ABSTRACT

IMPLEMENTATION OF BARCODE MEDICATION ADMINISTRATION (BCMA): EVALUATING MEDICATION ERRORS AND THE IMPACTS OF TRANSITION TO BCMA IN A HOSPITAL SETTING

Medication errors are preventable events that affect patient safety. Hospitals have implemented barcode medication administration (BCMA) technology to prevent and reduce these errors. However, the errors still occur as is the case in the rural hospital which served as the study setting. This retrospective study involved reviewing medication errors data before and after the implementation of BCMA at the medical-surgical unit and intensive care unit of the rural hospital and determine the factors contributing to the errors. The study was guided by Kurt Lewin's change theory. Data on medication errors was collected from the hospital's electronic health records. Pre-BCMA implementation data was collected for the period between 2003 and 2006 while post-implementation period was covered by the period between 2015 and 2019. The findings indicated that there were 219 medication errors pre-BCMA, which reduced to 100 in the post-BCMA period. However, some types of errors persisted post-BCMA. The top contributing factors for the errors included inappropriate action or inaction, failure to follow policies and procedures, and lack of knowledge, training, and education. The hospital should address these contributing factors to further reduce the incidences of medication errors. The study should be replicated in other facilities to achieve generalizability of the findings. Further research should also determine the best way of addressing the contributing factors.

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IMPLEMENTATION OF BARCODE MEDICATION ADMINISTRATION (BCMA): EVALUATING MEDICATION ERRORS AND THE IMPACTS OF TRANSITION TO BCMA IN A HOSPITAL SETTING

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CHAPTER 1: INTRODUCTION

Medication errors are preventable events. The problem of interest was medication administration errors (MAE) and the rates at which these events occur. The change and transition in the workflow from manual medication administration to electronic barcode medication administration (BCMA) has significant implications on nurses and patients. Although BCMA has been implemented across many different healthcare organizations to reduce medication error events, MAE continues across many healthcare institutions. The errors also manifest in hospitals in rural settings such as the one that served as the site of the current project.

Despite BCMA being in place, MAE continues to occur and remains a crucial aspect to address. Medication error-related injuries continue to happen to this day, despite advanced features and technical parameters implemented to ensure patient safety. As such, appropriate steps and actions must be taken to prevent mistakes from occurring. Medication errors are a concern as they lead to devastating outcomes such as patient mortality. "In 1999, death due to medication errors became the 8th leading cause of mortality in the United States" (Gann, 2015, p. 60). Many different initiatives were created to minimize and reduce medication errors. For example, implementing the five rights process, which includes the right patient, right drug, right dose, right route, and right time, was initiated to improve patient medication administration safety. The five rights became clear checkpoints to be utilized by frontline nurses in medication administration to help prevent medication errors from occurring. The five rights process is a systematic checkpoint method designed as a safety guardrail for medication administration. Today, these five rights have been incorporated as

safety features in the electronic health record (EHR) systems through the process of BCMA. BCMA has been considered as an innovative method and process in administering medications using the system electronically to prevent medication errors.

Background

The occurrence of MAE is not new and has long been an issue that remains a topic for discussion at a national and global level. The World Health Organization (WHO) ranks medication errors as third on the list of the most prominent patient safety concerns (WHO, 2021). Medication errors have long been an issue that healthcare organizations have struggled to minimize or eliminate. The use of the BCMA has significantly contributed to the reduction of the incidences of MAE; however, the question remains as to why medication errors are still happening, even at a lower rate with established barcoding technology.

A rural hospital in the San Joaquin Valley was the selected research setting location because of its outlying area and its community. This local hospital implemented an electronic health record (EHR) in 2006 and launched the barcoding medication administration project in 2014. While barcoding may have reduced the incidences of MAE using the BCMA process, compared to its history, medication errors continue to be reported post BCMA implementation at the local rural hospital. The numbers of errors are less today than years past; however, a medication error is an error and remains significant enough to be addressed due to the impact on injury or even patient mortality. The fact that medication errors occur and can affect the patient and their progress of health strikes a compelling interest in investigating the issues and further improving the process of medication

safety and care for all the patients at the local hospital. The community hospital serves a large minority population of agricultural and farm labor workers, and therefore the opportunity to improve the care this community receives holds great importance. This research focused on identifying the gaps of the local hospital's issues on medication errors that continue to occur although the barcoding mechanism has been implemented.

Project Statement

Although healthcare industries have designed technology with enhanced parameters to reduce errors, it is troubling to discover that medication errors continue to exist. This project intends to bring to light the issues of MAE and address why these errors continue to occur and negatively impact patient medication safety, despite the transition from manual documentation to BCMA technology. BCMA is intended to reduce error rates and improve medication safety for all inpatients throughout the duration in the hospital setting. Moreover, this project evaluated and reviewed pre-and post-outcomes of medication error rates in the transition to BCMA. The main objective was to review MAE data before EHR implementation from 2003-2006 and data post-BCMA implementation from 2015-2019. The study also considered workflow changes from paper-based medication administration to BCMA, which impacted both healthcare professionals and patients. This project focused on the new transition from the old to the new workflow, evaluated medication error data occurrences retrospectively, and reviewed the data outcome post-BCMA to examine whether MAE rates have improved in the new transition. This project helped to refine the methods of medication administration and target for the reduction in error rates.

Theoretical Framework

The study was guided by Kurt Lewin's change theory. Kurt Lewin is acknowledged as the "founding father of change management" (Cummings, Bridgman, & Brown, 2016, p. 69) and the "original thinker in the process of change" (Heim, 1978, p. 238). Kurt Lewin's change theory's assumptions consist of three stages: unfreeze, movement, and refreeze (Cummings et al., 2016; Kaminski, 2011; Manchester et al., 2014).

Lewin's change theory applies overall to this project focused on MAE as it reflects changes from paper-based to electronic-based medication administration. This study intends to identify the elements of failures that inhibit the new medication process, BCMA, to be successful in preventing harm and injury during the administration of medication. The change theory concepts apply to the new workflow. It provides an opportunity for gap analysis in each step in the transition, and it helps to identify the impact on medication error rates.

As mentioned in the study by Manchester et al. (2014), Kurt Lewin's theory of change explains the three-step phases of change, which include unfreezing, movement, and refreezing (Manchester et al., 2014, p. 82). Unfreezing is the detachment from the existing workflow or method. For instance, we will need to unfreeze the old paper-based medication administration procedure and disrupt the old workflow. According to Kritsonis (2005), for change to take effect, it is necessary to unfreeze the existing routine or previously established status quo and gravitate towards embracing the new recognized standard workflow or method. Therefore, the initial step is unfreezing the known old standard of paper-based administration and refreezing the new standard on medication documentation.

At the same time, Lewin's operational framework on force field analysis comes into play, which focuses on the "driving and restraining forces that

influence any change that may occur" (Kaminski, 2011, para. 10). There needs to be an increase in the driving force established away from the previous existing method (Kritsonis, 2005). The driving forces are the nurses' positive support for the new transition, and the positive effects of knowing patient safety are the benefits of this change. Also, there needs to be a decrease in the restraining or resistant forces that impact change negatively (Kritsonis, 2005). It is essential to identify and address the elements of resistance among the nurses. Further, it is important to outline the reasons for the change and the purpose of safe medication administration procedures. The equilibrium will then need to be re-established for the new standard or workflow change.

All of the elements in the change process previously mentioned are coinciding, and as the movement phase takes place, an introduction to the new changes occur. In the movement phase, it is crucial to persuade and convince the target audience that establishing the latest switch as the new standard is the best and most appropriate decision for the organization (Kritsonis, 2005). In this case, patient medication safety is the priority. The benefits and goals of this new way are the proper methods for the organization. Imparting that the importance of the change is essential, and therefore, all stakeholders must understand why the acceptance of the new standard is necessary.

Refreezing is the last phase in which the new changes will be stabilized, sustained, and reinforced (Kritsonis, 2005). Incorporating the transition into the policies or procedures as the importance becomes the documented protocol to follow. This phase implements standards to keep nurses accountable in following proper institution procedures for BCMA. In this manner, the new workflow or method is officially institutionalized and recognized as the standard. Continued

reinforcement will need to be necessary to ensure no backsliding occurs towards previous processes or unauthorized workflows.

Lewin's change theory was relevant to this study because it focuses on transition and adaptation to the new workflow. The change theory concepts are suitable because it outlines the necessary elements to sustain the newly established workflow for BCMA. The concepts of force field theory apply as well, suggesting positive forces promoting change or negative forces inhibiting and resisting change through the development of unauthorized workflows outside of the standard. The concept of force field applies as both positive and negative forces are evaluated in this project, and therefore, analyzing the process for new changes impacts patient safety parameters.

Kurt Lewin's theory of change concepts and force field analysis framework serve as a foundation for the intended MAE project. It aids in explaining the process of change on healthcare professionals and their workflow and the intricacies in the transition from manual paper medication administration to BCMA. Lewin's three phases and extension on force field analysis is what defines the classic theory of change. The concepts are simple and can apply in many different aspects within society, organizations, groups, workflows, etc. Ultimately, this project serves to find a resolution for MAE and improve medication safety.

Summary

Medication errors are not isolated only to local or rural surrounding community hospitals. They also occur in other large healthcare organizations across the nation and are globally recognized by WHO as a significant patient safety issue. Medication errors impact patient safety outcomes emphasizing the importance of targeted improvement interventions. Despite BCMA

implementation and its significant role in system alert features to avoid potential medication errors and harm, MAE is a common factor that remains an issue in different parts of the country. Therefore evaluating, reviewing, and analyzing the occurrences of MAE and the workflow in consideration of Lewin's theory of change at one local rural hospital will help bring forth significant findings associated with error events and ultimately be recognized to help improve patient medication administration safety. The next chapter presents a review of published literature on the causative factors of medication errors and the gaps that need to be addressed to mitigate MAE issues.

CHAPTER 2: LITERATURE REVIEW

Medication errors are still a major patient safety concern despite the adoption of BCMA technology. Examining existing literature on MAE and the use of technology points out that additional research and investigation are necessary to reduce these types of preventable errors. According to Shahrokhi et al. (2013), medication errors are the most common healthcare issue. Medication errors are preventable sentinel events (Bowers et al., 2015). MAE has significant implications on patient outcomes as they at times result in harm or death. The promotion of patient safety is a priority as healthcare professionals are entrusted with the primary role of promoting wellness and treating patients without causing any adverse effects on their safety, health, or hospitalization. Research has identified the common factors contributing to these errors as workarounds and poor system designs. Therefore, this project sought to identify those gaps and analyze data to address the issue.

Research studies, as well as interventional studies, have been implemented to assist in reducing MAE. However, there is a limited amount of research studies addressing MAE in relation to BCMA technology already established in institutions. Due to the complexity of collecting accurate data on medication errors, this barrier contributes to the limited research on the particular subject in addressing errors with BCMA components already set up. Identifying the gaps necessary to optimize BCMA workflow is key towards reducing medication errors.

Overview of Research Studies

This chapter includes an overview of research studies that have been conducted to address BCMA and medication errors in general. The selection

process and criteria for researching the most relevant journals and research studies are discussed to provide a balanced perspective of current information. The categorical themes among the literature point out the impacts of BCMA concerning medication errors. Several studies address and acknowledge the advantages of BCMA, disadvantages of developed workarounds, opportunities for improvement, and, lastly, MAE reporting issues regarding BCMA technology.

Criteria for Research Inclusion.

The main electronic databases used for searching published research evidence on the barcode medication administration and medication errors included Fresno State's online library database, PubMed, EBSCOhost, Cumulative Index of Nursing and Allied Health Literature (CINHAL), and Google Scholar. Fresno State's online library database system also searches within other shared databases of the Cal-State University (CSU) system, a great tool to search for valid and credible scholarly works throughout the University connected system. Keywords utilized for searches were medication administration errors, barcoding technology, and adverse drug events. The research articles selected and obtained through this literature review process primarily focused on data that contains BCMA technology and medication error-related events as the particular research subject.

Advantages of Barcoding Medication Administration

Several research studies address the advantages of BCMA. The driving factor for the implementation of BCMA has generally been recognized as reducing medication errors. A prospective study conducted by Drach-Zahavy et al. (2014) tested the effectiveness of four particular interventions on medication administration practice methods to reduce medication errors. The researchers

explored medication errors and concentrated on managing the issues and limiting the mistakes. The study included 360 nurses and included 76 departments (Drach-Zahavy et al., 2014). The results showed that supervisory learning practices reduced medication error incidences, while integrated patchy learning practices were associated with higher medication errors. However, the study may have been limited by bias since nurses were being observed during the medication process. Drach-Zahavy et al. (2014) concluded that the combination of learned and proper medication administration practices, reduced distraction, and supervision in the process played a role in effectively minimizing error.

In similar findings noted in a study by Henneman et al. (2012), the BCMA process generally reduced MAE occurrence; however, it does not eliminate the errors entirely. Henneman and colleagues conducted an observational study using an eye-tracking device in a simulated environment while nurses administered medications. The study consisted of 25 nurse participants and 50 patient scenarios. The study focused on medication errors and the actions nurses took during the process. Henneman et al. (2012) established that 84% of the nurses were able to identify the dose errors, while 19% identified the patient ID errors and did not administer the medication. However, 16% of nurses failed to recognize the medication issue and patient ID error and administered the drug. Unlike other studies that established a reduction of medication errors immediately after BCMA implementation, the research performed by Liao et al. (2017) in the medical intensive care unit (MICU) did not find an immediate reduction in errors until the second year post-BCMA implementation. The observational study evaluated 673 medication administration events. According to Liao and colleagues, there was an increase in administration errors in the post-implementation period compared to the pre-adoption of the EHR. For instance, the researchers noted 35% missed

doses and 18.9% of medications administered at the wrong time. Initially, no significant changes were recognized until two years later. Perhaps this may have been due to the adjustment and transition to incorporating technology in the medication administration process workflow.

Findings from research implemented by Thompson et al. (2018) supported the role of BCMA in reducing potential medication errors. The study involved an examination of medication errors pre-and post-implementation of BCMA and the electronic medication administration record (eMAR) process. A total of 775 medication events were reviewed in this study. The results demonstrated a significant decrease in medication errors after the adoption of BCMA. The results indicated a marginal reduction in medication errors from 0.26% pre-intervention to 0.20% post-intervention. Thus, consistent adherence to the recommended BCMA workflow process decreased these errors.

Although previous studies acknowledge that BCMA in general aids in reducing potential medication errors with consistent adherence to the designed administration workflow process, MAE continues to frequently happen regardless of established BCMA technology (Henneman et al., 2012; Kelly et al., 2016; Truitt et al., 2016). It is vital to view a balanced perspective on medication errors and to consider the data about the disadvantages found with BCMA implementation, as well.

Disadvantages and Developed Workarounds to Barcoding Medication Administration

Contrary to the advantages of BCMA, the disadvantages and developed workarounds surrounding the BCMA process is an important perspective to review. The development of workarounds is recognized as a common factor leading to medication errors (Henneman et al., 2012). The technical designs of

BCMA, such as the overriding features, allow nurses to bypass the system's safety guardrails, potentially opening the gates to errors and impacting safety.

Boonen et al. (2018) evaluated the nurse-patient relationship and primarily focused on observation and interview. This qualitative ethnographic study was conducted in the Netherlands in a 556-bed Dutch general hospital in the orthopedic department (Boonen et al., 2018). The participants consisted of 26 team members of various levels of experience, nursing skills, and training on BCMA. Boonen et al. found that nurses created significant workarounds to accommodate patient care needs and risk potential MAE occurrences, which indicates that the BCMA can become problematic when it comes to the medication administration process. The utilization of BCMA in this perspective is inflexible, and at times, patient concerns and involvement are limited and disregarded, therefore impacting the nurse-patient relationship.

Additionally, Van der Veen et al. (2018) conducted an observational study on MAE and BCMA, focusing on the associated types of workarounds and the frequency of these occurrences. Approximately "5793 Medication administrations for 1230 inpatients" were observed (Van Der Veen et al., 2018, p. 388). In evaluating the data, researchers utilized "univariate and multivariate multilevel logistic regression analysis" as well as descriptive statistics to determine results (Van Der Veen et al., 2018, p. 385). In the procedural workarounds observation, it was found that 36% of medications were not scanned at all, and 28% of drugs were not scanned due to patients without a wristband identifier (Van Der Veen et al., 2018). Incorrect medications were scanned, scanned multiple times, or alerts were ignored at 11% of the time (Van Der Veen et al., 2018). The wrong dose frequency was approximately 6%, non-ordered drugs administered at 8%, and common medication administration errors omitted was 78% (Van Der Veen et al.,

2018). The researchers concluded that procedural workarounds were observed and indicated that 36% of medications were not scanned due to patients with no wristbands. Again, deviations from standard workflow like these during the medication process bypass the safety parameters of BCMA. Notably, workarounds profoundly impact medication errors.

Samaranayake et al. (2012) likewise reviewed and analyzed medication incident reports over five years, ranging from January 2006 to December 2010, focusing on unintended errors with technology use. The study was conducted in a 1500-bed tertiary care hospital connected with the university located in Hong Kong (Samaranayake et al., 2012). The technology-related errors were categorized as device errors that originated from the design of the technology itself; and socio-technical errors, which involved human interaction in the use of technology in the medication process. According to Samaranayake et al. (2012), this "includes unintended errors such as slips, lapses, and mistakes by healthcare providers" (p.829). The severity scoring system using the ordinal scale from 0-6 was the tool utilized to review the incidences. The medication reported rates totaled 1538, which summed up to 17.1% of the technology-related occurrences, and 98.1% of these were socio-technical-related errors. Additional details and significant findings were also listed under other categories in the study. Overall, this study concludes that significant medication errors occurred through the medication processes of socio-technical aspect, which is impacted by the poorly created technology design.

In addition to the other studies addressing the perspective of workarounds, Xie et al. (2019) focused on understanding the nurses' perception of adopting BCMA in a mental health setting. Other studies have predominantly focused on non-mental health settings; however, the qualitative descriptive study performed

by Xie et al. interviewed ten mental health nurses. They concluded that there are minimal differences between mental health and non-mental health nurses' perceptions of BCMA adoption. Their findings suggested BCMA is acknowledged to reduce medication errors. However, there are similar considerations from the mental health nurse perspective in terms of creating workarounds and encountering the same challenges with the medication administration workflow that is not streamlined and leading to non-adherence in BCMA.

Workarounds appear to be the typical path for nurses to bypass the system during medication administration (Drach-Zahavey et al., 2014). However, nurses are less likely to bypass the system with a workaround when supervised and monitored. Drach-Zahavy and colleagues explored medication errors and focused on managing the issues and limiting the mistakes. The study included 360 nurses from 76 departments. The findings indicated that learning practices in the supervisory aspect influence the reduction in medication errors. The nurses' workflow, medication station environment, knowledge, and understanding of technologies should be considered in the administration of the medication process (Drach-Zahavy et al., 2014). Nevertheless, the perspective on the disadvantages of non-adherence to BCMA workflow and the deviation of created workarounds pinpoint that more in-depth analysis is necessary to address concerns relative to medication errors and BCMA.

Opportunities for Improvement to Barcoding Medication Administration

There are opportunities for further improvement on BCMA, as indicated from past research studies. Bowers et al. (2015) investigated the impact of barcode technology on the medication administration process with a specific focus on the improvements arising from the adoption of the technology. The study was

conducted in six units located in a Midwest hospital, which included three intensive care units (ICU) and three medical-surgical units (MSU) (Bowers et al., 2015). A convenience sample of 75 medication administration encounters was selected for each MSU and ICU unit. Bowers et al. collected data through direct observation and self-reporting via the safe event reporting system (SERS) method. A comparative design was utilized to assess pre- and post-implementation results. The findings indicated that BCMA can become a useful tool and provide the necessary guardrails for medication administration safety when proper adherence to workflow is enforced (Bowers et al., 2015). However, the study did not establish any significant change with barcode technology. Bowers et al. (2015) concluded that there are potential design improvement opportunities for barcoding that would impact patient medication safety through advances in technology.

Henneman et al. (2012) also found that BCMA has the potential to reduce medication errors. However, similarly to Bowers et al. (2015), their results indicated many improvement opportunities are still needed for the BCMA technology process. Henneman et al. pointed out that nursing workflow and medication administration with the use of technology must be streamlined to avoid the creation of workarounds. The researchers noted that nurses use workarounds to accommodate poorly designed technology methods, resulting in problematic situations and medication errors.

Additionally, Staggers et al. (2015) analyzed the usefulness in the design of BCMA in a Veteran Administration (VA) Hospital. The researchers focused on VA hospitals in the United States' Western areas, including 150 hospitals and 80,000 nurses. Staggers and colleagues reviewed the BCMA system's usability by using the Heuristic Evaluation (HE) tool, which three experts evaluated and scored. The researchers also evaluated the nurses' perceptions and the

understanding of using the electronic medication administration record (eMAR) task and BCMA process. According to Staggers et al. (2015), the study identified 99 problematic categories in usage and 440 usability violations. The usability issue ranking the highest out of the 15 categories. The issues that were considered as critically problematic included administration and charting of medications and comprehension of BCMA usage. Like Bowers et al. (2015) and Henneman et al. (2012), Staggers and colleagues found that further improvement to the BCMA process was needed. The medication administration process and workflow were not streamlined and have become disjointed within the EHR of the VA hospital. These factors were identified to cause nurses to deviate outside the recommended workflow.

Along with other literature focused on improvement opportunities for BCMA, Novak (2012) finds that BCMA requires optimization. In a qualitative ethnographic designed study, Novak (2012) uncovered that additional work and tasks considered problematic were added to the nurses' medication administration workflow upon implementing the BCMA process. This study was completed in an academic medical facility, in which Novak researched ten inpatient units. Novak (2012) primarily focused on the nurses' ability to adapt and integrate the new BCMA workflow with the existing medication process. The results demonstrated that BCMA workflow was not completely understood, which obscured additional work, making the new BCMA medication process challenging to follow. The new BCMA process contributed different issues to an already complicated medication process that is not entirely understood.

Overall, these studies indicate that further improvements must be made in the use of BCMA technology. Aspects such as streamlining the nursing routine workflow and the medication process require alignment to avoid deviation from

the designed workflow. The implementation of BCMA alone does not eliminate the issue of medication errors, and therefore, must be improved.

Medication Error Reporting Issues

Recognizing and reporting medication errors is essential to ensure quality and safe patient care. Nurses are responsible for identifying and reporting problems or issues that may lead to medication errors. Process improvement must be recognized as a positive preventative measure to help avoid other potential mistakes in the future and not as a punitive factor.

Hammoudi et al. (2018) conducted a descriptive cross-sectional study at a public hospital in Saudi Arabia to assess the reporting of medication errors and the circumstances from the nurses' perspective. A convenience sample of 367 nurses was used in the study, and data was collected through a six-point Likert scale questionnaire and 10-point scale to estimate error percentages. The survey included approximately 65 questions on the causes, reasons, reporting, and not reporting of MAE. The study findings indicated that various factors were associated with MAE including communication issues, packaging labels on medication, nurse staffing, and transcribing issues. Further, the key barriers to reporting MAE was fear of punishment and administrative discipline (Hammoudi et al., 2018). Medication error reporting is an issue that leads to inaccurate data and adversely impacts patients. Hammoudi et al. (2018) demonstrates there is hesitancy by nurses to report medication errors because of fear and consequences. Encouraging staff to report medication errors and view the reporting process as an excellent benefit to improve patient safety can help decrease medication error events.

Similarly, Treiber and Jones (2018) established that nurses were hesitant to report medication errors due to the stigma of blame and punishment. The descriptive mixed-methods study was conducted among 169 Bachelor of Science in Nursing (BSN) nurses between 2009 and 2013. The findings indicated that approximately 55% of the nurses had made a medication error in their career. However, 24% of the nurses did not report the error due to fear.

Yung et al. (2016) also explored nurses' barriers to reporting medication errors. The researchers conducted a cross-sectional descriptive study to evaluate nurses' perception and attitudes to medication error reporting. The questionnaire survey was given to 306 nurse participants. The study's finding indicated that fear was a significant factor in under-reporting medication errors because of administrative punishments. According to Yung et al. (2016), 88.6% of the nurses reported medication errors verbally, while 19.0% reported medication errors electronically through the hospital's local system. Overall, medication administration error under-reporting was identified as a significant concern and impacted patient safety.

Medication error underreporting is an issue that leads to inaccurate data and adversely impacts patients and quality improvement efforts. Studies by Hammoudi et al. (2018), Treiber and Jones (2018), and Yung et al. (2016) demonstrate there is hesitancy by nurses to report medication errors because of fear and consequences. Encouraging staff to report medication errors and view the reporting process as an excellent benefit to improve patient safety can potentially help decrease medication error events.

Summary

The reviewed literature has addressed many different aspects of MAE, which are valuable in supporting future studies. The reviewed studies adopt different methods including qualitative designs exploring practitioners' perspectives on medication errors and workarounds and quantitative designs focusing on specific frequencies in medication administration failures and mistakes. The findings from the reviewed studies show that MAE is a common occurrence in hospital settings, necessitating further investigation to enhance and improve safe medication administration. The studies have addressed the advantages of BCMA in potentially reducing medication errors. At the same time, there are disadvantages and workarounds that have been pointed out as one of the main concerns leading to medication errors. A review of the literature indicates there is an opportunity to improve the BCMA process, which can be enhanced to reduce MAE and create a more robust BCMA system. Although similar topics on MAE have been discussed in the literature, this study helps to increase knowledge in this field by addressing the transition from paper administration process to electronic barcoding process. This study contributes additional information to this field of interest.

CHAPTER 3: METHODOLOGY

This chapter presents the research methods adopted to determine the frequency and occurrences of MAE events. The study adopted a retrospective approach where data on historical medication errors primarily reported by nurses and other hospital staff through incident reporting was collected. The data was analyzed using chi-square test analysis to identify the categories of common occurrences of MAE at the study settings. This chapter discusses the research method elements consisting of the setting, sample, data collection, data analysis and measurement, validity concerns, and ethical considerations.

Setting

The study was conducted in a rural hospital located in the Central Valley. The hospital is a non-profit healthcare organization that provides full services from emergency, medical-surgical, pediatrics, obstetrics, and intensive care unit specialties. The organization has a total capacity of 156-beds, and this serves approximately ten other outlying rural area communities. This study involved the collection of historical medication error data in an acute inpatient care setting. The data collection efforts focused on the Medical-Surgical Unit (MSU) and the Intensive Care Unit (ICU). This study differs from other research studies due to its hospital community-based rural area location, which serves the local community and other outlying towns in the area. This setting was unique because of the patient population dynamics, which includes many underserved individuals in the community. Collecting research information from this setting, location, and environment adds to the literature in terms of addressing pertinent information related to medication errors in the context of a rural community that can be used for future research.

Project Design

The project adopted a retrospective research design, which is used to investigate specific outcomes by evaluating historical data. Retrospective studies are conducted as an audit tool for comparing historical data with current or future practice (Powell & Sweeting, 2015). In the study, retrospective data on medication errors at the rural hospital was obtained from the Outcomes Department database. The intent was to retrieve an electronic version of the incidence report. However, with the system issues and limitations, obtaining the data in an electronic form data was not possible. Therefore, information was obtained via PDF file format. All data within the document was entered individually and manually into an abstract tool (see Appendix A) uniquely created for this research purpose. The data was arranged and coded accordingly. The initial data request was to obtain data five years before Electronic Health Record (EHR) implementation, which was estimated to be from 2001 to 2006. However, according to the outcomes department designee, no records were found before 2003 on medication errors reported. Hence, this limited the data obtained from 2003 to 2006. Additionally, data from 2015 to 2019 was available in the records and was gathered. All data were categorized by theme and similar error type issues, which were grouped accordingly.

Study Sample

The study sample included a total of 319 retrospective medication administration errors that have taken place in the acute care unit in the rural hospital. The data was retrieved from the Department of Outcomes, and the researcher was provided access to the medication error records. The population consisted of the historical MAE data reported from the MSU and the ICU departments. At least four years of MAE data, pre and post-implementation of

BCMA, were anticipated to be reviewed, which includes error events prior to the EHR/Barcoding Medication Administration (BCMA) system and data four years after BCMA implementation. The four-year period was selected based on the knowledge that the BCMA was launched in 2014, and data was available from 2015 to 2019. However, the researcher experienced obstacles in obtaining retrospective data on medication error events before the EHR/BCMA system due to the medication administration process being on paper at that time. The retrospective data before EHR/BCMA became limited and narrowed data collection from 2003 to 2006. As such, the pre-implementation data focused on medication errors reported between 2003 and 2006. The retrieval of data after BCMA, on the other hand, focused on medication error events from 2015 to 2019. The MAE data collected involves three years before the EHR implementation and data five years after the BCMA implementation.

The study intended to obtain any available retrospective data on MAE within the selected time frames. The sample differs from other research studies, focusing on the workflow change from manual paper-based medication administration to the electronic version known as barcoding. The changes occurring during the transition from an old to a new process, BCMA, impacted both nurses and patients when proper steps were not carried out appropriately. The crucial elements of learning new processes and adhering to the proper medication administration transition workflow significantly impact MAE occurrence. Therefore, making the issue of MAE essential to address.

Data Collection

The data collected consists of retrospective medication error data recorded in the Department of Outcomes at the selected facility. To maintain MAE

information privacy, the researcher was the only one allowed to access to obtain the data. Data collection was done after appropriate facility and Fresno State University Institutional Review Board (IRB) approval. The collection of retrospective data and abstraction took an estimated three months, in which a few obstacles were encountered. For instance, due to system issues which made it challenging to obtain data in an electronic form from the system, a manual process in data abstraction was utilized by reviewing a PDF file log of recorded MAE events. The collected data was categorized accordingly by department, type of error event, contributing factor, and severity. The data obtained was placed in an abstracted data spreadsheet, categorized by theme, and appropriately scored with an indicator of one, signifying a valid medication error count. In this analysis method, each medication error event was reviewed and evaluated individually. Through this analysis, the errors arising from process failure and breakdown were identified in the workflow. Each medication error event and the contributing factor was assessed to identify gaps in the transition to BCMA. The analysis also involved evaluating whether BCMA reduced medication error events. The medication error data analysis brought to light the gaps identified. The provided data elements and results led to the development of a proposed resolution and focused on the implementation of only authorized safety standards as well as approved medication administration workflow expectations.

Validity Concerns

The validity concerns arising in the study are related to the data on incidences of medication errors at the facility. There was a possibility of under-reporting of medication errors by hospital staff, which may have skewed the data analysis of this study. According to Hammoudi et al. (2018), reporting of

medication errors was recognized as an issue that impacted the statistics and accuracy of tracking MAE data. Similarly, Treiber and Jones (2018) also acknowledged that underreporting of medication errors resulted from the stigma of blame. Therefore, fear is an obstacle to correctly reporting such errors. The reason for unreported error incidences was the related punitive actions. Consequently, it is not uncommon for healthcare staff to withhold reporting such errors. Thus, the concerns for completeness and inclusion of all medication errors impact the total medication error data accuracy.

Ethical Consideration

Approval to conduct the study at the rural hospital was acquired from the hospital's administration. The researcher presented and discussed the purpose of the study with the Adverse Drug Event Prevention Team (ADEPT) committee meeting led by the Pharmacy Director. The researcher also obtained a signature of approval from the President, Chief Nursing Officer (CNO), and Pharmacy Director.

The California State University of Fresno (CSUF) Institutional Review Board (IRB) also approved the research after proper review and evaluation of the study. The data obtained for the study was securely stored and kept confidential by the researcher. The data used for the analysis were free of patient identification and demographic information. The data obtained strictly focused on medication error events that did not require any linked patient data.

Summary

The study adopted a retrospective approach whereby pre- and post-BCMA data on medication errors from an acute care unit of a rural hospital was analyzed. Pre-implementation data focused on the 2003 to 2006 period while the post-

BCMA data focused on the 2015 to 2019 timeline. The approach helped determine the medication error frequencies and the significance of determining the associated root causes for these errors. This study's methodology design helped uncover why medication errors remained a common issue despite the safety guardrails associated with BCMA implementation. The method helped confirm and identify the regular presence of medication errors, bring forth the identified gaps in workflow, and develop resolutions to avoid future incidences of MAE. The study adhered with pertinent ethical considerations.

CHAPTER 4: RESULTS

The retrospective data collected were analyzed and reviewed, and different categories associated with medication error events were compared. The purpose was to compare the frequency of MAE before and after the electronic barcoding implementation and examine the rate at which MAE errors continue to occur post BCMA. The data consisted of 319 medication error events reported from the MSU and ICU setting from 2003 to 2006, before electronic barcoding implementation, and data from 2015 to 2019 after BCMA implementation. All data collected were historical medication error incidences from the institution and were submitted by hospital staff and nurses. This chapter presents the data analysis approach and method adopted in the study. The chapter also presents an analysis comparing associated MAE data from both MSU and ICU departments, the type of frequency error events, the severity of MAE occurrences, and the contributing factors discovered to be associated with MAE pre-and-post-BCMA implementation.

Data Analysis and Method

The chi-square test was performed through SPSS to calculate the statistical significance. The analysis sought to determine whether the categorical groups were significantly associated with one another and medication errors. Analyzing the data helped infer if there were any differences between MAE frequency before and after BCMA. The Chi-square test results illustrate a statistical significance based on the Pearson Chi-Square test p-value of 0.001, which is less than 0.05, indicating an association and rejecting the null hypothesis that there is no relationship between the categorical variables. Table 1 displays the results of the Chi-Square test analysis. The results indicated that there is a significant relationship between BCMA and medication error events ($p < 0.001$).

Table 1

Chi-Square tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	27.422a	9	0.001
Likelihood Ratio	27.975	9	0.001
N of Valid Cases	319		

10 cells (50.0%) have expected count less than 5. The minimum expected count is .31.

Table 2 provides the data value frequency count on the Type of Error Event and the percentages that these errors occurred. The results showed a total of 219 MAE pre-implementation of BCMA. Further, the results indicated that there were zero incidences of adverse drug reaction pre-implementation of BCMA. However, there were errors of omission (29.7%), wrong dose (23.7%), and wrong drug (8.75), wrong frequency (0%), wrong patient (4.1%), wrong preparation (0.9%), wrong rate (0.5%), wrong route (2.3%), and wrong timing (30.10%). An increase was noted in some of the errors in the post-BCMA period including adverse drug reaction (5%), wrong frequency (1.0%), wrong patient (9.0%), wrong preparation (2.0%), and wrong rate (3.0%).

Figure 1 depicts the type of error event frequencies, which compares the data before BCMA and data after BCMA on the bar graph. Based on the analysis of the chi-square test results, there is an association within the categorical groups of the study. Figure 1 illustrates a decrease in the frequencies of medication error event occurrences after-BCMA implementation. At the same time, Figure 1 provides the percentages of frequency occurrences found in each Type of Error Event reported in the data.

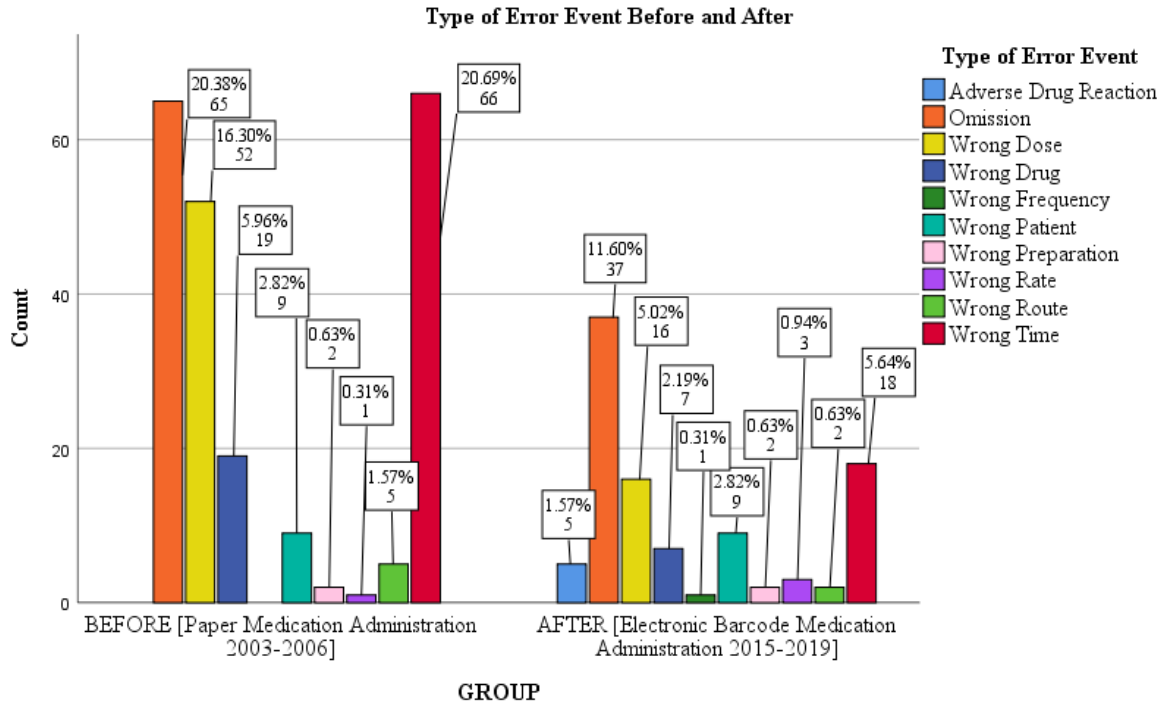
Table 2

Type of error event before and after

		Adverse Drug Reaction	Omission	Wrong Dose	Wrong Drug	Wrong Frequency	Wrong Patient	Wrong Preparation	Wrong Rate	Wrong Route	Wrong Time	Total
BEFORE	Count	0	65	52	19	0	9	2	1	5	66	219
	Expected Count	3.4	70	46.7	17.8	0.7	12.4	2.7	2.7	4.8	57.7	219
	% within GROUP	0.00%	29.70%	23.70%	8.70%	0.00%	4.10%	0.90%	0.50%	2.30%	30.10%	100.00%
	% within Type of Error Event	0.00%	63.70%	76.50%	73.10%	0.00%	50.00%	50.00%	25.00%	71.40%	78.60%	68.70%
	% of Total	0.00%	20.40%	16.30%	6.00%	0.00%	2.80%	0.60%	0.30%	1.60%	20.70%	68.70%
AFTER	Count	5	37	16	7	1	9	2	3	2	18	100
	Expected Count	1.6	32	21.3	8.2	0.3	5.6	1.3	1.3	2.2	26.3	100
	% within GROUP	5.00%	37.00%	16.00%	7.00%	1.00%	9.00%	2.00%	3.00%	2.00%	18.00%	100.00%
	% within Type of Error Event	100.00%	36.30%	23.50%	26.90%	100.00%	50.00%	50.00%	75.00%	28.60%	21.40%	31.30%
	% of Total	1.60%	11.60%	5.00%	2.20%	0.30%	2.80%	0.60%	0.90%	0.60%	5.60%	31.30%

Figure 1

Type of error event before and after



Although the data confirms a significant decrease in MAE from pre-to - post-BCMA, medication errors continued to occur after BCMA in place. Therefore, these results prompted further interest in examining and exploring the reasons for these occurrences, which has granted more opportunities to scrutinize the details of the data obtained in the following sections.

Comparing Medication Error Event Frequency in MSU and ICU

Upon reviewing the department category of MSU and ICU, the retrospective data displayed more MAE occurrences in MSU compared to the ICU. Table 3 displays the chi-square test calculated results on the aggregated data, total frequency count, and percentages comparing MSU and ICU departments. The chi-square test was used to analyze both departments and medication errors. However, in this case, the Pearson chi-square p-value resulted as 0.166, larger than 0.05, indicating acceptance of the null hypothesis, which means the categorical groups by department and medication errors have no association to one another. The chi-square test results point out that MSU medication error data and ICU medication error data are independent of one another.

Table 3

Medication error frequency by department

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	1.919[a]	1	.166		
Continuity Correction[b]	1.527	1	.217		
Likelihood Ratio	1.870	1	.171		
Fisher's Exact Test				.179	.109
N of Valid Cases	319				

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 20.38.
b. Computed only for a 2x2 table

Table 4 breaks down the frequency of medication errors by department. The results show that a total of 40 and 179 MAE occurred in the ICU and MSU, respectively. The pre-BMCA percentage of errors within the group was 18.3% and 81.7%, respectively. In the post-BCMA period, 25 and 75 MAE were recorded in the ICU and MSU, respectively. This represented 25% and 75% within group, respectively.

Table 4

Medication error frequency by department

Crosstab

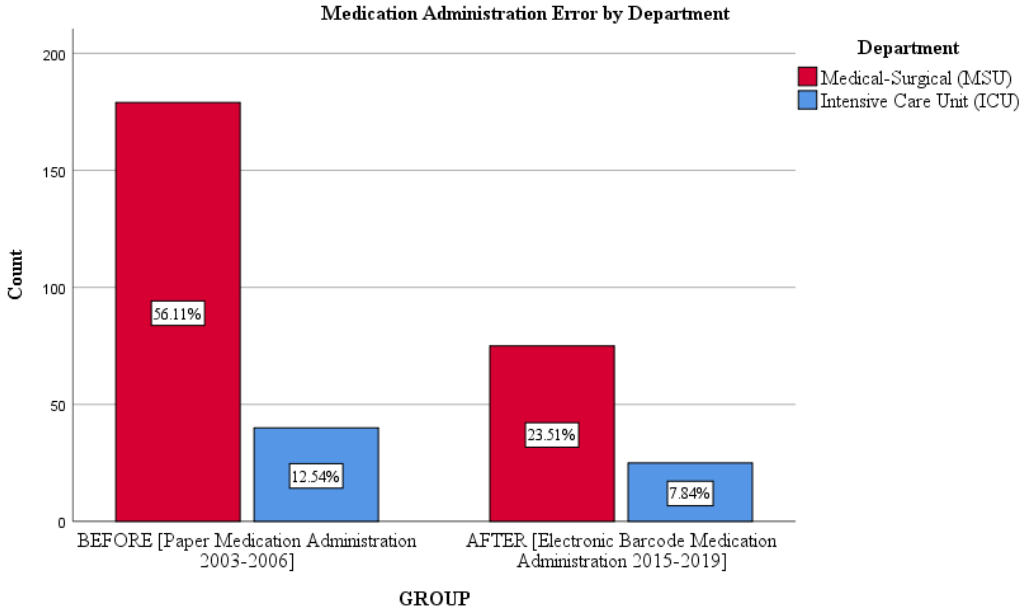
			Department		
			Intensive Care Unit (ICU)	Medical-Surgical (MSU)	Total
GROUP	BEFORE	Count	40	179	219
		Expected Count	44.6	174.4	219.0
		% within GROUP	18.3%	81.7%	100.0%
		% within Department	61.5%	70.5%	68.7%
		% of Total	12.5%	56.1%	68.7%
	AFTER	Count	25	75	100
		Expected Count	20.4	79.6	100.0
		% within GROUP	25.0%	75.0%	100.0%
		% within Department	38.5%	29.5%	31.3%
		% of Total	7.8%	23.5%	31.3%
	TOTAL	Count	65	254	319
		Expected Count	65.0	254.0	319.0
		% within GROUP	20.4%	79.6%	100.0%
		% within Department	100.0%	100.0%	100.0%
		% of Total	20.4%	79.6%	100.0%

Figure 2 illustrates that the frequency of MAE decreased for each department as per the comparison of the pre-and post-data. MSU medication errors

dropped from 56.11% to 23.51%, and ICU medication error occurrences dropped from 12.54% to 7.84%.

Figure 2

Medication error by department



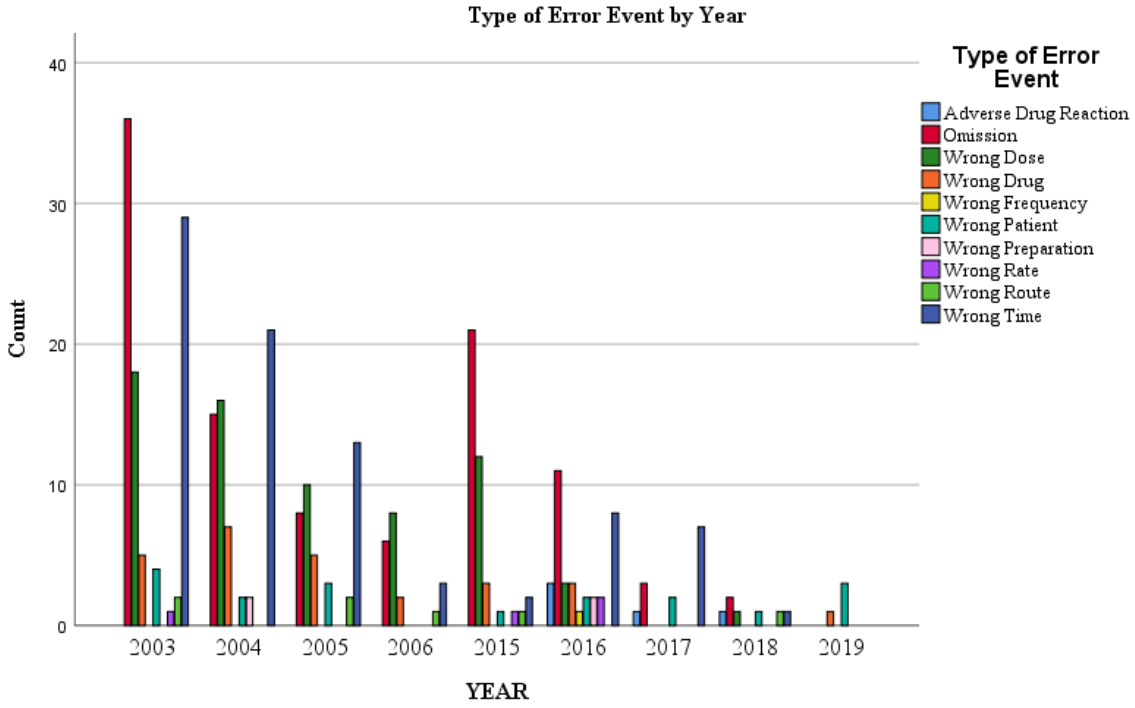
Medication Error Frequency and Category Types

Upon evaluating the details and the types of MAE occurrences, the data obtained were divided into categories recognized as similar MAE events. Figure 3 outlines the aggregated data listed by year. The type of error event categories includes adverse drug reaction, omission, wrong dose, wrong drug, wrong frequency, wrong patient, wrong preparation, wrong rate, wrong route, and wrong time. Figure 3 illustrates the decrease of error events showing a downward slope by year displaying data from before and after BCMA implementation. Comparing the aggregated data counts by year and reviewing the bar graph identifies the top three types of medication error events. The type of error event category of

omission appears to show the highest frequency rate. The wrong time error category was second, and the wrong dose ranked third in the type of medication error event.

Figure 3

Total type of medication error event



Severity of Medication Error Occurrences

Analysis was also conducted to evaluate the severity category for each MAE reported. The analysis primarily focuses on how medication errors affect each individual and the degree of harm that reached each patient. Figure 4 displays the frequency of medication errors and the severity impact data before BCMA from 2003-2006. The severity category of where MAE Reached the Patient but with No Adverse Reaction accounted for 50.47%, following the severity category

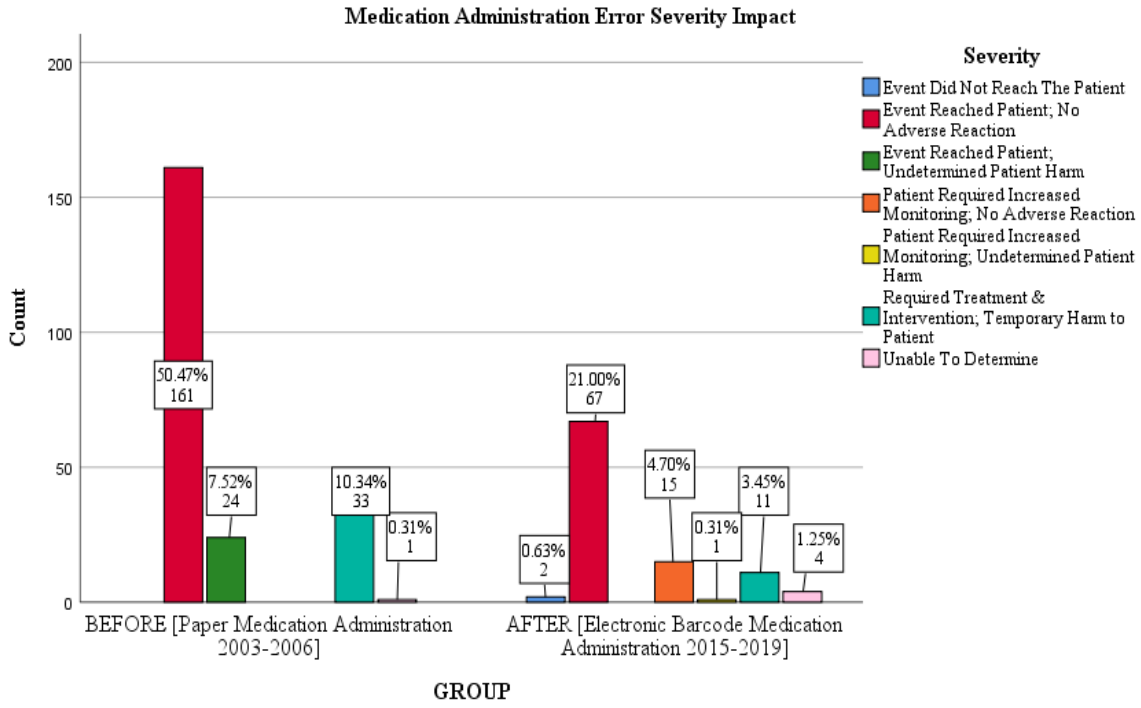
of Patients Requiring Treatment and Intervention Due to Temporary Patient Harm at 10.34%. The third-ranked severity category Reaching the Patient, but Undetermined Patient Harm accounted for 7.52%.

The severity results for data after BCMA from 2015 to 2019 had a slightly lower percentage than the data before BCMA. The severity category of medication errors Reaching the Patient but with No Adverse Reaction accounted for 21% of the incidences recorded. The severity category of patients Requiring Increased Monitoring and No Adverse Reaction accounted for 4.70% of the reported incidences. Lastly, the severity category of Patients Requiring Treatment and Intervention Due to Temporary Harm accounted for 3.45% of the incidences. Furthermore, the severity category of Unable to Determine accounted for 1.25% of the incidences. The severity category Event Not Reaching the Patient accounted for 0.63%, and the category of the Patient Requiring to be Monitored with Undetermined Patient Harm represented 0.31% of the reported incidences.

In analyzing the before and after data and calculating the total results, Figure 4 indicates that the severity impact to patients was highest in the category Event Reaching the Patient; No Adverse Reactions demonstrating the combined total of 71.47% of the incidences recorded. Second, in the severity of patient impact, the category of Patients that Required Treatment and Intervention; Temporary Harm to Patient demonstrated a combined total of 13.79% of the incidences recorded. The third-highest category ranked was Reached Patient with Undetermined Patient Harm, which accounted for a combined total of 7.52% of the incidences reported. Therefore, though the provided data in the severity group category depicts a lower percentage than data before BCMA, medication errors continued to happen and affected patients, potentially causing injury and impacting their care and recovery.

Figure 4

Total Medication Administration Error: Severity Impact [2003-2006 and 2015-2019]



Contributing Factors of Medication Administration Errors Before and After BCMA

The most common contributing factors of MAE before and after BCMA were identified and categorized. In addition, the chi-square test was conducted, which resulted in a p-value of .000 (4.419E-23), and is less than 0.05, therefore, rejecting the null hypothesis of independence. The results yield statistical significance in contributing factors associated with medication errors. Table 5 shows the significance of the factors contributing to the MAE at the rural hospital.

Table 5

Contributing factors analysis in chi-square test

Chi-Square Tests

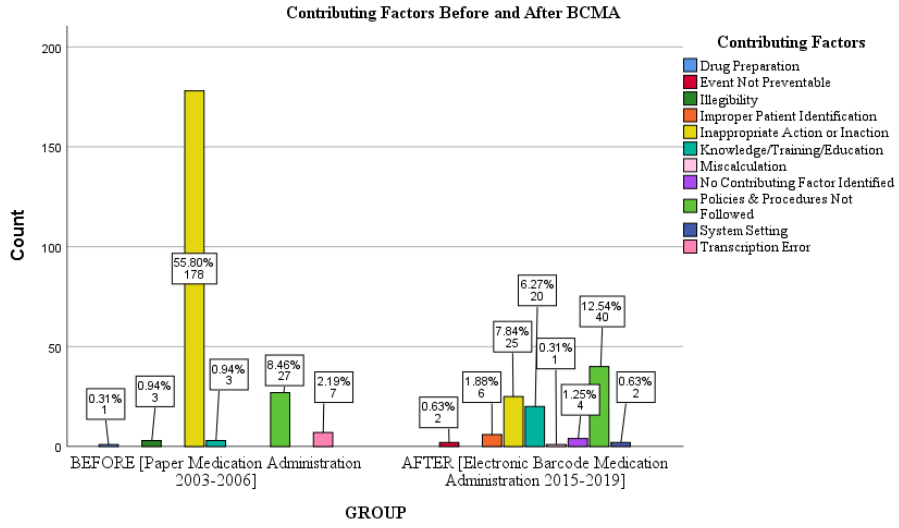
	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	130.118[a]	10	.000
Likelihood Ratio	137.087	10	.000
N of Valid Cases	319		

a. 16 cells (72.7%) have expected count less than 5. The minimum expected count is .31.

Figure 5 displays a bar graph to visually show the contributing factors, which were divided into groups before and after BCMA. Figure 5 depicts the highest contributing factor category group of Inappropriate Action or Inaction at 55.80% of incidences before BCMA. In comparison to the grouped data after BCMA, the highest contributing factor is the post BCMA category remains to be Inappropriate Action or Inaction; however, with a significant decrease at 7.84%, after BCMA. The other listed contributing factor categories similarly display a decrease in the frequency of occurrences, indicating medication errors continue to take place even after barcoding in place.

Figure 5

Contributing factors before and after BCMA



Analyzing the pre- and post-implementation data and calculating the total occurrences helped identify the top highest contributing factors associated with medication errors. The contributing factor category of Inappropriate Action or Inaction was the highest at 63.64%. Also, the group of Policies and Procedures Not Followed was the second-highest contributing factor to MAE at 21%. The third-highest contributing factor category as represented by 7.21% was Knowledge, Training, and Education. The additional common factors identified were transcription error accounting for 2.19%, followed by Improper Patient Identification representing 1.88%. The category group of No Contributing Factor Identified represented 1.25%. The rest of the categorical contributing factors remain under 1%. The top three main components identified as contributing factors associated with medication errors included the categories of Inappropriate Action or Inaction; the Policies and Procedures; and the identified gaps in Knowledge, Training, and Education.

Summary

Using the chi-square test helped determine an association among the category groups and medication errors in the pre- and post-BCMA data. Although the results yield a significant decrease in MAE after implementing BCMA, looking even further and analyzing the MAE data has shed some light on the contributing factors. The data analysis points out the significant decrease in BCMA overall and within each department. The data also highlights the frequency of MAE occurrences, severity, and the contributing factors. Discovering the overall gaps associated with medication errors is essential towards addressing them and ensuring safe administration of medication. Therefore, three main categories of contributing factors: Inappropriate Action or Inaction; Policies and

Procedures; and the identified gaps in Knowledge, Training, and Education should be addressed to address MAE that occur in the post-BCMA period.

CHAPTER 5: DISCUSSION

Medication errors impact patients and healthcare professionals at the national and global levels. Medication errors are among the preventable events that occur in clinical settings. Available literature supports that BCMA significantly reduces medication error occurrences; however, medication errors remain a significant challenge in the healthcare sector. Although the barcoding technology may be in place in healthcare institutions and have seen a significant decrease in medication errors, the question was why these medication errors continue to happen. This study provided an excellent opportunity to evaluate the before and after BCMA retrospective data. The identified components contributing to medication errors have been filtered after the analysis and review of the data. The contributing factors to these errors can now be opened for discussion with the organization's appropriate leaders. Addressing these factors helps to close the gaps and improve medication administration safety. Therefore, identifying the root causes of these errors is crucial towards reducing these adverse medication events or, even better, reducing the potential avenues that lead to MAE. Addressing the findings identified in this study is of importance to ensure each contributing factor is addressed.

Findings

The findings demonstrated recurrent and common mistakes were found after evaluating medication errors and the frequency of these occurrences at this rural hospital. The results also indicated that the change and transition to the BCMA workflow need to be revisited with a step-by-step process and evaluation method because medication errors continued to happen due to the lack of understanding. The most frequently reported medication errors under the Type of

Error Event category were Omission, Wrong Time, and Wrong Dose. The chi-square test analysis showed that these error events were statistically significant and were associated with the contributing factors frequently reported as Inappropriate Action or Inaction; Policies and Procedures; and the identified gaps found in knowledge, training, and education. Drach-Zahavy et al. (2014) noted that patchy learning practices lead to higher incidences of medication errors; emphasizing the need for the nurses at the hospital to be re-trained on proper medication administration practices.

The results showed that the barcoding process significantly reduced the frequency of medication errors at the local rural hospital. These findings align with the results of previous studies indicating that the BCMA process significantly reduces the occurrence of MAE (Henneman et al., 2012). The results point out that nurses were unsure of the policies and procedure, unclear in actions to take, and required additional training and education. Focusing on re-education and reiteration on the identified gaps relating to MAE may help reduce the number of these errors in the future. Teaching nurses the proper steps for medication administration is necessary to ensure nurses are cognizant of their actions in the process. Further, nurse retraining could aid in reducing workarounds which contribute to MAE despite the use of BCMA (Samaranayake et al., 2012; Van Der Veen et al., 2018; Xie et al., 2019).

As indicated by the results, there were more omissions in which medications were not administered to the patients. Withholding medication, known as omission, is a potential risk in patients not receiving the appropriate medications treatments essential to improving their illness. Omitting medications required for the patients' treatment prevents the patient from getting well sooner and potentially prolonging their hospital stay. Subsequently, omitting medications

can lead to the wrong timing and dosing of medications being administered. For example, nurses can mistakenly forget to properly double-check medication, such as the unclamping of IV meds when administered. In turn, this prevents the patient from receiving the medication on time and at its scheduled dose. Omission, Wrong Time, and Wrong Dose were crucial medication errors identified and are necessary to address with the nurses. When medications are delayed in patients, patient care is impacted and affects their healing and recovery process. The omission of medications was one of the highest medication errors noted as per the study results. Wrong Time and Wrong Dose follows as the other categories frequently reported medication errors and likewise presents the same concern and need to be addressed.

The results on the contributing factors indicated that nurses either chose not to follow or did not completely understand the organization's policies and procedures, which led to medication errors. In several instances, inappropriate action was taken by the nurses, resulting in their patients not receiving the proper medication treatment. The results also showed the nurses did not administer the medications because they did not know what needed to be done in the process. The other identified factors prominent in contributing to MAE were deficiency knowledge, training, and education.

The findings highlighted the categories of Omission, Wrong Time, Wrong Dose, Non-adherence to Policies and Procedures, Inaction, and Knowledge Deficits to be strongly associated with MAE. The results demonstrated the need for re-education and re-training on the barcoding medication workflow process. Incorporating Kurt Lewin's Change theory and dividing the process into a step-by-step method can help address the Policies and Procedure aspects as well as the workflow process. Furthermore, it appeared that additional follow-up and

supervision are necessary. Suggestions for a follow-up method within a 30, 60, 90-day window would encourage comprehension of the policies and procedures and assist in closing the knowledge deficit gap. Also, suggesting further follow-up with each nurse may help the nurses adhere to the medication administration workflow and decrease MAE even further. Follow-ups with the nurses should not be punitive but a way for nurses to step up and encourage identifying errors that can improve workflow and reduce MAE. Identifying these gaps will further help address the factors needed to properly understand BCMA practices and lead to a clearer understanding of the medication administration process through barcoding.

Strengths

The study addressed medication error events as a means of improving patient care. The findings support the need to address medication errors by building on the gains made from the adoption of BCMA. The findings indicate that various contributing factors have led to medication errors even with barcoding technology, emphasizing the need for further improvements in hospital settings. The acknowledgment of the opportunity for quality improvement and the refinement of the medication administration workflow process would help prevent future medication errors.

Limitations

The limitations identified in this study only reflect the fact that the study was conducted in one rural hospital institution, which was chosen as the research location in the Central Valley of California. The research data obtained from this facility cannot be generalized to other healthcare organizations. With the sample size of 319 medication errors reported, the stated sample is uniquely limited to this rural hospital. Furthermore, due to the limitation in this particular institution

relying heavily on self-reported medication error events, there is a great possibility that not all medication error data have been obtained.

Implications for Clinical Practice

As supported by the data, the implementation of the barcoding medication process significantly impacts medication errors and decreases errors over time. The analytical data results demonstrate the statistical significance is upon the calculation of the Chi-Square test in this study. The findings of this research help to conclude that a strong association exists with medication errors and that nurses' actions during the time of administration are necessary, especially in the process of preventing medication errors. Therefore, recognizing the contributing factors, addressing the issues, and providing the needed education and training is essential for nurses to know to prevent future medication errors from happening.

Further Research

The study will serve as the foundation for future research on medication errors. This study's sample size, as previously mentioned, is unique to the organization. Future research encompassing a similar method and project design can be taken to a larger scale and healthcare institutions. Moreover, more research is needed to determine the best way of addressing the causative factors for MAE despite the implementation of barcode technology.

Conclusions

Overall, the study findings showed that the categorical groups are strongly associated with medication errors. The findings demonstrate BCMA implementation reduced the frequency of MAE at the local rural hospital in the Central Valley. MAE continued to occur despite the adoption of BCMA due to

different contributing factors. The contributing factors will be discussed and addressed with the appropriate institution leaders. The re-education and re-training of healthcare staff require emphasizing every workflow step by incorporating Kurt Lewin's theory. With quarterly educational in-service meetings and checkpoints, the goal for the reduction of MAE may be accomplished. The gaps identified by the study point to the need for further training for all healthcare professional staff participating in the medication administration process. This study contributes valuable supporting evidence to the existing literature focused on BCMA and MAE. With continued work and effort to seek answers and improve healthcare quality, a resolution to medication errors and the better use of technology can be found.

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APPENDIX: MEDICATION ERROR DATA ABSTRACT SHEET

GROUP	ID	Medication Administration Error	Medication Error (Count)	Department	Event	Contributing Factor	Severity	Outcome	Comments