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Bar-Code Technology for Medication Administration: Medication Errors and Nurse Satisfaction

A barcode administration system provides a safe mechanism for the delivery of medications throughout the entire process, but factors that negatively impact nurse satisfaction need to be addressed. The impact of a barcode medication administration system on nurse satisfaction and Category C medication errors was investigated in this longitudinal, descriptive study.

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Administration of medications takes up to 40% of nurses' time in providing patient care (Armitage & Knapman, 2003). Multiple stages to the medication process include order entry, transcription and verification, dispensing, medication administration, and consumption by the patient. Inherent in all these stages are the five rights: the right patient, right medication, right dose, right route, and right time (Perry & Potter, 2004). In addition, numerous members of the health care team, such as physicians, pharmacists, pharmacy technicians, unit clerks, registered nurses, and patients, work collaboratively to ensure safe and accurate drug administration.

A *medication error* is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional or consumer (National Coordinating Council for Medication Error Reporting and Prevention [NCC MERP], 2006). Of the various types of medication errors, Category C errors happen when an actual error has occurred and reached the patient, but the patient has not been harmed by the error.

In 1995, the NCC MERP was formed by 15 interdisciplinary organizations to promote actively the reporting, understanding, and prevention of medication errors through the coordinated efforts of its member associations and agencies, and to focus on ways to enhance patient safety through a coordinated approach and a systems-based perspective (NCC MERP, 2005). In 2001, the council developed an Index for Categorizing Medication Errors (see Figure 1; Table 1) and Algorithm (see Figure 2) which has been adopted by many health care institutions. This approach allows a facility to apply a uniform taxonomy to medication errors according to the severity of outcome. Over the last 3 years, the authors' institution has seen a decrease in the Category E-I errors and an increase in Category A and B error reporting based on use of the taxonomy.

The Institute of Medicine (1999) suggested that preventable adverse drug events or harmful medication errors occur in 1%-10% of hospital admissions. Information technology such as bar codes can reduce errors throughout the medication process (Poon et al., 2006). Point-of-care administration of medications with bar-code scanning allows verification of the

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Figure 1.
NCC MERP Index for Categorizing Medication Errors

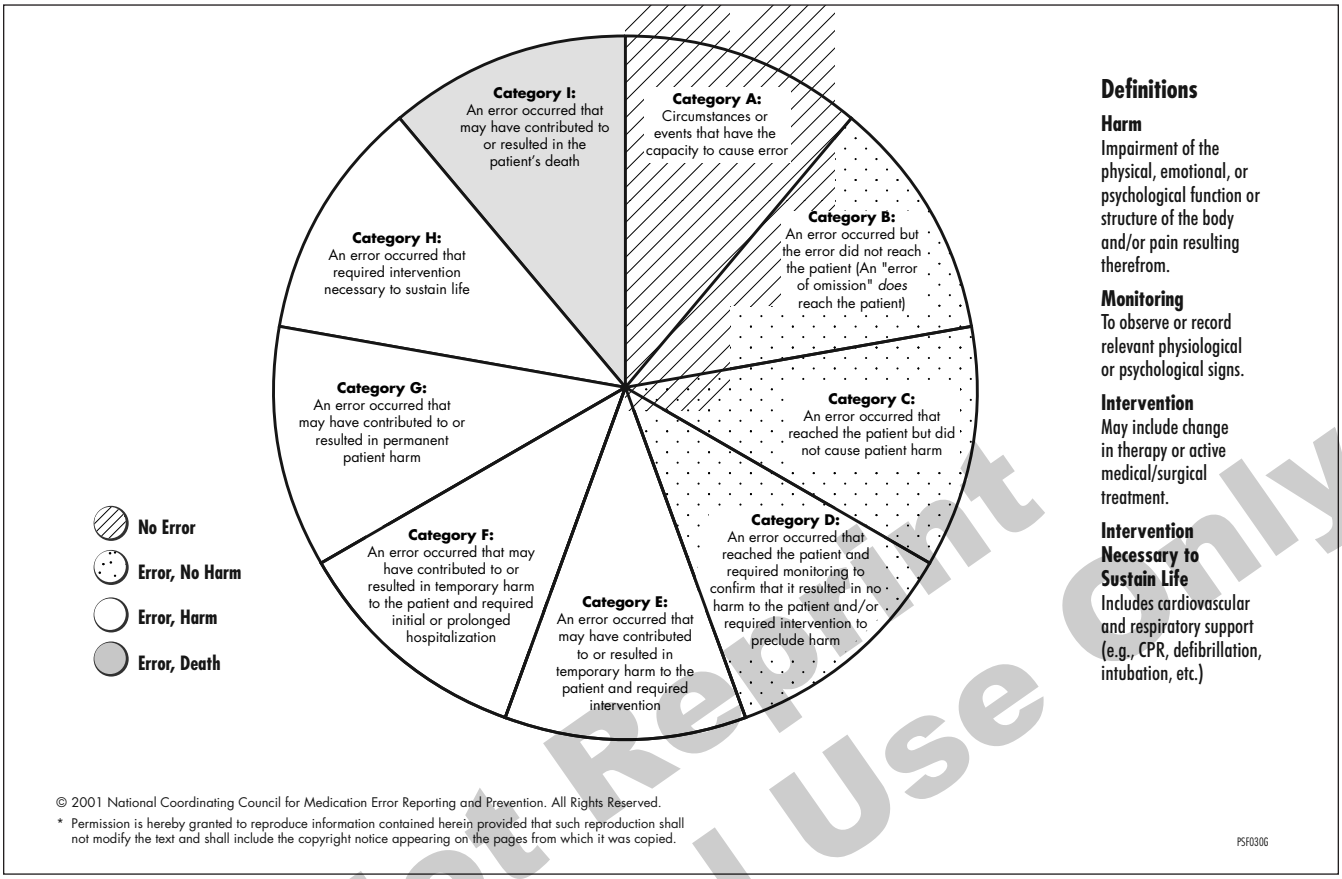


Table 1.
Categorizing Medication Errors

Category	Definition	Level of Error/Harm
A	Circumstances for events that have the capacity to cause harm.	No Error
B	An error occurred but the error did not reach the patient.	Error, No Harm
C	An error occurred that reached the patient but did not cause harm.	Error, No Harm
D	An error occurred that reached the patient and required monitoring to confirm that it resulted in no harm to the patient and/or required intervention to preclude harm.	Error, No Harm
E	An error occurred that may have contributed to or resulted in temporary harm to the patient and required intervention.	Error, Harm
F	An error occurred that may have contributed to or resulted in temporary harm to the patient and required initial or prolonged hospitalization.	Error, Harm
G	An error occurred that may have contributed to or resulted in permanent patient harm.	Error, Harm
H	An error occurred that required intervention necessary to sustain life.	Error, Harm
I	An error occurred that may have contributed to or resulted in the patient's death.	Error, Death

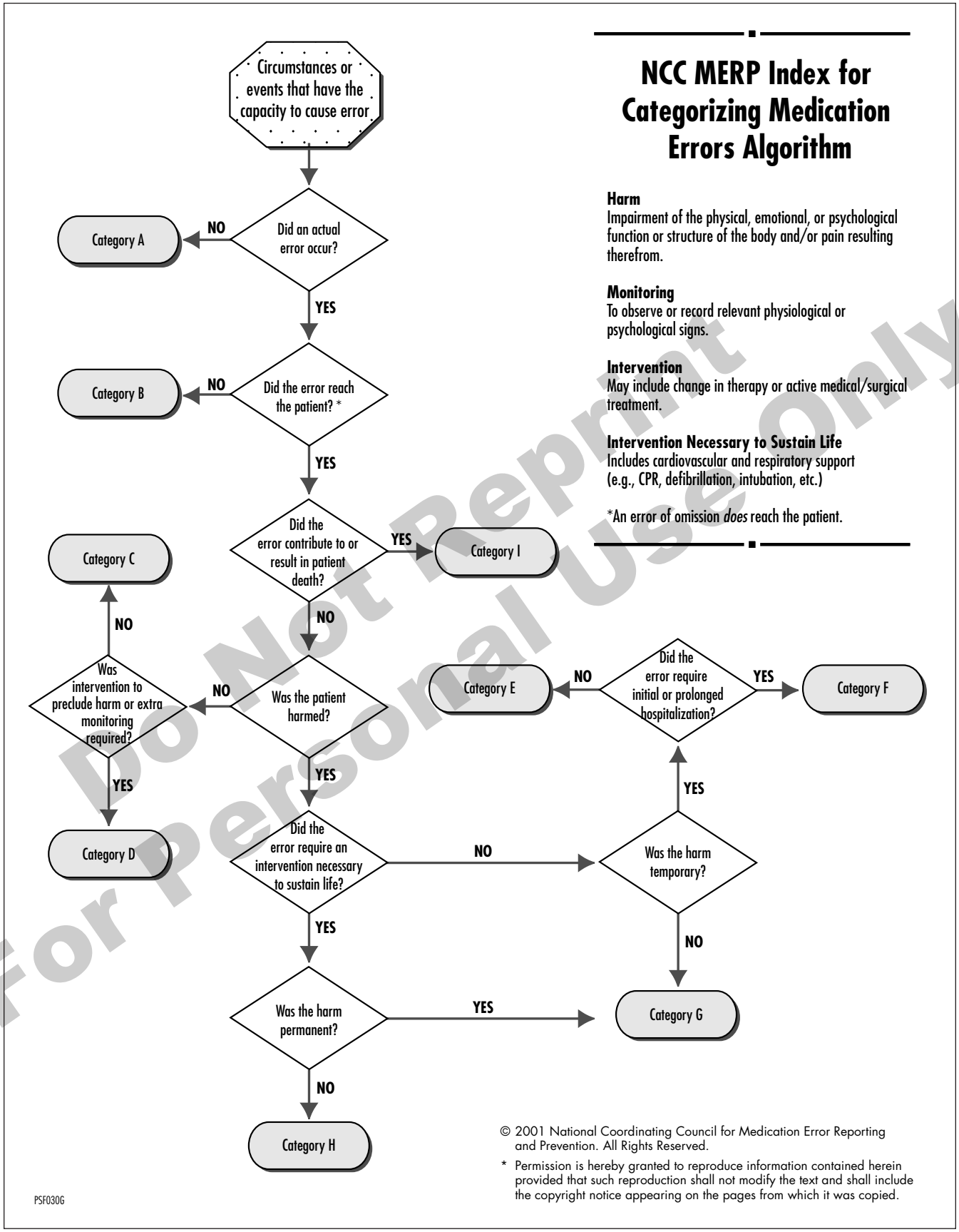
Source: NCC MERP, 2005

five rights of medication administration (Sakowski et al., 2005).

Bar-Code Technology

Implementation of a bar-coded bedside medication administration system by a hospital in Missouri, for example, led to reduced medication administration errors and increased patient safety and accurate reporting (Yates, 2007). Sakowski and colleagues (2005) studied the effect of this technology on medication errors in a network of 27 hospitals in northern California and found that errors were prevented in 1.1% of all attempted medication administrations. Errors primarily were prevented in doses being administered earlier than scheduled, administered without record of the medication or patient, and attempted administration when an order was discontinued or expired. The University of Pittsburgh Medical Center reported medication administration errors were reduced by 55% in a study of the effect that

Figure 2.
Index for Categorizing Medications Errors Algorithm



bar codes have on preventing medication errors (Raczkiewicz, 2005).

The basic concept for a bar code point-of-care test is that information is encoded in bar codes, allowing for the comparison of the medication being administered with what was ordered for the individual patient (Sakowski et al., 2005). After a medication order is written (electronically or manually), a pharmacist enters, verifies, and profiles the order. Prior to administration of the first dose, the nurse confirms a match between the written and electronically profiled order. When the nurse is ready to administer a medication to a patient, he or she uses a handheld bar-code reader to scan the patient's special wristband and medication, at which time the software verifies it is the correct medication and dose as well as the correct time and patient. The medications and handheld bar-code reader usually are housed on a cart designated for medications.

The Joint Commission (2007) identified improved accuracy in patient identification as a National Patient Safety Goal. Use of bar codes is one strategy to meet this goal. In addition, the U.S. Food and Drug Administration (FDA) issued a rule that required "bar codes" on most prescription drugs and certain over-the-counter (OTC) drugs by 2006 (Department of Health and Human Services, 2004). The FDA rule applies to drug manufacturers, repackagers, relabelers, and private label distributors of unit-dose medications. The mandate requires a machine-readable bar code on prescription drugs and OTC drugs that are commonly used and dispensed in the acute care setting pursuant to an order. While the FDA does not regulate hospital practice, the mandate was developed on an "if you build it, they will come" philosophy. Simply put, if hospitals are supplied with bar-coded drugs, they will scan them to improve safety (Navarra, 2004).

Experts in health care technology recommend that a single unit serve as a pilot to test technology, such as bar coding, at all levels prior to being rolled out on a larger scale (Cummings, Ratko, & Matuszewski, 2005). In terms of nursing, research has focused on issues or problems associated with this new technology of bar-code medication administration such as work-arounds, overrides, and potential accidents. Koppel, Wetterneck, Telles, and Karsh (2008) sought to identify reasons for work-arounds and found three categories that capture this phenomenon: (a) omission of process steps, (b) steps performed out of sequence, and (c) unauthorized process steps. Using ethnographic observations of nurse/bar-code medication administration interaction, Patterson, Cook, and Render (2002) found five negative side effects, including (a) nurse confusion about automated removal of medications, (b) degraded coordination between nurses and physicians, (c) reduction of workload during busy periods by "dropping" activities, (d) setting priorities of activities, and (e) struggle with deviating from routine sequences. Identification of work system factors that facilitate or hinder medication administration tasks was the focus of an investigation by Pascale et al. (2007). They observed nurses and found a large variability in the order of steps taken to administer medications at the bedside, some of which might be considered unsafe. There is limited information on nurse satisfaction with the bar-code administration system. We sought to understand nurse satisfaction with bar-code technology on a pilot nursing unit as well as the impact of the system on medication errors, as suggested in the literature.

Study Aims

The following research questions guided this investigation of a new medication administration system implemented on a 53-bed medical-surgical unit with a step-down area for more intense patient care delivery:

1. What is nurse satisfaction with the current medication system prior to implementing the electronic medication system?
2. What is nurse satisfaction with the electronic medication system using bar codes 3 and 6 months after implementation?
3. Is there a difference in nurse satisfaction between the prior medication system and the electronic medication system at 3 months after implementation?
4. Does nurse satisfaction with the electronic medical systems change over time (3-6 months after implementation)?
5. What impact does bar coding have on the number and type of technology for medication administration reported Category C medication errors?

Method

A descriptive, comparative design was used to answer the research questions. The convenience sample consisted of all 68 staff nurses working on a surgical unit in a Magnet®-designated community hospital that serves as a level I trauma center. This unit was the first patient care area to "go live" with bar-code technology for medication administration in mid-August 2007. Staff were surveyed prior to implementation of the bar-code technology (July 2007) and 3 and 6 months afterward (November 2007 and February 2008, respectively).

Of the nurses who responded during the three survey periods, 90% were female, ages 23-64. The majority of nurses throughout the study period who participated acknowledged they had average computer skills. No nurse who responded had used a point-of-care bar-code medication administration system before employment at this institution.

Data collection instruments included the incident report form used by the institution and the MEDMARX Medication Error Data Entry Form. The Medication Administration System – Nurses Assessment of Satisfaction (MAS-NAS) is a three-subscale (efficacy, safety, and access), 18-item questionnaire using a Likert-scale (1-6) (Hurley et al., 2006). Authors reported the reliability Cronbach alpha coefficient for the final 18-item scale was 0.86. Validity was determined using Principal Components Analysis revealing three subscales including efficacy, safety,

and access with individual items loading ranging from 0.36 to 0.80. A low score on a MAS-NAS item indicates high satisfaction. The MAS-NAS questionnaire was placed in all staff mailboxes and returned to a designated envelop for collection of completed questionnaires.

Data were collected on reported Category C medication errors (number and causes) 2.5 months prior to bar-code implementation (June 1-August 14) and 2.5 months afterward (August 15-October 31) for comparison. In addition, the entire year (2007) was evaluated for Category C medication errors before and after bar-code implementation (January 1-August 14 and August 15-December 31).

Medication errors were categorized as wrong dose, wrong medication, omission, given without an order, documentation or transcription error, missed dose, time error, and storage issue. Only some of the specific Category C medication errors can be directly impacted by a bar-code medication system. Bar-code technology has the potential to have positive impact on wrong doses and wrong medications. It may have limited influence on omissions, documentation, missed doses, time error, and storage. Some of these errors are more related to patient issues, such as the patient being "off the unit" for a procedure, pharmacy problems with profiling, and/or unit limitations in terms of space.

Results

Scores on the MAS-NAS ranged from 2.24 to 5.5 prior to implementation of the electronic medication system using bar codes (see Table 2). Nurses were most satisfied in answering question #6: "I have access to the systems that support medication administration (physician orders, drug information) when I need them." They were most dissatisfied at that time with turnaround time for "stat" medications (5.5).

After bar-code technology was in use for 3 months, the range of mean scores was 1.52-4.25. The item with the highest satisfaction focused on checks done by pharmacy (mean 1.52), with continued dissatisfaction with "stat" medication turnaround time (mean 4.25). Nurses indicated more satisfaction on 11 of the 18 MAS-NAS items 3 months after implementation of the electronic medication system using bar codes, more dissatisfaction on seven of the items, and no change in satisfaction on one item.

Table 2.
Medication Administration System Satisfaction (Mean)

Question	Pre (31-34 responses)	3 Months Post (20-26 responses)	6 Months Post (20-21 responses)
1. Actions and side effects	2.79	3.04	3.54
2. Drug alert helpful	2.74	2.80	3.55
3. Easy to check orders	3.0	1.92	2.71
4. Checked by pharmacy	3.06	1.52 most satisfied	2.28
5. Two-way communication	3.36	2.31	2.62
6. Other support systems	2.24 most satisfied	2.38	2.48
7. Drug information easy to get	2.64	2.46	3.0
8. Interaction: MD and pharmacy	3.70	3.25	4.19
9. Know where stored	2.58	2.42	2.05
10. Efficient at medication administration	2.97	3.0	2.90
11. Easy to check "five rights"	2.45	2.19	2.00 most satisfied
12. Adequate turnaround time for "stats"	5.15 most dissatisfied	4.35 most dissatisfied	4.67
13. Effective in reducing medication errors	3.48	2.88	3.09
14. User friendly	3.06	2.92	2.95
15. Equipment readily available	2.67	2.68	2.81
16. Know what to do if patient reacts to medication	3.25	3.25	4.71
17. Have to keep "a stash" of medications	3.12	3.81	3.43*
18. Drug interaction message safe	4.72	4.08	5.30 most dissatisfied

Note: Low mean implies high satisfaction.

At 6 months, there was overall more dissatisfaction with mean item scores ranging from 2.0-5.3. Nurses were most satisfied that the system made it easier to check the five rights of medication administration (mean 2.0). Nurses were most dissatisfied with the drug interaction message used and its safe nature (mean 5.3). There was an increase in nurse satisfaction from 3 to 6 months on 5 of the 18 MAS-NAS items, but more dissatisfaction on 13 of the 18 items.

Nurse satisfaction specifically targeting the bar-code system, which consisted of an additional seven questions, did not change much from 3 to 6 months after implementation (2.12 – 4.15 at 3 months and 2.14 – 4.20 at 6 months) (see Table 3). At 3 months, nurses were most satisfied with the safe nature of bar-code technology (2.12) but most dissatisfied with time spent with patients (4.15). This same satisfaction and dissatisfaction continued at 6 months. Nurses continued to struggle with the efficiency of the new medication administration system at 6 months (3.19 at 3 months, 3.67 at 6 months).

Six questions on the MAS-NAS pertained directly to bar-code technology. At 3 months, satisfaction ranged from a mean of 2.12 (indicating more satisfaction) to 4.15 (indicating less satisfaction or more dissatisfaction) (see Table 2).

Table 3.
Bar Code Satisfaction
(Means)

Question	3 Months Post (26 responses)	6 Months Post (19-20 responses)
1. Easier	2.77	2.85
2. Safer	2.12 most satisfied	2.14 most satisfied
3. Easier to access information	2.58	2.62
4. More satisfied	3.08	3.14
5. More time with patients	4.15 most dissatisfied	4.20 most dissatisfied
6. More efficient	3.19	3.67 biggest negative change
7. Medications readily available	3.85	4.05

Note: Low mean implies high satisfaction.

Nurses were most satisfied that the system was safe and most dissatisfied with not having more time to spend with patients. At 6 months, satisfaction scores were basically the same, ranging from a mean of 2.14 to 4.20, with nurses most satisfied that the system was safe but, once again, dissatisfied with not having more time to spend with patients.

In an informal discussion, nurses who had used the system for 10 months noted the new medication system provides more information about medications and improved overall patient safety but takes more time for bedside administration of medications. Communication with physicians may not be improved if physicians do not access the computer screens for patient information. Communication with pharmacists was improved with the use of the new system but also was dependent on utilization of the two-way communication option available within the computer.

In the 2.5 months prior to the system change, two Category C medication errors were reported, with one pertaining to a time error and the second one referring to a wrong intravenous solution. In the 2.5 months after bar-code technology was implemented, the number of Category C medication errors increased to six, with three omissions, one wrong dose, one time error, and one medication given without an order. For the entire year, the unit experienced 19 Category C medication errors from January to mid-August 2007 (7.5 months). Errors from mid-August to the end of the year (4.5 months) were 13. A decrease was seen in categories related to dose, storage, time, wrong patient, documentation, missed doses, and wrong intravenous solution/medication. The decrease ranged from one to two errors in most categories except omissions, which showed an increase from one to four errors.

Discussion and Implications

Nurses in this study indicated the bar-code medication administration system was safer than the previous system based on nurses' perception of increased satisfaction related to the ease of checking the five rights of medication administration. If "stat" medications were needed when the old medication administration system was in use, staff could "run down to the pharmacy," show the pharmacist the order, and quickly obtain the necessary medication. That practice is no longer possible because a pharmacist has to profile the medication before dispensing any doses. This was evident in the continued dissatisfaction with "stat" turnaround times in the survey at 3 months (mean score 4.35) and 6 months (mean score 4.67) after initiating the new system.

Reporting of medication errors is human dependent. The reason medication errors initially increased after the new medication administration system was implemented may be due in part to increased awareness, better reporting, and more assistance in the reporting process. Staff trained as "super users" were constant figures on this first unit to implement bar-code technology, readily available to help with system issues as well as challenges and errors. The unit on which this study occurred had a history of self-reporting errors before the change in the medication administration system. Decrease in errors related to the wrong patient was an immediate result of the bar-code system.

The increases in errors concerning omissions and documentation/transcription can be attributed to the time requirements of pharmacists in profiling the medications and subsequently delivering medications to the nursing unit, as well as time for nurses to confirm the orders prior to administration. Pharmacists and nurses must be accurate in their review of medication orders. Nurses want to give medications on time and may experience anxiety when medications have not been profiled or are not readily available at the expected administration time. These feelings by nurses in this study have been confirmed by other investigators who observed nurses utilizing a bar-code medication administration system instituted at the Veterans Health Administration (Carayon et al., 2007).

Medication omission errors may occur when patients are not able to receive their medications at prescribed/designated times because they are undergoing procedures. A change in level of care also can result in medications being dropped from the computer (Carayon et al., 2007). Staff at the study hospital continue to track and address trends in all categories of medication errors with anticipation of a sustained decrease as a direct result of a safer, more complex medication administration system.

A change in any medication administration system is a multidisciplinary process that requires all members of the health care team to make adjustments and thoughtfully plan for successful implementation. Initial demands may be extremely high for the

pharmacy, warranting additional staff members. Associated equipment such as mobile medication carts must have sufficient storage, as well as self-lock, and steer or roll easily. During the study period, the limited drawers and medication cart mobility may have contributed to staff dissatisfaction. More recently, new carts have been evaluated for purchase and utilization

Summary

A bar-code administration system provides a safe mechanism for delivering medications throughout the entire process, from medication ordering to patient consumption. Staff satisfaction with any change in medication administration system may develop over time. Medication errors still are likely to occur, but they may be different types of errors. One nursing area may serve as the pilot unit to evaluate the new system for necessary modifications so future roll-outs are more efficient and effective.

Nurse satisfaction should be tracked over time to determine at what point nurses are truly satisfied with a new medication system using bar-code technology after adequate training and use of the system. Our sample size did not allow detection of differences in satisfaction between nurses trained without technology versus those recently trained with the use of computers, online programs, and simulation. Satisfaction of pharmacists also might be considered and compared to that of the bedside nurse. ■

References

Armitage, G., & Knapman, H. (2003). Adverse events in drug administration: A literature review. *Journal of Nursing Management, 11*, 130-140.

Carayon, P., Wetterneck, T.B., Hundt, A.S., Ozkaynak, M., DeSilvey, J., Ludwig, B., et al. (2007). Evaluation of nurse interaction with bar code medication administration technology in the work environment. *Journal of Patient Safety, 3*(3), 34-42.

Cummings, J., Ratko, T., & Matuszewski, K. (2005, September/October). Barcoding to enhance patient safety. *Patient Safety & Quality Healthcare.* Retrieved January 28, 2009, from http://www.psqh.com/sepoct05/barcodingrfid1.html

Department of Health and Human Services: Food and Drug Administration. (2004). Bar code label requirements for human drug products and biological products; final rule. *Federal Register 69*(38):201-601.

Hurley, A.C., Lancaster, D., Hayes, J., Wilson-Chase, C., Bane, A., Griffin, M., et al. (2006). The Medication Administration System - Nurses Assessment of Satisfaction (MAS-NAS) scale. *Journal of Nursing Scholarship, 38*, 298-300.

Institute of Medicine. (1999). *To err is human: Building a safer health system.* Retrieved May 5, 2006, from http://www.iom.edu/CMS/8089/5575.aspx

Joint Commission. (2007). *2008 National patient safety goals hospital program.* Retrieved December 5, 2007, from http://www.jointcommission.org/PatientSafety/NationalPatientSafetyGoals/08_hap_npsgs.htm

Koppel, R., Wetterneck, T., Telles, J.L., & Karsh, B-T. (2008). Workarounds to barcode medication administration systems: Their occurrences, causes, and threats to patient safety. *Journal of the American Medical Informatics Association, 15*, 408-423.

National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP). (2006). *About medication errors: What is a medication error.* Retrieved May 5, 2006, from http://www.nccmerp.org/aboutMedErros.html

National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP). (2005). *The National Coordinating Council for Medication Error Reporting and Prevention: The first ten years.* Retrieved November 30, 2007, from http://www.nccmerp.org/tenYearReportExecSummary.html

Navarra, M.B. (2004). *FDA bar-code ruling will drive adoption of bar-code technology and improve patient safety.* Retrieved February 2, 2009, from http://www.mckesson.com/en_us/McKesson.com/Our%2BBusinesses/McKesson%2BProvider%2BTechn ologies/ANSWERS/ANSWERS%252C%2BSpring%2B2004/FDA%2BBar-Code%2BRuling%2BWill%2BD rive%2BAdoption%2Bof%2BBar-Code%2BTechnology%2Band%2BImprove%2BPatient%2BSafety.html

Pascale, C., Wetterneck, T.B., Hundt, A.S., Ozkaynak, M., DeSilvey, J., Ludwig, B., et al. (2007). Evaluation of nurse interaction with bar code medication administration technology in the work environment. *Journal of Patient Safety, 3*(1), 34-42.

Patterson, E.S., Cook, R.I., & Render, M.L. (2002). Improving patient safety by identifying side effects from introducing bar coding in medication administration. *Journal of the American Medical Informatics Association, 9*, 540-553.

Perry, A.G., & Potter, P.A. (2004). Preparing for medication administration. In *Clinical nursing skills and techniques* (5th ed., pp. 435-452). St. Louis, MO: Mosby, Inc.

Poon, E.G., Cina, J.L., Churchill, W., Patel, N., Featherstone, E., Rothschild, J.M., et al. (2006). Medication dispensing errors and potential adverse drug events before and after implementing bar code technology in the pharmacy. *Annals of Internal Medicine, 145*, 426-434.

Raczkiewicz, F. (2005). *Bar codes are helping prevent medication errors at UPMC.* Retrieved on February 5, 2009 from http://www.upmc.com/MediaRelations/NewsReleases/2005/Pages/UPMCBarcoding.aspx

Sakowski, J., Leonard, T., Colburn, S., Michaelsen, B., Schiro, T., Schneider, J., et al. (2005). Using a bard-coded medication administration system to prevent medication errors. *American Journal of Health-System Pharmacy, 62*, 2619-2625.

Yates, C. (2007) Implementing a bar-coded bedside medication administration system. *Critical Care Nursing Quarterly, 30*, 189-195.

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