FOCUS: Patient Safety

Using BCMA Software to Improve Patient Safety In Veterans Administration Medical Centers

ABSTRACT

Bar Code Medication Administration (BCMA) software, as developed by the Veterans Health Administration, is an innovative, automated system that uses wireless, point-of-care technology with an integrated bar code scanner. The system can dramatically reduce medication administration errors by letting clinicians verify a patient's identity and validate medications against active orders.

Connie L. Johnson, Russell A. Carlson, RN, BSN, Chris L. Tucker, RPh, and Candice Willette

Inspiration strikes everywhere. For Sue Kinnick, RN, it struck in 1994 while returning a rental car. Seeing the car rental employee use a handheld device to scan a barcode located in the trunk of the car she was returning was all it took.

Further investigation ensued, resulting in a prototype system being developed at the Colmery-O'Neil Veterans Affairs Medical Center (VAMC), VA Heartland Network VISN 15, a division of the Eastern Kansas Health Care System. Its success prompted the Veterans Health Administration to create Bar Code Medication Administration (BCMA) software.

The greatest measure of improvement has been seen in patient safety and care. Since implementing the software, the Eastern Kansas Health Care System (through March 2001) has no documented medication administration errors — and has prevented some 549,000 errors — while dispensing approximately eight million doses. This

KEYWORDS

Medication errors     Adverse drug events     Barcodes     Barcoding
Veterans Health Administration     Wireless technology     Point-of-care technology
The First Steps

For many years, medication errors have been recognized as a significant cause of morbidity and mortality in hospitalized patients. The Veterans Administration medical centers are no exception. Like many hospitals across America, these medical centers use multiple (and time-consuming) manual processes for the delivery of medications to patients. These include physician ordering, transcription and verification, dispensing and delivery, and the administration of medications to patients. The entire process is actually quite complex, involving the coordination of numerous disciplines, the implementation of system checks and balances, and the standardization of delivery and administration procedures from the time an order is written until the patient receives a medication as prescribed. A breakdown in any one of these systems can lead to adverse drug events for a patient. To address this serious issue, the Department of Veterans Affairs provided $50,000 in startup funds in 1992 to the Eastern Kansas Health Care System to test the feasibility of developing a barcoding system for administering medications that would improve patient safety and care by reducing medication errors. The resulting prototype was a real-time electronic medication administration system that used wireless, point-of-care technology with an integrated bar-code scanner. During the prototype development phase, a multidisciplinary team consisting of information management, nursing, and pharmacy specialists was empowered to make policy changes that improved the quality of the existing medication delivery system. The team based these changes upon process issues identified during their research of the medication delivery process.

Traditional unit dose method for medication administration required that the nursing staff manually verify the order, record medication administration data, and place this information on the patient’s paper chart. This manual method was prone to errors that may occur as a result of patient misidentification, incorrect medication, incorrect administration time, and transcription errors. This method also required that any verification and correlation of the medication data be performed manually. Two of the biggest challenges with designing the system were (1) writing the specific software checks into the system to ensure that the nursing personnel were prevented from making a medication error, and (2) finding a vendor to develop the lightweight portable hardware that would be easy for nursing personnel to use when scanning barcodes.

Software considerations included creating locally developed and supported software that integrated with the existing pharmacy and nursing software programs. Limiting the variation that required staff to learn several different procedures, using protocols, and reducing reliance on memory were important design characteristics for the end users. Making it difficult to make an error by forcing functions was an important software consideration. Minimizing user-entered keystrokes and maximizing automated sign-ins and security checks also played a key role in the software design. Making the right thing the easiest thing to do and identifying potential errors prior to administration were the integral parts of the software design process.

Hardware considerations involved the use of radio frequency, utilizing both UHF and spread-spectrum technology, to create a system that automatically communicates to the existing mainframe computer system (VistA). It was important that no downloading would be required. The system needed to automatically reference several different service component software systems to create a real-time device, automatically communicating critical information back to the nurse passing medications. End users wanted an easy-to-use, lightweight, and portable device to provide a point-of-care data entry and retrieval system. In 1994, the software and hardware design process was completed, thanks to the inspiration of Sue Kinnick, RN. A 30-bed gerontological psychiatry ward was chosen as the pilot ward. Over the next 12 months, the Eastern Kansas Health Care System fine-tuned the software and hardware design, thanks to extensive end-user involvement and feedback. In August 1995, the system was implemented throughout all 22 nursing units within facilities of the Eastern Kansas Health Care System.

Success of Prototype Established BCMA Project

The success of the prototype prompted the Veterans Health Administration (VHA) to create a system that could be used nationwide within all of its medical centers. Based on the Eastern Kansas prototype, the Department of Veterans Affairs (VA) established a new project in August 1998 and called it Bar Code Medication Administration (BCMA). The goal of this project was the design and implementation of software that would electronically validate medications for inpatients and document the medication administration process accurately and efficiently. BCMA quickly demonstrated that this goal was quite possible (and continues to do so today).

Ultimately, BCMA was designed so that each time a nurse scanned the barcode on an ordered medication, it would validate whether the patient received the correct medication, in the correct dose when scheduled, as well as electronically document the medication as “given.” It also visually alerted clinicians (i.e., nurses) when the proper parameters were not met or when a patient had a potential or adverse reaction to a particular medication. The software further reduced any reliance on the nurse’s memory by providing a system of reports that reminded them when medications needed to be administered or when clinicians needed to assess the effectiveness of doses already administered.

Not only was the VA’s nationwide team of practitioners and technical experts required to develop and support BCMA, but also to integrate it within the existing VA hospi-
tal pharmacy and nursing software programs. The BCMA team further mandated that all functions built into the software must be cost-effective and easy to use. Other system requirements included using protocols, limiting the variations that would require hospital staff to learn several different procedures, identifying potential errors before administering medication, and reducing a reliance on a nurse’s memory.

The team determined that the best solution for meeting these requirements was a Graphical User Interface (GUI) application built on standard MS Windows-based equipment. This architecture was chosen only after the team concluded that their users were more familiar with the GUI aspect of computer systems than any proprietary systems, and that Windows-based computer hardware could be used for other purposes. Combined, this overall solution created an ideal architecture for the development of the BCMA software. Such an automated system allows nurses administering medications to be extremely mobile, thereby moving from patient to patient and ward to ward, without the need to carry heavy, bulky paperwork and patient charts. (In areas of the hospital that do not require clinician mobility, wired networking can be used.)

By using a wireless local area network (WLAN) technology, the VA could place real-time information into the hands of clinicians, thereby decreasing the possibility of medication errors. To achieve this real-time capability, the software required a continuous Ethernet connection to the VA hospital information system database. With their new battery-powered laptop computers and handheld barcode scanners, nurses could quickly and easily move from patient to patient or ward to ward and electronically complete the medication administration process.

Wireless LAN technology creates a network that operates much like a wired Ethernet network, but without the wire. WLAN devices communicate network traffic via radio frequency (RF) transmissions. The personal computers (PCs) connected by WLAN technology can communicate using Transmission Communication Protocol/Internet Protocol (TCP/IP) anywhere in the RF coverage area. These devices avoid interference with other RF devices by using spread-spectrum technology. Interference is greatly reduced by spreading the transmissions out over a wide band of frequencies. This technology, combined with data encryption, creates a secure network infrastructure for many applications.

The implementation of WLAN technology required planning and input from many departments. When selecting the WLAN system, the planners considered the coverage areas, supported applications, point-of-care devices, infrastructure, and interference with other RF devices in the hospital. A site survey by experienced technical personnel averted problems in these areas before implementing the BCMA application.

Another Key Ingredient: Improving the Lines of Communication

Changes in technology often demand changes in policies and procedures and standardization of terms and processes. Historically in the VA, pharmacy and nursing have not worked cohesively to address issues related to drug delivery and administration. Lack of communication, ineffective standardization protocols, and a lack of understanding of the complete process have created barriers to patient safety. So it was clear that an important step in implementing BCMA would be the development of the multidisciplinary team to address these issues and foster understanding of the medication administration process. This process created an environment for change that benefited patient care, reduced hand-offs, and improved communication between the pharmacy and nursing staffs. This was accomplished by each facility establishing a focus group to discuss system-related concerns such as when medications do not scan properly due to equipment failure, policy deviation, or order entry procedure failure.

Standardizing order interpretation guidelines during this process also helped to ensure that nursing, pharmacy, and providers interpreted the medication order the same way. Physicians could feel confident knowing that their order was carried out correctly, and in a timely manner, regardless of the ward where a patient was assigned. The pharmacy is now more able to coordinate drug delivery processes that meet the nursing staff’s expectations.

Standardization also offers many benefits to both patient care and pharmacy-nursing communication. The electronic transcription process allows both pharmacy and nursing to use the same electronic document for dispensing and administering medications. This ensures that pharmacy and nursing are verifying the same electronic order. Because nursing and pharmacy share the transcription process, any discrepancies in transcription are identified during the verification process and corrected before a transcription error causes patient harm.

How BCMA Benefits VA Medical Centers Nationwide

During August 1999, the BCMA project came to fruition when the VA successfully implemented the software in most of its 172 medical centers nationwide. (Today, all VA medical centers are enjoying the benefits of this new breed of administration software.) It was not surprising that this new software received a mix of reactions from hospital staff experienced with the more traditional, “manual” method of administering medications to patients. Yet it still managed to quickly demonstrate how it could dramatically reduce medication errors.

For example, at Colmery-O’Neill VAMC, of the 1,885,651 patient doses dispensed in 1993 (the last full year of data using a completely manual system) and of the 409 reported medication errors, the reported error rate was 0.0217 percent or 21.7 incident reports for each 100,000 units. The error rate so far for 2001 is 0.0030 percent or 3.0 incidents...
Figure 1. Reported Error Rate as a Percent of Total Doses Dispensed

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<th>Reported Error Rate Percent</th>
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<tr>
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1993 1995 1997 1999 2001

per 100,000 units, with 460,795 units dispensed and 22 reported errors. This is an 86.2 percent improvement in the reported error rate for 2001 over that of 1993, as shown in figure 1.

Table 1 compares the types of reported medication errors between 1993 and 2001. In each category of error, fewer errors occurred while the electronic system was in use, as is demonstrated by the following:

- 75.47 percent improvement in errors caused by the wrong medication being administered to a patient
- 61.97 percent improvement in errors caused by the incorrect doses being administered
- 93.48 percent improvement in wrong patient errors
- 87.41 percent improvement in wrong time errors
- 70.34 percent improvement in errors caused when medications scheduled for administration were not given

Among preventable events that occur under manual systems: 56 percent of errors occurred in the ordering stage, 6 percent during the transcription process, 4 percent during the dispensing stage, and 34 percent at the point of administration (the second highest incidence of error). It’s been proven that errors are much more likely to be caught and intercepted if they occur early in the medication administration process, which means that most medication administration errors are not caught with manual systems. As an example, one study of manual systems indicates that 48 percent of ordering errors, 23 percent of transcription errors, and 37 percent of dispensing errors were intercepted, but that zero percent of administration errors were intercepted. The benefit of a computerized medication administration system, such as BCMA, is to intercept and prevent errors resulting from medication administration mistakes. Colmery-O’Neil attributes the profound reduction in reported medication errors directly to the computerized medication administration software developed at its facility.

Still to date, no medication errors have occurred as a result of BCMA. However, the VA does find that errors do continue to occur when the device or software is not used in accordance with the established BCMA business practices, that is, when nurses perform “workarounds.” These include typing in barcode information instead of scanning a patient’s wristband and medication for verification. Additional system failures — such as physician’s orders, transcription, verification, dispensing, delivery, and monitoring errors — make up the remainder of the reported errors. By analyzing any Missing Dose requests, the VA can better identify drug storage and delivery problems, unit-dose cart-filling concerns, and package identification issues. Correcting these problems has reduced workflow interruption that could lead to compromised patient safety.

A medication administration error file designed into BCMA catches deviations in drug, dose, frequency, and administration times prior to the drug being administered to the patient. These errors are considered averted errors because an intervention occurred before administration. BCMA creates an alert whenever the nurse scans medication that deviates from an order. A visual message displays for the nurse on the PC at the patient’s bedside. The nurse then reviews and corrects the error before administration, and the error is considered avoided.

A Quick Tour of the BCMA System — Then

The BCMA main screen, called the Virtual Due List or VDL, replaces the standard paper Medication Administration Record (MAR). Using the VDL, nurses can now electronical-ly view and record real-time information about medications ready for administration during a specified time frame. The software offers additional features not possible with manual medication administration systems. For example, if a nurse attempts to administer a medication outside the schedule for that medication, BCMA provides them with an alert indicating that this administration is “x” number of minutes from the scheduled administration time based on a parameter established by the facility.

Nurses are allowed to use their clinical judgment in determining whether or not to administer the medication to a patient. If they choose to administer the medication, the software requires documentation as to their clinical deci-sion. By displaying only “active” orders, BCMA can alto-gether eliminate the potential for administering a discontin-ued or expired order to a patient. The software is flexible enough that a nurse can even record refused medications, document the refusal reason, request missing doses electronically from the pharmacy, and record early or late medications approved by a physician outside the regular administration window.

Here’s a quick look at the many management and account-ability tools included in BCMA:
- Virtual Due List (VDL) lists medications that need to be administered to patients within specific time parameters. These include One-Time, On-Call, Continuous, and PRN orders, as well as regularly scheduled medications.
• PRN Effectiveness List alerts the nurse to record the effectiveness of PRN or as-needed doses after they are given.
• Medication Administration History (MAH) electronically records the nurse’s initials and the exact time the medication was scanned as “given” (in a conventional MAR format).
• Patient Medication Log is available for clinical staff to access and use to review patient medication needs. With this report, clinicians may review the number of doses or times a drug has been recorded as “given” for a requested date range.
• Missing Dose Requests automatically print on a designated printer in the pharmacy to alert pharmacy personnel when a dose needs to be reissued. The missing dose software also captures the nurse’s ID, the drug requested, the time requested, and the reason the dose was missing. These functions are carried out at the time the nurse is administering medication, thereby reducing any reliance on his/her memory, and minimizing user-required keystrokes and disruption to the pharmacy and nursing workflow.
• Medication Variance Log captures BCMA entries earlier or later than 60 minutes of the scheduled time, including late PRN effectiveness entries.
• Medication Administration Error File catches deviations in drug, dose, frequency, or administration time before a medication is actually administered to a patient. These errors are considered averted errors because an intervention occurs before administration.

Enhancements to BCMA — Today

The BCMA development team continues to make tremendous strides toward improving patient safety and care in VA medical centers. This year the team plans to release Version 2.0, which focuses on the intravenous therapy component of the medication administration process. New features include an IVP/IVPB tab (IV push and IV piggyback) and an IV admixture tab that incorporates additional check-and-balance mechanisms needed to further enhance patient safety. This version also provides a link to the computerized patient record order entry system for documenting the administration of verbal or phone-type STAT or NOW orders — designed to streamline the workflow in busy ICU settings.

How Real-Time Administration Benefits Nurses

Using a real-time computerized medication administration system, such as BCMA, provides a wealth of benefits to its many users. Take a hospital’s nursing staff, for example. Because BCMA does not rely on communication between individual nurses, order changes are communicated instantaneously and in real time. Multiple users can also access administration information, decreasing interruptions to the medication nurse and the potential for missing medications to be administered. It also helps prevent administering medications outside the medication administration window, because the information is presented to the medication nurse even if another individual is accessing the patient’s medication administration information.

This new electronic transcription process also allows the pharmacy and nursing to use the same electronic document for dispensing, verifying, and administering medications. This “sharing” of information quickly identifies any discrepancies in transcription — during the verification process — before causing harm to any patient.

Time delays are also avoided. Users can configure the format to suit their individual preferences, so that, unlike with a paper system, there is no need to rewrite information or spend time sifting through paper documents. The nurse can request a missing dose electronically in a process that takes approximately three seconds, and the information is communicated directly to the pharmacy for immediate action. The nurse can then continue with the medication administration process without leaving the computerized system, thereby decreasing workflow interruptions and minimizing medication administration errors. The electronic record (VDL) displays the actual time the medication was scanned as administered, which promotes accurate administration information and enhances decision making by clinicians in developing patient therapies and treatments. The many checks and balances built into the BCMA software help to augment, not replace, the clinical judgment of the nursing staff. The important clinical information the BCMA provides improves a nurse’s ability to safely administer patient medications.

Table 1. Reported Error Rate Per Total Doses Dispensed

<table>
<thead>
<tr>
<th>Error Type</th>
<th>1993 (%)</th>
<th>2001* (%)</th>
<th>Improvement (%)</th>
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<tbody>
<tr>
<td>Wrong Medication</td>
<td>0.00371</td>
<td>0.00091</td>
<td>75.47</td>
</tr>
<tr>
<td>Wrong Dose</td>
<td>0.00334</td>
<td>0.00127</td>
<td>61.97</td>
</tr>
<tr>
<td>Wrong Patient</td>
<td>0.00138</td>
<td>0.00009</td>
<td>93.48</td>
</tr>
<tr>
<td>Wrong Time</td>
<td>0.00143</td>
<td>0.00018</td>
<td>87.41</td>
</tr>
<tr>
<td>Omission</td>
<td>0.00917</td>
<td>0.00272</td>
<td>70.34</td>
</tr>
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The potential for errors in a manual system and the ability to manipulate a manual system can dramatically affect patient safety, care, and therapy. Errors can lead to prolonged hospital stays, physical injuries, disabilities, and even death. The impact goes far beyond the physical measures of the patient and the nurse. The psychological results can be devastating for the patient and nurse, as well as for family members, coworkers, and the healthcare institution involved.

Medication administration systems that use a traditional, manual process create adverse drug events, a result of (1) incomplete order handoffs between the various hospital disciplines involved in the process, (2) order misinterpreta-
tion, (3) incomplete or improper transcription, (4) communication breakdowns, (5) faulty drug identity checking, (6) rule violations, (7) faulty dose checking, (8) drug stocking and delivery problems, (9) slips and memory lapses, and (10) lack of standardization of terms and procedures.

Many of the resulting causes of adverse drug events directly affect the pharmacy’s role during the medication administration process. For example, in a “manual” environment, if a dose of medication is not available for administration, the nurse must stop administering medications, locate a telephone, and call the pharmacy for assistance. The missing dose interrupts the workflow in the pharmacy as it requires the pharmacist to answer the telephone; record the drug, patient, and date/time needed; verify the request; and deliver the medication to the nurse who called. This process creates several opportunities for error and is disruptive for both individuals. The medical community tends to agree.

In 1995, the Journal of the American Medical Association reported that most medication administration errors were the result of multiple system failures caused by faulty system design.1 The authors of the article believed that better systems must promote fewer errors and include effective mechanisms for catching those errors that do occur. Today, newly developed computerized systems (such as BCMA) that rely on real-time, electronic technology are addressing the problem of adverse drug events by transforming manual systems into automated systems that medical professionals can use at the patient point of care.

Unlike electronic systems, in a manual system, one paper document is used for many purposes during the medication administration process. These include communicating to the nurse any medications that are due or have been administered, and any changes in medication orders. This reliance on a single paper document creates numerous challenges. For one, the paper document, known as the MAR mentioned earlier, lists all medications for 24 hours, so that the nurse must review the entire MAR to select medications that must be administered at a specific current time during their shift. This document is changed as each new medication order is addressed; it typically includes many pages and a mix of active and inactive orders. Checking the document is a time-consuming process, and medications are often overlooked or administered at the incorrect time. Multiple clinical staff personnel need to view the same MAR to determine the appropriate care and treatment for the patient. When others are using the paper document, the nurse’s workflow is disrupted. Adding to these problems are other factors, such as inevitable time delays in communicating order changes and the potential for error and misinterpretation because the MAR is modified manually.

A Continued Quest to Improve Patient Safety

Future goals of the BCMA project are to interact with other clinical software packages (Vital Signs, Laboratory, Dietary, etc.) to streamline the efficiency and workflow of clinicians by providing them with the appropriate clinical data to make sound clinical decisions regarding the patient’s care.

The success of BCMA is due to the collegiality of patient care providers (nurses, pharmacists, doctors), technical support (information management, bio-technical engineers), and administration. Veterans are beneficiaries of this innovative computerized medicine administration system that enhances patients’ safety. Preliminary evaluations of this project’s outcomes support the original premise that a computerized medication administration process will reduce medication errors, improve medication administration process and procedures, and enhance documentation of medication administration data.

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Connie L. Johnson, with Electronic Data Systems, is the functional analyst and acting project manager for the Bar Code Medication Administration project. She has worked in the healthcare industry for more than 14 years.

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Candice Willette, implementation phase manager for the Bar Code Medication Administration project at the Department of Veterans Affairs, also serves as implementation manager for various other national projects.

References
