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What You Need to Know about Bar-Code Medication Administration

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Abstract
Medication errors are the most common type of preventable error. Bar-code medication administration (BCMA) technology was designed to reduce medication administration errors. Poor system design, implementation and workarounds remain a cause of errors. This paper reviews the literature on BCMA, identifies a gap in the findings and identifies three evidence based practices that could be used to improve system implementation and reduce error. The literature review identified that Bar-code medication administration and system workarounds are well documented and affect patient safety. Based on the critical analysis of 10 studies, we identified gaps in the standardization of BCMA planning, implementation, and sustainability. The themes that emerged from the literature were poor BCMA design and implementation that resulted in workarounds.The three evidence based strategies proposed to address this gap are, evidence based standardization in planning and implementation, the identification and elimination of workarounds and hard wiring. An evidence based checklist evaluates compliance with standard procedures. The LEAN model of Jodoka is used to assure adaptation of the machine to human workflow. Direct observation provides valuable workflow assessment. An effective BCMA implementation involves careful system design, identification of workflow issues which cause workarounds, and adapting the machine to nursing needs.

Keywords
Bar Code Administration, Safety, Quality, Workarounds

Cover Page Footnote
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Introduction

The 1999 seminal report on medical errors published by the Institute of Medicine reported that between 44,000 and 88,000 patients die in hospitals each year as a result of medical errors (Institute of Medicine [IOM], 1999). Yet almost two decades later, premature deaths caused by medical errors have risen to 400,000 per year (John, 2013). Medication administration errors alone cost the United States (US) over $3.5 billion each year, and on average, a hospitalized patient is subjected to at least one medication error each day (Rack, Dudjak, & Wolf, 2012). Medication errors are the most common type of preventable error, with 38% occurring at the point of administration, and only 2% of these errors are caught before the medication is administered (Voshall, Piscotty, Lawrence, & Targosz, 2013).

A possible solution to the problem of medication error is the use of bar-code medication administration (BCMA) technology designed to reduce medication administration errors, verify the five rights of administration, and alert the nurse to potential errors. While some hospitals have reported greater than 50% reduction in medication administration errors after implementing BCMA (Richardson, Bronirski, & Hayden, 2012), poor system design and nurse workarounds remain causes of error (Poon et al., 2010). Nurse leadership can mitigate risk through identification of improved system or practice redesigns (Richardson et al., 2012).

Workarounds are of particular concern in reference to patient safety. Rack, Dudjak, and Wolf (2012) defined workarounds as staff actions that do not follow workflow or intentions of system design. The purpose of this article was to assess current literature regarding BCMA technology and provide nurse leaders with information to improve adherence to BCMA through evidence-based implementation, organizational structure, and policy and procedure.

Review of Literature

The purpose of the literature review was to examine evidence related to BCMA technology, especially in how nurse workarounds may affect patient safety and quality of care. Search engines utilized included CINAHL Plus, PubMed and The Cochrane Library. Key words utilized for the search were bar-code medication administration, safety, quality, and workarounds.

Inclusion Criteria

The inclusion criteria for the articles selected were peer reviewed, evidence-based journal articles published in English within the last ten years. Particular attention was given to articles reporting on potential errors associated with identifying effects of BCMA workarounds.

Initial Article Yield

The initial article yield for PubMed was nine, three of which were observational studies, one was a mixed methods study, one was a retrospective study with direct observation and semi-structured interview, three were review articles, and one was a qualitative study in which a typology of workarounds was developed. The CINAH Plus database yielded 32 articles, of which 11 focused specifically on patient safety or nurse workarounds. These articles included a systematic review, a quality assurance methods summary, a longitudinal descriptive study, three observational studies, a cross-sectional observational pilot study, a non-experimental economic review of BCMA, a comparative study, an informatics editorial, and an advisory report. The remaining articles from The Cochrane Library keyword search yielded no articles of interest.

Rationale for Retention

The articles selected for inclusion were from peer-reviewed journal articles, and are listed in Appendix 1. Several of the articles retained were quantitative and qualitative studies with evidence

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relative to nursing medication administration using BCMA technology. Articles selected focused on findings related to patient safety, quality, and workarounds in acute care hospitals and long term care facilities.

Given that it is known that nurses often use workarounds of system procedures in medication administration, one study was selected because it identified types of deviations from a designed work flow (Voshall et al., 2013). One study was selected that used bar-code medication administration designed to verify the five rights of medication administration and alert the nurse of any potential error (Harrington, Clyne, Fuchs, Hardison, & Johnson, 2013). The five rights of medication administration are key to providing safe administration and were reviewed in an article, which included clinical trials, and was a systematic review of six studies investigating the effectiveness of BCMA (Young, Slebodnik, & Sands, 2010). A quality improvement study provided an implementation view of the design and practice change for sustaining safe practice in the clinical setting using BCMA (Richardson et al., 2012). Another study compared work time of the traditional administration system with BCMA and offered suggestions for training nurses with what to expect with BCMA (Tsai, Sun, & Taur, 2010). The seminal report on human error was chosen because of its importance in the United States patient safety movement (IOM, 1999).

Critical Appraisal of Evidence

A critical article appraisal revealed that medication errors are the most common type of preventable error and most errors occur at the point of administration (Voshall, et al., 2013; Gooder, 2011). On average, a hospitalized patient is subjected to at least one medication error each day at the cost to the health system of over $3.5 billion each year (Seibert, Maddox, Flynn, & Williams, 2014). Some hospitals have reported greater than 50% reduction in medication administration errors after implementation of BCMA (Poon et al., 2010).

Workarounds occurred when technology systems and processes did not match nursing workflow. The most frequent areas of concern related to tasks, errors of omission, environment, and organization (Rack et al., 2012). Without adequate organizational planning and multidisciplinary support, the organizational culture fails to sustain the commitment necessary for success. Staff education must prepare nurses to follow the defined processes to ensure tasks are completed properly and in correct order (i.e., scanning patient identification wristbands followed by scanning medication bar-code labels before administering medications). Technology failures, such as the inability to scan wristbands or medication bar-code labels, can result in errors of omission. Technology processes slow critical, rapid medication administration delivery times and may be abandoned in environments providing emergency care (Rack et al., 2011). The organization must develop a comprehensive strategy to address issues that diminish the effectiveness of BCMA, maintain vigilance to support nursing workflow, provide consistent technology support, and allow for maintenance of equipment.

Synthesis of Evidence

A review of the articles revealed three main themes: medication administration is a source of errors which significantly affects patient safety; bar-code medication administration technology provides a system to prevent errors at the point of administration where most errors occur; and, systems that are not implemented thoughtfully can lead to user dissatisfaction and foster development of workarounds which may increase the risk of errors.

Discussion

Gaps in BCMA administration

Critical analysis of the literature identified one major gap in the current literature on BCMA administration in today's healthcare environment. This gap is the lack of evidence-based standardization in the planning, implementation, and sustainability of BCMA administration in current

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practice. This manuscript addresses this major gap and provides study results to support the three evidence-based practice strategies we recommend. The three evidence-based strategies presented are (1) planning and implementation, (2) identification and elimination of workarounds, and (3) sustainability. After reviewing the literature, we concluded that a standardized plan in BCMA implementation has the potential to increase the benefits of BCMA in today's healthcare market. What are the other gaps?

Planning and implementation

The selection and deployment of information technology into healthcare settings has been successfully accomplished, beginning with implementation of computer-based technology within finance departments (Bhaskar, 2009). However, there has often been little coordination between departments, such as pharmacy, medical or information technology which has resulted in a fragmented approach to implementing health information technology. Additionally, financial concerns may weigh heavily in the vendor selection process, resulting in choosing a BCMA system that is not as desirable, and in turn then develops errors of functionality between systems and equipment interfacing. It is critical to involve nurses who work at the point of care in the planning aspects of technology purchase and technology functionality before introducing new technologies, and this holds for BCMA technology (Weckman & Janzen, 2009). Nurses must adjust to new processes imposed by the technology, carry an additional workload, and a have a perceived need to work around the system (Wulff, Cummings, Marck, & Yurtseven, 2011). When nurses are not included in the evaluation, selection, and implementation processes of BCMA technology, the desired improvement in patient safety outcomes may fail because the system does not meet the needs of the nurses who use the technology on a daily basis.

A collaborative team approach is critical to ensure successful use of a new technology. The process utilized by VA personnel illustrates the collaborative efforts implemented to ensure success of a newly developing bar code scanning method. The medication bar code scanning process began in 1999 when a nurse in a Department of Veterans Affairs (VA) hospital first proposed use of bar-code technology to scan medications. Facility level management appointed a BCMA Coordinator responsible for leading and implementing all processes to improve safety, efficacy, and efficiency of the medication administration management process. The Coordinator was responsible for process oversight, maintenance of equipment, and for guidance related to business processes. A multidisciplinary team that included representatives from front line nursing, nursing management, pharmacy, health information technology, labor unions, respiratory therapy, biomedical, quality improvement, risk management, staff education, laboratory, and blood bank personnel was appointed to work with the BCMA Coordinator. Ad hoc representative members were appointed from the chief of staff's office, medical staff, and engineering areas. The processes needed to implement BCMA and work out implementation issues were solved by a collaborative team, including nurses. Nurses, have proven effective for improving patient safety (Schneider, Mims, Carlson, & Tucker, 2009).

The bar-code medication administration team was responsible for the selection of technology, the initial policies and processes for staff training, and the deployment plan for implementation and maintenance throughout the hospital. Policies were written to address continuing staff education, new employee orientation, and annually updated competencies. Continued operational practice created solutions for problems, such as: missed medication doses; equipment malfunction, maintenance, and repair; life cycle replacement; and bar-code quality on wristbands and medication packaging. Performance measures were evaluated for as needed (PRN) medication effectiveness, medication variances, and intravenous fluid (IV) documentation. The VA has used the inter and intra departmental collaborative model for more fifteen years and attributes BCMA success to the expert knowledge base shared among the work groups (Schneider et al., 2009).

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Harrington et al. (2013) described a general hospital's successful effort to evaluate safe practices using BCMA technology. Nursing and pharmacy staff developed an evidence-based practice checklist for process evaluation to address situations where BCMA workarounds were most commonly observed. The checklist was useful in staff education, actual BCMA administration, and evaluation of effective BCMA processes. Processes related to the five rights of medication administration were addressed using bar code scanning of patient wristband and medication label. The checklist ensured a nurse's ability to document allergies, home use medications, STAT (immediate, emergency) medications, medication administration using multidose vials, and high-risk medication, all of which could be verified by a second nurse. Alert alarms and text messages provided clinical decision support to nurses administering medications which warned of a patient mismatch with a planned medication administration, wrong dosage, required vital signs check prior to administering certain medications, discontinued medications, and new STAT medication orders (Harrington et al., 2013).

Training on the use of the bar scanning processes ensured that nurses learned proper procedures to modify the scheduled medication time for special clinical situations, document STAT medication and emergency care medication administration, and input acceptable overrides. Nurses learned technology procedures, such as how to document IV fluid medication, handoff during transfer of care from one unit or shift to another, and how to accurately document medications when double scanning or scanning failure occurred.

An evidence based quality checklist was used to guide the medication administration process and, included steps to ensure documentation of proper equipment function, maintenance, and availability of backup replacement equipment. Following implementation of the evidence-based quality assurance checklist with the associated processes, compliance with BCMA improved from 72% to 81% (Harrington et al., 2013).

Identification and elimination of workarounds

Rack et al. (2012) defined a workaround as staff actions that do not follow workflow or intentions of the system design. The final step in medication administration is giving the medication to the patient, , and the last opportunity to identify errors before the medication reaches the patient. When nurses circumvent the system and use workarounds in the medication administration process, BCMA can provide a false sense of security related to medication administration. Despite safety measures embedded in the medication administration process, workarounds compromise the anticipated improvement in patient safety and can lead to medication errors Rack et al. (2012).

Workarounds can be categorized in several ways. Rack et al. (2012) identified five categories of workarounds that include task, environmental, patient, organization, and technology. Task-related workarounds can be the result of a lack of familiarity with the established procedures for BCMA. An example is not following the correct sequence in which barcodes should be scanned. Environmental workarounds are usually created to overcome technology flaws or physical issues in the hospital environment, such as a lack of Wi-Fi signal on some floors or patient rooms. Patient-related workarounds often pertain to the patient not wearing an armband, either because of removal by the patient or the inability to place an armband on the patient due to the use of medical devices. Organizational workarounds are most often the result of poor procedures, such as permitting a patient to arrive on the unit without an armband. Technology-related workarounds are most often problems with improperly functioning bar-code scanners (Rack et al., 2012).

The evaluation of BCMA by direct observation is time consuming and expensive, but is the gold standard for evaluation of compliance with policies and procedures. Direct observation was the evaluation method utilized in most of the studies reviewed for this manuscript (add some refs here). For example, the 32-item checklist Harrington et al. (2013) developed for the evaluation of compliance was used by observers who shadowed nurses during medication administration on both AM and PM shifts. The checklist included items related to characteristics of the armband, medication bar-code,

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five rights of medication administration, nurse alerts, and patient allergies. The researchers found this checklist was useful in the routine evaluation of BCMA and the optimization of performance.

Patient safety goals are achievable when BCMA systems are used as intended. Nursing involvement early in the implementation process of the system aids in identifying barriers to using the BCMA system. Early user involvement enables the team leader to quickly identify or anticipate workarounds that may occur. A system of ongoing monitoring should be established to verify that the BCMA system is being used as planned, and to identify areas for improvement.

Sustainability

The BCMA process, once implemented, must be continually monitored (Ching, Williams, Idemoto, & Blackmore, 2014). Sustainability to maintain current systems and to avoid workarounds requires ongoing action. Once BCMA has been implemented, sustainability can be accomplished with the combination of a process improvement (PI) method (e.g. Donabedian model) and an improvement model, such as the IHI Model for Improvement (IHI, 2012). The Lean model for healthcare is a model that has been successfully used in manufacturing has been adapted to health care to improve outcomes (Institute for Healthcare Improvement [IHI], 2005).

The Donabedian model is a process improvement (PI) framework for examining quality in healthcare utilizing the triad of structure, such as the buildings or environment; process, the transactions in healthcare between providers and patients; and outcomes, or the actual effects of healthcare on the patient (Ayanian & Markel, 2016). Process improvement measures small tests of change after implementation of an intervention, followed by testing the intervention's effectiveness on outcomes. The Lean model maps processes aimed at reducing waste, such as wasted steps, wasted time waiting for healthcare, or wasted resources (IHI, 2005). One method used within the Lean model is the Judoka method for improving automation of technology for human use (Ching et al., 2014). Both the Donabedian and Lean models provide methods to address all facets of sustaining BCMA. These methods provide continual enhancement and ongoing problem solving that inevitably occur when adopting machines to human workflow processes. Issues surrounding BCMA to be considered are many and varied, such as accuracy, usefulness, consistency, time efficiency, ease of performance, error likelihood, and error detection (Holden et al., 2011).

The process improvement model combined with Lean methodology provides the ability to continually improve and sustain positive change. These methods can be used to identify and correct issues that occur while improving quality and lowering costs. The Judoko method can be used to standardize as many nurse processes as possible to cover clinical situations (Ching et al., 2014). For instance, the authors noted that their organization adapted barcode printing not only to the medication container but also to the packaging, which in many instances is accidently discarded. If bar-codes are missing from medications, this may cause the nurse to work around the scanning system. Another process improvement method to address evolving issues of man with machinery and automated technology is to use proactive simulation to test for small changes in quality processes. In summary, the authors noted that bar-code medication administration requires continuous, ongoing modification and improvement (Ching et al., 2014). Ongoing monitoring of human interactions with the machine enables sustainability. If nurses' issues are not addressed up front, and they find the system difficult to use or inefficient, nurses will develop workarounds to address the perceived system flaws.

Using the Judoka method involves monitoring the ongoing interaction of the nurse with the machine to ensure issues are addressed adequately. For instance, the Judoka method provides automation of error extraction in order to identify issues. It is then important to provide timely follow-up to sustain the system (Bagby, Mims, Schneider, & Petrich, 2011). Nurses are more likely to use a system that is integrated into their workflow; however, if process issues are not addressed, nurses will use workarounds to complete the medication administration process. Studies show that

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seconds and minutes by nurses to bypass faulty or problematic systems can amount to thousands of hours in lost time for hospitals (Bagby et al., 2011). Thus, a recommendation is to develop administrative tracking systems to capture issues and trouble shoot problems that arise.

Sustaining BCMA systems takes continual observation, error detection and improvement. Sustainability requires continual change and adaption of the machine to accommodate work flow in order to remain successful and to reduce risk to patients. When machines are adapted to human work flow, the success rate increases (Holden et al., 2014).

Implications for Practice

Bar-code medication administration technology was designed to reduce medication administration errors. However, marrying efficiency and evidence at the bedside has challenges. The process of BCMA itself may have potential pitfalls. A standardized approach to BCMA use may prevent unforeseen risks related to the implementation, modification and sustainability of this technology. The purpose of this review manuscript was to discuss opportunities such as process improvement, Lean strategies, and change management that nursing leaders can implement to impact BCMA process adherence and reduce potential for development of workarounds.

Findings in literature emphasize the effectiveness of BCMA when used properly (Young et al., 2010; Seibert et al., 2014). Further nursing research is needed in developing best practices for optimal adherence to BCMA processes. An effective BCMA implementation process should involve careful system design and planning, technology infrastructure, ability to interface with other information technology systems, a robust nurse training program, and an accountability process using system reports. Additionally, ongoing process evaluation should include system quality control and refinement as well as user support. Strategies are also necessary to incorporate methods for nursing leaders to coach change management, promote positive impacts of the technology, and further create a safety culture around these new technologies. Effectiveness of BCMA for preventing patient harm may be greatest when implemented using processes that are optimized to ensure appropriate use of BCMA processes.

Conclusion

As health organizations and hospitals implement BCMA to increase patient safety, nursing leadership is called to action to research and define the best practices for the implementation of technology. Many hospitals have shown remarkable commitment and investment in the effort to implement effective BCMA, demonstrating that quality and patient safety are a top priority in our health care systems. While attention to nurse work flow may not result in zero medical errors, adherence to technology system operations and patient safety practice techniques can reduce medical error and improve quality of care (Bhaskar, 2009; Holden, 2011). The literature review of BCMA technology provided nurse leaders with information to improve adherence to BCMA through evidence-based implementation, organizational structure, and policy and procedure.

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