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Impact of BCMA on Medication Errors and Patient Safety: A Summary

Sana Daya MARINI[a] and Arie HASMAN[b]

[a] *School of Nursing, American University of Beirut Beirut, Lebanon*
[b] *Dept. of Medical Informatics, Academic Medical Center, University of Amsterdam Amsterdam, Netherlands*

Abstract. Purpose: To summarize key recommendations and supporting evidence from the most recent studies evaluating the impact of bar coded medication administration (BCMA) systems, and the complementary technologies: Computerized Physician Order Entry (CPOE) and automated dispensing carts (ADC) in preventing medication errors and enhancing patent safety. Summary: The IOM report in 2000 incited many healthcare institutions to implement e-prescribing and automated administration and dispensing of medications to prevent adverse drug events. Moreover, in 2004, the FDA call for bar codes on drugs and blood products has laid the groundwork for the widespread use of BCMA and the complementary technologies to reduce medication errors and improve patient safety. However, the implementation of this technology is a challenge because it introduces changes in the workflow and is costly as well. For a healthcare institution to think about adopting BCMA requires evidence supporting the recommendation to implement such technology. Challenges can be overcome by learning from others' experience with BCMA use. The evidence supporting the recommendation to properly use BCMA includes results on BCMA implementation in various healthcare facilities, and examination of the workarounds by nurses. Conclusion: The significant drop in medication errors rate achieved with the use of BCMA in various facilities presents a blueprint for its positive impact on patient safety. The observation measure to evaluate BCMAs use showed an increased rate of error detection because of the system ability to capture and record intercepted administration errors. However various workarounds by BCMAs users were detected. These workarounds were created to compensate for the flaws and inconvenient aspects of the barcode technology.

Keywords: BCMA, CPOE, medication administration errors, adverse drug events, nurses' attitudes

1. Introduction

Medication errors (ME) and adverse drug events (ADEs) are widely acknowledged as major threats to patient safety. An estimated 7,000 deaths in the US are associated with ME annually [1], [2], [3]. The adult hospital incidence rates for ADEs range from 2% to 7% of all admissions [3], [4], [5]. The Institute of Medicine (IOM) estimates that one hospitalized patient is on average subject to one medication error per day [2]. Medication errors that result in preventable adverse drug events (ADE) may occur during any stage of the medication-use process: ordering (56%), transcribing (6%), dispensing (4%), and administration (34%) [3]. Such estimates raised the issue of medication administration safety as a priority issue.

The use of information technology in the medication provision has revolutionized the medication administration process by preventing ME [6], [7], [8]. The Computerized Physician Order Entry (CPOE) system has permitted electronic prescribing that reduced prescribing errors, and the automated medication dispensing devices that electronically dispense medications in a controlled fashion and track medication use, reduced the rate of dispensing errors. The use of a BCMA system has decreased the errors in the administration phase by more likely intercepting administration errors before they reach the patients [7], [9].

The goal of this paper is to lay out a blueprint for change in BCMA system adoption for medication safety.

2. The BCMA system

2.1. Introduction of the Bar Coding Medication Administration (BCMA) System

The BCMA system was initially implemented by the Department of Veterans Affairs (VA) in 1999 as a patient safety tool to document the administration of pills, creams and injections [10]. At that time the BCMA system was able to provide a real time, point-of-care solution for validating the administration of unit dose medications to patients in the VA. The system had a graphical user interface with a MS Windows-based server which improved the accuracy of medication administration as well as the medication documentation process. The BCMA systems prevent ME by allowing the nurse to easily confirm the 8R's of medication delivery involving the basic nursing principles for medication administration at the point of care: right medication, right dose, right patient, right route, right time, right assessment, right reason, and right documentation. These 8Rs were known as 5Rs historically, and were taught to nurses as a means for minimizing opportunities for errors [11].

After scanning the patient's wristband with the bar code reader the nurse is able to identify the right patient (first R). Then the nurse scans the medication bar code and immediately the system validates that the prescribed medication is the one being ordered and correctly dispensed (2nd R), being given at the right time (3rd R) in the right dose (4th R) using the right route (5th R) as viewed on the screen. Moreover, the BCMA is able to electronically update the patients' medication administration records correctly (6th R) and can automatically display drug information about right reason for administration (7th R) with the right assessment for administration (8th R).

2.2. Bar Coding Medication Administration (BCMA) System: IT of Choice

The BCMA technology is meant to act as a point-of-care safety system that protects patients form potential errors and safeguards the medication administration process where none previously existed [11], [12], [13]. The system can be mainframe based, with laptops or computers on wheels used as point of care devices. The software can be accessed from any networked terminal or laptop in the hospital. Only legitimate users can have access to the system through passwords. Bar code scanners are connected to each computer to scan medications and wristbands. All computers communicate current information in real-time via a wireless network. The software will interface with the pharmacy software to validate and display medication orders. The physician order entry software will interface directly with the pharmacy software and the ordered drugs will come straight from the pharmacy [14]. Upon scanning the patient's wristband, the nurse can access the list of active medication orders for the patient. A bar code reader scans each medication. Then the system will validate whether the medication is administered timely and in the correct dosage [12], [14].

Several before and after BCMA implementation comparison studies have reported a reduction in medication administration error rates of 54% to 86% [15], [16]. Various studies on the impact of BCMA systems on ME showed a remarkable decrease in serious medication error rate. Cochran et al. report that nurses using a BCMA system at the point of drug administration were able to prevent 70 ME that originated in different

phases of the medication use process. 51 (73%) originated in the dispensing phase and 19 (27%) were intercepted in the administering phase [17].

A study by Poon et al. showed that the medication dispensing error rate fell 31% after bar-code implementation, and the potential ADE rate fell 63%. These reductions reflect the significant role of BCMA systems in reducing potential harmful errors. Moreover, Poon et al. reported that the BCMA system had a differential impact on different types of ME: a 58% reduction in wrong medication, a 53% reduction in wrong dose [18]. While in a study by Paoletti et al, BCMA use reduced medication error rates by 54% as evidenced by a direct-observation methodology. Such results make the BCMA system the technology of choice for save medication administration [19].

A study by Madison and Pittsburg based on a direct observational methodology the use of BCMA systems led to a 90% reduction in wrong dosages and a 75% reduction in wrong time administrations [20]. While Johnson et al. in their study about BCMA use reported a 86.2% decrease in ME, a 75% reduction in wrong medication administration, a 62% reduction in wrong dose administration, a 93% reduction in wrong patient, a 87% reduction in wrong time, and 70% decrease in omitted scheduled medications [15].

A study by Rough et al. reported improvement in medication administration and documentation after BCMA implementation. The ME rate declined by: 92% in omitted dose, 77% in wrong time, and wrong dosages were totally eliminated [21]. Whereas Franklin et al. who observed 1644 errors pre BCMA implementation and 1178 errors post BCMA implementation, reported a drop in medication administration errors from 141 (8.6%) pre BCMA implementation to 53 (4.4%) post BCMA use [22].

Appreciable reductions in medication error rate by the use of BCMA have been reported in the reviewed studies; however, due to differences in institutions, study methodologies, error definitions, and other significant variables it is difficult to cite a single number to express the significance of BCMA use in preventing ME and its adverse consequences and to appreciate the real significance of BCMA systems.

A mixed-method study by Koppel et al., conducted in five hospitals on how nurses use the BCMA system to check the 5Rs during bedside medication administration introduced surprising results. Koppel el al found 31 causes to 15 identified BCMA related workarounds, attributable to flaws in the BCMA system design and implementation mode, which in turn have increased the number of certain ME [23].

New types of ME erupted with the use of the BCMA systems when nurses and other BCMA system users scanning the patients wristbands and medications to identify right patient and right drug, overrode the technology in 4.2% of patients charted and in 10.3% of medications charted [23]. Koppel et al found that the urgencies of care and the creativity of nurses to cope with BCMA shortcomings such as the inability of the system to accept two 10mg tablet for a 20mg order. Such system ineffectiveness has urged nurses to devise workarounds that can compensate for such system flaws [23], which in turn could unintentionally have created new types of ME defeating the purpose of BCMA systems use and jeopardizing patient's safety.

Comparing these rates to the average rate of 26% to 32% of adult medication administration errors by IOM [2], definitely assures that the use of BCMA systems to validate right patient identity with the right drug order would support nurses enormously in administering medications safely.

3. Nurses attitude towards BCMA use

Over the past decade IT researchers have given increased attention to user attitudes towards and acceptance of new IT, realizing that user rejection to use IT can be a barrier to successful system implementation [7], [12], [24], [25]. Studies assessing nursing satisfaction showed that 97% of nurses' users of IT technology for medication administration agreed that the system decreased the risk for ME [10]. Further studies showed that nurses overall satisfaction increased 0.3 points on a 5-point Likert scale a year after using the system [26]. Other studies found that nurses showed dissatisfaction with the system when they faced problems generated with its use [9]. The most prominent problem was lack of system flexibility [23], [27], which made some nurses consider the system to be ineffective or inefficient, and started to bypass the required steps in using the BCMA system which defeated its purpose [23], [27], [28], [29].
Marini et al. found in their study for assessing nurses' attitude towards BCMA use, that the BCMA image profile (system characteristics, perceived usefulness, and perceived ease of use) affected users' attitude towards the system which in turn can influence system acceptance and system success [30].
In another study by Marini et al assessing readiness of potential users of BCMA, found that not every registered nurse is enthusiastic about the use of technology for medication administration [31]. An issue to be addressed by the institution prior to system implementation since user rejection to use the IT system can be a barrier to successful system implementation [7], [27].
Nonetheless, valuable debate is stimulated and some key points are identified from this review. The first is that prior to BCMA system implementation, iterative changes have to be made. A system should not be installed without continuous evaluation to identify implementation problems. The second point is that launching software alone is insufficient; users, software, and institution, must be addressed.

4. Discussion and Recommendations

Although the BCMA technology has been proven to be effective in making the medication administration process safer, there are many barriers to its implementation. The shift from manual to electronic medication administration is an intimidating and expensive venture for healthcare agencies. The FDA estimates the cost to an average hospital of buying and implementing IT technology such as the bar coding system to be $13.7 million [8]. Moreover, not every registered nurse is enthusiastic about the use of IT for medication administration. User rejection to use the IT system can be a barrier to successful system implementation [7], [32]. Many of the problems encountered when implementing BCMA systems are both organizational and behavioral, and may be attributed to attitudes towards the use of the system or failure of the implementers to seek input from potential users [33]. Koppel et al found that the urgencies of care and the creativity of nurses to cope with BCMA shortcomings such as inability of the system to accept two 10mg tablet for a 20mg order. Such system ineffectiveness has urged nurses to devise workarounds that can compensate for such system flaws [23], which in turn could unintentionally have created new types of ME defeating the purpose of BCMA systems' use and jeopardizing patient's safety.
Successful deployment of BCMA requires system acceptance by users. Having a many-faceted role in medication administration, nurses would be satisfied with a medication administration system that can support them in this multitask role. Any medication administration system that will promote efficacy in nursing, safety to

patients, and easy access of data can be considered as a supportive system in nursing practice and hence is able to satisfy nurses.

Incremental improvements in current BCMA systems is recommended to achieve

- Safe BCMA systems that prevent injuries to patients ,
- Effective BCMA systems that prevent ME and protect patients from ADEs,
- User-friendly BCMA systems that are easy to learn and use,
- Timely BCMA systems that reduce waits and harmful delays in medication administration,
- Efficient BCMA systems that avoid waste of time and energy in checking the 8Rs needed for medication administration without necessitating the user to ingeniously devise any workaround.

5. Conclusion

Prevention of ME is crucial for patients' safety. Nurses have many opportunities to improve the medication administration process. Proper use of the augmented/upgraded BCMA system together with the professional skills of the nurses will undoubtedly play a key role, and healthcare institutions should adequately and properly prepare the system users prior to software implementation. The incidence of ME can be significantly reduced and patients' safety can be greatly improved and secured.

References

[1] Migdial K. Medication errors: the scope of the problem. http://www.ahrq.gov/qual/ errback.htm (accessed 2004 Nov 9).

[2] Institute of Medicine. Preventing Medication errors. Washington DC: The National Academy Press, 2007.

[3] Bates DW, Cullen DJ, Laird N, et al. Incidence of adverse drug events and potential adverse drug events: Implications for prevention. *JAMA* 1995;274:29-34.

[4] Kopp BJ, Erstad BL, Allen ME, Theodorou AA, Priestly G. Medication errors and adverse drug events in an intensive care unit: Direct observation approach for detection. *Crit Care Med* 2006;34:415-25.

[5] Leape LL, Bates DW, Cullen DJ, et al. System analysis on adverse drug events. JAMA 1995;274:35-43.

[6] Gould D, Boies J, Lewis C. Making usable, useful, productivity-enhancing computer applications. *Communications of the ACM.* 1991;34:75-85.

[7] Davis D. User acceptance of information technology: System characteristics, user perceptions and behavioral impacts, *Int. J. of Man-Machine studies.* 1993;38: 475-487.

[8] http://www.fda.gov/CbER/rules/barcodelabel.pdf (last accessed Jun. 15, 2008).

[9] Murray M. Automated medication dispensing devices. In: Shojania K, Duncan B, McDonald K, Wachter R, eds. *Making Health Care Safer: A Critical Analysis of Patient Safety Practices.* Rockville, MD: AHRQ; 2001:111-117.

[10] Coyle GA, Heinen M. Evolution of BCMA within the Department of Veterans Affairs. *Nurs Admin Q* 2005;29:32-38.

[11] Ridge R. Go beyond the 5 rights. *Men in Nursing.* 2007;2(5):32-36.

[12] Cole G. User Acceptance Key to Success of Voice Processing. Computing-Canada. 1992;18(13):39-40.

[13] Ragan R, Bond J, Major K, Kingsford T, Eidem L, Garrelts JC. Improved Control of Medication Use with an Integrated Bar-code-Packaging and Distribution system. *Am J Health Syst Pharm.* 2005;62(10):1075-1079.

[14] Greenly M, Gugerty B. How bar coding reduces medication errors. FindArticles.com Nursing. 2002 May;cited 2007 May 8; Available from: http://findarticles.com/p/articles/mi_qa3689/is_200205/ai_n9084283

[15] Johnson CL, Carlson RA, Tucker CL, Willette C. Using BCMA software to improve patient-safety in Veterans Administration medical centers. *J Health Inf Manag.* 2002;16(1):46-51.

[16] Paoletti RD, Suess TM, Lesko MG, Feroli AA, Kennel JA, Mahler JA, Sauders T. Using bar-code technology and medication observation methodology for safer medication administration. *Am j health Syst Pharm.* 2007;64(5):536-543.

[17] Cochran GL, Jones KJ, Brockman J, Skinner A, Hicks RW. Errors prevented by and associated with bar-code medication administration systems. *The Joint Commission Journal on Quality and Patient Safety.* 2007;33(5):293-301.
[18] Poon EG, Cina JL, Churchill W, Patel N, Featherstone E, Rothschild JM, Keohane CA, Whittemore AD, BatesDW, Gandhi TK. Medication dispensing errors and potential adverse drug events before and after implementating bar code technology in the pharmacy. Ann Intern Med. 2006;145(6):426-34.
[19] Paoletti RD, Suess TM, Lesko MG, Feroli AA, Kennel JA, Mahler JA, Sauders T. Using bar-code technology and medication observation methodology for safer medication administration. *Am j health Syst Pharm.* 2007;64(5):536-543
[20] Madison WI, Pittsburg PA. Academic Medical Center announces 87 percent medication error reduction with point-of-care car code scanning technology. Meksson Automation, Press Releases. Nov 13, 2002
[21] Rough s, Ludwig B, Wilson E. Improving the medication administration process: the impact of point of care car code medication scanning technology. ASHP.2003 Best Practices award in Health-System Pharmacy.
[22] Franklin BD, O'Grady K, Donyai P, Jacklin A, Barber N. The impact of closed-loop electronic prescribing and administration system on prescribing errors, administration errors and staff time: a before-and-after study. *Qual Saf. Health Care.* 2007;16:279-284.
[23] Koppel R, Wetterneck T, Telles JL, Karsh BT. Workarounds to Barcode Medication Administration Systems: Their Occurrences, Causes, and Threats to Patient Safety. *Journal of the American Medical Informatics Association. 2008;15:408-423.*
[24] Davis D. Perceived usefulness, perceived ease of use, and user acceptance of information technology *MIS Quarterly.* 1989;13(4): 319-340.
[25] Anderson LK, Stafford CJ. The Big Bang implementation: not for the faint of heart. *Comput Nurs.* 2002;20(1):14-20.
[26] Anderson S, Wittwer W. Using bar-code point-of-care technology for patient safety. J Healthc Qual 2004; 26: 5–11.
[27] Patterson ES, Cook RI, Render ML. Improving patient safety by identifying side effects from introducing bar coding in medication administration. J Am Med Inform Assoc 2002; 9: 540–53.
[28] Patterson ES, Cook RI, Render ML. Fifteen best practice recommendations for bar-code medication administration in the Veterans Health Administration. Jt Comm J Qual Saf 2005; 30:355–65.
[29] Patterson ES, Rogers ML, Chapman RJ, Render ML. Compliance with intended use of Bar Code Medication Administration in acute and long-term care: an observational study. Hum Factors 2006; 48: 15–22.
[30] Marini SD, Huijer Abu Saad H, Hasman A, Dimassi H. Nurses' Attitudes towards the Use of Bar Coding Medication Administration System. CIN (2009). [Accepted not assigned to a volume yet].
[31] Marini SD, Hasman A, Huijer Abu Saad H. Information technology for medication administration: assessing bedside readiness among nurses in Lebanon. Int J Evid Based Healthc. 2009; 7: 49-58.
[32] Gould D, Boies J, Lewis C. Making usable, useful, productivity-enhancing computer applications. *Communications of the ACM.* 1991;34:75-85.
[33] Beuscart-Zephir C, Brender J, Beuscart R, Menager-Depriester I. Cognitive evaluation: how to assess the usability of information technology in healthcare. *Comput Methods Programs Biomed.* 1997 September;54:19-28.

Email address for correspondence: sana.dayeh-marini@aub.edu.lb