AUSTRALIAN COMMISSION
ON SAFETY AND QUALITY IN HEALTH CARE

Volume 1, Issue 1: June 2013

Evidence Briefings on Interventions to Improve Medication Safety

Bar code medication administration systems

Policy question: Do bar code medication administration (BCMA) systems reduce administration errors and improve efficiency?

Current evidence shows: BCMA systems have the potential to reduce administration errors but are sometimes used incorrectly due to technology limitations and poor design (e.g. faulty barcodes). Evidence for reduced error rates comes from studies using voluntary incident report data. Controlled observational studies report inconsistent findings. Limited work has assessed cost of BCMA, although time-and-motion studies reveal reduced time administering medications and potentially more time spent in patient care following BCMA implementation.

Background

Bar code medication administration (BCMA) systems (also referred to as bar code enabled point of care (BPOC) technology), are now adopted by the majority (65.5%) of American hospitals to allow patient identity verification and electronic checking of orders [1]. The nurse scans a bar code on their identification tag, the patient's wrist-band, and the medication to be administered. This information is compared with details in the electronic medication administration record (eMAR) and if a mismatch is detected, the nurse is alerted, typically via a visual or auditory warning on the computer screen. BCMA is believed to enable the verification of the 5 rights of medication management (and so prevent wrong-patient, wrong-dose, wrong-time, wrong-drug and wrong-route errors) [2]. The system also ensures accurate and complete documentation of the medication administration process [3]. BCMA implementation requires all medication packaging to contain bar codes that can be read by BCMA scanners and all ordered medications to be listed in an eMAR. In Australia, this may require pharmacists to affix appropriate barcodes to medications and manually enter doctor orders into an eMAR, significantly increasing pharmacy workload and creating new opportunities for error.

Methods

We searched PubMed, EMBASE and CINAHL using the terms Barcod* or Bar cod* and Admin*. The search yielded 818 articles. We excluded duplicates, review articles, commentaries and letters. Articles focusing on the adoption of bar coding for processes other than medication administration (e.g. pharmacy dispensing, point-of-care testing, blood transfusions) were excluded. Articles where bar coding was introduced and evaluated simultaneously with other technologies (e.g. computerised provider order entry, decision support, pharmacy information systems, automatic dispensing, smart pumps) were excluded as

CHSSR
CENTRE FOR HEALTH SYSTEMS AND SAFETY RESEARCH

This briefing paper was prepared by the
Centre for Health Systems and Safety Research
Australian Institute of Health Innovation, University of New South Wales
Authors: Baysari MT, Lehnbom EC, Westbrook JI

www.aihi.unsw.edu.au/chssr

it was not possible to determine the impact of BCMA on measured outcomes. Finally, articles describing implementation of BCMA (e.g. guidelines for successful implementation) were excluded. The remaining 43 articles were included in this review.

Results

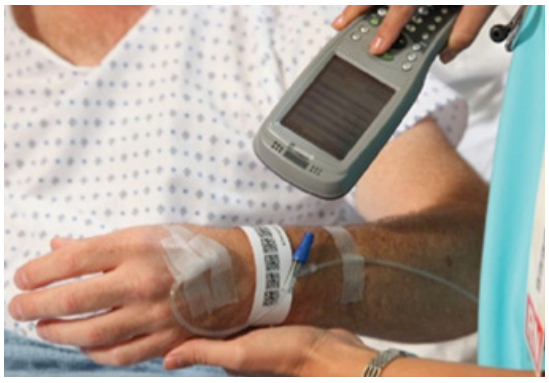
Safety

Observation of administration errors/review of medication charts

Several before- and after-observational studies determined the impact of BCMA on medication administration errors but results are inconsistent. In a study conducted in two medical-surgical wards and two intensive care units (ICUs), no change in administration errors rates was observed following BCMA implementation, but this was most likely due to the large increase in timing errors that occurred [4]. This finding is consistent with another study that reported more medication errors post-implementation in a neonatal ICU due to a large increase (117%) in timing errors [5]. However, it was inconsistent with a study in a medical ICU that found a 56% reduction in medication errors overall, primarily driven by a large decrease in wrong timing errors [6]. Further evidence of results being inconsistent comes from a before and after prospective observational study, where BCMA was associated with a 54% reduction in medication administration errors in one intervention ward, but no change in the other intervention ward [7].

BCMA is believed to enable the verification of the 5 rights of medication management (and so prevent wrong-patient, wrong-dose, wrong-time, wrong-drug and wrong-route errors)

Other observational studies have shown clear reductions in error rates: 41% reduction in non-timing administration errors and 27% reduction in timing errors following BCMA in an academic medical centre [8]; 50% reduction in administration errors following BCMA in a surgical ward in a community hospital [9].



Whether administration errors are reduced post-BCMA appears to be related to the inclusion/exclusion of timing errors in calculating the error rate, and how this error type is defined.

Incident reports

Several studies have involved review of incident reports before and after implementation of BCMA to determine any change in the number of medication errors reported [10-12]. All report significant reductions in the number of administration errors reported by staff.

...alerts rarely warn of true medication errors...

In a study that used incident data as a baseline measure of medication error rate and BCMA log data (i.e. alerts generated) as post implementation error rate, an 18% increase in medication errors was observed, but this was most likely due to the change in data source used [13].

Use of BCMA logs

Studies have used data extracted from BCMA logs to determine the number of errors potentially prevented by BCMA (i.e. alerts generated) and those actually prevented by BCMA (i.e. cases where an alert prevented an inappropriate administration) [13 14] but several reviews of the alerts generated and overridden by nurses in BCMA have demonstrated that alerts rarely warn of true medication errors [15-18]. For example, data extracted from six hospitals using BCMA revealed that although 42% of attempted administrations triggered an alert, 78% were overridden by users and of these, only 10% signaled a discrepancy between what was being administered and what was written in the order [18]. In a study assessing the severity of the medication errors detected by BCMA, it was discovered that only 1% of alerts warned of errors with potentially severe consequences [19].

Simulation

In a study where nurses used a manual process and then BCMA to administer medications to patients in a simulated scenario, fewer nurses administered medications to the incorrect patient when using BCMA (39% vs 8%) than when using the manual process [20].

Workflow

Many studies have adopted ethnographic approaches and interviews to understand the impact of BCMA on nurses' work [21-26]. These techniques have also resulted in the identification of a number of unanticipated side-effects of BCMA use (e.g. decreased ability to deviate from routine sequences) [27], a number of factors influencing use of BCMA (e.g. time shortages) [28], and the identification and description of a range of nurse

workarounds to BCMA use (e.g. scanning surrogate barcodes not on patients' wrists) [29-32]. Workarounds are a frequent occurrence and so represent a significant problem for hospitals with BCMA as they potentially compromise patient safety [33]. Workarounds are due to a number of technology related, task related, patient related, and environmental factors. Ensuring all medications are barcoded and that bar codes scan reliably and consistently appears to be critical for preventing workarounds.

Use of a 'think out loud' technique revealed that most nurses' thinking did not change after BCMA was introduced [34].

Time and motion

A number of studies have used 'time and motion' to assess impact of BCMA on workflow. In all cases, trained observers with stopwatches shadowed nurses during administration rounds. In some studies, time spent on medication administration did not change following implementation of BCMA [35 36], but in several other studies, time spent on medication administration decreased post BCMA [37-39]. There is also evidence to suggest that use of BCMA is associated with an increase in the time spent in direct patient care (e.g. 182.3s post BCMA vs. 47.4s pre BCMA [38]; 29.9% of all tasks post vs 26.1% of tasks pre BCMA [36]).

A study utilising work sampling to assess time spent on various tasks in a medication centre in Taiwan also reported that nurses spent less time on medication related activities following BCMA implementation [40].

Attitudes and perceptions

Many studies involved the administration of surveys to nurses pre and post BCMA implementation to gauge views and perceptions of the new technology [41-46]. In all cases, nurses believed that fewer errors were likely to occur with BCMA in place, but also felt that the system was more time consuming than the traditional paper approach, and so potentially reduced time spent with patients, contrary to what has been reported in 'time and motion' studies.

Cost

In only one study was cost of implementing and operating a BCMA system estimated [47]. Cost data were collected from interviews with key informants and the financial records of four community hospitals. Based on the authors' estimate of number of potential adverse drug events prevented by BCMA (based on BCMA log data), [18] the cost of BCMA was estimated to be US$2000 per harmful medication error avoided, less than the estimated cost of care associated with such errors (US$3100-$7400).

Conclusions

BCMA systems are potentially effective in reducing administration errors when designed well and used correctly, but the evidence for improved patient outcomes with these systems is less clear. Much research has utilised incident reports (which under-estimate error rates) and BCMA log data (which provide more comprehensive data but often overestimate error rate) to demonstrate effectiveness. Different data sources used to measure errors pre- and post-BCMA influence study results. Controlled observational studies that have been conducted report inconsistent findings. Technology limitations (e.g. system 'time outs', faulty bar codes) frequently prevent scanning of barcodes and result in nurse workarounds. Informing nurses of the impact of BCMA systems on time spent administering medications and time spent with patients may result in more frequent use and improved satisfaction with this technology. Alerts in BCMA systems warning of potential errors appear to be over-sensitive and require revision to minimise alert fatigue.

References

1. Pedersen CA, Schneider PJ, Scheckelhoff DJ. ASHP national survey of pharmacy practice in hospital settings: Monitoring and patient education - 2012. *American Journal of Health-System Pharmacy* 2013;70(9):787-803.
2. Young J, Slebodnik M, Sands L. Bar code technology and medication administration error. *Journal of Patient Safety* 2010;6(2):115-20.
3. Barry GA, Bass GE, Jr., Eddlemon JK, et al. Bar-code technology for documenting administration of large-volume intravenous solutions. *American Journal of Hospital Pharmacy* 1989;46(2):282-7.
4. Helmons PJ, Wargel LN, Daniels CE. Effect of bar-code-assisted medication administration on medication administration errors and accuracy in multiple patient care areas. American Journal of Health-System Pharmacy 2009;66(13):1202-10.
5. Morriss FH, Jr., Abramowitz PW, Nelson SP, et al. Effectiveness of a barcode medication administration system in reducing preventable adverse drug events in a neonatal intensive care unit: a prospective cohort study. *The Journal of Pediatrics* 2009;154(3):363-8, 68 e1.
6. DeYoung JL, VanderKooi ME, Barletta JF. Effect of bar-code-assisted medication administration on medication error rates in an adult medical intensive care unit. *American Journal of Health-System Pharmacy* 2009;66(12):1110-15.
7. Paoletti RD, Suess TM, Lesko MG, et al. Using bar-code technology and medication observation methodology for safer medication administration. *American Journal of Health-System Pharmacy* 2007;64(5):536-43.
8. Poon EG, Keohane CA, Yoon CS, et al. Effect of Bar-Code Technology on the Safety of Medication Administration. *New England Journal of Medicine* 2010;362(18):1698-707.
9. Hassink JJ, Essenberg MD, Roukema JA, et al. Effect of bar-code-assisted medication administration on medication administration errors. *American Journal of Health-System Pharmacy* 2013;70(7):572-3.
10. Puckett F. Medication-management component of a point-

of-care information system. *American Journal of Health-System Pharmacy* 1995;52(12):1305-9.
11. Johnson CL, Carlson RA, Tucker CL, et al. Using BCMA software to improve patient safety in Veterans Administration Medical Centers. *Journal of Healthcare Information Management* 2002;16(1):46-51.
12. Higgins T, Heelon M, Siano B, et al. Medication safety improves after implementation of positive patient identification. *Applied Clinical Informatics* 2010;1(3):213-20.
13. Low DK, Belcher JV. Reporting medication errors through computerized medication administration. *Computers, Informatics, Nursing* 2002;20(5):178-83.
14. Lawton G, Shields A. Bar-code verification of medication administration in a small hospital. *American Journal of Health-System Pharmacy* 2005;62(22):2413-5.
15. Radecki RP, McCoy AB, Sirajuddin AM, et al. Effectiveness of bar coded medication alerts for elevated potassium. *AMIA Annual Symposium Proceedings* 2012;2012:1360-5.
16. FitzHenry F, Doran J, Lobo B, et al. Medication-error alerts for warfarin orders detected by a bar-code-assisted medication administration system. *American Journal of Health-System Pharmacy* 2011;68(5):434-41.
17. Early C, Riha C, Martin J, et al. Scanning for safety: an integrated approach to improved bar-code medication administration. Computers, informatics, nursing : CIN 2011;29(4 Suppl):TC45-52.
18. Sakowski J, Leonard T, Colburn S, et al. Using a bar-coded medication administration system to prevent medication errors in a community hospital network. American Journal of Health-System Pharmacy 2005;62(24):2619-25.
19. Sakowski J, Newman JM, Dozier K. Severity of medication administration errors detected by a bar-code medication administration system. *American Journal of Health-System Pharmacy* 2008;65(17):1661-6.
20. Henneman PL, Marquard JL, Fisher DL, et al. Bar-code verification: reducing but not eliminating medication errors. *The Journal of Nursing Administration* 2012;42(12):562-6.
21. Carayon P, Wetterneck TB, Hundt AS, et al. Evaluation of Nurse Interaction With Bar Code Medication Administration Technology in the Work Environment. *Journal of Patient Safety* 2007;3(1):34-42.
22. Novak LL, Lorenzi NM. Barcode medication administration: supporting transitions in articulation work. *AMIA Annual Symposium Proceedings* 2008:515-9.
23. Bargren M, Lu DF. An evaluation process for an electronic bar code medication administration information system in an acute care unit. *Urologic Nursing* 2009;29(5):355-67, 391; quiz 368.
24. Novak LL, Anders S, Gadd CS, et al. Mediation of adoption and use: a key strategy for mitigating unintended consequences of health IT implementation. *Journal of the American Medical Informatics Association* 2012;19(6):1043-9.
25. Novak LL, Holden RJ, Anders SH, et al. Using a sociotechnical framework to understand adaptations in health IT implementation. *International Journal of Medical Informatics* 2013; in press.
26. Novak LL. Finding hidden sources of new work from BCMA implementation: the value of an organizational routines perspective. *AMIA Annual Symposium Proceedings* 2012;2012:673-80.
27. Patterson ES, Cook RI, Render ML. Improving patient safety by identifying side effects from inducing bar coding in medication administration. *Journal of the American Medical Informatics Association* 2002;9(5):540-53.
28. van Onzenoort HA, van de Plas A, Kessels AG, et al. Factors influencing bar-code verification by nurses during medication administration in a Dutch hospital. *American Journal of Health-System Pharmacy* 2008;65(7):644-48.
29. Patterson ES, Rogers ML, Chapman RJ, et al. Compliance With Intended Use of Bar Code Medication Administration in Acute and Long-Term Care: An Observational Study. *Human Factors* 2006;48(1):15-22.
30. Koppel R, Wetterneck T, Telles JL, et al. Workarounds to Barcode Medication Administration Systems: Their Occurrences, Causes, and Threats to Patient Safety. *Journal of the American Medical Informatics Association* 2008;15(4):408-23.
31. Rack LL, Dudjak LA, Wolf GA. Study of nurse workarounds in a hospital using bar code medication administration system. *Journal of Nursing Care Quality* 2012;27(3):232-9.
32. Miller DF, Fortier CR, Garrison KL. Bar Code Medication Administration Technology: Characterization of High-Alert Medication Triggers and Clinician Workarounds (February). *The Annals of Pharmacotherapy* 2011;45(2):162-68.
33. Wulff K, Cummings GG, Marck P, et al. Medication administration technologies and patient safety: a mixed-method systematic review. *Journal of Advanced Nursing* 2011;67(10):2080-95.
34. Eisenhauer LA, Hurley AC, Dolan N. Nurses' reported thinking during medication administration. *Journal of Nursing Scholarship* 2007;39(1):82-7.
35. Poon EG, Keohane C, Featherstone E, et al. Impact of barcode medication administration technology on how nurses spend their time on clinical care. *AMIA Annual Symposium Proceedings.* 2006:1065.
36. Poon EG, Keohane CA, Bane A, et al. Impact of Barcode Medication Administration Technology on How Nurses Spend Their Time Providing Patient Care. *Journal of Nursing Administration* 2008;38(12):541-49.
37. Dwibedi N, Sansgiry S, Frost C, et al. Bedside Barcode Technology: Impact on Medication Administration Tasks in an Intensive Care Unit. *Hospital Pharmacy* 2012;47(5):360-66.
38. Dwibedi N, Sansgiry SS, Frost CP, et al. Effect of bar-code-assisted medication administration on nurses' activities in an intensive care unit: a time-motion study. *American Journal of Health-System Pharmacy* 2011;68(11):1026-31.
39. Tsai SL, Sun YC, Taur FM. Comparing the working time between Bar-Code Medication Administration system and traditional medication administration system: an observational study. *International Journal of Medical Informatics* 2010;79(10):681-9.
40. Huang HY, Lee TT. Impact of bar-code medication administration on nursing activity patterns and usage experience in Taiwan. *Computers, Informatics, Nursing* 2011;29(10):554-63.
41. Topps C, Lopez L, Messmer PR, et al. Perceptions of Pediatric Nurses Toward Bar-code Point-of-care Medication Administration. *Nursing Administration Quarterly* 2005;29(1):102-07.
42. Fowler SB, Sohler P, Zarillo DF. Bar-code technology for medication administration: medication errors and nurse satisfaction. *Medsurg Nursing* 2009;18(2):103-9.
43. Holden RJ, Brown RL, Alper SJ, et al. That's nice, but what does IT do? Evaluating the impact of bar coded medication administration by measuring changes in the process of care. *International Journal of Industrial Ergonomics* 2011;41(4):370-79.
44. Morriss FH, Jr., Abramowitz PW, Carmen L, et al. "Nurses Don't Hate Change" - survey of nurses in a neonatal intensive care unit regarding the implementation, use and effectiveness of a bar code medication administration system. *Healthcare Quarterly* 2009;12 Spec No Patient:135-40.
45. Holden RJ, Brown RL, Scanlon MC, et al. Modeling nurses' acceptance of bar coded medication administration technology at a pediatric hospital. J*ournal of the American Medical Informatics Association* 2012;19(6):1050-8.
46. Hurley AC, Bane A, Fotakis S, et al. Nurses' satisfaction with medication administration point-of-care technology. *The Journal of Nursing Administration* 2007;37(7-8):343-9.
47. Sakowski JA, Ketchel A. The cost of implementing inpatient bar code medication administration. *The American Journal of Managed Care* 2013;19(2):e38-45.