

# Medication Safety Improves after Implementation of Positive Patient Identification

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## Keywords

Patient safety, pharmacy, positive patient identification, harm scores, computerized provider order entry, informatics

## Summary

**Objective:** To report the incidence and severity of medication safety events before and after initiation of barcode scanning for positive patient identification (PPID) in a large teaching hospital.

**Methods:** Retrospective analysis of data from an existing safety reporting system with anonymous and non-punitive self-reporting. Medication safety events were categorized as "near-miss" (unsafe conditions or caught before reaching the patient) or reaching the patient, with requisite additional monitoring or treatment. Baseline and post-PPID implementation data on events per 1,000,000 drug administrations were compared by chi-square with  $p < 0.05$  considered significant.

**Results:** An average of 510,541 doses were dispensed each month in 2008. Total self-reported medication errors initially increased from 20 per million doses dispensed pre-barcoding (first quarter 2008) to 38 per million doses dispensed immediately post-intervention (last quarter 2008), but errors reaching the patient decreased from 3.26 per million to 0.8 per million despite the increase in "near-misses". A number of process issues were identified and improved, including additional training and equipment, instituting ParX scanning when filling Pyxis machines, and lobbying for a manufacturing change in how bar codes were printed on bags of intravenous solutions to reduce scanning failures.

**Conclusion:** Introduction of barcoding of medications and patient wristbands reduced serious medication dispensing errors reaching the patient, but temporarily increased the number of "near-miss" situations reported. Overall patient safety improved with the barcoding and positive patient identification initiative. These results have been sustained during the 18 months following full implementation.

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## 1. Background

Medication errors in hospitalized patients are common, costly and a focus for patient safety interventions. Because the volume of medications dispensed by a hospital pharmacy can reach hundreds of thousands per month, even a low error rate can result in significant patient harm. Automating the medication process with provider order entry and decision support can reduce complications, mortality rates, and costs in the inpatient setting [1]. Barcode technology further automates the process and substantially reduces medication dispensing errors and potential adverse drug events [2, 3]. When barcode technology is configured to require pharmacy staff to scan all doses, a 93% to 96% reduction in the incidence of target dispensing errors has been noted [2]. The pharmacy dispensing function, however, is only part of the chain of events stretching from provider order entry to medication administration to a patient. Nurses may only detect one-third of serious medication dispensing errors [4]. Combining bar code technology in the pharmacy with positive patient identification (again using barcodes) at the point of medication administration further reduces the chance of a dispensing error reaching a patient [3].

## 2. Objectives

Our objective was to document the reduction in medication errors reaching patients after introduction of bar code scanning and positive patient identification in a large teaching hospital already using computerized provider order entry. Introduction of bar code scanning was associated with an unexpected increase in reported errors, so we further investigated the source of these error reports. We also report on the problems encountered and solutions deployed in implementing this practice change.

## 3. Methods

This study was conducted at Baystate Medical Center, a 655-bed general, acute care tertiary care teaching hospital. This study complies with the World Medical Association Declaration of Helsinki on Ethical Principles for Medical Research. As this study utilized de-identified data collected for quality improvement, it was not considered human subjects research and thus did not require Institutional Review Board approval.

Data analyzed for this study were collected routinely for clinical care and quality improvement, and beyond introduction of bar-code scanning, clinical practice was not affected in any way by the study. Computerized Provider Order Entry (CPOE) was first initiated at Baystate in 1995 and transitioned from a legacy TDS Hospital Information System to Cerner Millennium in 2005. All inpatient orders must be entered using CPOE. Positive Patient Identification (PPID) was implemented using handheld scanners (Barcode, Inc, Baltimore, MD) and patient wristbands equipped with bar codes. The standard of care using PPID is to check the patient activity list for current orders, click to bring up the patient's medication administration record (MAR), and retrieve medication from the automated dispensing cabinet (Pyxis, CareFusion, San Diego CA), which verifies a valid order before dispensing. At the bedside, the nurse clicks "Medication Administration" on the computer, which prompts barcode scanning of the patient's hospital ID bracelet. This action brings up the medication worksheet. The medication is then scanned to ensure the five "rights" (right drug, right dose, right patient, right route and right time). Drug name, dose, drug form, route of administration, and time of administration are all documented and update the medication administration record. Patient scan rates were defined as the percentage of medication administration events associated with a simultaneous wristband barcode scan. Medication scan rates were the number of barcode scans performed on doses dispensed relative to total doses dispensed. This number was expected to be well less than 100% since at implementation procedures were not in place for scanning of multi-dose vials or certain parenteral medications.

A limited pilot for PPID began on one surgical intermediate care unit and one medical nursing unit on 4/8/08, was expanded to critical care units on 7/8/08, and to the remainder of the hospital

(excluding Emergency Department) on 9/8/08. An existing on-line safety reporting system (UHC Patient Safety Net) [5] was used to capture baseline and post-implementation data on incidence and severity of medication events. This system allows for on-line reporting, and generates between 6500 and 8700 reports per year. Safety Reporting System events are filed on-line by hospital personnel (physicians, nurses, allied health professionals) and reviewed daily by a pharmacy medication safety specialist. Any adverse drug events thus identified would be reviewed and when appropriate submitted to the FDA, but this report concerns only dispensing errors. The terminology for safety reporting (▶Table 1) includes Category A (unsafe conditions noted by a provider); Category B (a situation with potential to cause patient harm, but corrected before reaching the patient) and Category C and above (where an event reached a patient). Category A and B events are considered “near-miss” events, since no patient harm occurred. Safety events involving pharmaceuticals are reviewed by a pharmacy safety team, and classified after investigation by pharmacists. Dispensing errors would include wrong dose, drug, patient, route, or time of administration. Baseline and post-implementation data was compared by chi-square, with  $p < 0.05$  considered significant.

## 4. Results

Average monthly IV and oral doses dispensed were 539,293 ( $\pm 29,086$ ) during calendar year 2007 and 510,540 ( $\pm 79,258$ ) in calendar year 2008. Total self-reported medication dispensing or administration errors were 28 per million medications dispensed in 2007 and 20 per million in the first quarter of 2008, immediately prior to intervention. Following introduction of PPID, the *total* self-reported error rate increased to 38 per million doses dispensed. However, fewer of these errors were classified (▶Table 1) as severity category C or higher (reaching the patient) with the increase occurring entirely in severity categories A and B (unsafe conditions or error identified before medication administration). ▶Figure 1 demonstrates dispensing errors per million doses with arrows denoting baseline, pilot, critical care and general deployment of PPID. An increase in the number of near-miss events occurred during the first full month of implementation (May) and with full roll-out in September. The most common “near-miss” error identified was wrong medication or dose strength in a dispensing machine drawer.

Patient scan rates were 74% immediately after full roll-out (in September 2008) and exceeded 95% by the end of 2008. Initially, issues with incomplete, incorrect or poorly scanning labels (due to wrinkles or ink smudges) were common. ▶Table 2 shows the distribution of errors by quarter in calendar year 2008. Close examination of type A and B errors revealed “wrong drug in automated dispensing machine drawer” to be a frequent error. In January 2009, Pyxis Par-X<sup>®</sup> (CareFusion, San Diego, CA), was introduced to accurately identify medications as they were put into automated dispensing cabinets, which resulted in a further decrease in total errors. The reductions in total and Class C and greater events (those reaching the patient) have been sustained during calendar year 2009, with just 5 events reaching a patient for a rate of 0.67 events per million doses dispensed. Of these 5 events, one was a delay in administration, and two were labeling errors that scanning would not detect. In the first quarter of calendar year 2010, total dispensing and administration errors identified are 18 per million, with events reaching the patient remaining low at 0.36 per million doses delivered. Medication errors reaching patients were reduced by 75% from first to last quarter in 2008; and by 73% looking at the broader comparison between 2007 and 2009.

## 5. Discussion

Medication errors are common, and often preventable [6]. Reported rates of pharmacy dispensing errors range from 0.0041% (41 per million) to 3.6% (36,000 per million) [7]. A prospective study using direct observation to detect medication-dispensing errors found an overall error rate of 2.5%; with 86.6% detected by pharmacists and 13.4% detected by nurses. [8]. There are also many medication errors that go undetected [7]. Bar-code technology to assist medication has been repeatedly shown to reduce administration errors by about 50% [3, 9, 10] although there is conflicting evidence in the intensive care setting [10, 11]. The American Society of Health-System Pharmacists

encourages the use of bar code medical administration technology and has called for all manufacturers to place machine-readable coding of the National Drug Code (NDC), lot number and expiration date on all drug packaging [12].

Our experience with the combination of pharmacy bar coding and positive patient identification (PPID) at the point of drug administration generated a post-implementation total rate of 38 error alerts per million doses administered, which was an 90% increase over the baseline, pre-intervention rate. However, when separating these medication administration events into those actually reaching a patient versus “near-misses”, we found a decrease in the former, and a statistically significant increase in the latter. Comparison of our absolute error rate to that reported in previous studies is limited, since smaller studies used direct observation, and the size and retrospective nature of this study necessitated reliance on existing safety reporting systems, which likely undercount compared to direct observation. Total errors nearly doubled from baseline to post-implementation, but category C and above errors (those reaching the patients) were reduced 75%. This improvement has been sustained in the 15 months following full implementation.

Technology may improve clinical practice [1, 2], but may also have unintended consequences [13]. For example, CPOE should (and does) reduce errors by eliminating handwriting recognition problems and facilitating drug-drug interaction and allergy checking. Collateral benefits include improved speed and quality of pharmacy processing and better tracking of utilization and adverse events. However, CPOE systems can facilitate medication errors with poor or fragmented displays, by limiting ordering flexibility, or by requiring providers to learn new and non-intuitive computer skills [13]. Bar-code assisted medication administration initially increased total reported errors at our hospital. While we documented a decrease in medication administration events actually reaching a patient, there was a near doubling in self-reported incidents from pre- to post-implementation, using a safety-reporting system that was constant during the study period. While a “Hawthorne effect” [14] of changing behavior due to increased attention is possible, we feel it is unlikely since the nurses and other health care personnel reporting these events were unaware that this data would later be analyzed. Before barcoding, many errors may have reached the patient without being realized or reported. The increase in “near-miss” reporting is therefore not completely unexpected.

A number of technical issues became apparent during the PPID implementation. Scanning failures occur if barcode labels are covered or smudged, and if product identifiers are not updated with new pharmacy inventory. Barcodes printed in white on parenteral infusion bags were often difficult to detect, and scanning errors occurred because the bar code for the Canadian Drug Identification Number (DIN) was situated too close to the United States National Drug Code (NDC) identifier. An on-line educational video and one-on-one instruction was provided to nurses in scanning techniques (specifically, holding the bag against a dark background) to immediately improve scanning success. Subsequently, one manufacturer (Baxter) has redesigned the bags to remove the Canadian DIN codes on bags of intravenous solutions, and the issue of scanning white labels on a plastic bag no longer seems to be problematic.

PPID alerts may fire for any number of reasons: wrong patient, wrong medication, wrong dose, wrong route or wrong time. Because an exact match is needed between the order and the delivered medication, some alerts may fire even when care is correctly delivered, requiring changes to procedure. Examples of this included dispensing insulin from a multi-dose vial, and delivering a medication that is normally intravenous (vancomycin) in an unusual manner (via gastrotomy tube for *Clostridium difficile* colitis). The former issue was resolved by creating barcode labels to be attached to individual insulin syringes once filled from a multi-dose vial, and the latter by adding additional CPOE details for oral vancomycin orders. Some alerts are purely technical: for example if the nurse caring for multiple patients scans a patient's wristband while the computer associated with the scanner is still open to another patient's chart. These particular “near misses” would not occur outside an electronic environment but may reduce provider efficiency. Increased numbers of “near-misses” can be considered yet another side-effect of bar coding [15].

The PPID initiative made it necessary to increase the number of mobile workstations, especially in the intensive care units, where infection control precautions (primarily due to methicillin-resistant *staphylococcus aureus* and *clostridium difficile* infections) led to *de-facto* sequestration of mobile computing devices within individual patient care rooms. Because the computers essentially

went from serving two patients to serving a single patient, an increase in the number of devices was needed to accommodate demand. As we are currently expecting an additional 30 ICU beds to open in 2012, we have designed the new rooms to include two boom-mounted computers, rather than a single mobile device with its attendant battery-life issues.

A limitation of this study is the use of self-reporting for safety issues, which may underestimate the true number of errors. The UHC patient safety reporting system [5] has long been the cornerstone of this hospital's culture of safety, and has a reputation for using reports only as opportunities for process improvement and never for employee discipline. Nonetheless, it does require active effort for providers to report unsafe conditions. We have no evidence, however, that reporting rates changed from pre- to post-PPID implementation. After addressing the issues causing many of the "near-miss" alerts, we have also seen the frequency of these alerts decrease to baseline, pre-intervention levels, while the reduction in errors actually reaching the patient has stayed at 23% of pre-intervention baseline.

## 6. Conclusions

The use of barcode scanning at both the dispensing and administration phases appears to reduce the number of medication errors reaching the patient by 75% immediately after implementation, and that this reduction is sustained over time. A temporary increase in "near-miss" errors was noted, but resolved after additional process changes.

### Implications of results for Practitioners

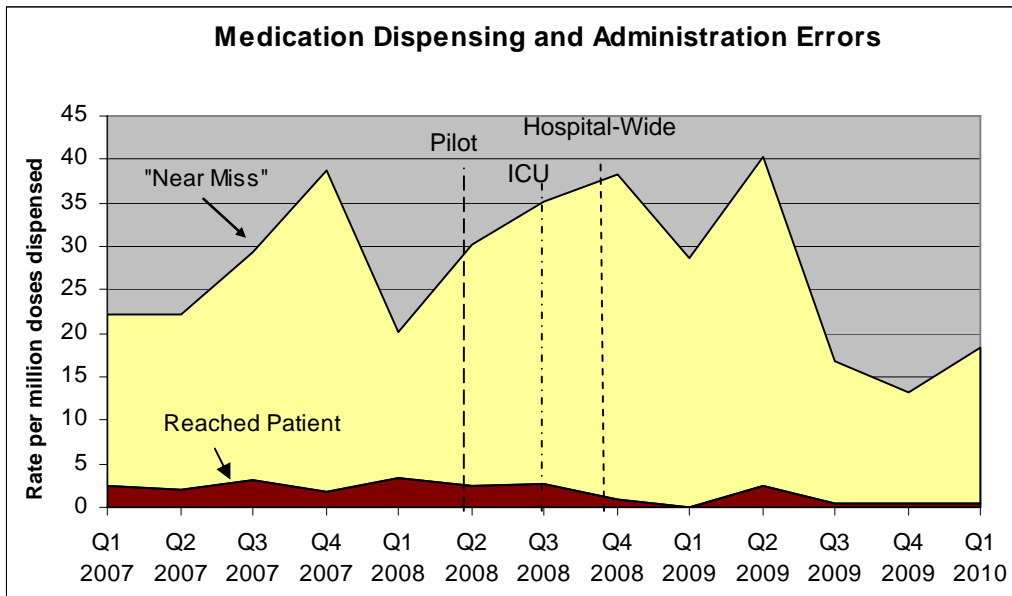
The use of bar-coding on patient wristbands (to provide positive patient identification) and medications dispensed from pharmacy reduced the number of medication errors that reached patients. In the early phases of adoption, an increase in self-reported "near-miss" events also occurred. Provider training and manufacturing changes were necessary to reduce the rate of technical malfunctions.

### Conflict of Interest

None of the authors report any conflicts of interest.

### Acknowledgments

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**Fig. 1** Dispensing errors per million doses, calendar year 2007-2009. In the five quarters prior to intervention, medication errors reaching patients averaged 2.53 per million (dark color), with 23.94 „near misses” per million (light color). The pilot program occurred during the Q2 of 2008, with roll-out to critical care units and hospital wide in Q3 of 2008. In the five quarters post-intervention, near misses remained at 23.5/million, but medication errors reaching the patient decreased to 0.69 per million doses, a 73% decrease ( $p < 0.05$ ).

**Table 1** Definition and examples of errors seen prior to implementation

Severity Category	Examples from Safety Reporting System
<b>A</b> Unsafe conditions	<ul style="list-style-type: none"> <li>• Wrong medication noted in automated dispensing cabinet (Pyxis) drawer</li> <li>• Outdated medication in cabinet drawer</li> </ul>
<b>B</b> Did not reach patient	<ul style="list-style-type: none"> <li>• Adult dose of Vit K removed from cabinet and drawn up for administration to neonate</li> <li>• Seroquel drawn up instead of sertraline</li> <li>• Hydralazine tabs dispensed instead of hydrochlorothiazide; noted by nurse</li> </ul>
<b>C</b> Reached patient, no harm	<ul style="list-style-type: none"> <li>• Incorrect concentration of opiates for patient-controlled analgesia (PCA) pump</li> <li>• Underdosing of furosemide due to product supplied at 1:1 concentration instead of 10:1</li> </ul>
<b>D and E</b> Patient required monitoring or treatment for harm	<ul style="list-style-type: none"> <li>• Wrong medication administered</li> <li>• Medications not available when needed resulting in delayed administration of antibiotics or analgesic (note: would not have been solved by barcoding)</li> </ul>

**Table 2** Number and severity of medication safety events before and after staged introduction of PPID

Severity Category	2007	Calendar Year 2008				2009
	Baseline	Jan – March (Pre-PPID)	April – June (PPID Pilot)	July – Sept. (Addi ICUs)	Oct. – Dec. (Full PPID)	Post-PPID
A and B events	168	31	44	47	47	152
C and above events	15	6	4	4	1	5
Doses	6,471,519	1,840,287	1,587,335	1,447,147	1,251,721	7,470,748
A + B events/million	25.78	16.85	27.72*	32.48*	37.55*	20.35
≥C events/million	2.33	3.26	2.52	2.76	0.80*	0.67
Total events/million	28.11	20.11	30.24	35.24*	38.35*	21.02

\* p < 0.05 compared to pre-PPID

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