

Medication Errors Occurring with the Use of Bar-Code Administration Technology

ABSTRACT

Bar-code medication administration (BCMA) systems can improve medication safety by verifying that the right drug is being administered to the right patient. Studies have shown that BCMA technology can reduce medication errors by 65% to 86%. But BCMA technology alone does not ensure a safe medication-use system. A number of reports submitted through PA-PSRS describe medication errors that occurred in organizations that used a bar-code system for administration. Some of these errors result from failures to use this technology appropriately, employing workarounds or overriding alerts, disruptions in the medication administration process, and dispensing errors that arise in the pharmacy. Strategies to address problems with this technology include reviewing BCMA logs to evaluate overrides and identify system weaknesses and monitoring and measuring compliance with the technology to identify and remove any barriers to its appropriate use. (Pa Patient Saf Advis 2008 Dec;5[4]:122-6.)

A prospective cohort study of medication errors by Leape et al.¹ determined that 39% of errors occurred during the prescribing phase, 12% during transcription, 11% during dispensing, and 38% during administration. Close to half of the errors that occurred during the prescribing phase were intercepted before they reached the patient; in contrast, only 2% of errors that occurred during the administration phase were intercepted. Another study using direct observation in 36 healthcare facilities found that medication administration errors occurred in almost 20% of doses administered.² Data from U.S. Pharmacopeia's (USP's) medication error reporting database, MEDMARX®, indicates that an error at the point of administration is least likely to be intercepted before reaching the patient, compared to other phases of the medication-use process.³

One form of technology that may address administration errors is a bar-code medication administration (BCMA) system. BCMA can improve medication safety through several levels. At the most basic level, the system helps to verify that the right drug is being administered to the right patient in the right dose and at the right time. The 1999 Institute of Medicine report *To Err Is Human* noted that point-of-care bar coding offers a simple way to ensure that the identity and dose of the drug are as prescribed, that the drug is being given to the right patient, and that all of the steps in the dispensing and administration processes are checked for timeliness and accuracy.⁴ Since the late 1990s, the use of bar coding in drug administration has increased.

Studies have shown that BCMA can reduce medication errors by 65% to 86%.^{5,6,7} To determine the effectiveness of its newly implemented bar-code system, one hospital in Pennsylvania showed that the direct-observation accuracy rate before BCMA was 86.5%; after BCMA, the rate rose to 97%.⁸ But technology alone does not ensure a safe medication-use system, and the process changes that accompany any technology can introduce new sources of error.⁴

Clinical analysts from PA-PSRS queried the database using keywords related to BCMA such as "bar code" and "scanned" as well as reports coded as involving BCMA when reviewing individual case reports. A review of medication error reports submitted through PA-PSRS since June 2004 revealed that there are reports that describe potential events that were detected and caught by BCMA technology. However, a number of reports submitted through PA-PSRS describe medication errors that occurred in organizations that used a bar-coding system for administration. Some of these errors are indirectly associated with the bar-code administration system, and some are the result of issues with the use and misuse of this technology.

Dispensing Node

Some errors associated with BCMA do not originate with the technology. Rather, they occur earlier in the medication-use process (i.e., dispensing phase) and are perpetuated by bar-code verification at administration. For example, pharmacy may mistakenly place the correct (e.g., right drug, right dose, right patient) pharmacy-generated label on the wrong medication. This type of error, especially if the pharmacy-generated label obscures critical information on the manufacturer's label, could make its way to the patient, as the BCMA system would read the bar code as the correct medication for the patient.

A review of medication errors associated with bar-code technology submitted to the USP MEDMARX program between June and August 2006 showed that the most frequent cause of BCMA-related errors was mislabeling. Sixty-five of the 128 (51%) reported labeling errors resulted from attaching a bar code associated with one product to a different product. Another 29 (22.7%) of the reports of mislabeling indicated that the bar code was affixed to the wrong strength of the correct medication.⁹

These types of errors may occur for many reasons. Reports submitted through PA-PSRS demonstrate that a wide variety of contributing factors may lead to selecting the wrong product from the pharmacy inventory, including similar packaging and labeling of medications, pharmacy order-entry errors, look-alike

names, and selection of the right drug but wrong concentration. For example, consider the following reports.

A patient was due to have hydrogen peroxide applied to her face. The medication was obtained from the medication room, as sent up from pharmacy. It was labeled correctly, but the bottle was magnesium citrate. The label was placed partially covering the magnesium citrate label. This would not have been picked up from scanning because staff scans the label.

Lamictal® (lamotrigine) 150 mg [orally twice daily] was ordered for a patient, but was transcribed into the [BCMA] system as lamivudine 150 mg po bid by the pharmacy. Both the bar code and Pyxis scanned correctly due to order being verified by nurse as correct drug. Error noticed by doctor when reviewing medication list.

A patient was ordered for a “now” dose of Thorazine (chlorpromazine) 25 mg. The pharmacy filled the order and dispensed Librium® (chlordiazepoxide) 25 mg. The nurse used the electronic scanner, and the device indicated a “wrong drug” error. The nurse looked at the drug, thought the name was correct, and overrode the device and administered the incorrect medication.

Vancomycin was dispensed for a neonate in a syringe labeled with the ordered dose, but with the wrong concentration of drug. The medication scanned correctly in [BCMA], since label with correct information. The error was discovered by pharmacy. The doses were retrieved from the floor.

In order to maximize the safety mechanisms that BCMA technology provides, medications need to be packaged in unit-dose or ready-to-use formats. However, the availability, or lack thereof, of manufacturer-supplied, bar-coded unit dose medications does not fully support this. Although the U.S. Food and Drug Administration requires bar codes on containers, it does not require that unit-dose containers be available for all medications. As a result, unit-dose packaging of some established products has been discontinued. Fully implementing a BCMA system, therefore, may involve repackaging many medications and relabeling each dose with a bar code. This may include the purchasing of automated repackaging equipment, increasing pharmacy staff, providing adequate space within the pharmacy to prepare these medications, and implementing a verification process to ensure that the bar code is correct and readable by the same scanners and database used by the nurses on the patient care units. In addition, some pharmacies do not prepare medications in a patient-specific ready-to-use form—for example, breaking tablets in half before unit-dosing the products for “half-tablet” orders or providing patient care areas with bulk bottles of liquid medications from which a nurse is required to measure a dose. In the following report submitted through PA-PSRS, a whole tablet was

administered to a patient when only one half of a tablet was ordered.

Nurse scanned Bumex® (bumetanide) 1 mg tab but forgot to break tab prior to administering 0.5 mg dose ordered; wrong dose error. The vital signs were monitored and serum electrolytes were rechecked.

Administering Node

BCMA technology can improve medication safety through several levels of functionality. At the most basic level, the system helps verify that the right drug is being administered to the right patient in the right dose and at the right time. When one of these items does not match, most systems alert the practitioner before administration. Alerts can also be generated when patients do not have an active order or are allergic to the scanned medication. However, problems may occur despite the display of an alert. Examples of reports submitted through PA-PSRS in which these alerts signaled a problem, yet an error occurred, include the following:

Nurse was assisting another nurse by giving a patient a dose of insulin. The nurse scanned and administered the insulin despite [BCMA] firing a “no order in system” warning. The insulin was given to wrong patient.

Patient who was on weight-based heparin protocol was ordered “No Bolus Ever” by the physician. [BCMA] fired a “no order in system” alert, but the nurse continued and administered bolus. No untoward reaction was reported.

[Morning] dose of Avandia® (rosiglitazone) administered early by the night shift nurse. Student nurse noted Avandia dose on [BCMA] worksheet and administered second dose. [BCMA] displayed appropriate “early dose” and “exceeding maximum daily dose” warnings; student proceeded through warnings and administered dose.

Patient’s order for Cardizem® (diltiazem) 120 mg four times a day was discontinued, and the dose was changed to 60 mg every six hours. The pharmacy entered the transcribed orders into the [BCMA] systems, awaiting confirmation by the nurse. The nurse administered the 120 mg dose, despite an alert from [BCMA] that stated the medication was discontinued and that there were medications that required confirmation. The nurse then confirmed orders and administered 60 mg dose within 2 hours of 120 mg dose. No untoward reaction was reported.

Alerts that are generated by BCMA systems often may not be noticeable. For example, a system may generate a visual display of the alert but not provide a distinct auditory alert. If a nurse does not look at the screen for any alerts after scanning a patient’s wristband and/or bar-coded medications, errors will ensue. Additionally, the alerts are not hard-stops, meaning that the system does not physically stop a practitioner from proceeding with scanning or administering a medication. The alert is merely a warning that may or

may not require a simple key stroke (e.g., hitting the “Enter” key on a keyboard) to override. One Pennsylvania facility submitted the following report through PA-PSRS that illustrates this.

A nurse drew up a medication for a patient in another room and mistakenly administered the medication to [another] patient. The [nurse] scanned each medication; however, the nurse went into the wrong room, scanned the patient’s bar code, and did not check the screen prior to giving medication to the patient. The screen did verify that it was the wrong patient. The patient received three incorrect medications.

Problems have also occurred when other processes surrounding medication administration have broken down. Although the steps directly involved with the scanning of the medication and patient may be completed, errors can be introduced if distractions occur or medications are laid down after the scanning process. Patients in Pennsylvania have received the incorrect medication or dose due to these types of process breakdowns, as evident from the following PA-PSRS reports.

Nurse pulled Unasyn® (ampicillin and sulbactam) 1.5 mg to hang for patient’s dose. She scanned the medication and the patient’s wristband appropriately. The nurse put down the medication on the medication cart to answer a call bell. She returned to the medication cart within approximately five minutes, took the medication into the wrong patient room, and hung on wrong patient.

Nurse removed morphine syringe for patient-controlled analgesia (PCA) to change the PCA pump since the previous syringe was empty. The doctor wrote an order for “sodium bicarbonate [intravenous] IV push x1.” The nurse scanned the sodium bicarbonate per protocol, but after scanning the patient and the medication, the nurse picked up PCA morphine syringe and administered morphine to patient instead of the sodium bicarbonate. The nurse began to scan the morphine PCA syringe to change PCA and then realized that morphine was given.

A patient with diabetes was to receive 4 units of regular insulin per sliding scale insulin coverage, but the patient received 10 units of regular insulin and 20 units of NPH insulin that was intended to be given to the patient’s roommate. The nurse drew both insulin doses from the automated dispensing cabinet and had properly labeled the syringes by bar coding them. Prior to administering the insulin, she scanned the patient and the syringe. She then obtained an alcohol swab, picked up the wrong syringe, and administered the wrong dose to the patient. The nurse immediately realized her mistake and notified the physician.

Failure to Scan Medications

The effectiveness of bar coding technology in safeguarding patients is limited by the extent to which it is correctly and consistently used at the bedside by each clinician administering medications. In a study

of the 85 facilities under the Hospital Corporation of America facilities using BCMA in June 2004, only 64% of patient armbands were scanned and only 86% of medication labels were scanned.¹⁰ Many reports submitted through PA-PSRS suggest that some medications and patient armbands continue to not be scanned.

A nurse found Brevibloc® (esmolol) to be infusing instead of a heparin infusion as ordered. Heparin was ordered to be resumed, and the nurse started wrong infusion. The nurse did not scan medication.

Nurse connected peripherally inserted central catheter line to central venous pressure transducer as ordered but used a heparin flush bag on patient with HIPA (+) [sic] history instead of normal saline flush. Nurse did not scan heparin bag into [BCMA] prior to administration so allergy alert could not fire.

Phenylephrine drip [was found] infusing at 35 mL/hour instead of ordered insulin drip at 7 units/hour (35 mL/hour). When hanging new bag of insulin, nurse failed to scan bar code into [BCMA] and hung wrong medication. There was no adverse effect to blood pressure or glucose noted.

Altace® (ramipril) was given in the morning by the nurse but was not scanned or documented into [BCMA] system. Later, another nurse noted that the medication was still profiled for administration on [BCMA], and she also administered the medication, which resulted in an extra dose error.

The patient’s bedtime medications were given but were not immediately recorded into the [BCMA] system because the nurse was suddenly called to a code blue elsewhere. Another staff member, in an effort to assist, checked to see if the patient’s medications were given, saw that they had not been scanned, and assumed they were not given. The medications were administered a second time at bedtime resulting in an extra dose.

Why practitioners choose not to use this technology when giving medications is a key question to ask in order to maximize the impact BCMA can have on medication safety. To determine the factors that influenced the bar-code verification undertaken by nurses during medication administration, one Dutch hospital asked the nurses why the bar-code system was not always used. The five most frequently cited reasons for not verifying bar codes were difficulties in scanning bar codes on the medication labels, lack of awareness of bar codes on medication labels, delays in responses from the computerized system, shortage of time, and administration of medication before prescription.¹¹

Workarounds and Overrides

A workaround is a method of accomplishing an activity when the usual system/process is not working well.¹² While a workaround provides a temporary solution to the immediate problem, it is also an indication that the system may need improvement. To save time, nurses may work around the safety features

of a BCMA system. For example, nurses may type the patient's Social Security number (which can be used as a patient identifier) into the system rather than scanning the patient's wristband. This avoids perceived difficulties (e.g., a damaged bar code, the curvature of the band on patients with small wrists) in scanning the wristband. Other examples of workarounds used to identify patients include keeping a second set of printed patient wristbands on a ring for scanning in the medication room or patient bedside or affixing the patient wristband to the bedside rather than on the patient to expedite scanning (e.g., when a new IV bag is hung and the patient is asleep).

Like automated dispensing cabinets (ADCs), BCMA systems allow overrides in case medications need to be administered in an emergency. All caregivers administering medications must understand that using an override bypasses the important safety checks. One workaround identified by the Institute for Safe Medication Practices (ISMP) that led to an error involved an order for digoxin elixir, which was stocked on the patient care unit as a 60 mL (0.05 mg/mL) multidose bottle (the usual dose is 0.125 to 0.25 mg [2.5 to 5 mL]).¹³ The nurse misinterpreted the dose of digoxin elixir as 60 mL. In addition, she accidentally retrieved a bottle of doxepin (an antidepressant) from unit stock and attempted to administer a 60 mL dose of what she thought was digoxin. Scanning the bar code on the bottle of doxepin generated an error window on the electronic medication administration record screen stating "drug not on profile," but the nurse did not investigate the warning. Instead, she manually entered the doxepin national drug code (NDC), overriding the digoxin NDC that had been entered by the pharmacy. The result was administration of 60 mL doxepin to the patient.

Another example of a workaround includes a failure to scan every tablet or capsule included in a patient's dose. A number of reports have been submitted by Pennsylvania facilities that illustrate this at-risk behavior.

A nurse withdrew the incorrect amount of Dolophine® (methadone) tablets from the ADC and administered the medication. The nurse scanned one tablet and manually entered the prescribed dose in [BCMA] instead of scanning each individual tablet until the total prescribed dose was obtained.

Risk Reduction Strategies

New technology will not be a panacea for medication errors, but it can provide safeguards not possible with fully manual processes. Organizations may consider some of the following steps to maximize BCMA's impact on medication safety.

- Analyze BCMA logs, and evaluate all overrides to identify system weaknesses and areas in need of process improvement.

Failure Modes in the BCMA Process

Examples of failure modes that can occur during the bar-code medication administration (BCMA) process include the following:

- Medication does not come packaged as bar-coded unit-dose product
- Pharmacy does not scan products arriving in pharmacy for readability
- Pharmacy applies correct label with bar code to wrong product
- Drugs not available in ready-to-use unit-doses for nurse (e.g., tablets not broken in half)
- Nurse fails to scan patient
- Nurse fails to scan medication
- Bar code on patient and/or medication is unreadable
- Patient wristbands are not on patients but other locations (e.g., clipboards, med rooms)
- Nurse overlooks alert displayed on computer screen
- Nurse overrides alert without investigating its cause

- Monitor and measure compliance with the technology to identify and remove any barriers to the safe and appropriate use of BCMA.
- Conduct focus groups and satisfaction surveys to solicit nursing feedback.
- Conduct executive rounds and direct observation of medication administration to help identify and correct workarounds. Keeping an open door policy will allow staff opportunities to discuss barriers and workarounds. The nurse executive should encourage staff participation in the continuing process improvement activities that follow the implementation period.¹⁰
- Dispense patient-specific doses with bar codes whenever possible. This includes half tablets, oral syringes that contain the exact dose of an oral solution, and IV syringes that contain the patient's exact dose.
- Scan all medications upon arriving in the pharmacy to verify that the bar code is part of the current database, and scan medications before dispensing.
- Develop a mechanism to alert pharmacy when there is a problem scanning medications on the patient care units.
- Computer screens that display patient information, including allergies and medication lists, should be positioned so that they can be easily viewed and read by nurses.

- Bar-code label equipment, including printers and batteries, must be continually checked for accuracy and readability and undergo routine preventive maintenance by information technology (IT) or biomedical staff.¹³
- Do not have healthcare clinicians view the verification that BCMA provides as a nice but unnecessary feature. The alerts that arise from the system should not be allowed to be bypassed without serious consideration. For every error like those described above, many more have been prevented because BCMA has been employed. There is little doubt that BCMA can save lives if properly implemented and used appropriately.
- For those organizations that plan on introducing BCMA into their facilities, conduct a readiness assessment or other proactive risk assessment to gain commitment and create enthusiasm for BCMA, identify challenges and plan accordingly, and remedy process problems before implementation. A bar-code readiness assessment tool is available free of charge from ISMP. To obtain a copy, visit: <http://www.ismp.org/selfassessments/barcoding.asp>.
- Establish a multidisciplinary team, including nursing, IT, and pharmacy staff, as well as frontline practitioners, to determine best practices and guide implementation.

Notes

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PENNSYLVANIA PATIENT SAFETY ADVISORY

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