing BCMA technology to reduce medication errors. According to the findings of the research conducted by Fuller et al. (2022), implementing BCMA technology helped reduce organizational and nurse-related factors contributing to medication errors. Specifically, for 264 resident-specific medication incidents, BCMA technology helped reduce

errors caused by medication omission by 43.7%, those associated with incorrect administration time by 22.6%, and those associated with the administration or dispensation by 44.9% (Fuller et al., 2022). According to Fuller et al. (2022), BCMA technology creates optimal conditions for medication administration by ensuring that the right patient, medication, dose, route, and time are followed (Mulac et al., 2021). Hutton et al. (2021) systematically searched databases that comprised studies published over 18 years and used a prospective before-and-after study design to compare the prevalence of medication errors before and after the implementation of the BCMA technology. An advantage of the study conducted by Hutton et al. (2021) is that it considered studies that focused on implementing the technology in inpatient and pharmacy settings. This is especially important because pharmacy processing and transcribing issues are common organizational factors contributing to medication errors (Hammoudi et al., 2018). In both pharmacy and inpatient environments, BCMA technology helped to reduce medication errors by preventing targeted wrong doses, wrong drugs, wrong route errors, wrong patient(s), and unauthorized drugs (Hutton et al., 2021)

From the perspective of Macias et al. (2018) and Küng et al. (2021), BCMA technology helps reduce medication errors and address the challenges caused by inadequate staffing. As the medication process is enhanced and automated by BCMA technology, nurses get more time to spend on direct patient care activities, which helps address the nurse-related factors of burnout and work distress contributing to medication errors (Macias et al., 2018). Küng et al. (2021) found that the time required to prepare medications for 24 hours decreased significantly from 30.2 minutes to 17.2 minutes using BCMA technology. The mean preparation time for each medication dose fell from 24.3 seconds to 15.1 seconds. With this significant reduction in the time spent preparing medication, Küng et al. (2021) agree with Macias et al. (2018) that when BCMA technology is utilized, nurses have additional time to

engage in other direct patient care activities. As such, this reduces the chances of burnout and work-related distress that negatively affect productivity and exacerbate medication errors. Additionally, Küng et al. (2021) mentioned that BCMA technology helped reduce dosage errors while eliminating errors associated with the wrong patient, wrong form, and ambiguous dispensers, which can be systemic or nurse-related factors that contribute to errors.

Some nurse-related factors contributing to medication errors are a culture that does not uphold workplace etiquette and respect for patients when administering medication (Eid et al., 2022). Negative attitudes toward safety practices (Rodziewicz et al., 2018) and the prevalence of distractions during medications (Johnson et al., 2017; Thomas et al., 2017) cannot be addressed solely by implementing BCMA technology. However, Strudwick et al. (2018) indicated that implementing the technology is a step in the right direction. It helps create a culture that upholds patient safety and encourages nurses to play their part in reducing medication administration errors. As BCMA technology is embraced as standard protocol, it becomes a constant reminder to nurses to avoid medication administration errors and embrace patient safety as the culture in their units. In agreement, Xie et al. (2019) indicated that BCMA technology helps enhance the safety culture, especially by improving accountability among the nursing team. Xie et al. (2019) sought to determine the effectiveness of BCMA technology and found that this technology helped management to hold individual nurses accountable for specific medication errors. This was facilitated by the proper documentation and clinical workflow created by using BCMA technology. BCMA technology helped create an organizational culture that embraces patient safety. Baiden (2018) referred to BCMA technology's accountability feature as routine quality assurance. From Baiden's (2018) perspective, management can easily attribute medication errors to omission, incompetence, or failure to follow routine procedures when using BCMA

technology. Therefore, BCMA technology helps to create a culture where patient safety is prioritized.

Existing literature discusses how BCMA technology can help reduce medication errors caused by organizational and nurse-related factors. However, some issues may hinder the successful implementation of BCMA technology. For example, Fuller et al. (2022) noted that nurse workaround occurred in 41.1% (78/190) of the medication incidents they studied. The most common workaround that Fuller et al. (2022) observed was that nurses would document administration before actually administering the medication. Although nurse workarounds were prevalent when BCMA technology was used, Fuller et al. (2022) stated that 52.7% (59/112) of workarounds still occurred when the BCMA technology was not implemented.

Similarly, van der Veen et al. (2017) found that workarounds remained prevalent and contributed to medication errors when BCMA technology was used. Some common workarounds identified by van der Veen et al. (2017) include nurses failing to scan medications, scanning patients' barcodes remotely instead of scanning their wristbands, scanning medication for multiple patients simultaneously, and ignoring signals and alerts. McBee et al. (2019) also found that workarounds are common when implementing BCMA technology in practice. They further highlighted that they adversely affect the standardization of BCMA planning and the implementation and sustainability of the BCMA protocol. McBee et al. (2019) explained that workarounds cause problems because they make it challenging to evaluate compliance with the standard procedures that the BCMA technology sets for medication administration and, consequently, its effectiveness in reducing or eliminating medication errors.

Theme 3: Methods to Enhance the Effectiveness of the BCMA Technology

Past research findings have helped identify BCMA technology's effectiveness in reducing medication errors and the time required to administer medication, allowing nurses to engage more in other direct patient care activities. Having identified these advantages, it is vital to look at methods to deal with the challenges still faced when BCMA technology is used to enhance its effectiveness in practice. Supporting findings related to the prevalence of policy deviations as one of the challenges that negatively impact the effectiveness of the BCMA technology, Jessurun et al. (2021) indicated that enhancing nurse satisfaction regarding using this technology can improve compliance. According to Jessurun et al.'s (2021) research findings, the nurses who were satisfied with the BCMA technology before and after implementation were more likely to comply with the scanning procedures. Similarly, in a 6-month follow-up after implementing BCMA technology, Baiden (2018) identified that the nurses who were content with the technology were more likely to comply with the set standards and protocol. Conversely, the nurses within acute inpatient settings who expressed discontent with the BCMA technology were less likely to comply with set standards and utilize the scanning procedure to eliminate medication errors (Baiden, 2018).

As such, Hong et al. (2021) and Mulac et al. (2021) highlighted the need for nurse involvement during the implementation process to enhance nurse satisfaction and commitment and, consequently, adherence to the BCMA technology. According to Mulac et al. (2021), nurses should be involved in informing the decision on environmental factors that would cause them to engage in workarounds and policy deviation when the BCMA technology is implemented. Specifically, Mulac et al. (2021) highlighted that environmental factors such as medication room location and patient drawer size affect medication preparation and administration workflow. These factors should be considered when BCMA technology is implemented. As nurses become involved in making decisions regarding issues

such as the environment in which they administer medication, they become more likely to adhere to the protocol set by the BCMA technology (Mulac et al., 2021). Agreeing with the need for nurse involvement Dykes and Chu (2021) noted that digitalization and the use of technology will increase significantly post the COVID-19 pandemic. Drawing from the lessons on the use of technology during the COVID-19 pandemic, Dykes and Chu (2021) indicated that nurse-related factors such as lack of comfort using technology, negative attitudes toward technology, or the technology designs were some of the reasons nurses did not embrace their use. As such, from the perspective of Dykes and Chu (2021), the COVID-19 pandemic helped to inform the need for nurse involvement during the implementation of new technology.

Nurses can be involved in shared decision-making to help inform the decisions on incorporating BCMA technology without disrupting the workflow when administering medication (Mulac et al., 2021). Nurses can decide how the BCMA technology can be implemented flexibly, considering their workload, complexity, or emergencies (Hong et al., 2021). Nurse involvement in decision-making around BCMA technology implementation in practice helps to affirm their autonomy, which is associated with nurse satisfaction with the technology and willingness to comply with the protocol (Hong et al., 2021). Darawad et al. (2019) asserted that nurse involvement in implementing BCMA technology is positively associated with nurse satisfaction and increased likelihood of embracing the technology. Using a sample of 207 nurses from three public hospitals with varying ages and levels of nursing experience and computer competence, Darawad et al. (2019) found a positive correlation between satisfaction with the technology and the tendency to use it. Moderate to high satisfaction levels with the BCMA technology encouraged the nurses to adhere to the standard. It discouraged them from workarounds and policy deviations even during complex and urgent medication administrations (Darawad et al., 2019).

As Darawad et al. (2019) highlighted, satisfaction with the BCMA technology is strongly associated with the tendency to adhere to the protocol and avoid workarounds and policy deviations. They recommended integrating training and education while implementing BCMA technology. The training and education would focus on helping nurses understand the importance of implementing BCMA technology. The instruction would focus on reducing medication errors, promoting a culture of safety, implementing the technology without causing disruptions to the medication workflow, and implementing the best practices related to BCMA implementation to avoid workarounds and policy deviation (Booth et al., 2017). Lack of competence is one of the nurse-related factors contributing to the prevalence of medication errors (Rodziewicz et al., 2018). Andersson et al. (2018) and Booth et al. (2017) mentioned that providing education and training during the implementation phase ensures that nurses have the required skills, competencies, and knowledge to utilize BCMA safely and effectively. Asserting the need for education during the implementation of BCMA technology, Zheng et al. (2021) noted that it also helps nurses understand its risks. Zheng et al. (2021) explained that although BCMA technology helps reduce medication administration errors, it can cause confusion and administration errors when medications are labeled with wrong or unreadable barcodes. When comprehensive education is provided, Zheng et al. (2021) indicated that nurses are made aware of such risks to enhance the effectiveness of the technology.

Craig et al. (2021) suggested using simulation programs to deliver this education. Simulation programs replicate the events that would take place in the real care environment, thus promoting the competency and confidence levels of the learners (Craig et al., 2021; Zheng et al., 2021). Craig et al. (2021) split a sample of 83 learners who were being educated on various medication practices into two groups. One group received standard training, while the intervention group received simulation learning experiences. An analysis of the learning

process post-training showed that the students who received simulation experiences had better knowledge and understanding of medication practices. They implemented medication safety practices more effectively than their counterparts in the clinical setting (Craig et al., 2021). Ledlow et al. (2022) added that simulation programs, when educating nurses on using BCMA technology, help increase realism and improve nurses' clinical preparedness. In their research, Ledlow et al. (2022) focused on 96 student nurses who were educated on using BCMA and electronic medical record technologies during their prelicensure curriculum using a simulation program. Of the student nurses, 96% indicated that simulation helped make training more realistic, allowing them to transfer the theoretical knowledge they had gathered into real-life tasks (Ledlow et al., 2022).

Additionally, 94% of the respondents indicated they felt adequately prepared for the clinical setting after training using the simulation program (Ledlow et al., 2022). Angel et al. (2016) affirmed these findings by indicating that simulation programs allow nurses to make mistakes during the learning process instead of in practice, enhancing their preparedness to implement the technology. Simulation experiences help improve the nurses' learning process and strengthen competence during the implementation of BCMA technology, clinical preparedness, and transfer of learning to real-life tasks.

The case for comprehensive education during the implementation of BCMA technology in inpatient settings, especially simulation programs, is further affirmed by how it prepares nurses to address patient concerns that may come when this technology is implemented. Using a sample of 52 patients in a hospital utilizing BCMA to reduce medication errors, Strudwick et al. (2017) identified that the patients were concerned about managing information, privacy, security, stigma, safety, safety, and comfort and held negative associations with the technology. The patients further indicated that they would prefer to be involved in decision-making on the type of identification used in BCMA to make

the process patient-centered (Strudwick et al., 2017). Although Strudwick et al. (2017) focused on patients hospitalized within mental health facilities, patient concerns are likely similar across settings. This scholarly project does not focus on patient perspectives while implementing the BCMA technology. Still, the findings by Strudwick et al. (2017) reveal common issues that can occur in practice and affirm the role of comprehensive education in preparing nurses to transfer learning in their clinical practice. Finally, as comprehensive education enhances the mastery and competence of nurses when using the BCMA technology, it prepares them to become peer educators within the clinical practice. According to Yuan et al. (2020), the beliefs of experienced nurses play a key role in influencing workplace culture in healthcare organizations since they affect the organizational/systemic way of doing things.

Similarly, when nurses receive comprehensive education on BCMA and are adequately involved from the implementation stage, they are likely to develop positive attitudes and beliefs, which they transfer to the nurses who join the team later. These attitudes and beliefs influence the culture to prioritize patient safety. Therefore, according to the current literature findings, nurses' involvement in the implementation process and comprehensive education delivered via simulation programs are key to ensuring the successful implementation and adoption of BCMA technology in inpatient healthcare settings to reduce medication errors.

Section Six: Discussion

The results of this review reveal that implementing BCMA technology can help reduce medication administration errors within inpatient settings. The findings of the research studies conducted in the past align with one another, showing that BCMA technology allows for addressing both organizational and individual nurse factors that contribute to errors. Implementing BCMA technology creates a protocol and standard that ensures that the right drug is administered to the right patient, at the right time, in the right dose, and using the right

route. Moreover, BCMA technology enhances accountability among the nursing team as it is easy to track errors, omissions, and improper documentation. As BCMA technology is embraced as a standard protocol within inpatient settings, it helps create a culture that prioritizes patient care and upholds etiquette and respect during medication administration to reduce disruptions contributing to medication errors.

Nevertheless, the findings of past studies highlight that challenges of policy deviations and workarounds can exist when the BCMA technology is implemented, and these issues can contribute to medication errors. Workarounds and policy deviations are particularly prevalent where nurses fail to adhere to the BCMA protocol due to a negative attitude toward the technology, lack of competence, technology disruption to the workflow, or organizational culture. Workarounds include all practices that nurses carry out to work around the system, such as scanning medications for multiple patients simultaneously, failing to scan both the medication barcode and the patient's wristband, documenting administration before medication administration, and ignoring signals and alerts.

Nurse involvement and comprehensive education and training during the implementation process are essential to address these challenges and encourage nurses to embrace BCMA technology. Nurses' participation in the implementation process allows them to express their opinions on how the technology can be implemented in a way that suits their workplace environment best. As nurses are involved in the implementation process, they develop a sense of belonging and contentment with the technology, increasing their chances of complying and reducing the likelihood of engaging in the various practices to work around the BCMA system.

Comprehensive education during the implementation process, on the other hand, ensures that nurses understand the need to embrace the technology to avoid workarounds and policy deviations, how to implement the technology without causing disruptions to the

existing workflow, and how to respond to patients' concerns that may arise when using the technology. Given that lack of competence is one of the nurse-related factors contributing to errors, comprehensive education is critical to ensure that nurses are equipped with adequate skills, competencies, and knowledge to utilize when using the BCMA technology and to transfer learning to their peers. Comprehensive education on BCMA technology implementation delivered via simulation programs enhances transference of learning as it exposes the nurses to real-life practices, thus preparing them adequately to implement the technology in practice. Therefore, the findings of this review indicate that comprehensive education and adequate nurse involvement during the implementation of the BCMA technology are key to enhancing the effectiveness of the technology in reducing errors in inpatient health settings.

Implications for Practice/Future Work

Reducing medication errors is a National Patient Safety Goal for ambulatory clinics and hospitals (Joint Commission, 2022). One of the interventions recommended by the Joint Commission (2022) to reduce medication errors within hospitals and ambulatory clinics was barcode scanning. As such, the implication of this project on clinical practice is the increased need to embrace the use of BCMA technology regardless of the high cost associated with its implementation and the expected disruption to the already existing way of administering medication. BCMA technology helps reduce medication errors by creating a protocol to ensure that the right drug is administered to the right patient, at the right time, in the right dose, and using the right route. Adherence to the BCMA standards also means inpatient health settings create a culture that significantly embraces and prioritizes patient safety, enhancing individual accountability for actions taken.

The implication for the nurse leaders and other health care providers in leadership is ensuring seamless technology adoption. To achieve this, the leaders should create

communication channels to ensure the nursing team is involved in shared decision-making while implementing the technology. Moreover, the leadership should provide comprehensive education, preferably simulation strategies, to develop the nursing team's skills, competencies, and knowledge while implementing the BCMA technology. As nurses become educated, remain updated on BCMA technology, and feel involved in the decision-making process, their chances of following the protocol when administering medication increase, and the chances of workarounds around the barcode scanning system and policy deviations decrease. Eventually, using BCMA technology will reduce medication errors and enhance patient safety, patient outcomes, and patient satisfaction rates.

Strengths and Limitations

The findings of this review are informed by contemporary literature, with most of the studies involving nurse participants within inpatient hospital settings. As such, the results of this scholarly project adequately embody the voice of nurses within inpatient hospital settings, who are the primary stakeholders in implementing BCMA technology. A limitation of this study is that it does not consider patients' voices regarding using BCMA technology to reduce medication errors. Since patients are the primary recipients of this technology and may have concerns or opinions on using BCMA when administering medication, it is important to consider their voices. As such, future scholarly projects and studies can look into how patients' perspectives and preferences impact the effective implementation of BCMA technology in inpatient settings to reduce medication errors.

Dissemination

The project leader plans to disseminate this scholarly project's findings in inpatient settings. This scholarly project aims to determine the impact of using BCMA technology to reduce medication errors in inpatient hospital settings. Therefore, the results of this scholarly project contribute to existing knowledge on how BCMA technology can reduce medication

errors. The findings of this scholarly project indicate that nurse involvement in the implementation process and comprehensive education enhances nurses' satisfaction with the technology and, consequently, results in an increased likelihood of nurses utilizing it during medication administration. Moreover, comprehensive education enhances understanding and appreciation of the technology, which encourages the transfer of learning among nursing peers to strengthen the sustainability of the change created by the BCMA technology.

DNP Essentials

Essential I: Scientific Underpinnings for Practice

Per the American Association of Colleges and Nurses (AACN, 2006) guidelines, Doctor of Nursing Practice (DNP) graduates should possess a wide array of knowledge gleaned from the sciences and demonstrate the ability to translate that knowledge quickly to benefit patients in the daily demands of practice environments effectively. This DNP scholarly project presents a depth of knowledge on the prevalence of medication errors within inpatient settings and their adverse effects on patient health outcomes, patient satisfaction, care quality, and safety of care. To meet the demands of the practice environment and continually enhance the quality and safety of patient care, this scholarly project gathers knowledge on using BCMA technology and how it can be translated into practice to reduce medication administration errors.

Essential II: Organizational and Systems Leadership for Quality Improvement and Systems Thinking

Per this essential, the DNP graduate nurse should be prepared to develop and evaluate care delivery approaches sensitive to the current and future needs of the patient population (AACN, 2006). The need to enhance the safety of care by reducing medication errors is an ongoing need that this scholarly project has identified (Joint Commission, 2022). Moreover, this essential requires enhanced accountability for the quality of health care and patient

safety. Implementing BCMA technology, as suggested in this scholarly project, improves accountability by requiring every nurse to utilize the technology during medication administration errors (Baiden, 2018).

Essential III: Clinical Scholarship and Analytical Methods for Evidence-Based Practice

According to this essential, scholarship and research are the hallmarks of doctoral education (AACN, 2006). DNP nurses are prepared to critically appraise existing literature and other evidence to determine and implement the best evidence for practice. Evidence informs practice and facilitates the design and implementation of processes to evaluate outcomes of practice. This scholarly project has critically evaluated existing literature to determine individual and systemic factors contributing to medication errors. In addition, the impact of BCMA technology on medication errors and methods can be embraced to enhance the effectiveness of BCMA technology as it is implemented in inpatient health settings. Based on the findings drawn from the research synthesis, the project leader can design, direct, and evaluate the quality improvement strategy of implementing the BCMA technology to reduce medication errors per this essential.

Essential IV: Information Systems/Technology and Patient Care Technology for Improving and Transforming Health Care

Doctor of Nursing Practice graduates stands out because they can use information systems/technology to support and enhance patient care and health care systems. Per this essential, this scholarly project focused on identifying ways BCMA technology could improve and transform health care by reducing medication errors within inpatient settings. Moreover, having been the project leader, the DNP nurse is adequately equipped to provide leadership and training to other healthcare providers in healthcare organizations on implementing BCMA technology. As the leader, the DNP nurse can evaluate and monitor the

outcomes of the BCMA technology to identify potential areas of improvement to enhance its accuracy and effectiveness in inpatient healthcare settings.

Essential V: Health Care Policy for Advocacy in Health Care

DNP nurses are prepared to influence and/or lead health care policy creation and implementation, educate others on policymaking, critically analyze health policies, and advocate for more policies. In this scholarly project and as part of the practicum, the DNP nurse advocated for implementing the BCMA technology as standard protocol in their organization to enhance patient safety and positive outcomes. Although the technology was not adopted for financial reasons, this project provided an excellent opportunity for the DNP nurse to identify how they can assess patient needs and advocate for implementing relevant policies to address them.

Essential VI: Interprofessional Collaboration for Improving Patient and Population Health Outcomes

Per this essential, the DNP nurse should be prepared to lead interprofessional teams, provide consultative leadership skills, and employ effective communication and collaborative skills to enhance teamwork (AACN, 2006). Part of the findings of this scholarly project identified the need for comprehensive education during the implementation of BCMA technology to help address the challenges of policy deviation and workarounds (Jessurun et al., 2021). As the project leader, the DNP nurse would have an excellent opportunity to enhance interprofessional collaboration when delivering the education to ensure that every interdisciplinary team member is aware of their role in improving the effectiveness of BCMA technology.

Essential VII: Clinical Prevention and Population Health for Improving the Nation's Health

This essential outline the role of the DNP nurse in health promotion and disease prevention to enhance positive health outcomes for the patient population. This scholarly project aims to strengthen health outcomes by eliminating errors often associated with comorbidity, morbidity, and lengthened hospital stays (SingleCare Team, 2022). Specifically, this scholarly project evaluates the use of BCMA technology as a care strategy to enhance patient safety and quality of care.

Essential VIII: Advanced Nursing Practice

Per this essential, DNP nurses should possess increased knowledge and sophistication to enhance their competence in highly complex areas of practice (AACN, 2006). As part of enhanced competence, this scholarly project focuses on the specialty of patient safety, specifically the reduction of medication errors within inpatient healthcare settings. The DNP nurse can develop an intervention to address this challenge and guide, mentor, and support other nurses in implementing BCMA technology to achieve excellence in nursing. Comprehensive education during the implementation of BCMA technology has been identified as a method to enhance its effectiveness (Craig et al., 2021; Zheng et al., 2021). This finding aligns with this DNP essential that prepares nurses to educate and guide other individuals and groups through complex health and situational transitions.

Conclusion

The results of this review indicate that BCMA impacts the reduction of medication errors in inpatient hospital settings. Implementing BCMA technology creates a protocol that ensures the right drug is administered to the right patient, at the right time, in the right dose, and using the right route. This protocol helps reduce systemic factors contributing to errors, such as communication breakdown, packaging, pharmacy processes, transcription issues, and

inadequate nursing staffing. It also helps to address nurse-related factors such as disruptions during medication administration, a negative attitude toward medication safety practices, and incompetence. BCMA technology creates a culture prioritizing patient safety and holds individual nurses accountable for errors, incompetence, and omissions.

Regarding best practices during the implementation of BCMA technology, the nursing team should be adequately involved to boost their contentment with the technology and increase the likelihood of adherence. Moreover, comprehensive education and training should be provided to the nursing team to equip them with skills, competence, and knowledge on the importance of properly using BCMA technology during medication administration. With the understanding of the positive impact BCMA technology has on reducing medication errors and the best practices to embrace, nurse leaders must advocate for its adoption within inpatient settings to enhance patient safety and promote positive patient outcomes and satisfaction.

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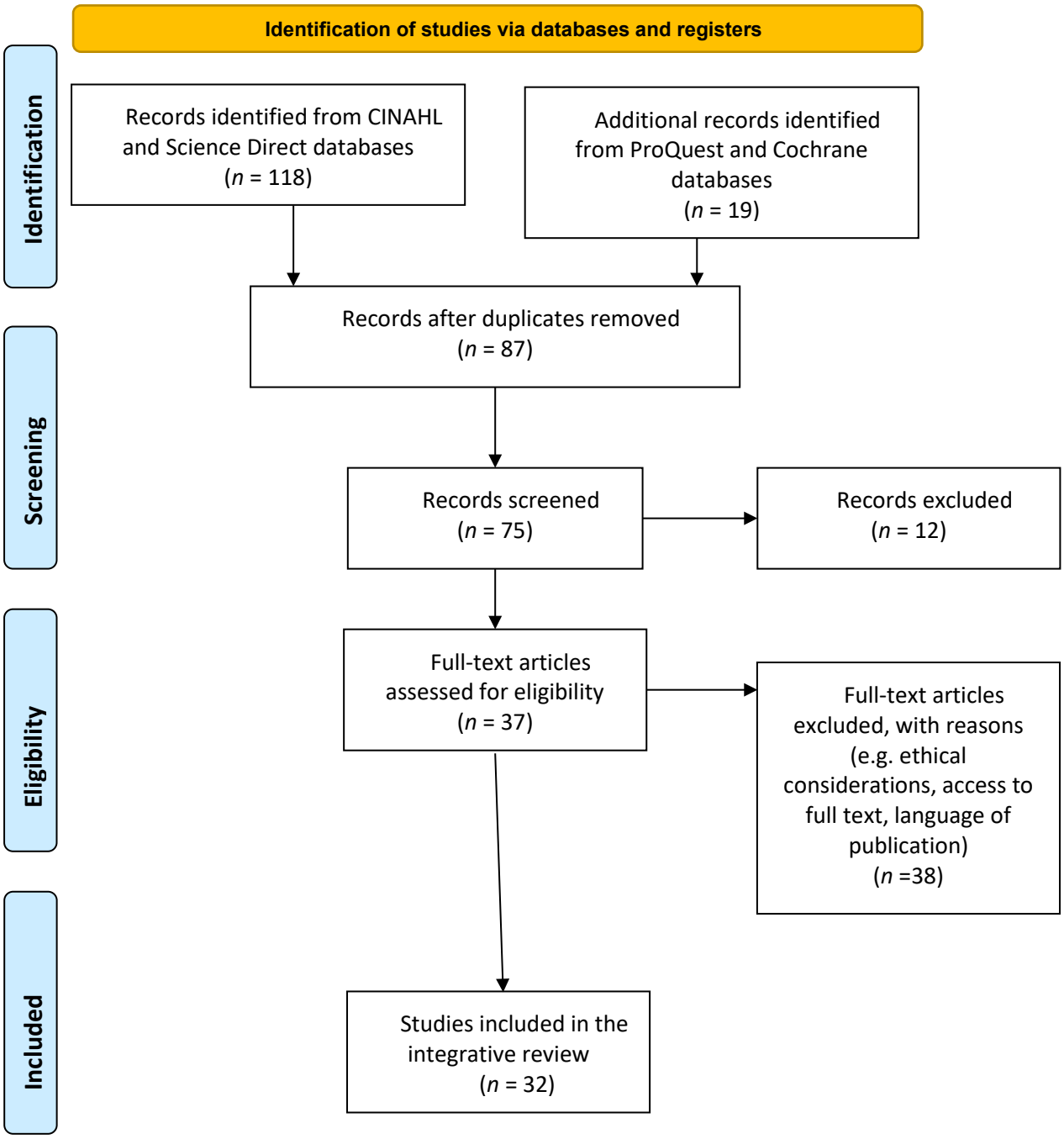
Xie, N., Kalia, K., Strudwick, G., & Lau, F. (2019). Understanding mental health nurses' perceptions of barcode medication administration: A qualitative descriptive study. *Issues in Mental Health Nursing, 40*(4), 326–334. https://doi.org/10.1080/01612840.2018.1528321

Yuan, C. T., Nembhard, I. M., & Kane, G. C. (2020). The influence of peer beliefs on nurses' use of new health information technology: A social network analysis. *Social Science & Medicine, 255,* Article 113002. https://doi.org/10.1016/j.socscimed.2020.113002

Zheng, W. Y., Lichtner, V., Dort, B. A., & Baysari, M. T. (2021). The impact of introducing automated dispensing cabinets, barcode medication administration, and closed-loop electronic medication management systems on work processes and safety of controlled medications in hospitals: A systematic review. *Research in Social and Administrative Pharmacy, 17*(5), 832–841. https://doi.org/10.1016/j.sapharm.2020.08.001

Appendix A: PRISMA Flow Diagram



Appendix B: Literature Review Matrix

Article	Study Purpose	Sample	Methods	Study Results	Level of Evidence	Study Limitations	Would Use as Evidence to Support a Change?
Andersson, Å., Frank, C., Willman, A. M., Sandman, P.-O., & Hansebo, G. (2018). Factors contributing to serious adverse events in nursing homes. *Journal of Clinical Nursing, 27*(1–2), e354–e362. https://doi.org/10.1111/jocn.13914	To determine the factors that contribute to adverse events in nursing homes.	173 nursing homes.	Retrospective study.	Medication errors constitute a significant share of the factors that contribute to adverse events in nursing homes.	Level 6: Evidence from a single descriptive study.	The study focused on nursing homes, not inpatient settings.	Yes. It affirms the findings of other studies that medication errors are prevalent across all healthcare settings and consequently affirms the need for BCMA technology.
Angel, V. M., Friedman, M. H., & Friedman, A. L. (2016). Integrating barcode medication administration competencies in the curriculum: Implications for nursing education and interprofessional collaboration. *Nursing Education Perspectives,*	To identify ways to integrate BCMA education into the curriculum.	Review of one BCMA project.	Evidence from a report.	Simulation programs are vital in delivering education on BCMA technology.	Level 7: Evidence from the opinion of a report.	Risk of bias as it focused only on one study.	Yes. It affirmed the findings on using simulations to deliver learning on BCMA technology.

37(4), 239–241. https://doi.org/10.1097/01.NEP.0000000000000038							
Baiden, D. (2018). Factors affecting the impact of barcode medication administration technology in reducing medication administration errors by nurses. *Canadian Journal of Nursing Informatics, 13*(1). https://cjni.net/journal/?p=5368	To determine the factors that impact BCMA in the nursing environment.	24 articles.	A systematic review of the literature.	Nurse contentment and competence with BCMA increased the likelihood of utilizing it during medication administration.	Level 5: Evidence from systematic reviews of descriptive and qualitative studies.	No primary data was collected.	Yes. To inform findings on the nurse-related factors contributing to the successful implementation of BCMA technology.
Aljabari & Kadhim (2021). Common barriers to reporting medical errors. *The Scientific World Journal, 2921* (6494889), 1-8. *https*://doi.org/10.1155%2F2021%2F6494889	To identify the common barriers that prevent reporting of medical errors.	Thirty studies were reviewed.	A systematic review of the literature.	Fear of consequences was the most reported barrier to reporting medical errors, followed by a lack of feedback from the administration and/or negative feedback. A negative work climate/culture	Level 5: Evidence from a systematic review of descriptive and qualitative studies.	Potential social-desirability bias since all the published reports used self-administered questionnaires or interviews to collect primary data.	Yes. The findings provide information on some barriers that lead to underreporting medical errors, which is key for this research.

				was also identified.			
Kiymaz & Koç (2017). Identification of factors that affect the tendency towards and attitudes of emergency unit nurses to make medical errors. *Journal of Clinical Nursing, 27*(5-6), 1160-1169. https://doi.org/10.1111/jocn.14148	To determine professional and individual factors influencing nurses' likelihood of making medical errors in emergency units and examine their attitudes towards them.	Two hundred eighty-four nurses work in emergency units across 18 public hospitals and one university hospital.	A descriptive cross-sectional study.	The findings indicated that job satisfaction and working during the day shift were positively linked with a lower tendency for medical errors.	Level 6: Evidence from a single descriptive or qualitative study.	The findings were focused on a local area in Northern Turkey where circumstances may differ from other nursing environments.	Yes. The findings help inform the factors that cause medication errors as well as the attitudes of nurses towards them.
Booth, R. G., Sinclair, B., Strudwick, G., Hall, J., Tong, J., Loggie, B., & Chan, R. (2017). Strategies through clinical simulation to support nursing students and their learning of barcode medication administration (BCMA) and electronic medication administration	To determine how simulations can support nursing students when learning about BCMA.	Articles reviewed not specified.	Literature review.	Simulation programs enhance understanding and translation of knowledge when learning about BCMA technology.	Level 5: Evidence from systematic reviews of descriptive and qualitative studies.	Failure to specify the number of articles reviewed.	Yes. It informs findings on ways to deliver education on BCMA to nurses.

record (eMAR) technologies. In A. Shachak, E. M. Borycki, & S. P. Reis (Eds.), *Health professionals' education in the age of clinical information systems, mobile computing and social networks* (pp. 245–266). Academic Press. https://doi.org/10.1016/B978-0-12-805362-1.00012-7							
Craig, S. J., Kastello, J. C., Cieslowski, B. J., & Rovnyak, V. (2021). Simulation strategies to increase nursing student clinical competence in safe medication administration practices: A quasi-experimental study. *Nurse Education Today, 96,* Article 104605. https://doi.org/10.1016/j.nedt.2020.104605	To determine the effectiveness of simulation strategies when teaching safe medication administration practices.	83 nursing students.	Quasi-experimental study.	Simulation programs enhance student learning on medication administration practices.	Level 6: Evidence from a single descriptive or qualitative study.	Limited time and space to conduct repeat simulations.	Yes. It informs findings on how simulations can deliver learning on BCMA technology.
Darawad, M. W., Othman, E. H., & Alosta, M. R. (2019). Nurses' satisfaction with barcode medication-administration technology: Results of a cross-sectional study. *Nursing and Health Sciences, 21*(4), 461–469. https://doi.org/10.1111/nhs.12620	To determine whether nurses were satisfied with the introduction and use of the BCMA technology.	A convenient sample of 207 nurses from three public hospitals.	A descriptive, cross-sectional study.	Nurses' satisfaction with using the BCMA is associated with training, perceived job productivity, technology comfort, and	Level 6: Single descriptive or qualitative study.	The use of self-reported questionnaires poses the challenge of social-desirability bias.	Yes. The study findings help identify nurse-related factors that can help promote satisfaction when using

				computer competence.			BCMA technology.
Dykes, S., & Chu, C. H. (2021). Now more than ever, nurses need to be involved in technology design: Lessons from the COVID-19 pandemic. *Journal of Clinical Nursing, 30*(7–8), e25–e28. https://doi.org/10.1111/jocn.15581	To determine the role of nurse involvement when implementing technology in practice.	Expert opinion.	Expert opinion.	Drawing lessons from the COVID-19 pandemic, there is an increased need to involve nurses in implementing technology.	Level 7: Evidence from the opinion of reports.	No primary or secondary data was collected.	Yes. It informs findings on the role of nurses when implementing technology in practice.
Dyre, L., Grierson, L., Møller, K., Rasmussen, B., Ringsted, C., & Tolsgaard, M. G. (2022). The concept of errors in medical education: A scoping review. *Advances in Health Sciences Education, 27*(3), 761–792. https://doi.org/10.1007/s10459-022-10091-0	To understand the conceptualization of errors in medical education and how this affects practice.	Seventy-nine articles were systematically selected and reviewed.	Scoping review.	Three key themes in conceptualizing errors emerged: understanding, avoiding, and learning from mistakes.	Level 5: Systematic review of descriptive and qualitative studies.	The study focuses on errors from the broader perspective of medical education instead of the specific role of nursing education.	Yes. As this study seeks to conduct education to encourage the adoption of BCMA, it will ensure that the concept of medication errors is conceptualized in a way that promotes understanding it and learning from it to

							eliminate them.
Eid, T., Machudo, S., & Eid, R. (2022). Interruptions during medication work in a Saudi Arabian hospital: An observational and interview study of nurses. *Journal of Nursing Scholarship, 54*(5), 639–647. https://doi.org/10.1111/jnu.12765	To examine the nature and impact of interruptions when administering medication.	Twenty-eight nurses provide medication rounds at a 1000-bed hospital in the medical, surgical, and gynecology wards.	An exploratory, descriptive study.	Interruptions accounted for about 90% of the errors that occurred. Most of the interruptions came from other nurse colleagues. It is crucial to create a culture of respect to prevent interruptions and promote patient safety.	Level 6: Single descriptive or qualitative study.	Using the observational approach poses a challenge of social-desirability bias, where participants may behave differently when observed.	Yes. This study's findings help identify a nurse-related issue that should be addressed even as the BCMA technology is implemented to prevent medication errors.
Fuller, A. E., Guirguis, L. M., Sadowski, C. A., & Makowsky, M. J. (2022). Evaluation of medication incidents in a long-term care facility using electronic medication administration records and barcode technology. *The Senior Care Pharmacist, 37*(9), 421–477. https://doi.org/10.4140/TCP.n.2022.421	To determine medication errors' types, frequency, and severity after implementing the BCMA.	Two hundred seventy paper-based medication incident reports were reviewed.	Retrospective incident report review.	Implementing the BCMA was associated with reducing severe medication errors and errors related to administration and dispensing. BCMA workarounds	Level 6: A single descriptive or qualitative study.	The incident reports used were submitted voluntarily, which poses participant bias.	Yes. The study findings help identify factors that can be used to determine the effectiveness of the BCMA technology.

				continue to pose a shortcoming that contributes to errors.			
Hammoudi, B. M., Ismaile, S., & Yahya, O. A. (2018). Factors associated with medication administration errors and why nurses fail to report them. *Scandinavian Journal of Caring Sciences, 32*(3), 1038–1046. https://doi.org/10.1111/scs.12546	To determine the factors associated with medication administration errors and why nurses fail to report them.	A convenience sample of 367 nurses working at a large public hospital, with a response rate of 73.4%	A descriptive cross-sectional study	Findings indicated that nurse-physician communication, nurse staffing, pharmacy processes, transcribing issues, and medication packaging were the critical factors related to nurses that cause medication administration errors. The barriers that limit reporting include fear of disagreements and the administration's response.	Level 6: Single descriptive design.	The potential for nonresponse bias is high.	Yes. The article helps identify some nurse-related factors contributing to medication administration errors.

Hong, J. Y., Ivory, C. H., VanHouten, C. B., Simpson, C. L., & Novak, L. L. (2021). Disappearing expertise in clinical automation: Barcode medication administration and nurse autonomy. *Journal of the American Medical Informatics Association, 28*(2), 232–238. https://doi.org/10.1093/jamia/ocaa135	To identify the challenges nurses face when utilizing BCMA technology.	One academic medical center.	Qualitative study using observation and interviews.	System rigidity when using BCMA affects nurses' autonomy.	Level 6: Evidence from a single descriptive or qualitative study.	Risk of observer bias.	Yes. It helps to inform findings on nurses' perspectives when utilizing the BCMA technology.
Hutton, K., Ding, Q., & Wellman, G. (2021). The effects of bar-coding technology on medication errors: A systematic literature review. *Journal of Patient Safety, 17*(3), e192–e206. https://doi.org/10.1097/PTS.0000000000000366	To identify whether the use of bar-coding technology helps to reduce medication errors.	Ten articles were reviewed; nine were US-based, with only one having its research conducted in the U.K.	A systematic literature review.	The results indicated that bar-coding technology helps reduce medication errors, particularly those associated with the wrong patient, wrong drug, wrong dose, wrong route, and unauthorized drug.	Level 3: Systematic review of well-designed controlled trials without randomization and quasi-experiments.	The findings do not indicate how the BCMA technology affected specific medication error categories. The information provided is general and not clear.	Yes. The study provides information on how the BCMA can enhance medication safety, an essential quality metric for the project.
Jessurun, J. G., Hunfeld, N. G., Rosmalen, J. V., Dijk, M. V., & Bemt, P. M. (2021).	To determine whether implementing the	Six clinical wards in	A prospective uncontrolled study was	The implementation of the	Level 6: Single descriptive	An uncontrolled study is	Yes. The study helps to

Effect of automated unit dose dispensing with barcode scanning on medication administration errors: an uncontrolled before-and-after study. *International Journal for Quality in Health Care, 33*(4), 1–8. https://doi.org/10.1093/intqhc/mzab142	BCMA helps reduce medication administration and focus specifically on the type and severity of medication errors.	a Dutch University Hospital.	conducted over two years.	BCMA helped to reduce medication administration errors that ranged from mildly harmful ones to potentially harmful ones. Nurses' satisfaction with the BCMA technology was associated with compliance.	or qualitative study.	subject to researcher bias.	inform how BCMA technology can reduce medication administration errors that range in severity.
Johnson, M., Sanchez, P., Langdon, R., Manias, E., Levett-Jones, T., Weidemann, G., Aguilar, V., & Everett, B. (2017). The impact of interruptions on medication errors in hospitals: An observational study of nurses. *Journal of Nursing Management, 25*(7), 498–507. https://doi.org/10.1111/jonm.12486	To determine how interruption affects medication errors in hospitals.	Fifty-six medication events, including 101 interruptions.	A non-participant observational study.	About 99% of the medication events were interrupted. Interruptions are a key nurse-related factor that contributes to medication errors.	Level 6: Evidence from a single descriptive study.	Findings may not be generalizable as the study focused on a large metropolitan hospital in Australia.	Yes. The findings inform some of the nurse-related factors that contribute to medication errors.

Küng, K., Aeschbacher, K., Rütsche, A., Goette, J., Zürcher, S., Schmidli, J., & Schwendimann, R. (2021). Effect of barcode technology on medication preparation safety: A quasi-experimental study. *International Journal for Quality in Health Care, 33*(1), 1–8. https://doi.org/10.1093/intqhc/mzab043	To determine whether implementing the BCMA technology helped reduce medication preparation errors and/or the time spent on medication preparation and administration.	79 instances of 5,932 medication selection and dosing procedures were observed in a tertiary teaching hospital's mixed medical/surgical units.	Quasi-experimental study.	Implementing the BCMA technology helped reduce medication preparation and administration time spent and errors.	Level 6: A single descriptive or qualitative study.	The pre-post-test study design poses a limitation to the internal validity of the study.	Yes. The study helps identify the impact of using the BCMA on medication preparation, a crucial aspect of medication administration.
Ledlow, J. H., Judson, T., Watts, P., Vance, D. E., & Moss, J. (2022). Integrating a simulated electronic medical record system and barcode medication administration into a pre-licensure nursing program. *Journal of Professional Nursing, 40*, 38–41. https://doi.org/10.1016/j.profnurs.2022.02.008	To determine the effectiveness of using simulations to teach about BCMA.	96 students.	Observational study.	Using simulations to conduct education on BCMA increased realism and improved clinical preparedness.	Level 6: Evidence from a single descriptive or qualitative study.	Case studies used in the simulation programs were built by the faculty. No real-life case studies were utilized.	Yes. To inform findings on the effectiveness of using the simulation program to deliver education on BCMA technology.

Macias, M., Bernabeu-Andreu, F., Arribas, I., Navarro, F., & Baldominos, G. (2018). Outpatient care, medication errors, barcode medication administration. *ONF, 45*(1), E1–E13. https://doi.org/10.1188/18.ONF.E1-E13	To determine the impact of BCMA on the incidence of medication administration errors.	Seven hundred fifteen patients in an onco-hematology unit.	Pre-/postintervention study.	The use of BCMA technology helped to reduce the incidence of medication errors.	Level 6: Evidence from a single qualitative study.	Risk of bias.	Yes. To inform findings on the impact of implementing BCMA technology.
McBee, M., Kuhlmann, M., & Patterson, P. (2019). What you need to know about barcode medication administration. *Journal of Nursing & Interprofessional Leadership in Quality & Safety, 2*(2), Article 2. https://digitalcommons.library.tmc.edu/uthoustonjqualsafe/vol2/iss2/2	To provide an overview of the barcode medication administration (BCMA) technology and how it is utilized to prevent medication errors.	Ten articles.	A systematic review of the literature.	The findings explained how the BCMA technology prevents errors and the challenges in implementation resulting in workarounds.	Level 5: A systematic review of descriptive and qualitative studies design.	The study does not provide adequate summaries of the articles used.	Yes. The study identifies some issues with implementing the BCMA that nurse leaders can identify and deal with to promote its effectiveness in preventing medication administration errors.
Mulac, A., Mathiesen, L., Taxis, K., & Granås, A. G. (2021). Barcode medication administration technology use in hospital practice: A mixed-methods observational study	To gain insight from nurses on using the BCMA technology, identify deviations from	Forty-four nurses administered 884 medicatio	Mixed-methods design comprising structured observation	In more than half of the observations recorded, there was a deviation in BCMA	Level 6: Single descriptive or qualitative study.	Possibility of social-desirability bias from the nurses since they	Yes. It helps identify factors that can cause deviations

of policy deviations. *BMJ Quality and Safety, 30*(12), 1021–1030. https://qualitysafety.bmj.com/content/30/12/1021	BCMA policy and understand their causes.	ns to 213 patients in two medical wards at a 700-bed hospital.	and field notes, and nurses' comments.	policy deviations related to the organization, level of tasks, technology, environment, or nurses.		were aware that they were being observed.	when the BCMA technology is implemented to help identify and prevent them.
Rodziewicz, T. L., Houseman, B., & Hipskind, J. E. (2018). *Medical error reduction and prevention.* StatPearls Publishing.	To determine medication error reduction and prevention strategies.	Expert opinion.	Opinion of experts.	Medical errors are prevalent within the U.S. inpatient setting.	Level 7: Evidence from the opinion of expert committees.	Failed to specify the search and review process.	Yes. To help identify how BCMA technology can be used to reduce medication errors.
Strudwick, G., Clark, C., McBride, B., Sakal, M., & Kalia, K. (2017). Thank you for asking: Exploring patient perceptions of barcode medication administration identification practices in inpatient mental health settings. *International Journal of Medical Informatics, 105*, 31–37. https://doi.org/10.1016/j.ijmedinf.2017.05.019	To explore patients' perceptions of using BCMA to reduce medication administration errors in mental health facilities.	A convenience sample of 52 hospitalized patients in urban mental health facilities.	A qualitative descriptive approach.	The findings indicated that patients were concerned about aspects of the BCMA, such as information management, stigma, safety and comfort, and negative associations with technology.	Level 6: A descriptive and qualitative design.	Some patients' opinions and perspectives were not included as they were either too ill or did not have a good command of English.	Yes. The study gives patients within mental facilities a voice to express their opinions on using BCMA technology, an aspect of patient-centered care.

				The patients also indicated the need to be included in the BCMA process and make it more patient-centered.			
Strudwick, G., Reisdorfer, E., Warnock, C., Kalia, K., Sulkers, H., Clark, C., & Booth, R. (2018). Factors associated with barcode medication administration technology that contribute to patient safety: An integrative review. *Journal of Nursing Care Quality, 33*(1), 79–85. https://doi.org/10.1097/NCQ.0000000000000270	To identify how barcode technology can be used in medication administration to improve patient safety.	Eleven articles that focused on the use of BCMA technology were used.	An integrative review.	The findings indicated that using the BCMA technology helped reduce medication errors by fostering factors that promote medication safety.	Level 5: Systematic reviews of descriptive and qualitative studies.	The fundamental limitation is that the time frame in which the data on the BCMA was collected differed significantly for the 11 studies reviewed.	Yes. It provides information on how the BCMA can help reduce medication administration errors over different periods.
Tawfik, D. S., Profit, J., Morgenthaler, T. I., Satele, D. V., Sinsky, C. A., Dyrbye, L. N., Tutty, A. M., West. P. C., & Shanafelt, T. D. (2018). Physician burnout, well-being, and work unit safety grades in relationship to reported medical errors. *Mayo Clinic Proceedings, 93*(11),	To determine nurse-related factors that contribute to medication errors.	6,695 nurses and physicians.	Cross-sectional study.	Burnout, excessive fatigue, and well-being contribute to medication errors. Fear of response limit	Level 6: Evidence from a single descriptive study.	Failure to determine the causality of the observed associations.	Yes. To inform findings on nurse-related factors contributing to medication errors and factors affecting

1571–1580. https://doi.org/10.1016/j.mayocp.2018.05.014				willingness to report medication errors.			reporting errors.
Thomas, L., Donohue-Porter, P., & Fishbein, J. S. (2017). Impact of interruptions, distractions, and cognitive load on procedure failures and medication administration errors. *Journal of Nursing Care Quality, 32*(4), 309–317. https://doi.org/10.1097/NCQ.0000000000000256	To determine the impact of interruption, distractions, and cognitive load on medication administration errors.	Nine hospitals with 200 or more beds, 30 beds or greater unit size, and an average stay of 2-7 days.	Direct structured observation.	Interruptions, distractions, and cognitive load contribute to medication errors.	Level 6: Evidence from a single qualitative study.	Risk of social-desirability bias.	Yes. To inform findings on how distractions and interruptions cause medication errors.
van der Veen, W., Bemt, P. M., Bijlsma, M., Gier, H. J., & Taxis, K. (2017). Association between workarounds and medication administration errors in Barcode-assisted medication administration: Protocol of a multicenter study. *JMIR Research Protocols, 6*(4), Article e74. https://doi.org/10.2196%2Fresprot.7060	To determine the association of workarounds with medication errors in the BCMA process.	Six thousand drug administrations in internal and surgical wards of four hospitals.	Direct observation.	Workarounds contribute to medication errors in BCMA technology.	Level 6: Evidence from a single descriptive or qualitative study.	Risk of social-desirability bias during observation.	Yes. To inform findings on the challenges associated with the BCMA process.
Wei, H., Sewell, K. A., Woody, G., & Rose, M. A. (2018). The state of the	To determine the state of nurse work	A review of 54 studies.	Systematic review with	Helped identify the aspects of the	Level 5: evidence from	No primary data was collected.	Yes.

science of nurse work environments in the United States: A systematic review. *International Journal of Nursing Sciences, 5*(3), 287–300. https://doi.org/10.1016/j.ijnss.2018.04.010	environments in the U.S.		narrative synthesis.	nurse work environment in the U.S. that are healthy and unhealthy.	systematic reviews.		To inform findings on systemic factors that contribute to medication errors.
Xie, N., Kalia, K., Strudwick, G., & Lau, F. (2019). Understanding mental health nurses' perceptions of barcode medication administration: A qualitative descriptive study. *Issues in Mental Health Nursing, 40*(4), 326–334. https://doi.org/10.1080/01612840.2018.1528321	To understand the perception of mental health nurses of the BCMA technology.	A convenience sample of 10 nurses in a large mental facility.	A qualitative descriptive study.	The findings indicated that the nurses considered factors associated with safety, accountability, clinical workflow, education, and strategies when using the BCMA to prevent medication errors in mental health facilities.	Level 6: A single qualitative descriptive design.	The sample used was relatively small for a facility with over 800 nurses.	Yes. The findings help to explain the perceptions of mental health nurses on the use of BCMA technology.
Yuan, C. T., Nembhard, I. M., & Kane, G. C. (2020). The influence of peer beliefs on nurses' use of new health information technology: A	To determine how peer beliefs influence the adoption of technology.	Six clinical units of a hospital.	Qualitative study using surveys.	Peer beliefs reinforce the likelihood of nurses embracing and	Level 6: Evidence from a single descriptive	Risk of bias.	Yes. To inform findings on the role of peer support

social network analysis. *Social Science & Medicine, 255,* Article 113002. https://doi.org/10.1016/j.socscimed.2020.113002				utilizing technology.	or qualitative study.		when implementing the BCMA technology.
Zheng, W. Y., Lichtner, V., Dort, B. A., & Baysari, M. T. (2021). The impact of introducing automated dispensing cabinets, barcode medication administration, and closed-loop electronic medication management systems on work processes and safety of controlled medications in hospitals: A systematic review. *Research in Social and Administrative Pharmacy, 17*(5), 832–841. https://doi.org/10.1016/j.sapharm.2020.08.001	To determine the impact of BCMA on medication administration in hospitals.	16 articles.	A systematic review of the literature.	As BCMA contributes to reducing medication errors, it is important to take measures to safeguard against the inappropriate use of controlled medications in the inpatient setting.	Level 5: Evidence from systematic reviews of descriptive and qualitative studies.	No primary data was collected.	Yes. To inform findings on benefits and challenges of the BCMA technology.

Appendix C: Data Summary and Analysis

Color Code	Theme	Articles	Main Findings
Blue	Causes of medication errors in inpatient health settings	Hammoudi et al. (2018), Wei et al. (2018)	Most medication errors are caused by systemic factors such as medication packaging, nurse-physician communication breakdown, inadequate nurse staffing, pharmacy processes, inadequate staffing, and transcribing issues.
		Rodziewicz et al. (2018), Tawfik et al. (2018)	Fear of consequences, the response from the administration, and fear of punishment keep nurses from reporting medication errors.
		Dyre et al. (2022)	Conceptualization of errors impacts reporting.
		Anderson et al. (2018), Rodziewicz (2018)	Nurse-related factors that cause medication errors; include lack of competence, inadequate communication, poor teamwork, and negative attitude to safety practices.
		Eid et al. (2022), Johnson et al. (2017), Thomas et al. (2017)	Unhealthy working environment, medication administration disruptions, and lack of workplace etiquette.
Yellow	The impact of implementing the BCMA technology	Fuller et al. (2022), Hutton et al. (2021)	Reduction of errors caused by both systemic and individual factors. Creating optimal conditions of medication administration.
		Macias et al. (2018), Küng et al. (2021) Strudwick et al. (2018), Xie et al. (2019)	Reduction of time spent on medication administration. Creating a culture that prioritizes patient safety.
		Baiden (2018)	Enhances accountability.
		Fuller et al. (2022), Van der Veen et al.	Challenge of workarounds when BCMA technology is implemented.

		(2017), McBee et al. (2019)	
Green	Methods to enhance the effectiveness of the BCMA technology	Jessurun et al. (2021), Baiden (2018), Dykes and Chu (2021)	Nurse involvement to enhance satisfaction, contentment, and compliance.
		Hong et al. (2021), Mulac et al. (2021), Darawad et al. (2019)	Involvement of nurses in decision-making.
		Darawad et al. (2019), Booth et al. (2017), Zheng et al. (2021), Yuan et al. (2020)	Comprehensive education for the nurses.
		Zheng et al. (2021), Craig et al. (2021), Ledlow et al. (2022), Angel et al. (2016), Strudwick et al. (2017)	Use of simulation to deliver education and training.

Appendix D: CITI Certificate

Appendix E: Institutional Review Board Approval Letter

LIBERTY UNIVERSITY.
INSTITUTIONAL REVIEW BOARD

December 28, 2022

Kali Brown
Sharon Kopis

Re: IRB Application - IRB-FY22-23-634 REDUCING MEDICATION ERRORS IN INPATIENT HOSPITAL SETTINGS BY IMPLEMENTING THE BCMA TECHNOLOGY: AN INTEGRATIVE REVIEW

Dear Kali Brown and Sharon Kopis,

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds that your study does not meet the definition of human subjects research. This means you may begin your project with the data safeguarding methods mentioned in your IRB application.

Decision: No Human Subjects Research

Explanation: Your study is not considered human subjects research because it will not involve the collection of identifiable, private information from or about living individuals (45 CFR 46.102).

Please note that this decision only applies to your current application. Any modifications to your protocol must be reported to the Liberty University IRB for verification of continued non-human subjects research status. You may report these changes by completing a modification submission through your Cayuse IRB account.

If you have any questions about this determination or need assistance in determining whether possible modifications to your protocol would change your application's status, please email us at irb@liberty.edu.

Sincerely,

G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
Research Ethics Office