Effect of bar-code-assisted medication administration on medication administration errors and accuracy in multiple patient care areas

PIETER J. HELMONS, LINDSAY N. WARGEL, AND CHARLES E. DANIELS

Since the publication of "To Err Is Human,"[1] two other reports issued by the Institute of Medicine have addressed the importance of preventing medication errors.[2,3] The administration of medication is one of the most errorprone steps of the medication-use process, with 34% of all errors originating in this phase.[4] In addition, less than 2% of medication administration errors are intercepted at the patient bedside. Bar-code-assisted medication administration (BCMA) was developed as an additional safety barrier between the nurse and the patient if a medication error reaches the patient's bedside. This technology assists the nurse in confirming the patient's identity and confirms the appropriate identity, dose, time, and form of the medication. The number of hospitals using BCMA is increasing; in 2002, only 5% of hospitals with 300–399 staffed beds

Purpose. The effect of a commercially available bar-code-assisted medication administration (BCMA) technology on six indicators of medication administration accuracy and nine types of medication administration errors in distinct patient care areas were studied.

Methods. This prospective, before-and-after, observational study was conducted in two medical–surgical units, one medical intensive care unit (ICU), and one surgical ICU of a 386-bed academic teaching hospital. Nursing staff were observed administering medications one month before and three months after implementation of BCMA technology. Observations were conducted by two pharmacists and four pharmacy students on weekdays and weekends. Medication administration accuracy was measured using the accuracy indicator of the California Nursing Outcomes Coalition.

Results. The majority of medication administrations occurred during the 9 a.m. medication round. After BCMA implementation in the medical–surgical units, improved adherence to patient identification policies was observed, but more distractions of the nursing staff occurred and the medications administered were less frequently explained to the patient. Although an increase in wrong-time errors was observed in the medical–surgical units, the total number of medication errors did not change. When wrong-time errors were excluded, the rate of medication errors decreased by 58%. In the ICUs, the charting of medication administration improved after BCMA implementation, but total medication errors and wrong-time errors did not change.

Conclusion. Implementing BCMA technology decreased medication administration errors in medical–surgical units but not in ICUs when time errors were excluded. BCMA technology affected different types of medication administration errors in different patient care areas.

Index terms: Codes; Drug administration; Errors, medication; Hospitals; Quality assurance; Technology
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had implemented this technology, compared with 40.2% in 2007.[5]

Organizations such as the Food and Drug Administration, the Healthcare Information and Management Systems Society, and the American Society of Health-System Pharmacists have urged the adoption of BCMA, and the Institute for Safe Medication Practices considers BCMA a "mature technology."[6] However, only a few studies have investigated the effect of BCMA on medication error rates.[7-11] These studies were conducted in different settings, limiting the external validity of the results. Some studies were conducted in only one or two general care areas (medical–surgical and cardiac telemetry units),[8,9] without implementing a computerized prescriber-order-entry (CPOE) system[9] or using an institution-specific BCMA system.[7,9] Other studies focused on warning and alert data as a surrogate marker for certain types of medication administration errors prevented by the BCMA system.[10,11]

The evaluation of BCMA should not be limited to its effect on the prevention of medication administration errors, as implementing BCMA has important implications for nursing workflow as well. An average of 25% of nursing time is spent on medication-related activities,[12] and the error-prevention potential of BCMA is greatly diminished if the technology does not support nursing workflow. Already, numerous work-around strategies after implementation of BCMA have been described,[13-16] illustrating the need to assess medication administration accuracy in addition to medication administration errors after BCMA implementation. Direct observation of medication administration is the most efficient and practical medication-error detection method and produces valid and reliable results.[17-19] The objective of this study was to determine the effect of a commercially available BCMA system on medication administration accuracy and medication administration errors on two patient care areas (general and intensive care) in a highly computerized setting using a validated observation method.

Methods

This was a prospective, before-and-after, observational study. Data on all outcome measures were collected one month before and three months after BCMA implementation. Observations were scheduled on both weekdays and weekends. The medication administrations scheduled for 9 a.m. were the focus of this study, as the majority of medications on the study units were administered at that time.

Setting. This study was conducted in two medical–surgical units (22 and 26 beds) and two intensive care units (ICUs) (one 13-bed medical ICU and one 20-bed surgical ICU) of a 386-bed academic teaching hospital in southern California. The maximum nurse:patient ratios were 1:4 on the medical–surgical units, 1:2 on the medical ICU, and 1:2 on the surgical ICU. Additional study unit characteristics during the preintervention and postintervention periods are summarized in Table 1.

CPOE was bidirectionally interfaced with the pharmacy information system, eliminating the transcription of medication orders by the pharmacy. Pharmacists' service to the medical–surgical units consists of continuous centralized order validation and the daily presence of a clinical pharmacist on the units. Specialized clinical pharmacists are stationed on the medical and surgical ICUs daily. Medication dispensing is facilitated by unit-based automated dispensing cabinets (ADCs). High-volume medication administration times are 9 a.m., 12 p.m., 6 p.m., and 9 p.m., with the majority of medications administered at 9 a.m.

Before BCMA implementation, the patient-specific medication administration record (MAR) was printed once daily and served as a paper reference for the medications to be given to patients and completed administrations for that day. The hospital's CPOE system had to be regularly checked for new or modified medication orders. Any changes

Table 1. Characteristics of Study Units Before and After Implementation of Bar-Code-Assisted Medication Administration (BCMA)								
	Medical–Surgical Unit 1		Medical–Surgical Unit 2		Medical Intensive Care Unit		Surgical Intensive Care Unit	
Characteristic	Before BCMA	After BCMA	Before BCMA	After BCMA	Before BCMA	After BCMA	Before BCMA	After BCMA
Daily occupancy, %	82	86	78	81	84	94	97	93
No. patients discharged	119	93	202	149	13	14	19	31
Length of patient stay, days	4.6	5.8	4.5	5.1	7.3	15.4	9.0	11.5
Career nurses, %	75	82	98	90	87	86	90	89
Nurse vacancy rate, %	11	4	−6[a]	−8[a]	0	8	10	15

[a]Negative values indicate a surplus in staffing.

needed to be transcribed on the paper MAR as this document was used to retrieve medication from the ADC.

BCMA implementation. BCMA technology (Medication Administration Check using Med Administration Check, version 23.04.9, Siemens, Malvern, PA) was implemented in the hospital from May 2007 to February 2008. Both medical–surgical units "went live" in October 2007; the surgical and medical ICUs followed in December 2007 and January 2008, respectively. BCMA was based on an electronic MAR (eMAR), accessible on computers throughout the hospital, including the medication storage room and each patient room. The BCMA system was integrated with the pharmacy information system and interfaced with the CPOE system. This allowed the eMAR to be automatically updated when new medication orders were entered into the CPOE system or when existing orders were modified. The BCMA software displayed medications due at a certain time in the "active work list," which was used to retrieve medication from the ADC. In the patient's room, the nurse used the bedside computer to select the appropriate eMAR and confirmed the patient's identity by scanning the bar code on the patient's wristband. By scanning the bar code on each dosage form, the medication, dosage form, dose, and administration time were verified using the patient's eMAR. Staff was trained on the new technology by completing a mandatory training program consisting of an online training module and hands-on training sessions in the hospital units.

Data collection. Medication administration accuracy was measured using the accuracy indicator of the California Nursing Outcomes Coalition (CalNOC).[20] CalNOC is the largest ongoing statewide nursing quality database project in the nation and engages approximately 150 hospitals in nursing quality database

development, benchmarking, and research efforts. CalNOC's medication administration accuracy indicator was made available to other hospitals in July 2006. The indicator contains a component to detect medication administration errors, which was adapted from a nationally recognized observational medication-error-detection methodology previously published.[17,18,21] An observed medication administration error is defined as any discrepancy between the medication administered to the patient and the medication ordered on the patient's medical record.[21] The indicator also uses identical subclasses of medication administration errors (appendix). However, the CalNOC tool also contains six indicators of medication administration accuracy that reflect error-prone process variations. Some of these accuracy indicators have been proven effective in other studies that focused on the quality of medication administration[22] or work-around scenario after the implementation of BCMA.[13,23]

In addition to collecting data for these indicators, the duration of the medication administration process for each patient was recorded. To assess compliance with the BCMA technology, additional information (medication name, strength, route of administration, and reason for override) was collected if BCMA was not or could not be used.

Observation procedures. Two pharmacists and six pharmacy students were trained to unobtrusively perform the observations. Training consisted of studying the manual for the CalNOC medication administration accuracy indicator. Adequate knowledge of study procedures was ensured by attending a two-hour review session of CalNOC's training manual and study procedures, developed by one of the pharmacists. The data collection form provided by CalNOC was modified to allow faster data collection and to accommodate the additional variables unique to

this study. Usability of the data collection form and interrater reliability were assessed during two pilot observation sessions on one medical–surgical unit. During the first pilot session, the two pharmacists simultaneously observed one nurse, and the data collected were used to ensure interrater reliability between the two pharmacists. During the second pilot session, two groups of three students and one pharmacist observed medication administered by one nurse, with each group observing a different medical–surgical unit. Interrater reliability between the students and the pharmacist was ensured by comparing the observation data of each student with those of their peers.

Before the study observation sessions began, the study team informed the nurse managers and nursing staff of each unit of the study's purpose and methodology. Practical issues, such as the proposed observation schedule, situations that were excluded from observations, and the informed-consent procedure, were discussed. To prevent interference with nursing workflow, a maximum of two observers could be assigned to each study unit during the observation sessions. However, a nurse was accompanied by only one observer during the medication administration round.

Since nurses were the subjects of our study, informed consent from the patient was not required by the hospital's institutional review board. After contacting the nurse at the beginning of the medication administration round, explaining the purpose of the study, emphasizing that none of the nurse's personal information was collected, and stating that study participation was entirely voluntary, oral informed consent was obtained from the nurse. Observer interaction with the patient was limited to explaining the nature of the study and the presence of the observer. If the patient was uncomfortable with the presence of the observer

at the bedside, the observer left the room, and no data were collected. Medication administrations during emergencies (e.g., cardiopulmonary resuscitation) were also excluded from this study. The observers were instructed to intervene if they witnessed actions of the nurse that could lead to a medication administration error.

Observers arrived on the nursing unit approximately one hour before the scheduled medication administration time, as nursing staff were allowed to administer medication one hour before to one hour after the scheduled administration time. The observation period started when a nurse entered the medication room and began retrieving medication from the ADC. The identity, strength, and dose of the medication removed from the ADC were recorded by the observer. The route, infusion rate (when applicable), and medication administration accuracy indicators were assessed at the patient bedside. After completion of the medication administration, the observer returned to the medication room and followed additional nurses until the medication administration period on the unit was completed.

Medication administration errors were assessed by comparing the observed medication administered to the medication intended for that patient. Before the intervention, the intended medication was determined by photocopying the paper MAR of each observed patient, as well as retrieving the medication data in the electronic medical record. After the intervention, the medication data in the patient's electronic medical record was interfaced with the eMAR, resulting in a continuously updated eMAR. Thus, after the intervention, the intended medication was derived from the information in the eMAR only. The rate of medication administration errors was calculated by dividing the number of errors by the total opportunities for error

(OEs). OEs were defined as the sum of observed administrations and omitted medications. As wrong-time errors were generally considered less severe than other errors,[24] overall results were reported as total errors and errors excluding wrong-time errors.

Data analysis. In the medical–surgical units, the number of observations needed to adequately power this study was based on the results of a similar study investigating the effect of BCMA on medication errors in a similar patient care area.[7] Assuming a similar baseline error rate of 6.3%, an α of 0.05, and a power of 80%, at least 654 medication administrations had to be observed before and after BCMA implementation on both medical–surgical units combined to detect a similar 54% decrease in medication administration errors.

Depending on the type of medication errors, medication administration error rates in an intensive care setting using observational methodologies varied between 6.6% and 54%.[25-27] Two of these three studies were conducted in European ICUs.[26,27] Therefore, the medication error rates found by Kopp et al.[25] were used in our sample size calculation, as the setting of this study was similar to ours. Assuming a similar baseline error rate of 20%, an α of 0.05, and a power of 80%, at least 262 medication administrations had to be observed before and after BCMA implementation on both ICUs combined to detect an expected 54% decrease in medication administration errors.

Data were initially entered into spreadsheets (Excel, Microsoft Corp., Redmond, WA) for initial analysis and summary statistics. Stata 10 (StataCorp LP, College Station, TX) was used to calculate power and conduct additional statistical tests. For nominal data, chi-square analysis was used; if five or fewer data points were analyzed, Fisher's exact test was used. Continuous data were analyzed using the unpaired *t* test. A *p* value of

less than 0.05 was considered statistically significant.

Results

Observation characteristics. The preintervention and postintervention characteristics are summarized in Table 2. On the medical–surgical units, all observation characteristics were similar before and after BCMA implementation except for a slight increase in topical medication administrations after BCMA. On the ICUs, fewer subcutaneous administrations but more infusions by i.v. minibag were observed after BCMA implementation. Also, more observations were conducted during the 9 a.m. medication administration round postimplementation, resulting in fewer observations during the 6 p.m. and 9 p.m. medication administration rounds. After the intervention, fewer observations were conducted during weekends.

Medication administration accuracy. Baseline medication administration accuracy was higher in the medical–surgical units compared with the ICUs. On the medical–surgical units, three accuracy indicators changed after the introduction of BCMA; improved compliance with checking patient identity after BCMA implementation was offset by more distractions and interruptions and less explanation of the medication to the patient (Table 3). These three indicators did not change in the ICUs. However, implementation of BCMA resulted in improved charting and labeling of medications administered in the ICUs.

Medication administration errors. The baseline medication error rate was 10.7% and 12.6% on the medical–surgical units and ICUs, respectively, or 8.0% and 11.0%, respectively, if wrong-time errors were excluded. Although the total error rates on the medical–surgical units did not significantly decrease and an increase in time errors after BCMA implementation was noted,

Table 2.
Observation Characteristics of Study Units Before and After Implementation of Bar-Code-Assisted Medication Administration (BCMA)

Variable	Medical–Surgical Units[a]		Intensive Care Units[a]	
	Before BCMA	After BCMA	Before BCMA	After BCMA
Total no. OE[b]	888	697	374	394
Median (range) OE per patient	5 (1–14)	5 (1–16)	5 (1–11)	4 (1–14)
No. (%) OE per administration route				
Oral	736 (82.9)	581 (83.4)	255 (68.2)	261 (66.2)
Subcutaneous	60 (6.8)	35 (5.0)	35 (9.4)	22 (5.6)[c]
I.V. minibag	34 (3.8)	19 (2.7)	38 (10.2)	72 (18.3)[d]
I.V. bolus dose	18 (2.0)	19 (2.7)	30 (8.0)	22 (5.6)
I.V. large-volume parenteral	5 (0.6)	0	1 (0.3)	0
Intramuscular	1 (0.1)	1 (0.1)	0	0
Topical	21 (2.4)	29 (4.2)[e]	5 (1.3)	8 (2.0)
Miscellaneous[f]	0	0	10 (2.7)	9 (2.3)
No. (%) observations				
9 a.m.	839 (94.5)	651 (93.4)	329 (88.0)	389 (98.7)[g]
12 p.m.	2 (0.2)	0	0	0
6 p.m.	47 (5.3)	46 (6.6)	32 (8.6)	5 (1.3)[g]
9 p.m.	0	0	13 (3.5)	0[g]
Weekend observations, %	6.2	7.2	6.7	2.5[h]
Median (range) duration of medication administration, min	10 (1–30)	10 (1–50)	12 (1–58)	13.5 (1–53)

[a]Unless otherwise noted, *p* not significant.
[b]OE = opportunities for error, defined as the sum of observed administrations and omitted medications.
[c]*p* = 0.046.
[d]*p* = 0.001
[e]*p* = 0.042
[f]Examples include rectal, intraocular, and intranasal routes.
[g]*p* < 0.0001.
[h]*p* = 0.006.

the error rate excluding wrong-time errors decreased by almost 58% after BCMA implementation on these units (Figure 1). Substantially fewer omitted medications and a decrease in the number of medications that were unavailable at the time of administration contributed to this effect.

In contrast, no differences were found for the overall error rate (12.6% before BCMA and 13.5% after BCMA), the error rate excluding wrong-time errors (11.0% before BCMA and 9.9% after BCMA), and the error types after BCMA implementation (Figure 2) on the ICUs.

Discussion

A general medication administration accuracy and error-assessment tool, designed for use in multiple hospitals and in different care areas, was used to investigate the effects of a commercially available BCMA system on two medical–surgical units and two ICUs. This tool was specifically developed to compare medication administration accuracy among hospitals with different levels of automation. Therefore, this tool contains general medication administration accuracy indicators and multiple medication administration error categories. However, the

effect of bar-coding technology on medication administration accuracy is reflected in only a limited number of accuracy indicators (i.e., improved checking of patient identity, improved charting after administration, availability of MAR at the patient's bedside while administering medication). BCMA technology specifically aims to decrease the following error types: unauthorized drug, wrong form, wrong dose, wrong route, extra dose, and omission. The tool used in this study will only show a decrease in medication errors if a large number of these error types were present at baseline, which explains the difference in the rates of medication administration errors between medical–surgical units and ICUs after BCMA implementation. Omission was the predominant error type on the medical–surgical units. As a result, the 58% reduction of total errors excluding wrong-time errors on the medical–surgical units can be largely explained by the decrease in errors of omission. Few errors of omission were detected in the ICUs at baseline. Even though these errors decreased by 50% (from six to three errors), the low prevalence of this type and other types of errors susceptible to improvement by BCMA technology resulted in a nonsignificant decrease in the total number of medication administration errors.

On the medical–surgical units, the number of wrong-time errors increased after BCMA implementation. It is unlikely that the observed increase in these errors was a result of a longer duration of the medication administration round after BCMA implementation, as the median duration of medication administration on these units did not change after BCMA implementation and varied widely per patient (Table 2). Similarly, the number of wrong-time errors observed did not change after BCMA implementation in the ICUs. These findings are consistent with results of a recent study that detected

Table 3.

Accuracy of Medication Administration Before and After Implementation of Bar-Code-Assisted Medication Administration (BCMA)

| Indicator | No. (%) Observations[a] | | | |
| | Medical–Surgical Units | | Intensive Care Units | |
	Before BCMA	After BCMA	Before BCMA	After BCMA
Distraction or interruption during medication administration	127/822 (15.5)	169/670 (25.2)[b]	104/352 (29.5)	113/373 (30.3)
Two forms of identification not checked	110/822 (13.4)	46/667 (6.9)[b]	104/353 (29.5)	90/372 (24.2)
Medication not explained to patient[c]	88/808 (10.9)	93/623 (14.9)[d]	53/170 (31.2)	50/155 (32.3)
Medication charted immediately after administration	74/825 (9.0)	56/668 (8.4)	86/352 (24.4)	25/371 (6.7)[b]
Medication not labeled at patient bedside	17/838 (2.0)	7/666 (1.1)	25/353 (7.1)	12/370 (3.2)[e]
Medication not compared to MAR before administration	4/837 (0.5)	9/686 (1.3)	3/365 (0.8)	0/393 (0)

[a]% observations = no. observed indicator/no. possible occurrence of the indicator (e.g., medications could only be explained to a conscious patient).
[b]$p < 0.0001$.
[c]MAR = medication administration record. Medication is considered adequately explained if at least the name of the medication is mentioned to a conscious patient.
[d]$p = 0.045$.
[e]$p = 0.026$.

differences in nursing time spent on medication administration after BCMA implementation, which also failed to show a difference.[28]

The number of medications not available on the medical–surgical units at the time of administration decreased by 61%. A possible explanation for this is the implementation of a new hospitalwide ADC refill policy. However, this seems unlikely, as the new policy resulted in fewer daily refills of the ADCs, which theoretically could lead to more unavailability errors. Also, this was a hospitalwide policy change, and similar decreases on the ICUs would have been observed. More-likely explanations are changes in pharmacy procurement practices and thorough checks of bar-code readability on arrival of new inventory in the pharmacy as a result of the BCMA implementation. Differences in the types of medications used in the ICUs versus the medical–surgical units could explain the differences between the number of wrong-time errors in these patient care areas.

Nurses were often distracted during medication administration: one of every six and almost one of every
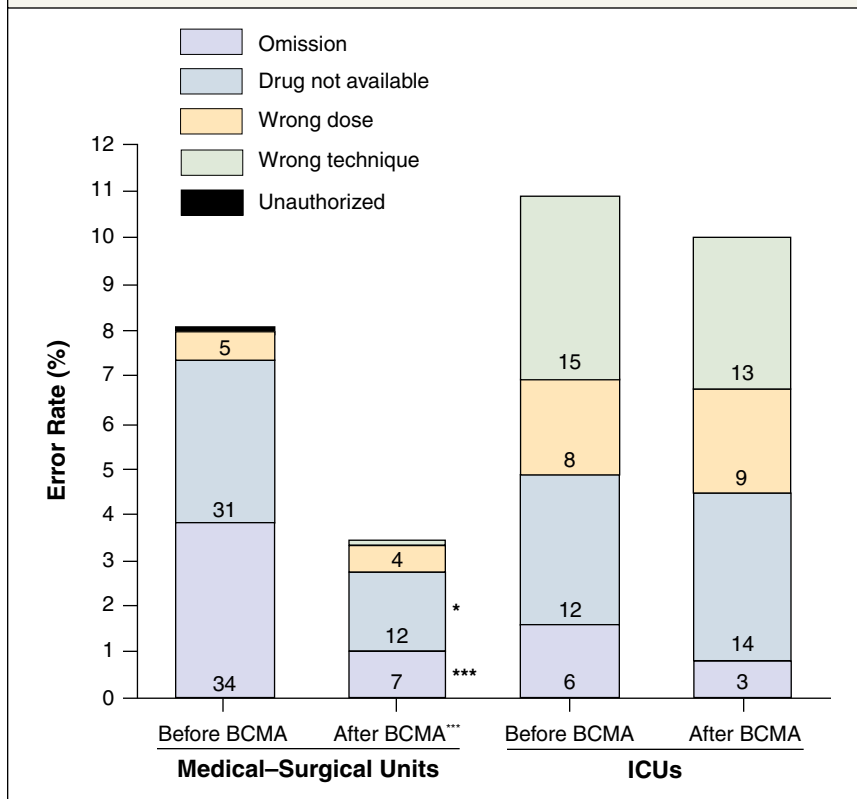

Figure 1. Total errors in the medical–surgical units and intensive care units (ICUs) before and after bar-code-assisted medication administration (BCMA) implementation. Error rates were calculated by dividing the number of errors by the total opportunities for error (observed administrations plus omitted medications). Numbers in bars indicate absolute numbers of errors, * indicates $p < 0.05$, and *** indicates $p < 0.0001$.
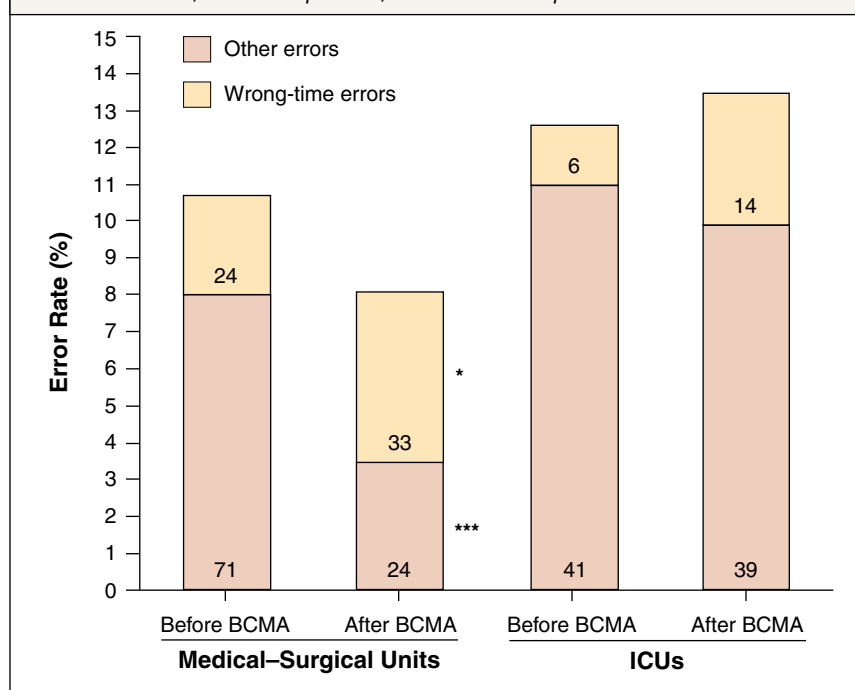
three medication administrations were interrupted on the medical–surgical units and ICUs, respectively. After BCMA implementation, the number of interruptions on the medical–surgical units increased. It is unlikely that this was due to BCMA implementation, as there were no

Figure 2. Types of errors excluding wrong-time errors before and after bar-code-assisted medication administration (BCMA) implementation. Error rates were calculated by dividing the number of errors by the total opportunities for error (observed administrations plus omitted medications). Numbers in bars indicate absolute numbers of errors, * indicates $p < 0.05$, and *** indicates $p < 0.0001$.

harm, even after BCMA had been implemented.[30]

After BCMA implementation, medications were less frequently explained to the patients on the medical–surgical units. This finding warrants further investigation.

In the ICUs, charting compliance after medication administration greatly improved. Baseline charting compliance was low in the ICUs; as BCMA technology is specifically designed to facilitate this process, this indicator was expected to improve.

CalNOC's medication administration accuracy tool allowed for the monitoring of medication accuracy and errors in different care areas, using indicators of multiple error-prone steps of the medication administration process. This is important, as implementation of BCMA technology can result in improvements in one error-prone process but have unintended consequences on others.[13,16,23,30]

This study had several limitations. The observational methodology has been criticized for causing altered behavior of the observed subject (the Hawthorne effect). This effect has been shown to be negligible if the observers are experienced, objective, unobtrusive, and nonjudgmental.[17] In this study, almost half of the observations were done by fourth-year pharmacy students who could be considered nonexperienced observers. However, the expected change in behavior of the nursing staff would result in improved medication administration accuracy and fewer errors, as nursing staff were aware of the purpose of the study. Also, we did not match the route of administration of the preintervention observations to the postintervention observations, as this proved to be very impractical. As a result, the distribution of the observed routes of administration differed between the preintervention and postintervention periods (Table 2). In addition, the majority of observations of medication administration

obvious differences between the two observation periods that could explain this. Although decreasing the number of interruptions and distractions should always be a priority during medication administration, they will never be fully eliminated (especially in critical care areas). It is therefore reassuring that BCMA is now in place to prevent medication administration errors resulting from these interruptions.

In the medical–surgical units, BCMA implementation resulted in increased compliance with the hospital's policy of checking a patient's identity; no difference was observed in the ICUs. Current policy requires two forms of identification to be checked (orally confirming the patient's name and scanning the bar

code on the patient's wristband). In the ICUs, baseline compliance with this policy remained low after BCMA implementation. One reason could be that most patients in the ICUs are unconscious, so oral verification of the patient's identity is impossible. The second method, visually checking the patient name and medical record number on the wristband and scanning the wristband, was often not performed, as nurses were assigned to the same patient for the entire day. This accuracy indicator is probably less suitable for ICU settings, where the nurse:patient ratio is very high. However, checking two forms of identification is one of the Joint Commission's National Patient Safety Goals[29] and failing to check patient identity has led to patient

occurred during the 9 a.m. medication round. Further, the observer who conducted 50% of the observations was also responsible for most of the data entry. However, it is unlikely that this biased the results, as data integrity was ensured by using an automated data-checking tool developed by CalNOC. Further, errors were assessed by the observers immediately after each observation and not by independent researchers. In addition, we did not assess the severity of the administration errors detected but based error assessment on the rigid error definitions of CalNOC. Finally, the postintervention assessment was conducted three months after BCMA implementation, which could be considered too short. However, other studies evaluating the effects of technology on health care have also used a three-month implementation period.[31-33] We ensured appropriate use of BCMA technology by assessing scanning compliance during the post-implementation observations. The compliance rates were 89% on the medical–surgical units and 94% on the ICUs, similar to compliance rates found in other studies investigating BCMA technology.[7,16]

Despite these potential limitations, the error rates found were similar to those found in other studies using similar methodologies and definitions of medication administration errors. Paoletti et al.[7] found a preimplementation error rate of 6.3% on a 36-bed medical–surgical unit, excluding wrong-time errors. Another study investigating the effect of a closed-loop electronic prescribing and administration system on administration errors in a 28-bed general surgical unit found an error rate of 8.6% if wrong-time errors were excluded.[8] Although baseline error rates in the ICUs were lower than expected, this study was adequately powered to detect a 50% decrease in errors after BCMA implementation.

This is the first study showing major differences in the effect of BCMA

technology on medication administration accuracy and errors in different patient care areas. Recently, similar results in medication administration errors and improvements in accuracy were reported in a subset of seven California hospitals, using the CalNOC medication accuracy indicator.[34] These improvements were achieved by adherence to protocols and increased auditing. Their results and the effects shown in this study emphasize that implementing BCMA forces organizations to take a closer look at the whole medication administration process. Implementing BCMA technology has been shown to be a cost-effective intervention[28] and makes empirical sense. However, other hospitals using the CalNOC methodology have found that improving current systems by adhering to protocols and educating staff can generate similar results.[34]

Conclusion

Implementing BCMA technology decreased medication administration errors in medical–surgical units but not in ICUs when time errors were excluded. BCMA technology affected different types of medication administration errors in different patient care areas.

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Appendix—Variables of the medication administration accuracy tool developed by the California Nursing Outcomes Coalition[20]

Medication administration errors
1. Unauthorized drug
2. Wrong dose
3. Wrong form
4. Wrong route
5. Wrong technique
6. Extra dose
7. Omission
8. Wrong time
9. Drug not available

Medication administration accuracy indicators
1. Medication is not compared to medication administration record (MAR) before administration
2. Distraction or interruption of the nurse during medication administration
3. Medication is not labeled at patient bedside
4. Two forms of patient identification are not checked
5. Medication is not explained to the patient during administration
6. Medication is charted on the MAR or electronic MAR immediately after administration