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Improving Patient Safety in the Post-Anesthesia Care Unit by Identifying Nurses' Perceived Barriers to the Implementation of Barcode Medication Administration

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Abstract

Background: In the landmark report *To Err is Human: Building a Safer Health System* published by the Institute of Medicine in 1999, it was estimated that 98,000 Americans die annually due to medical mistakes (Institute of Medicine et al., 2000). Since then, major advancements have been made to improve patient safety in the United States relating to safe medication administration. Barcode medication administration (BCMA) is a technology that was designed to help decrease medication errors by automating the five rights of medication administration (Thompson et al., 2018). BCMA was first utilized at a Veteran Affairs (VA) Medical Center in Topeka, Kansas in 1995, and by 2002, all VA Medical Centers were utilizing the new technology (Office of Public and Intergovernmental Affairs, 2002). At a VA Medical Center in the northeastern United States, BCMA is being utilized in most units of the medical center except for the post-anesthesia care unit (PACU) in the Same-Day Surgery (SDS) center. Resistance to change is believed to be one of the barriers to the implementation of the BCMA in the microsystem.

Global Aim: In this quality improvement project, the global aim is to improve patient safety in the VA Medical Center's PACU by identifying the nurses' perceived barriers to the implementation of BCMA and decreasing resistance to change by providing evidence-based education about safe medication administration.

Methods: The registered nurses' perceived barriers were identified using a survey (n=7) based off of the Technology Acceptance Model (Venkatesh & Bala, 2008). The education provided to the nurses directly targeted the perceived barriers identified in the pre-intervention survey and included only evidence-based research. The nurses were re-surveyed after the educational intervention to determine if the education impacted their perception of the usefulness of BCMA.

Results: After the educational session, the nurses were more likely to perceive BCMA as useful

when administering medication, reducing its likelihood of being a barrier to implementation. Although the perceived usefulness of BCMA increased among the nurses, perceived barriers still existed post-intervention and included BCMA causing medication administration to be slower and more difficult, as well as perceived reduction in productivity when caring for patients. The nurses also identified additional barriers, such as pharmacy staff availability during PACU operating hours, and the need for additional mobile computers on the unit.

Conclusion: Future efforts to address these perceived barriers can improve patient safety during the medication administration process in the microsystem.

Key words: Barcode medication administration, resistance to change, perceived barriers, medication safety

Introduction

Problem Description

Medication administration errors pose a serious risk to patients, and are among the most common medical errors made in the clinical setting (Thompson et al., 2018). Studies of medication administration errors report an incidence rate of 7%-20% in inpatient settings (Macias et al., 2018), leading to approximately 7,000 deaths and 400,000 cases of patient harm each year in the United States (Tsegaye et al., 2020).

Although medication errors can occur at any stage of the medication process (ordering, transcribing, dispensing, and administration), barcode medication administration (BCMA) can help prevent errors at the administration stage by automating the five rights of medication administration. These five rights include: patient, drug, dose, route, and time. Although medical personnel are still expected to mentally complete these checks on their own prior to medication administration, supplementing with BCMA at the point of care has been shown to significantly decrease medication errors. Some studies found reductions of over 40% in the number of administration errors after BCMA technology was implemented (Thompson et al., 2018).

BCMA has been endorsed as the best evidence-based practice for medication safety by many organizations including the Agency for Healthcare Research and Quality (AHRQ) and the Institute of Medicine (IOM) (Cochran et al., 2007). In the recently released 2022-2023 Targeted Medication Safety Best Practices for Hospitals, the Institute for Safe Medication Practices (ISMP) strongly advocates for the expansion of BCMA technology throughout all patient care settings. ISMP recommends that hospitals utilize BCMA specifically in perioperative and outpatient areas in order to maximize patient safety (Brehio, 2022).

In the post-anesthesia care unit (PACU) of an ambulatory surgical center at a Veterans Affairs (VA) hospital, an average of 1,600 medications are administered preoperatively and postoperatively each year without the use of BCMA. Although the unit has a low reported medication error rate of 0.12%, the surgical center may be putting future patients at risk of an adverse drug event (ADE) by not utilizing the best evidence-based medication safety practices. This potential problem can have serious consequences for the patient, their family, the nursing staff and the facility. Key stakeholders at the VA, including leaders in pharmacy and informatics, perceive that the PACU nurses' resistance to change is responsible for the lack of BCMA in the microsystem. Resistance to change is a common barrier to quality improvement, and must be minimized or overcome in order for microsystems to evolve and adhere to the latest safety and quality improvement practices (Nilsen et al., 2020).

Available Knowledge

Owens et. al (2020) conducted a study comparing medication error rates before and three months after implementing BCMA in a 55-bed community hospital emergency department. 14 nurses on the hospital's nurse practice council were trained and used as observers, who watched consenting nurses in the emergency department as they administered medications to patients. 676 medication administrations were observed prior to BCMA implementation, compared to 656 after. Owens et al. (2020) noted that prior to the implementation of BCMA, the medication error rate was 2.96% with *wrong dose* errors being the most common type of medication error. After implementing BCMA, the error rate decreased to 0.76%, representing an error reduction of 74.2% (Owens et al., 2020).

This particular study was able to correlate the use of BCMA with a decrease in medication errors, which satisfied the authors' original hypothesis. However, this study had

limitations primarily involving the sample size. The study was conducted in one unit of one hospital, which makes it difficult to generalize across all hospital settings. In addition, this was not a randomized-controlled trial which may imply biases. Medication administration observations occurred during the hours of 7:00 AM and 11:00 PM when observers were available. All medication administrations between the hours of 11:00 PM and 7:00 AM were excluded, which may have had an impact on the study's results. Lastly, the authors did not define medication errors, which also makes the study difficult to replicate (Owens et al., 2020).

Küng et. al (2021) conducted a quasi-experimental before-and-after study investigating the effect of barcode medication technology on medication error rates. The study was performed over a 12-month period in two medical-surgical units of a 1037-bed hospital in Switzerland. The authors define medication errors as "any preventable event that may cause or lead to inappropriate medication use or patient harm and may occur during all steps of the medication process" (Küng et al., 2021, p. 2). Medication errors were categorized by type including wrong medication, wrong dosage, and wrong patient. Data collection was based on direct observation, and two trained hospital staff members observed consenting nurses as they prepared medications for six months prior to, and three months after implementation of BCMA (Küng et al., 2021).

2,726 medication doses were observed prior to implementation, and 3,206 medication doses were observed post-implementation of BCMA. Medication preparation errors were reduced from 9.9% at baseline to 4.5% post-implementation, revealing a risk reduction of 54.5%, with signification reductions found in the wrong medication and wrong dosage categories (Küng et al., 2021).

The authors found a significant reduction in medication preparation errors after the implementation of BCMA. However, the study concluded that some medication errors cannot be

reduced, including errors of omission (the nurse forgets to prepare a medication), and the preparation of unordered medications (nurses could bypass certain processes). Other limitations included the sample size, which only included one hospital setting. The pre-post study design without a control group or randomization also limits the use of the study. Also, nurses that are aware they are being watched by the observers may perform better, known as observation bias. Lastly, this study only investigated medication preparation errors before the medication ever reached a patient. The *right time* nursing right of medication administration was not studied which could have an impact on the medication error rates (Küng et al., 2021).

Macias et. al (2018) conducted a before-and-after study on an oncology-hematology unit in order to determine the impact of BCMA on the incidence of medication errors. The authors utilized a control group and an intervention group, and hypothesized that the utilization of the technology would reduce the incidence of errors in medication administration (Macias et al., 2018). The authors defined medication errors by organizing them into 14 categories such as wrong medication, wrong dose, wrong patient, and wrong infusion rate. The authors hypothesized that seven categories could be influenced by the BCMA system: wrong medication, dose omission, incorrect dose, wrong date, wrong route, wrong patient, and wrong order (Macias et al., 2018).

Data was collected by using trained observers to observe consenting nurses as they administered medication for one month prior to implementation and one-month post-implementation of the technology. A total of 2,912 medication administrations were observed between the control and intervention groups. In the intervention group, 1,281 medication administrations were observed before the intervention, and 1,272 were observed post-implementation. Data was analyzed using the chi-square test with 95% confidence intervals, and

the authors found that medication error rates were reduced by 85%. Significant reduction in medication errors were noted in the categories of wrong medication, wrong dose, and wrong order. There was no statistical difference in medication error rates among the control group (Macias et al., 2018).

The authors were able to present evidence that medication errors can be reduced with the implementation of BCMA in an oncology-hematology unit. However, it would be difficult to generalize the findings to other settings due to the study's implementation in one single microsystem. Another limitation was that the nurses may have modified their actions because they knew they were being observed (known as the Hawthorne effect). The study also reported a higher incidence of medication errors pre-implementation than most other studies, which may have an effect on the high rate of reduction in medication errors. Lastly, almost all of the medications observed in the study were administered via the intravenous (IV) route, which is unique to this type of microsystem and limits the ability to compare with other studies (Macias et al., 2018).

The final publication included in this literature review is a systematic review published by Ciapponi et. al (2021). The objective of the systematic review is to determine the effectiveness of multiple interventions used to reduce medication errors in hospital settings. The review defines medication errors as "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient or consumer" (Ciapponi et al., 2021, pg. 20). The authors used CENTRAL, MEDLINE, Embase, and five other databases to find 51 randomized-controlled trials involving 23,182 total participants (Ciapponi et al., 2021).

The systematic review found with low-certainty evidence that utilizing BCMA may reduce medication errors. Although studies included in the systematic review did imply that BCMA helped reduce medication errors, the results were not significant due to concerns of bias in more than half of the studies. Only one-third of the studies utilized blinding throughout the study, which led to most of the concerns. The authors concluded that compared to typical care, utilizing interventions to reduce medication errors is likely beneficial, but methodologically sound studies are needed to further address the evidence gaps (Ciapponi et al., 2021).

The research supports the hypothesis that the implementation BCMA may reduce medication error rates in the hospital setting. All three of the before-and-after studies reported a significant reduction in medication error rates after the implementation of BCMA. Most of the studies were able to significantly reduce the medication error categorized as "wrong dose." However, there are some limitations to the use of the technology such as its inability to correct errors that occur in other stages of medication administration, such as an incorrect rate input on an IV infusion pump as discussed in Macias et al. (2018).

More research should be done on the implementation of BCMA. Most of the articles reviewed in this literature review include before-and-after studies after implementation in a single microsystem, which makes the findings difficult to apply to general settings. Future studies should be randomized, controlled, and blind in order to further the research on this topic.

Rationale

In order to complete this quality improvement project, the Plan-Do-Study-Act (PDSA) method was utilized. In the planning stage, data on the PACU's medication error rates was collected and semi-structured interviews were conducted in order to gather information on the potential effects of BCMA implementation in the microsystem. A survey was also created via

Qualtrics ™ for distribution to the nurses regarding their perceived barriers to the implementation of BCMA in their microsystem. In the second stage, VA PACU nurses were surveyed in order to gather baseline data on their perceived barriers to the implementation of BCMA in the microsystem. Next, the nurses were provided education that directly addressed the perceived barriers and usefulness of BCMA. Nurses were surveyed again directly following the educational session. In the study stage, the pre- and post-intervention survey data was analyzed in order to determine if the intervention was successful in increasing the perceived usefulness of BCMA. In the final step, a recommended plan for PACU BCMA implementation was presented that addressed the nurses' perceived barriers. The plan was presented to the key stakeholders in the medication administration process including PACU nurse management and leaders in pharmacy, quality improvement, and informatics (Institute for Healthcare Improvement, n.d.).

This quality improvement project was guided by Kurt Lewin's Change Theory of Nursing, which considers the psychological tendency to resist change (Joseph Galli, 2018). Implementing BCMA in the microsystem would change the nurses' current medication administration workflow, and their resistance to this change has been identified by VA leadership as a barrier to the implementation. Kurt Lewin's Change Model was also utilized. This model describes three phases of change: unfreezing, changing, and refreezing. In the unfreezing stage, tactics must be used to reduce employee resistance to change. This can be achieved by educating employees on the benefits of the change, communicating how the change will affect them, providing proper training, and involving employees in the decisions made about the change. This quality improvement project will focus on the unfreezing stage and use Lewin's suggested tactics in order to decrease resistance to the proposed change of BCMA implementation (Kreitner & Kinicki, 2022).

Specific Aim

The global aim of this quality improvement project was to improve patient safety in the VA Medical Center's PACU by identifying the nurses' perceived barriers to the implementation of BCMA and decreasing resistance to change. The specific aim of this quality improvement project was to increase the percentage of PACU nurses at the VA SDS center who perceive BCMA as useful from baseline to 100% by July 1, 2022.

Methods

Context

This quality improvement project was conducted in the PACU of a VA ambulatory surgical center in the northeastern United States. The ambulatory surgical center performs an average of 1,600 surgeries annually. The majority of the surgical procedures performed are gastrointestinal (GI) procedures (45%) followed by urology (19%), general surgery (15%), and ophthalmology (15%). The remaining 6% of cases include orthopedics, podiatry, vascular, and gynecology.

There are approximately 1,600 medication administrations performed among the registered nurses each year in the PACU between the preoperative and postoperative stages of surgery. The majority (83%) of medications administered to patients include lidocaine (ocular), cyclopentolate (ocular), phenylephrine (ocular), and acetaminophen (oral).

The nurses in the PACU do not utilize BCMA for medication administration, although they have the technology required to do so. Currently, the nurses print paper copies of medication orders from the patient's electronic health record, and retrieve the medications from the *Omnicell*™ dispensing system. Next, the nurses bring the medications to their patients and perform medication checks at bedside against the printed order before administration.

Although not being used in the PACU, BCMA is currently utilized in most other units of the VA hospital. Semi-structured interviews were conducted with the VA's pharmacy and informatics teams, who claimed the barrier to the implementation of BCMA in the PACU was nurse perception and resistance to change. The nurses were surveyed on their perceived usefulness and perceived ease-of-use of BCMA in order to determine potential barriers and resistance to chance prior to the intervention.

Between April 2021 and April 2022, two medication errors were reported by the PACU nursing staff. Both medication errors were classified as *mild harm*. The medication error rate in the PACU during this time was calculated to be 0.12%.

Cost Benefit Analysis

BCMA has been shown to reduce medication administration errors by over 40% **(**Thompson et al., 2018). Medication errors may lead to ADEs, which can cause injury or death to a patient. According to Sultana et al. (2013), ADEs have a significant economic impact on hospitals when they lead to hospital admission, prolongation of hospitals stays, and emergency room visits. Significant ADEs have been estimated to cost hospitals between $2,852 and $8,116 per individual, however, this estimate does not include malpractice costs, or costs of injuries to the patient (Slight et al., 2018). Nationally, medication errors cause an average of 7,000 deaths per year (Grissinger & Kelly, 2005), and the total cost associated with preventable ADEs in the United States exceeds $5 billion per year (Pan et al., 2015).

All of the staff members involved in this project are salaried employees of the VA. All activities were conducted during their standard working hours without negatively affecting patient caseloads or the number of surgical procedures performed.

Description of the Intervention

Pre-intervention data was collected by surveying all seven PACU registered nurses regarding their perception of barriers to implementing BCMA in their microsystem. The survey was emailed to their VA email addresses via a hyperlink that directed them to a *Qualtrics™* survey. All responses were submitted anonymously. Survey responses were voluntary. Respondents had at least seven days to complete the survey before the survey closed and were notified of the deadline.

Based on the survey responses, an educational session on the advantages to utilizing BCMA in the microsystem was designed. The education directly focused on the nurses' perceived barriers to the implementation of the technology while providing data to support that it is the best evidence-based practice for medication administration. The educational session was a previously recorded 12-minute *PowerPoint™* presentation with video and audio that the registered nurses could watch independently on their computers.

Study of the Intervention

The nurses were instructed to complete the post-intervention survey immediately following the completion of the educational session. Similar to the pre-intervention survey, the nurses were emailed a link to complete the survey anonymously in *Qualtrics™.* The post-intervention survey was identical to the pre-intervention survey, with the exception of 1-2 free-text questions. Nurses were encouraged but not required to fill out the survey.

Measures

The Technology Acceptance Model 3 (TAM3) was used to develop the survey questions. TAM3 uses determinants to help understand the respondents' perspectives on information technology (IT) adoption and use. The determinants include perceived usefulness (PU),

perceived ease of use (PEOU), computer self-efficacy (CSE), perceptions of external control (PEC), computer playfulness (CPLAY), computer anxiety (CANX), perceived enjoyment (ENJ), subjective norm (SN), voluntariness (VOL), image (IMG), job relevance (REL), output quality (OUT), result demonstrability (RES), behavioral intention (BI), and use (USE) (Venkatesh & Bala, 2008). Only perceived usefulness (PU) and perceived ease-of-use (PEOU) were utilized in this quality improvement project due to their relevance.

TAM3 uses a 7-point Likert scale which was utilized throughout the pre- and post-intervention survey, ranging from 1 (*strongly disagree)* to 7 (*strongly agree).* All TAM3 survey questions have been proven reliable by Vankatesh and Bala (2008) to have a Cronbach alpha greater than .70 (Venkatesh & Bala, 2008).

Analysis

Data was analyzed by comparing the results from the two surveys (pre- and post-intervention) to determine if the intervention changed the nurses' perceptions of the barriers to implementation of BCMA. Mean, range, and standard deviation was calculated and compared for Likert scale items. Free text responses were reviewed and analyzed for recurring themes.

Ethical Considerations

The study was conducted in an ethical manner. Survey responses were anonymous and voluntary. An informed consent agreement was added to the survey. Only survey respondents who signed the informed consent agreement were included in data collection and data reporting. Demographics were excluded from the survey due to the low number of survey respondents. This information was excluded in order to maintain anonymity of survey respondents and decrease the prevalence of response bias.

Response bias may have had an impact on survey results. The nurses surveyed would be directly impacted by BCMA implementation in the PACU. The nurses may not want to accurately respond to survey questions if they are not in favor of the implementation of BCMA in the PACU and want to avoid a disruption in their current workflow.

This project proposal was reviewed by the University of New Hampshire's Department of Nursing Quality Committee. It was determined that it meets the criteria for quality improvement, which is exempt from Institutional Review Board review.

Results

Results

Pre-Intervention: Perceived Usefulness of BCMA

The pre-intervention survey link was sent out via email to all seven registered nurses in Same-Day Surgery. The survey was available for ten days. All seven nurses took the survey, yet only five nurses finished the survey. All survey respondents signed the consent form to be included in this quality improvement project. Due to the small sample size, demographic information was not included in the survey and was not able to be analyzed as the information could compromise survey respondent anonymity.

The first section of the pre-intervention survey inquired about the perceived usefulness of BCMA. The first seven questions used a Likert-scale from 1 (extremely unlikely) to 7 (extremely likely). The final question was open-ended and respondents were able to enter a free text response. In the first question, *using BCMA would enable me to administer medication more quickly,* the majority of respondents (71%) believed it was unlikely. Regarding the question for usefulness of the technology, the mean of 4.71 (*SD* 1.67, Range 1-7) suggests that respondents perceived that it would be slightly useful for medication administration.

Questions six and seven in the first section focused on patient safety. Question six states, *Using BCMA would make medication administration safer.* The majority of respondents (86%) believed it was likely that BCMA would make medication administration safer. Question seven states, *Using BCMA would benefit patients.* With a mean of 5.71 (*SD* 1.67, range 1-7), this suggests that respondents perceived that BCMA would beneficial.

The final question of section one asked respondents to enter a free text response about their opinion on the usefulness of BCMA in Same-Day Surgery. Two respondents shared concerns about BCMA increasing the time they would spend on patient care, citing *I'm concerned about the learning curve. It will likely slow down the admission process and I am concerned this will not be factored in by management.* Another respondent said, *It does take a little longer, but I think it would be worth it to reduce the possibility of a medication error.* One respondent voiced concerns about the unit not having the appropriate technology to successfully implement BCMA, citing *More work stations on wheels would be needed. A pharmacist would need to be available to process orders.* Four respondents agreed that BCMA would make medication administration safer, citing *It would be quite likely to increase patient safety,* and *This method can help ensure the safe delivery of medications.*

Overall, the registered nurses were only slightly likely to perceive BCMA as useful with an overall aggregate mean of 4.86. Survey respondents were the least likely to believe that BCMA would enable them to administer medication more quickly, and that BCMA would make medication administration easier. Survey respondents were most likely to believe that BCMA would make medication administration safer, and that BCMA would benefit patients.

Table 1

Pre-Intervention Survey Results: Perceived Usefulness of BCMA

Variable	Mean	Standard Deviation	Range
Using BCMA would enable me to administer medication more quickly.	3.57	1.92	1-7
Using BCMA would make medication administration easier.	4.29	1.98	1-7
Using BCMA would increase my productivity while caring for patients.	5	1.6	1-7
Using BCMA would be a more effective way to administer medication.	4.71	1.48	1-7
I would find BCMA useful when administering medication.	4.71	1.67	1-7
Using BCMA would make medication administration safer.	6	1.69	1-7
Using BCMA would benefit patients.	5.71	1.67	1-7

Pre-Intervention: Perceived Ease-of-Use of BCMA

The second section of the pre-intervention survey inquired about the perceived ease-of-use of BCMA. Only five of the seven nurses who started the survey completed the second section. The first six questions used a Likert-scale from 1 (extremely unlikely) to 7 (extremely likely). The final question was open-ended and respondents were asked to enter a free text response.

All five respondents agreed that it was likely that learning how to use BCMA would be easy, that their interaction with BCMA would be clear and understandable, and that using BCMA would be easy for them. In this perceived ease-of-use section, respondents were least likely to believe that BCMA would do what they wanted it to do with a mean of 4.8 (*SD* 0.75, range 1-7).

Respondents were asked to submit a free text response on their opinion about the potential ease-of-use in Same-Day Surgery. One respondent expressed that BCMA would be easy to use, writing *I have used BCMA in other areas. It is not that difficult.* Three respondents expressed concern about technology limitations in Same-Day Surgery, writing *A barrier I see is having enough computers on wheels to go around* and *Pharmacist availability and computer availability could delay care*. One respondent expressed the need for hands-on training, which has not typically been provided by management in the past and wrote, *Previous training on CLC did not include hands on practice. Nurses need hands-on training rather than viewing a PowerPoint of the steps of how to do it.*

The aggregate mean score of perceived usefulness of BCMA was 4.86. The aggregate mean score of the second section, perceived ease-of-use of BCMA, was 5.70. The registered nurses in Same-Day Surgery were more likely to perceive BCMA as easy to use than perceive BCMA as useful in the pre-intervention survey.

Table 2

Pre-Intervention Survey Results: Perceived Ease-of-Use of BCMA

Variable	Mean	Standard Deviation	Range
Learning how to use BCMA would be easy for me.	6.2	0.75	1-7

I would find it easy to get BCMA to do what I want it to do.	4.8	0.75	1-6
My interaction with BCMA would be clear and understandable.	5.6	0.49	1-6
It would be easy for me to become skillful at using BCMA.	6.4	0.49	1-7
I would find BCMA easy to use.	5.8	0.75	1-7
I would receive the training I would need to use BCMA effectively.	5.4	1.36	1-7

Post-Intervention: Perceived Usefulness of BCMA

The post-intervention survey link was sent out via email to all seven registered nurses in Same-Day Surgery. The survey was available for seven days. The registered nurses were asked to complete the post-intervention survey immediately after watching the educational session on BCMA. Only four of the seven nurses took the post-intervention survey, and all four nurses completed the full survey. All survey respondents signed the consent form to be included in this quality improvement project. Similar to the pre-intervention survey, demographic data was not included in order to protect anonymity.

The post-intervention survey was identical to the pre-intervention survey, and asked a series of questions pertaining to the perceived usefulness of BCMA and the perceived ease-of-use of BCMA. However, the two free-text response questions from the pre-intervention survey were eliminated and replaced and with one free-text response question, *How has your opinion on the usefulness of BCMA changed since you watched the video?*

Using BCMA would enable me to administer medication more quickly decreased from a mean of 3.57 in the pre-intervention survey to a mean of 3.33 in the post-intervention survey (*SD* 0.47, Range 1-7). *Using BCMA would make medication administration easier* slightly increased from a 4.29 in the pre-intervention survey to a mean of 4.33 in the post-intervention survey (*SD* 0.47, Range 1-7). *Using BCMA would increase my productivity while caring for patients* decreased from a mean of 5 in the pre-intervention survey to a mean of 4.33 in the post-intervention survey (*SD* 0.47, Range 1-7). *Using BCMA would be a more effective way to administer medication* increased from a mean of 4.71 to a mean of 5.67 (*SD* 0.94, Range: 1-7). *I would find BCMA useful when administering medication* increased from a mean of 4.71 in the pre-intervention survey to 5.67 in the post-intervention survey (*SD* 0.94, Range 1-7). *Using BCMA would make medication administration safer* increased from a mean of 6 in the pre-intervention survey to a mean of 7 in the post-intervention survey (*SD* 0, Range 1-7). *Using BCMA would benefit patients* increased from a mean of 5.71 to a mean of 7 in the post-intervention survey (*SD* 0, Range 1-7).

The aggregate mean of the perceived usefulness of BCMA increased from a 4.86 in the pre-intervention survey to 5.33 in the post-intervention survey. Overall, nurses were more likely to perceive BCMA as useful post-intervention with notable increases in the mean scores for the questions pertaining to patient safety, benefits to the patient, and the usefulness when administering medication.

Table 3

Post-Intervention Survey Results: Perceived Usefulness of BCMA

Variable	Mean	Standard Deviation	Range

Using BCMA would enable me to administer medication more quickly.	3.33	0.47	1-4
Using BCMA would make medication administration easier.	4.33	0.47	1-5
Using BCMA would increase my productivity while caring for patients.	4.33	0.47	1-5
Using BCMA would be a more effective way to administer medication.	5.67	0.94	1-7
I would find BCMA useful when administering medication.	5.67	0.94	1-7
Using BCMA would make medication administration safer.	7	0	1-7
Using BCMA would benefit patients.	7	0	1-7

Post-Intervention: Perceived Usefulness of BCMA

Learning how to use BCMA would be easy for me slightly increased from a mean of 6.2 to a mean of 6.33 (*SD* 0. 94, Range 1-7). *I would find it easy to get BCMA to do what I want it to do* increased from a mean of 4.8 to a mean of 6 in the post-intervention survey (*SD* 0.82, Range 1-7). *My interaction with BCMA would be clear and understandable* slightly increased from a

mean of 5.6 to a mean of 6 (*SD* 0.82, Range 1-7). *It would be easy for me to become skillful at using BCMA* decreased from a mean of 6.4 to a mean of 6 in the post-intervention survey (*SD* 0.82, Range 1-7). *I would find BCMA easy to use* decreased slightly from a mean of 5.8 to a mean of 5.67 in the post-intervention survey (*SD* 0.94, Range 1-7). *I would receive the training I would need to use BCMA effectively* increased from mean of 5.4 to a mean of 6.67 in the post-intervention survey (*SD* 0.47, Range 1-7).

The final question in the post-intervention survey was a free-text response question which asked participants, *How has your opinion on the usefulness of BCMA changed since you watched the presentation?* Two of the four survey respondents mentioned the effectiveness of the educational intervention, citing *I feel like I am more likely to want to start using BCMA after watching this presentation. It is good to know the data behind it to show that is really is safer,* and *I am extremely confident it would increase patient safety based on the evidence that it would decrease the number of errors.* Another respond reiterated the effectiveness of BCMA, but cited *BCMA is a great product, but it needs the support of pharmacy.*

The aggregate mean of the perceived ease-of-use of BCMA increased from 5.7 in the pre-intervention to 6.11 in the post-intervention survey. After the intervention, PACU RNs were more likely to perceive BCMA as easy to use than before the intervention.

Table 4

Post-Intervention Survey Results: Perceived Ease-of-Use of BCMA

Variable	Mean	Standard Deviation	Range
Learning how to use BCMA would be easy for me.	6.33	0.94	1-7

I would find it easy to get BCMA to do what I want it to do.	6	0.82	1-7
My interaction with BCMA would be clear and understandable.	6	0.82	1-7
It would be easy for me to become skillful at using BCMA.	6	0.82	1-7
I would find BCMA easy to use.	5.67	0.94	1-7
I would receive the training I would need to use BCMA effectively.	6.67	0.47	1-7

Unexpected Consequences

Unexpected consequences have impacted the results of this quality improvement project. Only five of the seven respondents completed the full pre-intervention survey. Respondents were required to advance to the next page of the survey in order to complete the second section, which may have led to the incomplete surveys. Edits were made to the post-implementation survey so that both sections were visible on the same page. This quality improvement project was also completed over the summer when many nurses were utilizing their paid time off. Due to the low sample size, the surveys were made available longer than expected in order to capture the majority of the sample size. The intervention required approval from the unit's nursing manager, who unexpectedly went on military leave for two weeks which delayed the intervention.

Discussion

Summary

Key Findings

Valuable insight was gained from the pre- and post-intervention surveys regarding the nurses' perceived barriers to the implementation of BCMA in the PACU. BCMA usefulness was the primary perceived barrier to implementation among the PACU nurses. Prior to the intervention, nurses were most concerned BCMA would increase medication administration times, make medication administration more difficult, would be a less effective way to administer medication, and would not be useful when administering medication. However, with the addition of evidence-based education regarding BCMA, the nurses were more likely to perceive BCMA as useful post-intervention than pre-intervention. As noted, the aggregate mean of the perceived usefulness of BCMA pre-intervention was 4.86 *(neutral)* while the post-intervention mean increased to 5.33 (*slightly agree).*

There were also notable increases to the individual survey questions in the perceived usefulness category. After the intervention, nurses were more likely to believe that BCMA would increase productivity while caring for patients, would be a more effective way to administer medication, would be useful when administering medication, would make medication administration safer, and would benefit patients. There was still concern amongst the nurses that BCMA would not make medication administration faster, nor would BCMA make medication administration easier. These specific questions scored the lowest in both pre- and post-implementation in the perceived usefulness category.

Overall, PACU nurses were more likely to perceive BCMA as easy-to-use than useful. Pre-intervention, the perceived ease-of-use section had an aggregate mean score of 5.7 *(slightly agree)* which increased to 6.11 *(agree)* post-intervention. In the post-intervention survey, nurses were more likely to believe that learning how to use BCMA would be easy, it would be easy to get BCMA to do what they wanted it to do, their interaction with BCMA would be clear and

understandable, and they would receive the training they would need to use BCMA effectively. Nurses were less likely to believe that it would be easy for them to become skillful while using BCMA, and that they would find it easy to use. However, although these survey questions scored the lowest in the perceived ease-of-use category, they did not score low enough (less than 5) to be considered barriers to the implementation of BCMA in the PACU.

Common themes emerged from the free-text response questions. Nurses perceived external barriers to the implementation of BCMA, including pharmacy availability and the availability of computers on wheels. Nurses also expressed concern that hospital leadership may not provide adequate training when implementing the new technology. Previous training provided by leadership did not provide hands-on training. If the VA Medical Center is interested in implementing BCMA in the PACU, efforts should be focused on providing adequate pharmacy staffing during PACU business hours and eliminating technological barriers in the microsystem. Leadership should also consider hands-on training for the registered nurses when implanting the new technology.

The specific aim of the project was to increase the percentage of PACU nurses at the VA SDS center who perceive BCMA as useful from baseline to 100%. The intervention was successful in achieving this goal. In the pre-intervention survey, only 4 of 7 respondents (57%) believed it was likely that BCMA would be useful when administering medication. In the post-intervention survey, 4 of 4 respondents (100%) believed BCMA would be useful when administering medication. The intervention helped increase the perceived usefulness of BCMA by educating the nurses on the best evidence-based practice for medication administration.

Strengths

This quality improvement project utilized Kurt Lewin's Change Model which describes three phases of change: unfreezing, changing, and refreezing. The intervention in this quality improvement project was able to help unfreeze the nurses' resistance to change by educating the PACU nurses on the benefits of a potential change. If the Manchester VA Medical Center would like to pursue the implementation of BCMA in the PACU, the nurses may be less resistant to the change.

Another strength of this project was substantial stakeholder support. The nursing staff was willing to participate in the survey and educational intervention. VA leadership was also extremely supportive of this project and was willing to provide data and other helpful information that was necessary in guiding this quality improvement project.

Interpretation

Specific Aim

The specific aim of this quality improvement project was to increase the percentage of PACU nurses at the VA SDS center who perceive BCMA as useful from baseline to 100% by July 1, 2022. The specific aim was achieved. After the educational intervention, 4 of 4 nurses (100%) believed BCMA would be useful when administering medication, compared to 4 of 7 nurses (56%) in the pre-intervention survey. Utilizing evidence-based research to support the usefulness of BCMA was successful in increasing the percentage of registered nurses who perceived BCMA as useful. This likely eliminates the perception of usefulness as a potential barrier to the implementation of BCMA in the microsystem.

Intervention Versus Outcomes

After the educational intervention, the registered nurses were more likely to believe that BCMA would be a more effective way to administer education, that they would find BCMA useful when administering medication, that BCMA would make medication administration safer, and that BCMA would benefit patients. They were also more likely to believe that BCMA would be easy for them to use, it would be easy for BCMA to do what they would want it to do, that their interaction with BCMA would be clear and understandable, and that they would receive the training they would need to use BCMA effectively.

The educational session focused mainly on the usefulness of BCMA and how the technology could increase patient safety in the microsystem. The intervention had a positive impact on the nurses' beliefs that BCMA could improve patient safety. After receiving the education on BCMA, 4 of 4 nurses (100%) agreed BCMA would make medication administration safer. After the intervention, 4 of 4 nurses (100%) agreed that BCMA would benefit patients. Using evidence-based research in the educational session was successful in educating the nurses about BCMA as an effective tool that can help improve patient safety and decrease medical errors. According to Kurt Lewin's Change Model, educating employees on the benefits of a potential change helps *unfreeze* employees in order to decrease resistance to change (Kreitner & Kinicki, 2022). The intervention may have been successful in progressing the registered nurses from the *unfreezing stage* to the *changing stage.*

Although the educational intervention did not focus on BCMA's ease-of-use, the PACU nurses perceived BCMA as easy to use in both the pre- and post-intervention surveys. The registered nurses in the PACU do not recognize the ease-of-use as a barrier to implementing the technology in the microsystem.

Impact of the Project

The leadership at the VA Medical Center was concerned that the PACU nurses' resistance to change was the driving force behind the delayed implementation of BCMA in the SDS center. However, based on the post-intervention survey, the PACU nurses currently perceive BCMA as both useful and easy-to-use. Post-intervention, potential barriers still exist for the nurses, including BCMA causing medication administration to be slower and more difficult, and BCMA decreasing productivity when caring for patients. The nurses also identified additional barriers to BCMA implementation, which include pharmacy availability and computer availability. If the VA Medical Center is interested in implementing BCMA in the PACU, leadership should focus future efforts on these potential barriers. They should ensure there is adequate pharmacy support during PACU operational hours and adequate technology on the unit in order to eliminate barriers that could make BCMA implementation unsuccessful. The nurses' resistance to change may no longer be the primary barrier to the implementation of BCMA in the PACU.

Potential Cost-Savings

Not only would BCMA implementation in the PACU improve patient safety for the VA Medical Center, but there are also potential cost savings. BCMA has been shown to reduce medical errors significantly in hospital settings. Significant medication errors can cost hospitals between $2,852 and $8,116 per patient before factoring in malpractice costs and costs of injuries to the patient (Slight et al., 2018). There are approximately 1,600 medications administered in the PACU each year, and with the nation's average medication error rate of 7-20% (Macias et al., 2018), there's a potential for 112-320 medication errors per year in the SDS center. Although most medication errors do not cause significant adverse drug events, BCMA could reduce the

likelihood of an adverse drug event as well as reducing significant costs associated with malpractice and patient injury.

Important Lessons

There were many educational lessons learned as a student navigating quality improvement. First, this quality improvement project would not have been possible without interprofessional collaboration. In order to successfully gather data and design an intervention, assistance was needed from nursing staff, nursing leadership, informatics, clinical nurse leaders, and pharmacists. Collaboration in healthcare allows for employees to achieve more together than what they can individually, and in this particular project, it may help improve safety for over 1,600 patients seen annually in the PACU.

Additionally, the use of evidence-based research was extremely important for this quality improvement project. It is not enough to simply tell nursing staff that it is better or safer to use BCMA. Utilizing evidence-based research throughout the intervention was successful in progressing nurses from the unfreezing stage and increasing their perceived usefulness of BCMA.

Limitations

One limitation of this quality improvement project was the number of participants. There are only seven registered nurses that work in the SDS center. The sample size may affect survey validity. In addition, demographic data was not able to be studied in order to maintain participant anonymity. This limited the generalizability to other microsystems that was able to be drawn from survey results.

A second limitation was the number of incomplete surveys in the pre-intervention survey. Two of seven respondents did not complete the full survey and missed the perceived ease-of-use

section. This was likely due to respondents needing to advance to the next page. To minimize incomplete surveys in the post-intervention survey, the survey was condensed onto one page without the need to advance. This increased the post-intervention survey completion rate to 100%.

An additional limitation of this quality improvement project was the number of registered nurses who completed the post-intervention survey. 100% of the registered nurses completed the pre-intervention survey, while only 57% (4/7) of registered nurses completed the post-intervention survey. Survey fatigue may have had an effect on the registered nurses, as well as competing priorities on a busy unit.

Lastly, this project took place during the summer months which had a profound effect on the timeline of the quality improvement project. Many nurses were utilizing their paid-time off, which caused the need to extend the number of days both surveys remained open. There was also an unexpected 3-week gap between the pre-intervention survey and the intervention due to the nursing manager's military leave-of-absence. This may have had an impact on the registered nurses' interest to participate in the project.

Conclusions

The global aim of this quality improvement project was to improve patient safety in the VA Medical Center's PACU by identifying the nurses' perceived barriers to the implementation of BCMA and decreasing resistance to change. The specific aim of this quality improvement project was to increase the percentage of PACU nurses at the VA SDS center who perceive BCMA as useful from baseline to 100% by July 1, 2022. By utilizing the Technology Acceptance Model as a framework, this qualitive improvement project was successful in identifying the nurses' perceived barriers to the implementation of barcode medication

administration. It was also successful in helping to decrease resistance to change by utilizing evidence-based research to educate and *unfreeze* the nurses while increasing the likelihood they would perceive BCMA as useful.

Now that the nurses' perceived barriers to the implementation of BCMA have been identified, the VA Medical Center could address and possibly eliminate these barriers in order to successfully implement BCMA in the microsystem and improve patient safety.

Implications for Practice

After the intervention, the registered nurses perceived the following as barriers to BCMA implementation: BCMA would make medication administration slower, BCMA would make medication administration harder, BCMA would decrease productivity while caring for patients, pharmacy staff is not available during PACU operating hours, and there are not enough computers-on-wheels on the unit to support BCMA. The VA Medical Center should work to eliminate these barriers if they would like to successfully implement BCMA in the PACU. Now that the nursing staff believes BCMA is both helpful and easy-to-use, nursing resistance to change may no longer be the primary barrier to successful implementation and the nurses are likely out of the *unfreezing* stage. The VA Medical Center should focus on the next steps in Kurt Lewin's Change Theory of Nursing, which are *changing* and *refreezing*.

Final Thoughts

BCMA is the best evidence-based practice for medication administration, and should be utilized to increase patient safety and decrease medical errors. The SDS-center at the VA Medical Center serves over 1,600 patients every year, and could improve the safety of these patients by implementing BCMA technology to automate the medication administration process. The registered nurses agree that implementing this technology would improve patient safety,

would benefit patients, and would be useful when administering medication. They also believe that BCMA is easy to use. Future quality improvement projects could build on this work to address other potential barriers noted to support BCMA implementation in the perioperative setting.

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Appendix

Appendix I: Approval to use the Technology Acceptance Model

May 2, 2022

Dear Colleen Gauvin,

My name is Carolina Reis, and I am contacting you on behalf of Prof. Dr. Venkatesh regarding your request. Thank you for your interest.

All permissions and access to papers are typically handled through the website: http://vvenkatesh.com. However, the system is currently undergoing an update. Therefore, I am sending the permission email below on behalf of Dr. Venkatesh:

Thank you for your interest. Your permission to use content from the paper is granted. Please cite the work appropriately. Note that this permission does not exempt you from seeking the necessary permission from the copyright owner (typically, the publisher of the journal) for any reproduction of any materials contained in this paper.

Sincerely,
Viswanath Venkatesh
Eminent Scholar and Verizon Chair of Business Information Technology
Email: vvenkatesh@vvenkatesh.us
Website: http://vvenkatesh.com

You may also find Prof. Dr. Venkatesh's book to be of use: http://www.vvenkatesh.com/book/!

Thank you,
Carolina Reis
creis2@vt.edu

Appendix II: Informed Consent for Survey Respondents

University of New Hampshire

Dear nursing staff,

I am a nursing student at the University of New Hampshire and I am working on a quality improvement (QI) project to learn about barriers to the implementation of barcode medication administration. By participating in this survey, you are participating in this project.

This consent form describes the project and helps you to decide if you want to participate. It provides important information about what you will be asked to do in the project, about the risks and benefits of participating in the project, and about your rights as a participant. You should:

- Read the information in this document carefully, and ask me or my faculty advisor any questions, particularly if you do not understand something.
- Not agree to participate until all your questions have been answered, or until you are sure that you want to.
- Understand that your participation in this project involves you to complete a survey that will take about 15 minutes.
- Understand that the potential risks of participating in this project are minimal.

You must be at least 18 years old to participate in this project, and you must be a registered nurse at the Manchester VA working in the Same-Day Surgery Center.

If you agree to participate in this project after reading this document, you will be asked to participate in a survey that will take approximately 15 minutes. You will not be paid to participate in this project.

You should complete the survey only once. The project lead may exclude your data if they determine that you did not meet the eligibility criteria for the project. For questions about eligibility, please contact the project lead (information provided at the end of the form).

Although you are not anticipated to receive any direct benefits from participating in this project, the benefits of the knowledge gained are expected to help guide VA implementation of barcode medication administration in order to potentially improve patient safety.

Taking part in this project is completely voluntary. You may choose not to take part at all. If you agree to participate, you may refuse to answer any question. If you change your mind, you may stop participating at any time. Any data collected as part of your participation will remain part of the project records. If you decide not to participate or if you stop participating at any time, you will not be penalized.

I plan to maintain the confidentiality of all data and records associated with your participation in this project. Due to the low number of respondents, individually identifiable information is excluded from this survey in order to protect your privacy. Responses are anonymous. As a reminder, any communication via the internet poses minimal risk of a breach of confidentiality.

To help protect the confidentiality of your information, data will be stored via the USNH IT secure cloud storage [e.g., SharePoint, Teams]. Only the project lead, Colleen Gauvin, and her faculty advisor, Dr. Pamela Kallmerten, will have access to the data. Data, even if de-identified, will not be used for future projects. I will report the de-identified data in an educational paper that will be available via the UNH Scholar's Repository. The results may be used in reports, presentations, and publications for educational purposes only.

If you have any questions about this project or would like more information before, during, or after the project, you may contact Colleen Gauvin at Colleen.Gauvin@unh.edu. If you have questions about your rights as a participant, you may contact Dr. Pamela Kallmerten at UNH to discuss them (Pamela.Kallmerten@unh.edu).

Thank you for your consideration.

Sincerely,
Colleen Gauvin

UNH Nursing Student
Colleen.Gauvin@unh.edu