Implementation of a Web-based medication tracking system in a large academic medical center

SAM V. CALABRESE AND JONATHAN P. WILLIAMS

Purpose. Pharmacy workflow efficiencies achieved through the use of an electronic medication-tracking system are described.

Methods. Medication dispensing turnaround times at the inpatient pharmacy of a large hospital were evaluated before and after transition from manual medication tracking to a Web-based tracking process involving sequential bar-code scanning and real-time monitoring of medication status. The transition was carried out in three phases: (1) a workflow analysis, including the identification of optimal points for medication scanning with hand-held wireless devices, (2) the phased implementation of an automated solution and associated hardware at a central dispensing pharmacy and three satellite locations, and (3) postimplementation data collection to evaluate the impact of the new tracking system and areas for improvement.

Results. Relative to the manual tracking method, electronic medication tracking allowed the capture of far more data points, enabling the pharmacy team to delineate the time required for each step of the medication dispensing process and to identify the steps most likely to involve delays. A comparison of baseline and postimplementation data showed substantial reductions in overall medication turnaround times with the use of the Web-based tracking system (time reductions of 45% and 22% at the central and satellite sites, respectively). In addition to more accurate projections and documentation of turnaround times, the Web-based tracking system has facilitated quality-improvement initiatives.

Conclusion. Implementation of an electronic tracking system for monitoring the delivery of medications provided a comprehensive mechanism for calculating turnaround times and allowed the pharmacy to identify bottlenecks within the medication distribution system. Altering processes removed these bottlenecks and decreased delivery turnaround times.

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The consensus statements from the Pharmacy Practice Model Summit in November 2010 included recommendations to leverage automation and well-trained pharmacy technicians to manage the drug distribution process, thus allowing pharmacists to focus on patient care.[1] As stated in Pharmacy Practice Model Initiative documents, pharmacy departments must continuously search for methods to improve the efficiency of their operations.

Having the right medications available in a timely manner is paramount to optimal patient care and to patient and nurse satisfaction. Over the last several decades, health-system pharmacies have implemented technology to improve the medication distribution system. Carousel distribution technology, automated dispensing machines (ADMs), and centralized robotics are specifically designed to facilitate the efficient dispensing and delivery of medications. Temple and Ludwig[2] showed that the combination of automated technology within a central pharmacy and ADMs on individual nursing units constitutes a robust and efficient system for decentralized medication distribution. Although decentralized distribution is not without its drawbacks, articles dating back to the 1970s and 1980s have reported that it provides significantly shorter turnaround times than centralized distribution by eliminating the delivery step from the process.[3,4] Primarily for this reason, there is wide acceptance of ADMs, with over 80% of hospitals in the United States using the technology.[5]

SAM V. CALABRESE, B.S.PHARM., M.B.A., is Associate Chief Pharmacy Officer, Cleveland Clinic, Cleveland, OH. JONATHAN P. WILLIAMS, PHARM.D., M.S., is Pharmacy Manager, Miller Family Heart and Vascular Institute, Cleveland Clinic.

Address correspondence to Mr. Calabrese at the Cleveland Clinic, 9500 Euclid Avenue, HB-105, Cleveland, OH 44195 (calabrs@ccf.org).

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While the widespread use of ADMs has allowed for an improvement in turnaround times for the majority of medications dispensed, there will always be a subset of medications that must be distributed from a central or satellite location. This subset of medications includes nonstandard stock, large products, and sterile product preparations requiring pharmacy admixture. These medications require a "traditional" method of delivery, which has the potential to delay administration and involves a risk of medications being lost within the distribution system.

Medications residing in an ADM are electronically tracked, allowing for easy calculation of turnaround times. Medications requiring delivery from the pharmacy to a hospital unit are more challenging to monitor, and tracking is typically done by direct observation. This tracking method has several limitations, including the inability to know where a product is in "real time," difficulty in obtaining a representative sample, and high resource use. The lack of real-time data often results in duplicated efforts due to lost doses; that can lead to inefficiencies for nursing staff if they must make several phone calls to the pharmacy searching for medications.

Real-time tracking of product processing and delivery is common in other industries, including package delivery companies such as FedEx. The delivery of product has been optimized and automated in the shipping industry through the implementation of unit-specific bar codes and electronic databases that record and store tracking information.[6] Combining this information with a Web-based interface, customers and vendors are able to retrieve real-time delivery data. By applying a similar model using existing medication bar codes, pharmacies can enable real-time tracking within the medication distribution process. Accurate tracking of turnaround times, as well as precise product location, can be achieved when items are delivered from a central or satellite location using this technology. This article describes the implementation of a commercially available Web-based, bar-code-enabled tracking system for patient-specific medications at the Cleveland Clinic.

Methods

Site description. The Cleveland Clinic Main Campus is a 1300-bed academic, tertiary, acute care medical center. The inpatient pharmacy comprises a main pharmacy and three satellite locations that serve the Children's Hospital, the intensive care units (ICUs), and the Miller Family Heart and Vascular Institute. The pharmacy department employs 92 staff pharmacists, 28 clinical specialists, and 144 pharmacy technicians. The medication distribution system is supported by computerized prescriber order entry (CPOE), 344 ADMs, six vertical carousels, two open-architecture cleanrooms, and a hospitalwide pneumatic tube system. On an annual basis, the inpatient pharmacy processes 7.5 million orders.

Beginning in 2006, the Cleveland Clinic and the department of pharmacy underwent significant changes to improve the safety and efficiency of pharmacy services. These changes included the implementation of CPOE; the implementation of smart-pump technology; the expansion of ADMs to include newly initiated and routine medications in addition to the traditional as-needed medication and narcotics inventories; the renovation of the central pharmacy, including the i.v. compounding room; the implementation of carousel dispensing technology; the implementation of an onsite repackaging system; and the construction of a new pharmacy satellite location to support a 300-bed expansion of the heart and vascular institute.

In conjunction with these improvements, the department of pharmacy routinely reviewed measures of quality for pharmacy services, including cost-saving initiatives, pharmacist interventions, and pharmacy turnaround times. The decentralization of medication dispensing immediately decreased the turnaround time for up to 75% of medication orders. The remaining 25% of orders continued to be a focus of review for potential further optimization of pharmacy services, and observational studies were completed at regular intervals to assess turnaround times for these medication deliveries. These studies were limited, however, in that the collected data excluded certain forms of delivery, provided minimal information on process bottlenecks, and often took greater than two weeks to compile and review. In 2009, the department of pharmacy reviewed potential automated solutions for the tracking and reporting of the medication dispensing process. After reviewing the work of other investigators who analyzed the effect of Web-based tracking systems on turnaround times for stat medications,[7] the Cleveland Clinic pharmacy assessed the potential impact of such technology on the processing of first-dose and redispensed medications, and it was decided that the pharmacy would implement the MedBoard tracking system (Pharmacy OneSource, Bellevue, WA).

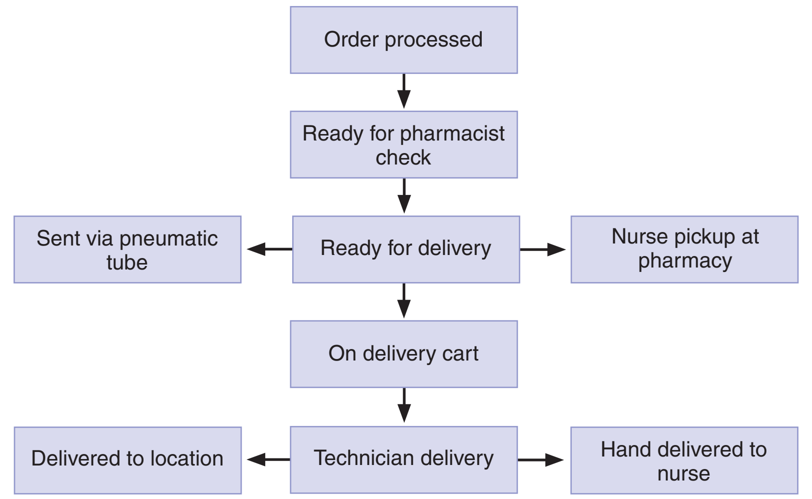
Baseline data collection. Before implementation of the new tracking system, studies of baseline turnaround times were conducted on a bimonthly basis. Using manual data collection sheets and direct observation, the pharmacy technicians recorded the medication order number, the label print time, the destination nursing unit, the medication name, and the actual delivery time for all dispensed medications during a specified period (24-hour cart-fill orders and scheduled i.v. batch orders, as well as orders delivered through alternative methods such as the pneumatic tube system, were excluded from the evaluation).

A total of approximately 500 first-dose and redispensed medications were recorded at the four pharmacy locations over a three-day period during the first and second shifts (i.e., 7 a.m.–11 p.m.).

Web-based tracking system. Planning for the implementation of the tracking system occurred in three phases: workflow analysis, equipment selection and procurement, and interface development. During the workflow analysis, planning sessions were held in order to create process-flow diagrams for the medication distribution system. Using the diagrams, distinct points within the distribution process were identified as bar-code scanning points (Figure 1). These scan points were selected in order to allow the capture of specific "cycle times," or task-completion times, within the medication distribution process, including the times required for pharmacist CPOE review, technician preparation of medications, pharmacist verification, technician preparation for delivery rounds, and technician delivery to the final destination.

To ensure accurate representation of all deliveries, additional scan points were added to encompass nursing staff pickups at the pharmacy, technician hand deliveries to nurses, and deliveries via the pneumatic tube system (for tube-delivered orders, the time the medication left the pharmacy was considered the final destination scan). All scan points required the use of a unique bar code. The pharmacy information system was used to create the bar code for each item to be delivered. The 2-D bar codes supplied by the tracking system vendor (and applied to physical locations throughout the pharmacies and nursing units) were used at each delivery scan point. In addition, the MedBoard software was configured to provide a visual display of order status based on predefined target turnaround times (Figure 2).

Figure 1. Medication distribution scan points monitored by the Web-based tracking system.

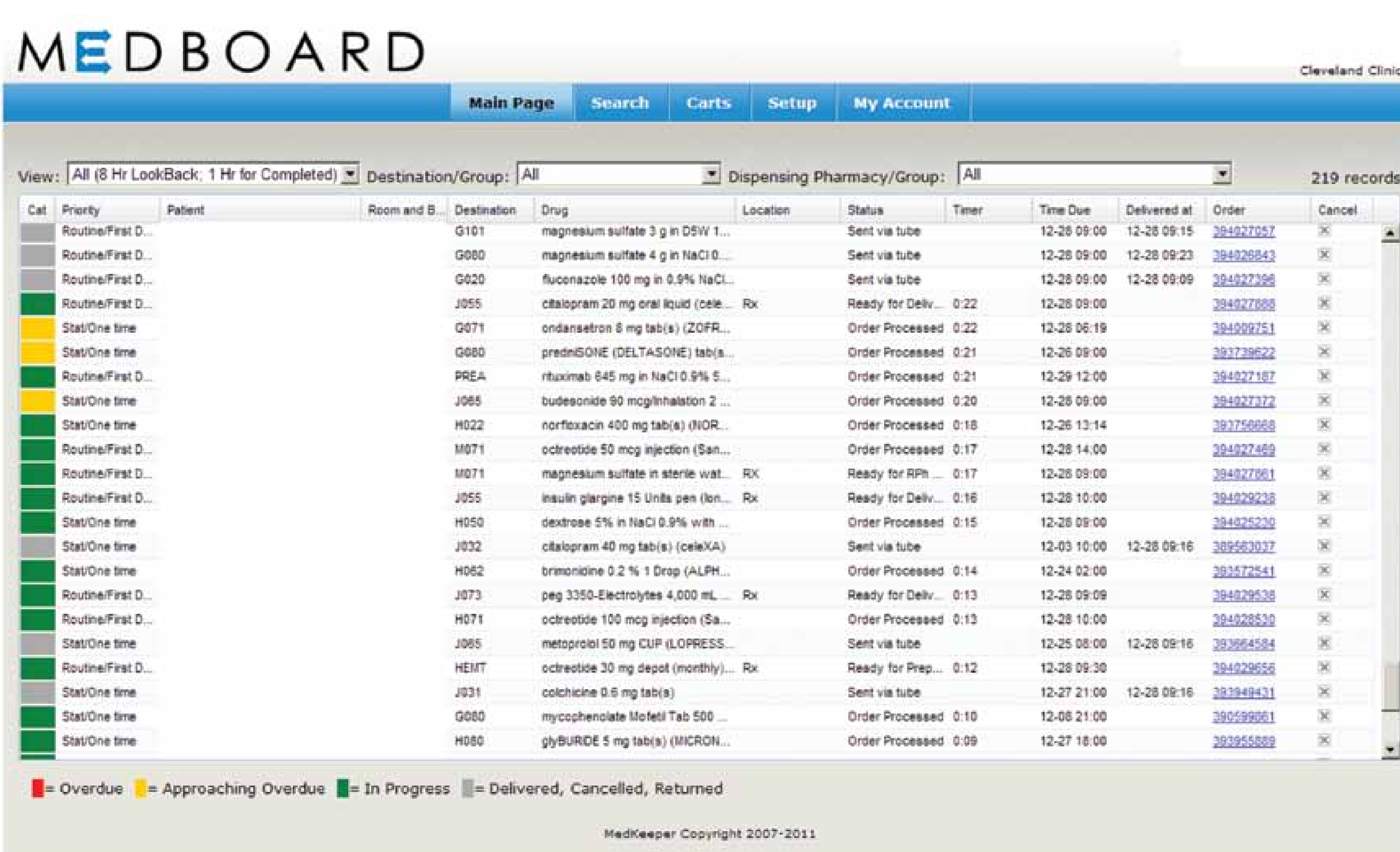


During the equipment selection and procurement phase, the implementation team reviewed several options for capturing bar-code scans with handheld devices. Based on ease of use, portability, and durability, the team selected the following hardware: Bluetooth-enabled (Bluetooth Special Interest Group, Kirkland, WA) scanners, wireless hand-held personal computers, and 42-inch monitors for the dispensing locations. Finally, the pharmacy informatics team worked closely with the information system vendor and the carousel vendor to create a one-way interface between each of those systems and the automated tracking system. Interface testing was conducted to ensure that transaction data were being appropriately transferred to the automated tracking system.

Implementation. The Web-based tracking system was implemented in two phases. During a pilot phase, the hardware and software were installed in one satellite location with a coverage area of about 350 patient beds. Staff members in that area were educated on the system's functionality, with informational signs and how-to documents also provided, and compiled data on scanning completion percentages and turnaround times were reviewed. After the completion of the pilot phase, the hardware and software were installed in the other designated pharmacy locations.

Postimplementation data collection was initiated two weeks after housewide installation of the hardware and tracking system; data review was accomplished through the use of database queries of the Web-based tracking system. Pursuant to a review of data gathered during the first two weeks of data collection, additional education and system optimization were performed to minimize variations in human performance. The data review process was repeated six months after implementation, with bimonthly analysis of data covering seven-day periods thereafter. The compiled data were analyzed to determine differences in overall turnaround times by dispensing location (central versus satellite pharmacy) and delivery type (technician versus pneumatic tube delivery). Cycle times for various steps of the medication distribution process were also reviewed. The percentage rate of completed

Figure 2. Screenshot of medication tracking system display.



technician destination scans (i.e., the total number of orders scanned by technicians as "delivered to location" divided by the total number of orders scanned by the pharmacist as "ready for delivery") was calculated; a scan completion rate of ≥90% was identified as a goal.

Results

Preimplementation results. During the specified three-day baseline data collection period, 440 medication orders (184 processed by the central pharmacy and 256 processed by the satellite locations) were reviewed. At the central pharmacy, the mean turnaround time (i.e., the time from physician order entry to final medication delivery) was 74 minutes per order (Figure 3), including a mean of 4 minutes for pharmacist verification. The three satellite pharmacies had a mean turnaround time of 40 minutes per order (Figure 4); as at the central pharmacy, the time required for pharmacist verification averaged 4 minutes.

Postimplementation results. During the first week of postimplementation data collection, 9718 medication orders (5334 processed by the central pharmacy and 4384 processed by the satellite locations) were reviewed. For orders processed by the central pharmacy, the mean turnaround time (i.e., the time from order entry to final delivery to a patient care unit by a technician or via pneumatic tube) was 45 minutes; the mean turnaround time for medications delivered by technicians was 66 minutes, and the mean turnaround time for hand-delivered medications was 15 minutes (Figure 3). Among the three satellite pharmacies, the mean turnaround time was 35 minutes per order; the mean turnaround times for technician- and tube-delivered medications were 45 and 10 minutes, respectively (Figure 4).

The medication tracking system provided additional information on the cycle time of each step in the dispensing process. For medications delivered to the designated location by technicians (n = 2276), six steps were analyzed: CPOE verification, preparation, pharmacist check, wait for delivery, on delivery cart, and final delivery. For those six steps, the central pharmacy's mean cycle times were 6, 9, 3, 31, 2, and 15 minutes, respectively; the corresponding cycle times at the three satellite locations (n = 3116) averaged 4, 4, 6, 17, 2, and 12 minutes, respectively. In both the central and the satellite pharmacy locations, wait for delivery and delivery

Figure 3. Central pharmacy cycle times and mean turnaround times before and after implementation of the tracking system.

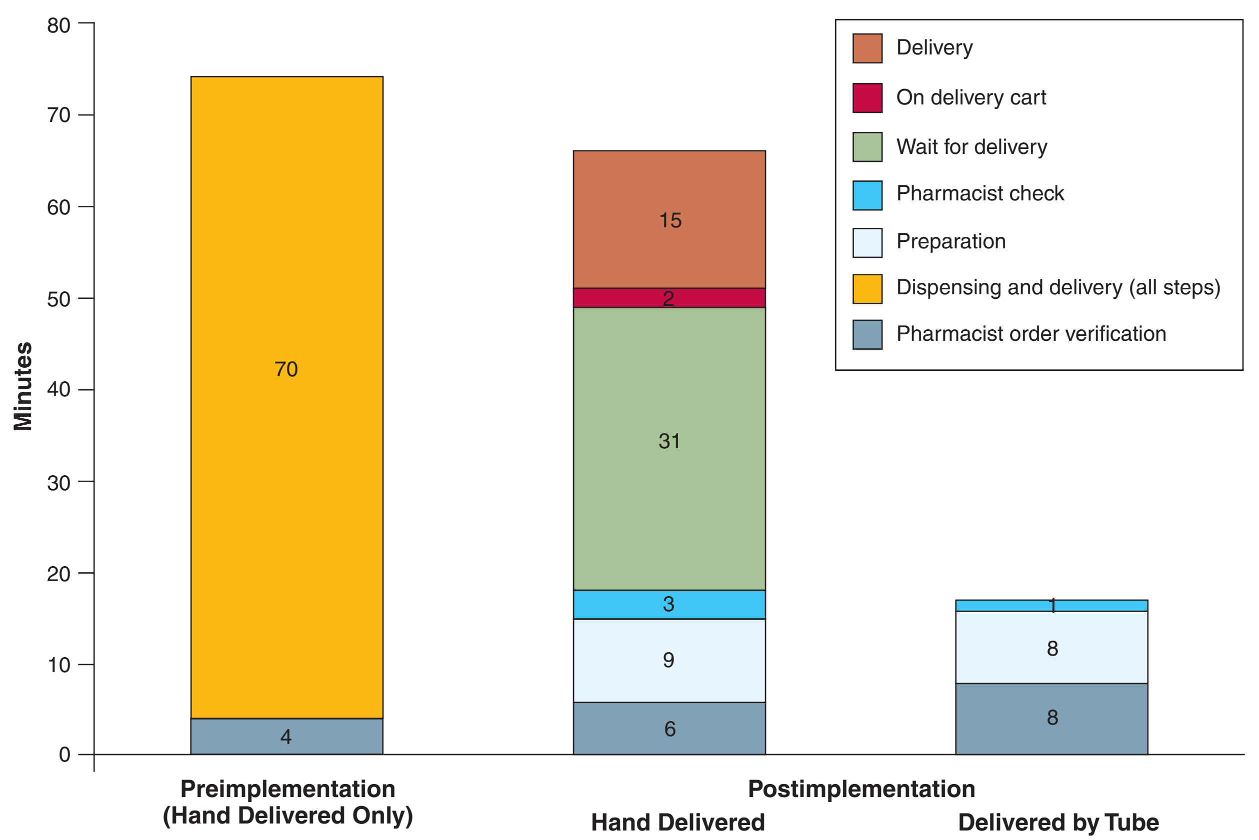
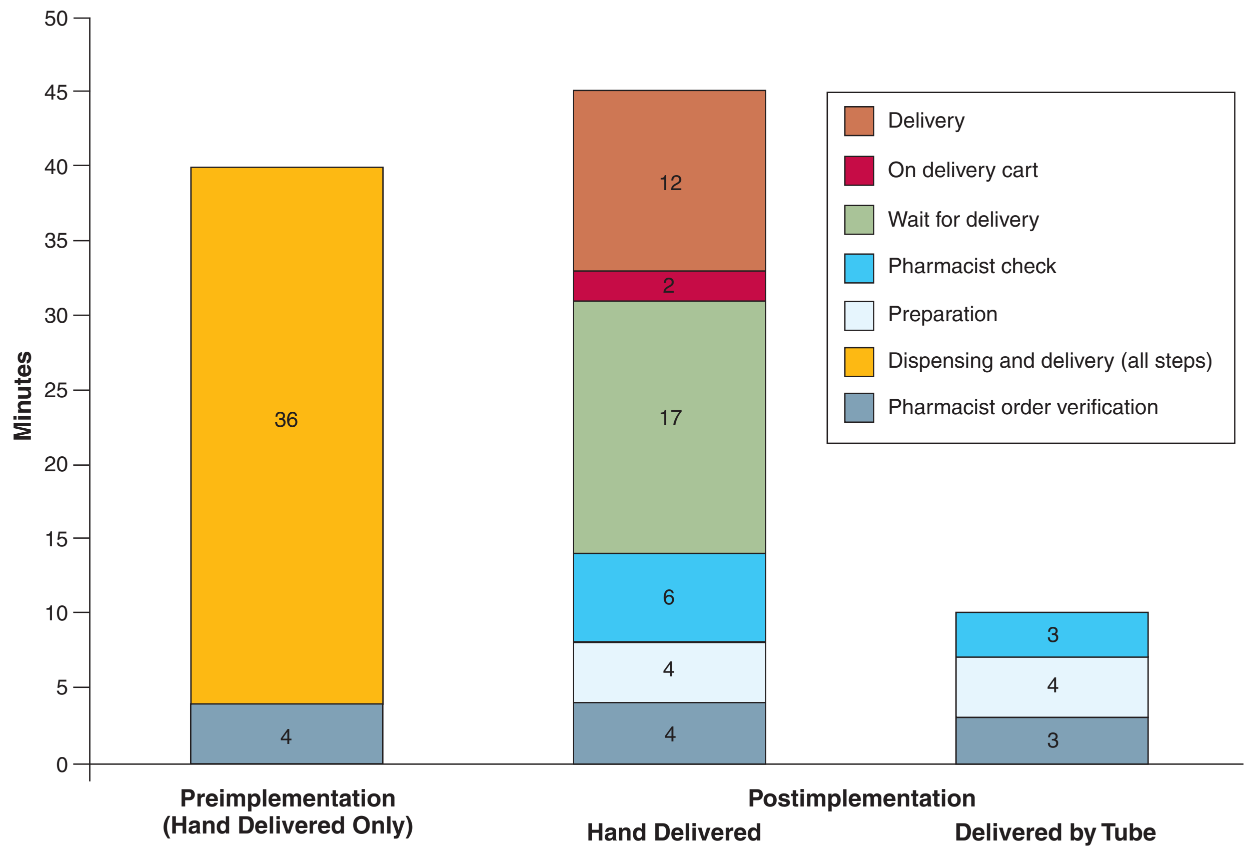


Figure 4. Satellite pharmacy cycle times and mean turnaround times before and after implementation of the tracking system. Values are the means of time values recorded at three satellite locations.



were the most time-consuming steps in processing medication orders.

With regard to medications delivered via the pneumatic tube system, the dispensing steps analyzed were CPOE verification, preparation, and pharmacist check. For orders processed at the central pharmacy (n = 3058), the mean cycle times for those steps were, respectively, 6 minutes, 8 minutes, and 1 minute; the corresponding mean cycle times at the satellite locations (n = 1268) were considerably shorter (3, 4, and 3 minutes).

Scan completion percentage. Rates of completed destination scans were determined for the central pharmacy as well as the three satellite locations. The highest scan rate was documented in the pediatrics satellite, where 513 (98%) of 524 evaluated orders were scanned. The pharmacy serving the heart and vascular institute had a completed-scan rate of 93% (2508 of 2697 orders), also exceeding the goal of ≥90%. The central pharmacy and the intensive care satellite pharmacy had below-goal scan rates of 85% (4706 of 5537 orders) and 82% (1177 of 1435 orders), respectively.

Discussion

Pharmacies have been concerned with the identification of medication order turnaround times for years.[2,3] A Web-based tracking system using bar-code technology provides a means to obtain these data in real time. Delivering 70–80% of medications via an ADM has changed the expectations of nursing staff regarding acceptable turnaround times for medications delivered by alternative methods. Our analysis of the data collected in the study described here indicated that medications located in an ADM were accessible in less than 10 minutes (the average verification time). To address nursing staff expectations, the pharmacy management team decreased the turnaround time for items not dispensed through an ADM. In addition, the new automated system enabled pharmacists and technicians processing orders to assist the nursing staff in locating products within the medication distribution system more precisely.

Medication turnaround time. The turnaround time of medication dispensing and delivery has an impact on both pharmacy and nursing workflows. Implementing a Web-based tracking system using bar codes and scanners can facilitate robust turnaround-time documentation. When comparing the data received from direct observations versus the automated system, we found a significant increase in the number of data points with the use of the automated system. Through the direct observation method, 440 data points were collected over three days per month compared with 9718 data elements gathered by the automated tracking system over a seven-day period. Due to the scope of data collection achieved with the Web-based system, extensive subanalysis was also possible to further differentiate process variables and allow for adjustments to increase efficiency.

Quality improvement. The ability to track medication order turnaround times—not only overall turnaround times but also the time required to perform each step of the process—provides further opportunities for quality improvement. For example, delays in the admixture process may warrant a closer look at cleanroom procedures. Applying "lean process improvement techniques" could reduce admixture times and, in turn, lower the overall medication turnaround time.[8]

Using the data obtained through automation and the predefined scan points, bottlenecks within the medication distribution process were identified. We identified opportunities to improve cycle times at the "wait for delivery" and the "delivery" steps. After the review of these processes and rate-limiting steps, we found that the scheduled delivery rounds limited our ability to decrease the mean turnaround time. The most common scenario was that a medication was checked for delivery immediately after a delivery round was initiated. Following this determination, the "just in time" theory was applied to delivery rounds. Technicians were instructed to continue a minimum of hourly delivery rounds, with the addition of nonscheduled rounds for items listed on the tracking monitor as "approaching overdue" or "overdue." This process change assisted in decreasing the mean turnaround time at the central pharmacy, from 74 to 66 minutes.

The reduced turnaround times documented at the satellite areas versus the central location also validated the results of previous studies indicating that a decentralized delivery method is more efficient.[4,5] This decrease has been attributed to the distance from the dispensing location to the delivery location. The implementation of a decentralized technician model, wherein the products are sent via pneumatic tube, could enhance the delivery process and reduce the transit time of products. Additional studies are required to validate this model.

Staff training. To obtain comprehensive data from the tracking system, our professional personnel and technical staff were required to use the system consistently. Group presentations, as well as one-on-one training sessions, were conducted for the technician staff. A training checklist was developed, and each technician was required to demonstrate competency in using the system. A quick-reference card was developed for the technicians to carry on delivery rounds. Technicians were coached daily on their scan-completion percentages, and retraining was provided as needed.

Scan-completion rate. Highly competitive scan-completion percentages were documented in the pharmacy satellites serving the Children's Hospital and the heart and vascular institute, exceeding our goal of 90%, while our central pharmacy and ICU satellite fell short of that goal, with average rates of 85% and 82%, respectively. The lower compliance in the central pharmacy was attributed to additional training needs, which were met after the analysis. At the ICU satellite, unscanned medication deliveries were often the result of urgent medication requests whose prompt fulfillment precluded the scanning of medications.

Nurse satisfaction. The automated system is also used by technicians when answering questions regarding missing doses. Technicians can now inform the nursing staff where a medication is within the medication distribution process, including final delivery locations. An hourly report is reviewed to identify any medications delivered to an incorrect location based on data received from the pharmacy information system and the final delivery location. Misdelivered medications are retrieved and delivered to the correct nursing unit.

The system is also capable of providing a customized display on each nursing unit to allow nurses to directly view the status of their patients' medications; our institution plans to implement this capability in the future.

Limitations. Due to limitations in staffing and the logistics of data collection over a 24-hour period, data from direct observations during the preimplementation period were recorded primarily between the hours of 8 a.m. and 8 p.m. The lack of sampling at other times reduced our ability to generalize the collected data to describe the medication dispensing process as it occurs "around the clock." In addition, the preimplementation data did not include medications that were sent out via the pneumatic tube system (such orders can represent greater than 50% of first doses and redispensed medications sent from the pharmacy). The decision to exclude these items from the baseline analysis was made in an effort to focus on items associated with the longest delivery times, but it limited our ability to capture all aspects of the distribution process. During implementation of the Web-based tracking system, we determined that it would be beneficial to describe the entire medication distribution process, including deliveries through the pneumatic tube system, and such deliveries were included in the postimplementation analysis.

We found that a significant limitation of the Web-based tracking system was the difficulty of reviewing medications that did not receive a final destination scan. It was ultimately decided to exclude these items from the study sample, as many of them were not scanned due to legitimate reasons; the pharmacists were able to remove these items from the database manually, but some may have been overlooked. Unscanned items were not included in the calculations of the scanning compliance rate, whose validity depended on the pharmacist scanning an item as "ready for delivery"; medications not receiving that scan were considered to represent individual performance issues, which have been addressed through staff training.

Conclusion

Implementation of an electronic tracking system for monitoring the delivery of medications provided a comprehensive mechanism for calculating turnaround times and allowed the pharmacy to identify bottlenecks within the medication distribution system. Altering processes removed these bottlenecks and decreased delivery turnaround times.

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