Improved Arrangement and Capacity for Medication Transactions: A Pilot Study to Determine the Impact of New Technology on Medication Storage and Accessibility

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Abstract

Purpose: A new-generation automated dispensing cabinet (ADC) deployment is described. **Methods:** A single-center retrospective-prospective pilot product performance study was conducted, and prospective nurse satisfaction survey and pharmacy technician product performance feedback survey were performed to determine the impact of new technology on medication storage and accessibility. The study measured efficiency of the 9:00 AM medication pull for nursing users, assessment of nursing perceptions of medication administration pre- and postinstallation of the cabinetry, pharmacy technician perceptions of working with the cabinetry, and assessment of the efficiency of the pharmacy technician restock process. **Results:** In total, 2981 total nursing medication retrieval processes for the 9 AM standard medication administration time (SMAT) time were analyzed: 1321 in the preoptimization phase and 1660 in the postoptimization phase. Analysis of the mean time per transaction confirmed a significant improvement from 10.5 to 10.3 seconds per transaction ($P = .026$) in the postoptimization configuration. The modified assessment of nursing satisfaction survey demonstrated increased satisfaction with many aspects of the new-generation cabinetry. Pharmacy technician survey data highlighted beneficial aspects of the device, while restock data showed an increase in the time spent restocking the cabinet from 11.5 seconds in the preoptimization phase compared with 21.3 seconds in the postoptimization phase ($P < .0001$). **Conclusion:** ADC installation and inventory optimization had a statistically significant improvement in the mean time per nursing transaction. Nursing and pharmacy technician surveys demonstrated a trend of enhanced satisfaction with the platform.

Keywords

automation, dispensing, information systems and technology, management

Introduction

Management of the medication administration process in hospitals is a critical role of the nurse in the delivery of patient care. Efforts at continuous improvement of this process are necessary to decrease health care costs and most importantly improve patient care.

Nursing and pharmacy staff work together at different steps in the medication use process to provide accurate and timely care, and also evaluate the efficacy of prescribed therapies. Many factors such as the use of electronic medication administration records (e-MARs), staffing resources, the use of bar code technology, decentralized medication distribution systems, and automated dispensing cabinet (ADC) systems with adequate capacity impact the efficiency and timeliness of medication administration by pharmacy and nursing staff.¹⁻⁴

The unit dose system of medication distribution using ADCs is an accepted technology used widely throughout the

United States. Although ADCs have been available and have been purchased throughout the world for over 50 years to improve medication distribution and administration processes, there are limited data in peer-reviewed journals demonstrating increased efficiency and increase in nurse satisfaction from optimization of ADCs. Literature published through 2013 includes studies, though not showing statistical significance, which reported increased rates of nurse satisfaction derived via questionnaire data, a reduction in time from order entry to first dose, reduction in pharmacist time

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and costs of personnel, positive impact in workflow, and other variables.⁵⁻¹⁰

In this article, we describe findings related to use of a newly released generation of an ADC. User perceptions of the cabinetry combined with a novel methodology for cabinet inventory design are described in the following study.

Background

Duke University Hospital is a 957-bed academic, quaternary, acute care medical center, with 24/7 clinical and operational pharmacy services. The medication distribution model is hybrid in nature, comprised of a 24-hour cart fill process and a heavy reliance on ADCs. In September 2016, Duke University Hospital partnered with Omnicell (Mountain View, California) to serve as a beta testing site for the new XT cabinet platform. Compared with the older generation of cabinets, the XT was intended to be improved with regard to capacity, touch screen hardware, lighting enhancements, and novel drawer configurations. With deployment of this new technology, the pharmacy department sought to study user perception of the cabinetry and effects of implementing an inventory categorization technique typically utilized in the materials management business sectors and central pharmacies to improve timeliness and efficiency associated with inventory product retrieval.

Methods

Prior to implementation of the new-generation cabinet, a team which included pharmacists, nursing leadership, front-line nurses, and technicians met to review the different aspects of the cabinetry design and functionality, and brainstorm on facets of the cabinet user interface that would be important to study. The team chose four specific areas of study: efficiency of the 9:00 AM medication pull for nursing users, assessment of nursing perceptions of medication administration pre- and postinstallation of the cabinetry, pharmacy technician perceptions of working with the cabinetry, and assessment of the efficiency of the pharmacy technician restock process.

With the opportunity to deploy a new cabinet, the team decided to use available data and critically evaluate the process by which individual inventory times were assigned to the cabinet. Historically, the design of cabinet inventory layout was dependent on arranging inventory to maximize the geographical distance between look-alike sound-alike (LASA) items, assure appropriate security in bin type selection, and physical space needed to house the desired inventory par. With the new-generation cabinet, new drawer types and configurations such as an increased variety of locking lid-based drawers are available. This allowed the pharmacy team to think of a design that deemphasized the need for geographic distance between LASA inventories and allowed for a focus on improving efficiency in the medication administration process.

Data from 6 months (February 2016 through July 2016) prior to the new cabinet installation of user medication withdrawal information were exported from the cabinet server and analyzed in two ways. First, data were analyzed by volume of removal. Medication listings were arranged in descending order by the total number of removals over a 6-month time frame. Second, the data were analyzed in a per-patient manner to find trends where specific inventory items were requested together with reoccurring frequency. Combining these two analyses with the physical space required to house the desired par, inventory was assigned to the cabinet to minimize the movement of a user to pull out medications by placing the most frequently used items centrally within the cabinet and the same drawer. We used the software's alphabetical queuing strategy to then order inventory within a given drawer. Items of low use or poor correlation were placed in drawers most geographically distant from the cabinet center.

To measure the impact of this optimized layout, we choose to study the 9 AM medication retrieval process in an adult pulmonary step-down care unit. The 9 AM process was selected as it is the institution's standard medication administration time (SMAT) for daily medications. Common disease states for patients in this unit include pulmonary hypertension, post-lung transplantation, or adult cystic fibrosis. Patients with these conditions often have a high pill burden for this population, with the average patient receiving 7.5 items (range, 2-21) during the 9 AM medication administration. Therefore, if the optimized layout contributed to making this process more efficient, it would most easily be detected on this unit.

Baseline nursing removal transactions were pulled for June, July, and August of 2016. The transactions were reviewed in a per-patient manner, allowing for determination of the time from first removal to last removal and total number of medications removed. We then implemented the new-generation cabinet with optimized inventory in late September. October was designated as a washout period to mitigate any effect of staff learning to use the new cabinet. Removal transactions were then queried for the months of November, December, and January as the postintervention period.

The second objective of this project was to assess the impact of the new cabinetry on nursing perception of the medication administration process. Nursing satisfaction survey scores were analyzed through a modified version of the validated Medication Administration System–Nurses Assessment of Satisfaction (MAS-NAS) scale. The 12 modified MAS-NAS items were scored on a 6-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = somewhat agree, 5 = agree, 6 = strongly agree). The survey was distributed to nurses in the target unit to obtain a baseline satisfaction of aspects of their existing cabinetry. The survey was open for 4 weeks to allow for nursing response. After cabinet installation, a 2-week washout period

Table 1. Modified MAS-NAS Survey Results.

Questions	Preimplementation survey	Postimplementation survey	P value
	n = 25	n = 25	
1. The newly installed automated dispensing cabinet (Omniceil) system helps me to be efficient at medication administration.	4.96	5.16	.139
2. The newly installed automated dispensing cabinet (Omniceil) is user-friendly to the nurses who administer medications.	4.96	5.24	.027*
3. The current medication administration system makes it easy to check active medication orders before administering medications.	4.44	4.8	.017*
4. The current medication administration system makes it easy to check that I am following the "5 rights" when I administer medications.	4.52	4.84	.074
5. The fingerprint technology for logging into the newly installed automated dispensing cabinet enhances efficiency when using the cabinet.	5.04	5.28	.096
6. I know where all the medications I need are stored (either on the unit or if they need to be procured from the pharmacy).	4.48	4.64	.282
7. The newly installed automated dispensing cabinet (Omniceil) technology is very easy to see, navigate through the controls, and operate.	4.76	5.2	.0433*
8. The automated dispensing cabinet (Omniceil) we recently installed has adequate storage capacity allowing for the availability for most medications I need.	4.44	5.24	.0006*
9. The newly installed automated dispensing cabinet (Omniceil) has responsive software that processes information efficiently.	4.6	5.12	.0184*

Note. Responses to items on the modified MAS-NAS scale were on a 6-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = somewhat agree, 5 = agree, 6 = strongly agree). MAS-NAS = Medication Administration System-Nurses Assessment of Satisfaction.

* $P \geq .05$.

allowed users to gain familiarity and experience with the new-generation cabinet. After this period, the survey was opened for 4 weeks. The survey questions were nearly identical to the baseline survey. The only change in language directed the users to reflect their responses to the newly installed cabinet. The modifications to the MAS-NAS survey are displayed in Table 1.

The third objective of the project was to assess pharmacy technician satisfaction with the newly installed cabinetry. Unfortunately, there is not currently a validated tool to assess the satisfaction and work tasks a pharmacy technician would perform using this type of equipment. As such, a survey was developed to target known changes presented to the technician with the new technology. Pharmacy technicians were surveyed 1 month after product implementation.

The final objective of the study was to determine whether the optimized configuration of inventory impacted the restock process for the pharmacy technician. To measure the restocking process, transactions were queried from the cabinet per user. Retrieving transactions in this manner allows for determination of the time from the first restock to the last restock and total number of medications restocked. Baseline pharmacy technician restocking transactions were pulled for June, July, and August of 2016. Restock transactions were then queried for the months of November, December, and January as the postintervention period.

Results

The results of the analysis of the 9 AM medication pass are detailed in Figure 1.

In total, 2981 total nursing medication retrieval processes for the 9 AM SMAT time were analyzed: 1321 in the preoptimization phase and 1660 in the postoptimization phase. In the preoptimization phase, 9846 medication removal transactions were reviewed. The mean time per transaction was 10.5 seconds (range, 1-58.3). In the postoptimization phase, 12 250 medication removal transactions were reviewed. The mean time per transaction was 10.2 seconds (range, 1.9-92). The datasets were compared using a *t* test. This analysis demonstrated a statistically significant decrease in the average time per transaction from the preimplementation period to the postimplementation period of 0.3 seconds per transaction ($P = .026$). When this value is then extrapolated to average number of removal transactions on this unit for a month (10 500), the unit saves 50 minutes per month in nursing time at the cabinet.

The results of the nursing survey are detailed in Table 1. The preimplementation survey was completed by 41 unique users. The postimplementation survey was completed by 44 unique users. We then conducted a Wilcoxon rank-sum test for the 25 users who participated in both the pre- and postimplementation surveys. The results of this survey

Figure 1. Time to complete medication transactions pre- and postoptimization.

Table 2. Technician Perception Survey.

	Percent	n
1. How has the new ADC impacted restocking time?		
Increased restock	23	6
Decreased restock	19	5
No impact	58	15
Total	100	26
2. How has the new ADC impacted restocking frequency?		
Increased frequency	4	1
Decreased frequency	27	7
No impact	69	18
Total	100	26
3. What impact has the new Omnicell ADC had on ease of restocking?		
Easier restock	58	15
More difficult restock	8	2
No impact	34	9
Total	100	26
4. Select the statement that is true for you		
I believe the new Omnicell ADC drawer configuration is easier to use compared with the old configuration	88	23
I do not believe the new Omnicell ADC drawer configuration is easier to use compared with the old configuration	12	3
3. What impact has the new Omnicell ADC had on ease of restocking?		
Very satisfied	35	9
Satisfied	46	12
Somewhat satisfied	4	1
Neither satisfied or dissatisfied	11	3
Dissatisfied	4	1
Very dissatisfied	0	0

Note. ADC = automated dispensing cabinet.

demonstrate a trend of enhanced satisfaction across all questions. A statistically significant improvement was seen for questions 2, 3, 4, 5, 7, 8, and 9 (Table 1). Significantly improved responses included that the new-generation

cabinet was user-friendly ($P = .0274$) and made the process of checking for active orders easier ($P = .0171$), that the new cabinet had improved visibility and navigation control ($P = .0433$) and adequate cabinet storage capacity ($P = .0006$),

Figure 2. Results of the technician survey.
Note. ADC = automated dispensing cabinet.

Figure 3. Time to complete restock transactions pre- and postoptimization.

and that the software was responsive and efficient in processing information ($P = .0184$).

The results of the technician survey are described in Table 2 and Figure 2. In total, 26 pharmacy technicians responded to the survey. Generally, the results showed little impact on the technician's perception of restock frequency or time to restock. In all, 58% of respondents felt the restock process was easier, with only 8% finding it more difficult. Figure 2 demonstrates the features of the new cabinet that technicians found most beneficial. Last, 85% of technicians responded that they were either satisfied or very satisfied on a 6-point Likert scale.

The results of the analysis of the time to restock the cabinet are detailed in Figure 3. In total, 2538 total restocks were analyzed: 434 in the preoptimization phase and 2104 in the postoptimization phase. In the preoptimization phase, mean time per transaction was 11.5 seconds (SD = 5.4 seconds). In the postoptimization phase, mean time per transaction was 21.3 seconds (SD = 6.9 seconds). The datasets were compared using a t test. This analysis demonstrated a statistically significant increase in the average time per transaction from the preimplementation period to the postimplementation period of 10 seconds per transaction ($P < .0001$).

Discussion

This study is the first of its kind to describe this new generation of ADC technology. The study sought to measure both end user perception of the devices and effects of a unique ADC data analysis technique to optimize inventory placement for enhanced nursing efficiency. The approach explored borrows from the well-established A-B-C inventory management methodology which generally requires more attention to improve efficiency and cost of impactful high-volume or high-cost products. In our study, the selection of the 9 AM medication pass period, known to be the busiest medication administration period at the institution, represents a high ADC transaction period worthy of focus.

The study successfully measured both nursing and pharmacy perceptions of the newly implemented devices. Limitations to the survey data could include the Hawthorne effect where respondents are biased, by knowing the process is being studied.¹¹ While not all survey responses support this trend, the possibility cannot be ruled out. In addition, while not constructed in a manner to induce bias, there is not a validated survey tool available that specifically met the

needs of this project for assessment of technician perception of the technology.

The results for the technician restock time were initially unexpected by the study authors. The results are further clarified by operational considerations. Given the expanded capacity of these devices, the pharmacy team was able to add 72 new line items to the cabinet, not previously available in the preoptimization phase. This resulted in a larger number of line items being restocked, as well as more items on the technician cart to sort through to find the correct item. Second, with the availability of more bins per drawer, pharmacy set pocket level par levels that reduced the individual bin inventory. While time was added to the technician restock process, it simplifies the nursing and pharmacy blind count of the bin on a removal or stocking transaction. Finally, on reviewing the time frames of the study, seasonal changes to restocking requirements for needed medication, such as influenza vaccine, may account for the increased restock demand as well as slower process to complete the transaction at a refrigerator.

The ability to detect the demonstrated efficiency in the nursing removal process was heightened by selection of a unit with a high pill burden. By studying a unit with a larger number of transactions per patient, the difference was most easily detected. The results are likely to be less impactful in a low transaction count per patient, such as an emergency department, where a large daily med pass is less likely to occur.

An area for future study of this enhanced layout would be evaluation of the ergonomic benefits appreciated by users, with the potential for less repetitive motion and bending to reach inventory at geographically distant points.

Conclusions

ADC installation and inventory optimization had a statistically significant improvement in the mean time per nursing transaction by 0.3 seconds ($P = .026$), saving nearly 50 minutes per month at the cabinet. As well, nursing and pharmacy technician surveys demonstrated a trend of enhanced satisfaction with the platform.

Declaration of Conflicting Interests

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