Improved control of medication use with an integrated bar-code-packaging and distribution system

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The U.S. health care system has been under intense scrutiny because of a perceived lack of quality and unacceptably high error rates. The application of technology to prevent errors has become a major emphasis in quality improvement programs.

The Committee on the Quality of Healthcare in America identified health information technology (HIT) as one of the four primary methods for improving health care quality. Other influential entities, such as the Leapfrog Group, have also supported HIT as a means of improving quality. Despite the efforts of such groups, the implementation of HIT has, so far, been slow. For instance, a recent survey indicated that bar-code medication administration (BCMA) and electronic medication administration record (EMAR) technology is used in just 2% of U.S. hospitals.

Similarly, computerized prescriber order entry has been adopted in just 7% of hospitals. To successfully implement a BCMA system, a usable bar code must be included on the unit-of-use packaging for each drug product. However, a majority of commercially available medications do not include a standardized bar code that can be scanned by the nurse at the point of administration. Therefore, the pharmacy must manage multiple, disparate drug product identifiers to create a bar code that can be used in a BCMA system.

Several challenges must be overcome to create and successfully manage a bar-code-driven process. Depending on availability and cost, the pharmacy may purchase a generic medication (e.g., acetaminophen) from several suppliers, each with its own unique product identifier. In addition to medication issues, the pharmacy often works with several information systems, each with its own database. Examples include the pharmacy information system, unit dose packaging equipment, drug wholesaler software, dispensing robot, and unit-based drug-dispensing cabinets. Multiple interfaces must be developed to allow these databases to communicate, or a method for unifying the information from each database to create a common bar code must be developed.

We describe the development and implementation of a pharmacy-based, bar-code-driven process that supports BCMA and improves efficiency and dispensing accuracy in the pharmacy.

Description of the institution. Wesley Medical Center is licensed for 640 beds and 102 bassinets and is a tertiary care community teaching hospital. Pharmaceutical services are provided from four satellite pharmacies and the central pharmacy. The satellite pharmacies are responsible for both clinical and distributive functions and are organized along specific service lines. The central pharmacy is responsible for limited production (e.g., compounding and

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Determination of goals. In early 2003, the hospital decided to implement an integrated BCMA and EMAR system. It was determined that this patient safety system would be initiated in October 2003, with all patient care areas being converted within six months (by March 2004). To support the BCMA system, the pharmacy needed to be able to provide a usable bar code for each of the approximately 3.2 million doses it dispensed each year. No additional personnel resources were allocated to accomplish this task.

After discussing ideas for a system to support BCMA, pharmacy teams set the following goals:

1. Develop a bar code for each unit dose drug product that could be used at each step in the system,
2. Integrate “forcing function” (barriers that require the user to take an improved action before he or she can proceed further with the activity) into the pharmacy receiving, packaging, and dispensing processes to improve patient safety,
3. Reduce the opportunity for errors in pharmacy dispensing,
4. Use automation to optimize efficiency,
5. Expand service levels within the pharmacy to meet the BCMA and EMAR initiative without adding personnel resources, and
6. Improve supply-chain management to increase inventory turnover, optimize stock levels, and minimize “out-of-stock” (stock-out) occurrences.

After evaluating products and services available from vendors, we realized that three additional systems were needed: (1) a medication-packaging system (for solid and liquid oral dosage forms) capable of incorporating a compatible bar code, (2) a bar-code-driven medication storage and inventory management system to enhance inventory control and dispensing accuracy, and (3) software to link the disparate information from each of the separate existing systems to create a database for tracking bar codes containing national drug codes (NDCs).

Packaging resources. Only 30% of the drug products that we purchased at the time had a bar code that was usable at the unit dose level. FDA issued a final rule in February 2004 requiring the inclusion of a linear bar code on most prescription drugs and some nonprescription products. Since manufacturers have two years to comply with this rule, pharmacy departments will still have to apply bar codes to drug products for some time. Also, pharmacies will have to repack products not provided by manufacturers in unit dose packaging and apply a bar code. The possibility exists that manufacturers will reduce the number of products available in unit dose packaging to avoid the cost of complying with the FDA rule. If this occurs, pharmacy departments could face substantial bar-code-packaging requirements for an extended period.

Ideally, a bar code would be incorporated into the unit dose packaging at the time of packaging. Other products (e.g., injectable medication syringes) are already available in unit dose packaging but do not have a usable bar code. The pharmacy needs only attach a bar-code label to such products. Liquid dosage forms are another common packaging and bar-coding challenge, particularly if the hospital treats pediatric and neonatal patients. Liquid drug products are usually available in bulk packaging or as common adult doses, which may or may not include a usable bar code.

This means that the pharmacy must be prepared to repackage and incorporate a bar code with many liquid drug products. Another challenge is attaching a bar code to very small unit dose packages (e.g., vials and ampuls). Not only must the bar-code label be small enough to fit the dosage form, it must not cover up essential information and must still allow for easy inspection during compounding.

For most solid oral dosage forms, we chose the Cadet Twin (Euclid, Apple Creek, OH) and Cadet Twin 2X2. These products provide a small, flexible unit dose package that includes a bar code. For liquid dosage forms, we chose the Speedy Wet Cadet (Euclid) and hand-drawn oral syringes, to which we attach labels. For drug dosage forms that are large, have an unusual shape, or cannot be heat sealed (e.g., suppositories), we use the Pace Setter (Accu-Chart Plus Healthcare Systems, Hoffman Estates, IL) to overwrap the product. We use two sizes of bar-code labels, standard (1 in × 1 in) and small (0.25 in × 0.75 in), that can be attached to drug products (e.g., vials, syringes, patches) that do not require repacking. The small bar-code stickers are particularly useful for small dosage forms and can still be easily scanned. Finally, we use bubble packs for specialty dosage forms, such as hazardous oral drugs (e.g., antineoplastics). This allows us to handle packaging and bar coding of such hazardous products in the relative safety of a vertical-laminar-airflow hood.

Integration of technology. Modern hospital pharmacies often use several software and hardware platforms in the medication-use-control process. Examples include the pharmacy information system, dispensing robots, unit-based cabinets, unit dose-packaging systems, and wholesaler software. Each of these platforms has its own independent database for storing drug product in-
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formation and tracking transactions. Unless expensive and complicated interfaces are built, these platforms will not intercommunicate or share data. The result is an inability to integrate systems, necessitating manual intervention.

To overcome these problems, we developed a database application using Clarion programming language (Softvelocity, Pompano Beach, FL) to link the information from various standalone systems. We called this database application the product manager. This application accomplishes many important tasks, including (1) serving as a quality assurance system during the pharmacist check of the bar-coded, packaged product, (2) managing all aspects of packaging (e.g., lot numbers, expiration dates, pharmacist verification of the packaging check, NDCs, packaging history, and the bar code itself and related product mnemonics), and (3) when a product is received in the pharmacy, determining whether it has ever been stocked before, providing decision points guiding the staff on all steps needed for that product, producing a packaging record showing which packaging or bar-coding process should be used, and producing the bar code to be used with the product. These steps were intended to avoid the biggest problem faced by pharmacy and nursing when using a BCMA or EMAR system, which is having barcode products reach the patient care area without a usable bar code.

Each time a drug ordered from a supplier or borrowed from another pharmacy is received by the pharmacy, its bar code is scanned into the product manager. If the product manager does not recognize the medication’s bar code, a message is automatically generated and e-mailed to the pharmacy coordinator of each of the other systems (e.g., automated medication storage devices, packaging systems). This message tells the coordinators that a new drug product is available and that they need to update this information. The product manager records the key information from each pharmacy system and then assigns a unique bar code based on the NDC. If no NDC exists for the product or dosage form produced, the product manager assigns a unique, pharmacy-generated NDC and bar code.

The most important link to the bar code is the formulary item mnemonic in the pharmacy information system (Meditech 4.9.1, Meditech Corporation, Westwood, MA). While the pharmacy may purchase acetaminophen 325-mg tablets from several suppliers, depending on availability throughout the year, each is tied into and tracked by the same mnemonic in Meditech. The product manager is designed to track each supplier’s product separately using the supplier’s NDC, while linking all of them together under the Meditech mnemonic. The data in the product manager are then used to link each product with the unique product identifiers assigned in each of the other pharmacy systems (e.g., automated medication storage devices). This creates a “parent–child” relationship between the mnemonic and the product NDC, bar code, and other identifiers.

The product manager drives the drug-packaging process by producing a packaging record containing pertinent product information. This information includes three separate bar codes: (1) a control number (a consecutive sequence number), (2) the NDC bar code from the source product’s packaging, and (3) the final, unique bar code assigned to the product as packaged by the pharmacy. The system automatically generates directions for packaging, special handling instructions, bar-code labeling, and expiration dating and prints the information in worksheet form. The pharmacy technician uses the information and labels to set up and produce the final product. The packaged product is checked by a pharmacist, who logs in to the product manager and scans the control number’s bar code on the worksheet. This brings up the electronic record and attaches an electronic signature with a final keystroke.

Medication storage and dispensing. Physical space in our pharmacy is limited, and additional space was needed to accommodate new packaging and bar-code operations. We also wanted to improve efficiency and dispensing accuracy. These needs led us to evaluate a medication storage system that optimized space efficiency and used each product’s bar code for scanning. We selected a vertically oriented medication storage device (MedCarousel, McKesson Corporation, San Francisco, CA) containing storage shelves that rotate products up and down in a continuous circular motion similar to that of a ferry wheel. When a product name or bar code is selected in the system, the shelves rotate and bring the product to the work surface level. A light embedded in the countertop automatically identifies the bin location on the shelf containing the selected product. To remove the product for dispensing, the user must scan the bar code and indicate the number of dosage units being removed. A warning is issued if the user tries to remove the wrong product. We were able to store our entire inventory (except large-volume injectable products and refrigerated items) in three cabinets, each with a footprint of 10 ft × 5 ft and extending 11.5 ft vertically. Other potential benefits of this vertical medication storage device include reduction in dispensing errors, reduction in time needed to restock automated medication storage devices, and tighter control of inventory.

The availability of a bar code on all medications has allowed us to “close the loop” on medication handling in other ways as well. For instance, when medications arrive in
the pharmacy from our wholesaler, the bar code on the tote is scanned. The tote scan creates a list of all medications in the tote. These medications are divided into those needing packaging and those ready to be loaded into the vertically oriented medication storage device. The bar code on the latter medications is scanned to spin the medication storage device to the correct stock location. A final scan of the stock location’s bar code completes the electronic receipt invoice for that medication. Bar codes on medications are also scanned during sterile compounding of intravenous admixtures to lessen the chance of error. When medications are sent to the patient care area via pneumatic tube or dumbwaiter, they are scanned first, which creates an electronic record of when the dose was sent. This has been invaluable in resolving discrepancies with nurses and minimizing the extra work associated with sending the same dose a second time. The bar code is also scanned when restocking unit-based dispensing cabinets, thus minimizing the chance that the wrong medication will be placed into a pocket, since the scan process pops the lid on the appropriate storage pocket. Finally, when medications are returned to the pharmacy to be returned to stock (within the vertical storage unit), they are scanned first so that inventory is adjusted and to guide them to the correct storage location.

Outcomes and improvements. After our bar-code-driven processes were implemented, we documented a 96% reduction in dispensing errors, from an average of 42 errors per week to 1.8. In other words, pharmacy errors in selecting products from storage decreased dramatically. The time needed to retrieve medication doses to be dispensed was reduced from 0.61 to 0.49 minute per retrieval, a 20% decrease. The time required to train a new pharmacy technician for unit-based cabinet retrieval and replenishment activities fell from three months to two weeks at the lower error rate.

Several benefits in inventory management were also noted. The number of times the pharmacy had to urgently obtain medication stock from another pharmacy due to a stock-out fell from an average of 16 per month to just 4 (a 75% decline). The time spent daily creating a medication record for the wholesaler declined from an average of four hours to one hour, and the time spent receiving and checking the daily medication order from the wholesaler was reduced from two hours to one hour on average. Coupled with these improved efficiencies was a 7% increase in inventory turnover, from 10.8 to 11.5.

Lessons learned. We learned early in the planning process that “a bar code is not necessarily a bar code,” meaning that just because a product has a bar code on it, the bar code will not necessarily be usable in a BCMA system. The lack of a standard barcode format is a significant hurdle, although the recent FDA bar-code rule should improve this situation. We also found that managing drug purchasing and distribution issues within the pharmacy becomes more complex when driven by the need for a usable bar code. Conversely, incorporation of a usable bar code affords several opportunities to improve drug dispensing and inventory management. Hence, the significant time and effort required to set up a barcode system can produce a very important return on investment. Finally, we learned that some key drug products had to be brought under the direct control of the pharmacy so that a usable bar code could be incorporated for use in the system. Drugs such as radiologic contrast agents and inhaled products administered by respiratory therapists had not previously been dispensed by the pharmacy. Switching these products to the pharmacy consumed substantial amounts of time for building formula-
Conclusion. An integrated bar-code-packaging and distribution system reduced medication errors and improved inventory management.

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