CONTINUING EDUCATION

Scanning for Safety

An Integrated Approach to Improved Bar-Code Medication Administration

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This is a review of lessons learned in the post-implementation evaluation of a bar-code medication administration technology implemented at a major tertiary-care hospital in 2001. In 2006, with a bar-code medication administration scan compliance rate of 82%, a near-miss sentinel event prompted review of this technology as part of an institutional recommitment to a "culture of safety." Multifaceted problems with bar-code medication administration created an environment of circumventing safeguards as demonstrated by an increase in manual overrides to ensure timely medication administration. A multiprofessional team composed of nursing, pharmacy, human resources, quality, and technical services formalized. Each step in the bar-code medication administration process was reviewed. Technology, process, and educational solutions were identified and implemented systematically. Overall compliance with bar-code medication administration rose from 82% to 97%, which resulted in a calculated cost avoidance of more than $2.8 million during this time frame of the project.

KEY WORDS

Bar code • BCMA • Medication administration • Medication safety • Scanning compliance

Despite the significant attention drawn to the problem of patient safety and medical errors, 10 years after the IOM report,[1] *To Err Is Human*,[2] medical errors continue to occur at alarming rates.[3,4] Of importance is the safe administration of medication, a fundamental healthcare process, which is essential to prevent morbidity, mortality, and excessive cost for hospitalized patients.[5–7] Coupled with the integration of new medical technologies in the hospital setting, the medication delivery process is more complex and error prone each day.[8,9]

After more than a decade of research in a variety of settings and using a number of different methodologies, it is clear that healthcare has not embraced a systems approach to this fundamental healthcare process.[3,5,6,10–13] The following three common themes emerge from a synthesis of these studies:

1. Medication errors still occur with amazing frequency, despite the attention drawn to the problem.[10–13]
2. Most medication errors are preventable.[3,6,10,11]
3. Hospitals represent a setting where significant risks for medication errors exist and thus where mitigation activities should be prioritized since the patients are often receiving multiple medications, thus creating more opportunities for adverse occurrences to occur.[5,8,14]

While medication errors can occur through the medication administration process,[10,15] prescribing and administration account for nearly 80% of the errors.[15] Healthcare technologies aimed at different components of the medication delivery process represent an important opportunity to prevent adverse drug events.[16,17]

A variety of studies have evaluated the impact of both computerized provider order entry (CPOE) on the prevention of prescribing errors[7,18,19] and bar-code medication administration (BCMA) technology.[20–29] Diffusion of these technologies into the healthcare setting is growing; however, as recently as 2008, less than 25% of healthcare institutions have fully adopted these evidence-based practices.[30–32]

With each technological intervention, clinical processes are altered, and providers become inundated with changes that inhibit their ability to accomplish care for their

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patient if a "systems view" is not taken.[22,23,33–40] Without consistent medication delivery processes, technology has the potential to reduce human vigilance and increase the capacity for error.[33,34,41–47] At our facility, technology within the context of inconsistent process resulted in a near-miss sentinel event involving a preventable bar-code scanning error.

The specific aim of our BCMA performance improvement project was to reenergize an institutional commitment to a "culture of safety," through a renewed multiprofessional commitment to safe medication administration practices. The primary project objective was to evaluate, using a systems approach, process improvements in utilization of a BCMA system. Our multidisciplinary team sought to promote a culture of safety and identify the impact on medication error prevention, morbidity, mortality, and cost savings for hospitalized patients.

METHODS

Ethical Issues

The project was begun after a root-cause analysis of a near-miss event highlighted the extent of overrides of the safety features of our BCMA system. Recognition was given that this practice was not unique to the individual involved and, in fact, was common practice among those who administer medications. Based on this knowledge, we deemed it an ethical priority to identify systemwide solutions. Overrides have a multitude of causes including technology problems and human "workaround." This project focused on identifying the multitude of reasons why medications were overridden, correction of these issues, and changing the culture to see overrides as unacceptable. The initiative was designated as a quality improvement project by the facility institutional review board.

Setting

This facility is a not-for-profit, integrated healthcare system composed of seven hospitals that range in size from a 30-bed critical-access hospital to an academic medical center. At the time of this project, the adult acute-care facility housed 628 licensed beds. There were 27 adult inpatient nursing care units using a BCMA with more than 800 licensed providers administering medications to the inpatient population via this software system. The emergency department and surgical care areas including preoperative and postoperative care did not use the BCMA system.

The Siemens Medical System (Malvern, PA) pharmacy system was the system used within the facility during the project period. It is integrated with the Siemens Medication Administration Check (MAK) system. These systems require nursing personnel to scan their employee identification (ID) bar code to identify themselves, along with the patient's bar-code ID from a wrist band to positively identify the patient. After identifying the provider administering the medication and the patient, nursing personnel would then scan the bar code on the medication to correctly identify the drug. This information is captured in the MAK system, and, coupled with the time on the server, provides the data points for a computer analysis to ensure that the correct medication is administered to the correct patient, in the correct dosage, using the approved method of administration, at the correct time. Additionally, the MAK system provides an electronic log for this information. The bar-code scanners used were initially the Welch Allyn (Skaneateles Falls, NY) model 3870s. These were later replaced with the Honeywell Products (Skaneateles Falls, NY) Handheld 4600 and 4800 series bar-code scanners as it was discovered that the older Welch Allyn devices were unable to read the newer bar codes.

Planning/Intervention

A multiprofessional team composed of nursing, pharmacy, human resources, quality management, and technology services (TSG) formalized to evaluate medication overrides and address concerns. All inpatient care units at the adult acute-care facility using BCMA were included. The evaluation began at the facility level and extended to both the departmental and individual user level. An override was defined as an error message displayed as a result of the system's inability to read a bar code or the bar code reading wrong medication, dose, and/or route; the message alerts the provider, but the provider administers the medication despite the warning. The team developed a plan focused on three major areas: products, technology, and education to address areas of vulnerabilities. The plan was implemented systematically in stages with measures of effectiveness.

Key leadership teams were brought on board to implement this cultural change. Strong executive senior leadership support was central to the success of the project. To facilitate engagement in the necessary culture change, vital information regarding the current culture and the singular event that precipitated need for change was discussed at pertinent management and staff levels. Information specifically included were facility override history data, cost of adverse events, literature related to best practice, and solution necessary to ensure patient safety.

Methods of Evaluation

The medication process was reviewed step-by-step with solutions identified. A detailed review of documented

medication override reasons with rationales was completed. Across the facility, a number of reasons for overrides were identified. These included equipment problems, internal process problems, human factors, and non–bar-code issues. The assessment of override reasons was completed by reviewing a 1-week sample of data each month for 3 consecutive months.

A total of 26 675 medication overrides documented were reviewed. The overrides were analyzed based on the reason provided by the nurse, type of medication, and if it required a pharmacy produced label (Figure 1). This detailed analysis revealed that the process for insulin administration required an override and produced 13% of the total overrides reviewed. Medications with a pharmacy-produced, patient-specific label comprised 26% of the overrides. Non–bar-code–related overrides accounted for 20% and were due to such reasons as nursing message (defined as a message sent from pharmacy to nursing through the MAK system), system downtime, and medications at the bedside, as well as a patient's own medications. The largest number of overrides (41%) was found to be related to either equipment or personnel, that is, "human factors."

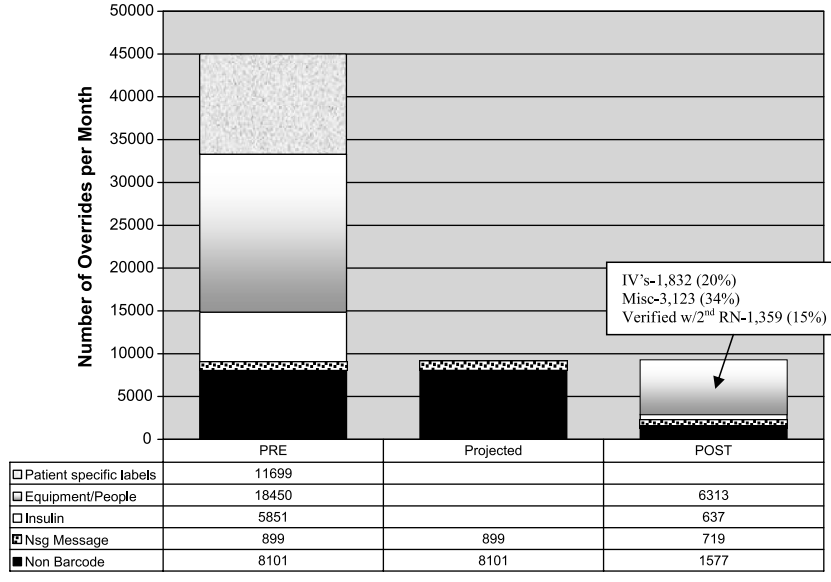
Equipment problems included aging scanners, new types of bar codes that the systems were unable to read, changes to manufacturer bar codes, and patient label issues. Internal process problems related to specific medication packaging and labeling issues. The human factors included issues such as simple noncompliance and multiple bar codes on medication packages.

Feedback from nursing bedside staff reported a perception that large numbers of medications would not scan. This contributed to the practice of overrides being an everyday occurrence and part of the accepted norm. As a simple feedback measure to facilitate pharmacy follow-up on bar-code problems, containers were placed in key locations, in medication rooms, next to the automated drug-dispensing stations, to collect medication labels with scanning problems. In addition to medication labels supplied by nursing units, pharmacy reviewed data for high override drugs and developed resolutions for specific medications and products. A trend of problems with labels produced in the pharmacy was corrected by the purchase and installation of new thermal label printers.

While communication and education progressed, analysis of processes and data continued. Override reports were evaluated to identify trends and problematic drugs. The cross-reference file in the pharmacy information system was reviewed to ensure that the correct bar codes for drugs on the reports were properly identified.

Pharmacy also reviewed all electronic Rx messages sent by nursing when a staff member identified a medication scanning issue. Additionally, the pharmacy staff reviewed each identified drug in the cross-reference file and provided follow-up with nursing as needed. Pharmacy reviewed the data pertaining to specific medication bar codes that could not be read by the scanners and took appropriate action to produce a readable bar code. When an issue with a manufacturer's bar code on the package was identified, a facility-produced bar code was applied by pharmacy to each dose before sending to the nursing units. Pharmacy then notified the manufacturer of the identified issue, and resolution was requested. If pharmacy could not identify the cause of the scanning issues for medications identified by these electronic reports, they contacted TSG for further assistance in testing bar codes and scanners.

Insulin was found to be an outlier in override volume. A decision was made to convert to insulin pens to enable



	PRE	Projected	POST
Patient specific labels	11699		
Equipment/People	18450		6313
Insulin	5851		637
Nsg Message	899	899	719
Non Barcode	8101	8101	1577

FIGURE 1. Comparison of monthly overrides—before and after solutions.

patient-specific labeling to occur on product distribution. A trial was performed on a variety of pens prior to final product selection. Insulin administration changes were made to include use of insulin pens.

Two major equipment issues were identified: (1) there were connectivity issues with the wireless computer network, which was corrected with the implementation of an upgrade to the wireless network; and (2) bar-code quality was found to be a contributor to inability to scan medications, which was corrected by implementation of new bar-code scanners and installation of new bar-code printers.

A wireless network upgrade was completed during the course of the project to improve mobile computer reliability. Outdated wireless scanners were found to contribute to scanning problems due to multiple steps required to correct scans at the bedside, which was resolved by TSG and nursing evaluating and selecting a new type of bar-code scanner. The vast majority of the new bar-code scanners used tethered scanners because of increased reliability; this in turn excluded some ICUs because of safety risks associated with tether lengths and ICU room configuration issues with stationary BCMA.

After equipment/product solutions were implemented, the process for medication overrides was reviewed and revised. The original list of rationales for overrides included more than 20 options. Rationales for acceptable override reasons were redefined into the following four simple categories:

- computer system downtime,
- patient not in the unit where BCMA was available,
- emergent event, and
- nursing message sent from pharmacy.

An algorithm of the revised process was outlined and distributed (Figure 2). In addition to the new classifications for overrides, a requirement was set that all overrides that did not meet one of the four acceptable reasons now required a second licensed verification of correct drug. The facility policy and procedure for BCMA were revised to reflect these changes.

Medication and bar-code scanner problem-solving quick reference cards were placed with all wireless carts or wired bedside devices used for medication administration. Data were captured electronically through the BCMA system by examining the "five rights" of medication administration: right patient, right drug, right dose, right time, and right route. Additional variables were reviewed: unit of occurrence,

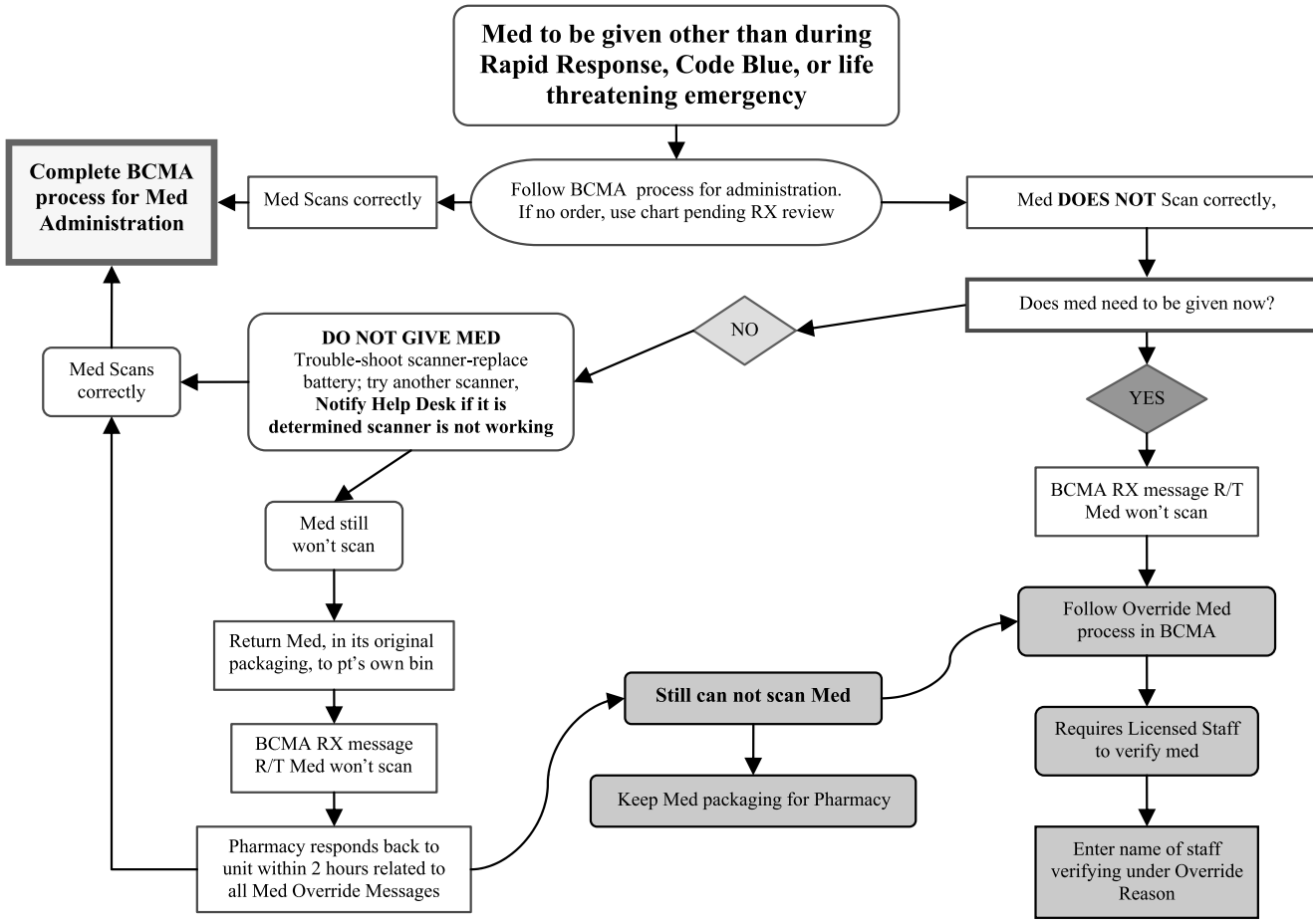


FIGURE 2. Override algorithm.

medication (dose, route, and administration time) and staff member involved, patient, and override reasons.

More than 800 individual providers received initial education overview and later specific details explaining operational change. Educational programming included mandatory Web-based education followed by regular updates on project outcomes. In addition, the central nursing BCMA orientation program was evaluated and found to emphasize override steps because of inability to accurately simulate BCMA processes. Retired scanners were used to implement a simulated experience characteristic of the actual BCMA process along with development of a competency-based guideline for orientation of new nursing staff at the unit level.

Individual providers changed practices to troubleshoot scanning problems in a systematic process to ensure that all possible attempts to correct the problem had failed. They also completed additional education and received direct feedback from management related to their patterns with overrides in addition to corrective action when appropriate. Lastly, individuals changed their practice patterns with implementation and surveillance of second licensed verification for all overrides.

Analysis

Data were initially extracted and reviewed weekly after the implementation of the thermal printers in November 2006. Specific data points were extracted after the deployment of new tethered scanners in March 2007 as well as the implementation of changes to the "acceptable" override list in April 2007.

Each unit's compliance was individually calculated as a percentage and then aggregated into a total compliance rate for the facility. In addition, aggregate totals were compared with the previous fiscal year's data as a measure of overall improvement.

These data points were analyzed to determine the impact of these individual changes on overall compliance. The impact of sequential system changes is demonstrated in Figure 3. Beginning in May 2007, data were reviewed monthly. Individual units' compliance was reviewed in an effort to determine process differences between units and the educational needs of the staff.

HOSPITAL-LEVEL ANALYSIS

Based on the solutions determined, it was projected that the facility could reduce overrides to 9000 per month (Figure 1). The overrides not eliminated would consist of non–bar-code–related overrides (emergent administrations, patient off unit, nursing message, and downtimes).

Postintervention data indeed showed a significant decrease from 43 852 overrides in October 2006 to 9239 in April 2007 as projected. The non–bar-code–related overrides reduced from 8101 to 1577. Data showed that nursing message consisted of 719 overrides, down from 899. There continued to be overrides related to insulin administration, with a total of 637, initially 5851. Equipment and people included an additional breakdown of these overrides. It included second licensed staff verification, intravenous (IV) medications, and miscellaneous for overrides with reasons provided that did not identify the specific requirement for override (Figure 1).

The single, most significant improvement was noted after mandatory education and the implementation of a thermal label printer, showing a reduction in overrides of 17 068 (6.7%). Upgrading the wireless system, implementing new bar-code scanners, and requiring a second verification for all nonemergent overrides, each had a noted improvement in compliance of less than 0.8% (168–2464). Significant improvements were noted with implementing insulin pens with a bar code, new label printer, and mandatory

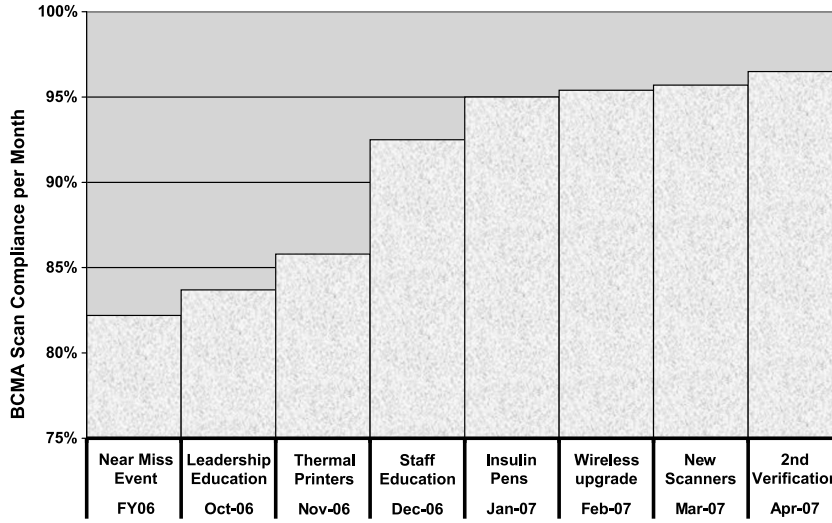


FIGURE 3. Systematic implementation.

staff education, each showing improvement greater than 2% (4500–17 068).

Overall, the average daily census (ADC) during the study period was 438.9 ± 17.0 (range, 442-459). The ADC increased during the course of the study by 1.3%. There was a corresponding increase in the number of licensed staff from 794 to 813 (2.4%). The mean number of doses charted per month was 263 377 ± 11 639 (range, 249 223–263 781). The scanning compliance improved during the course of the study from 83.7% to 96.6%. The total number of drug overrides during the study period was 145 192, with a mean of 20 742 ± 13 534. During the study period, there was a significant reduction in the number of drug overrides per month from 43 852 to 9239. As a result, the number of avoided errors increased from 733 to 1054 (43%), resulting in a corresponding increase in avoided errors per 1000 doses dispensed from 3 to 4.

UNIT-LEVEL ANALYSIS

Data were collected and analyzed at the unit level in both the preintervention (October 2006) and postintervention (April 2007) time frames. Of importance, there were no significant differences in the doses charted, licensed staff, or ADC on any of the unit types. There were statistically significant differences in the number of drug overrides and avoided errors. In addition, the number of avoided errors per 1000 doses was also significantly different by unit type. Each unit showed significant improvement in medication override compliance; the average compliance rate rose from 83.7% to 96.5%. Units ranged from 93% to 99% compliance at the end of the period evaluated.

In October 2006, an intensive review of medication overrides demonstrated considerable variability in the units' override compliance from 73.8% to 94.9%. With an average of 77.4% compliance, ICUs consistently had the lowest compliance. Those units with the highest compliance were rehabilitation and psychiatric, with an average compliance rate of 92.5%. The units with the highest compliance rates had limited IV medications such as large-volume continuous infusions and IV piggybacks such as antibiotics, as well as limited medications that were labeled by pharmacy.

This noted the significance of the safety features associated with the BCMA system. It still left a large number of medications that did not have the full safety features of the system because of overriding a medication bar code. A further evaluation of why the facility had a number of medication overrides was completed.

PROVIDER-LEVEL ANALYSIS

Provider-level analysis in the postintervention time frame was collected. Provider detail indicated that it was often one staff person on a unit who was responsible for a statistically significant number of overrides for the individual unit. A total of 15 staff (1.8%) were responsible for 1559 overrides (16.9%). The ICUs showed an average of 79 medication overrides (20%) by an individual provider; medical-surgical areas showed an average of 69 (16%); progressive care units showed an average of 53 (15%), and other units showed 12 (23%). A total of 329 providers (40%), range by unit type 25 to 116, were responsible for 7398 overrides (80%). The additional 1849 overrides were completed by 60% of licensed staff.

OUTCOMES

A study[48] performed in Utah in 1997 estimated that medication errors accounted for an attributable mortality of 2.43 deaths per 100 hospital admissions. Another study found that medication errors contributed to increased length of stay (LOS) by 4.6 days with an associated total cost average of $5857 after adjusting for comorbidities and case mix.[49] Bates'[49] data, cost adjusted for inflation, total $8912 per preventable ADE in 2006 dollars. Extrapolating from these studies, based on the findings at our facility of 321 additional avoided errors, additional avoided errors statistically account for an overall decrease in LOS of 1476.6 days and a cost avoidance of $2 860 752 during the several months of this study.

While medication overrides were the focus of the solutions implemented, there was a noted improvement in patient overrides from 1512 to 427, a 79% reduction. Patient override was defined as the improper scanning of a patient identifier (eg, patient label on a form) other than a patient's scanned attached armband as required by hospital policy and procedure. This same reduction, 79%, was noted in medication overrides per month (43 852 to 9239). As a result, increasing the compliance of medication overrides improved the capture of preventable errors.

DISCUSSION

Medical errors have been a focal point of action in healthcare for more than 10 years, yet on a daily basis, patients are still harmed by clinical processes that were intended to help them. As a high-risk process for nearly every hospitalized patient,[3,4] medication delivery remains a significant contributor to harm.[5,6] While evidence-based strategies, including BCMA technologies, have the potential to significantly improve the safety of medication administration in healthcare settings, to date their effects have been insignificant.[16,31] The successful infusion of technology demands an approach that is project oriented and focused on clinical processes using a multidisciplinary team.[24]

Our institution implemented a BCMA system to improve medication administration and found that despite the attention given to the implementation, failed clinical

processes and workflow challenges limited our success. We found that overridden bar-coded doses represented a significant proportion of potential medication errors after implementation of a BCMA system. By performing a systematic implementation of change, we were able to reduce medication bar-code overrides by 12.8% for the overall hospital, decrease the LOS by 1476.6 days, and reduce the cost related to medication errors by $2 860 752. Overall, our experience highlights the need to continually improve the clinical components of the medication delivery process, by using a multidisciplinary team particularly where providers and technology intersect and focus on different levels of the system. Improvement was achieved when the multidisciplinary team focused on BCMA.

Strengths of this work are the commitments from the disciplines of nursing, pharmacy, technology support, human resources, and quality management. This was essential to affecting changes in those clinical processes and workflows. The medication-use process was reviewed with real users to better incorporate BCMA. Bar-code medication administration compliance following our system changes and ongoing vigilance sustained for fiscal year 2008 through July 2008 at 96.7%. Our own experiences proved to provide valuable guidance to our system with implementation of an integrated electronic medical record, CPOE, and BCMA system in July 2008 (EPIC, Madison, WI) and contributed to our mission to share this work with the broader healthcare community.

Essential to the culture change was facility recognition and celebration of the hard work of departments, units, and individuals. Each was recognized for excellence in BCMA practices. Leadership presented plaques and cakes decorated using the theme, "we are '*over*whelmed' with thanks." The multidisciplinary override team was subsequently awarded the American Association of Critical-Care Nurses and Baxter Excellence in Patient Safety Award in 2008.

Limitations of the review are that although we made changes each month, the impact of singular changes was difficult to isolate. How management maintains vigilance to this medication safety effort in light of many other projects upcoming in a complex environment is yet to be determined. These changes implemented in an academic medical center with more than 400 beds may not be applicable to community hospitals or ambulatory settings.

CONCLUSION

As institutions adopt complex, costly technologies to deliver safer care, success rests on integrated approaches that enhance work processes while emphasizing professional responsibility to patient safety. Additionally, process should be in place to continually monitor the efficacy of these technologies and provide ongoing surveillance to ensure that ancillary processes and technology changes do not cause unwanted or unforeseen circumstances that could compromise patient safety.

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