MEDICATION ADMINISTRATION AND THE COMPLEXITY OF NURSING WORKFLOW

Sandra K. Garrett, Ph.D. and Janet B. Craig, RN, DHA
Clemson University, Clemson, South Carolina 29634

Abstract

Medication administration is an increasingly complex process, influenced by the number of medications on the market, the number of medications prescribed for each patient, new medical technology and numerous administration policies and procedures. Adverse events initiated by medication error are a crucial area to improve patient safety. This project looked at the complexity of the medication administration process at a regional hospital and the effect of two medication distribution systems. A reduction in work complexity and time spent gathering medication and supplies, was a goal of this work; but more importantly was determining what barriers to safety and efficiency exist in the medication administration process and the impact of barcode scanning and other technologies. The concept of mobile medication units is attractive to both managers and clinicians; however it is only one solution to the problems with medication administration.

Introduction and Background

Medication administration is an increasingly complex process, influenced by the number of medications on the market, the number of medications prescribed for each patient, and the numerous policies and procedures created for their administration. Mayo and Duncan (2004) found that a "single [hospital] patient can receive up to 18 medications per day, and a nurse can administer as many as 50 medications per shift" (p. 209). While some researchers indicated that the solution is more nurse education or training (e.g. see Mayo & Duncan, 2004; and Tang, Sheu, Yu, Wei, & Chen, 2007), it does not appear that they have determined the feasibility of this solution and the increased time necessary to look up every unfamiliar medication.

Most of the research which focuses on the causes of medication errors does not examine the processes involved in the administration of the medication. And yet, understanding the complexity in the nurses' processes and workflow is necessary to develop safeguards and create more robust systems that reduce the probability of errors and adverse events. Current medication administration processes include many \ tasks, including but not limited to, assessing the patient to obtain pertinent data, gathering medications, confirming the five rights (right dose, patient, route, medication, and time), administering the medications, documenting administration, and observing for therapeutic and untoward effects.

In studies of the delivery of nursing care in acute care settings, Potter et al. (2005) found that nurses spent 16% their time preparing or administering medication. In addition to the amount of time that the nurses spent in preparing and administering medication, Potter et al found that a significant number of interruptions occurred during this critical process. Interruptions impact the cognitive workload of the nurse, and create an environment where medication errors are more likely to occur.

A second environmental factor that affects the nurses' workflow, is the distance traveled to administer care during a shift. Welker, Decker, Adam, & Zone-Smith (2006) found that on average, ward nurses who were assigned three patients walked just over 4.1 miles per shift while a nurse assigned to six patients walked over 4.8 miles. As a large number of interruptions (22%) occurred within the medication rooms, which were highly visible and in high traffic locations (Potter et al., 2005), and while collecting supplies or traveling to and from patient rooms (Ebright, Patterson, Chalko, & Render, 2003), reducing the distances and frequency of repeated travel could have the ability to decrease the number of interruptions and possibly errors in medication administration.

Adding new technology, revising policies and procedures, and providing more education have often been the approaches taken to reduce medication errors. Unfortunately these new technologies, such as computerized order entry and electronic medical records / charting, and new procedures, for instance bar code scanning both the medicine and the patient, can add complexity to the nurse's taskload. The added complexity in correspondence with the additional time necessary to complete the additional steps can lead to workarounds and variations in care.

Given the problems in the current medication administration processes, this work focused on facilitating the nurse's role in the medication administration process. This study expands on the Braswell and Duggar (2006) investigation and compares processes at baseline and post-introduction of a new mobile medication system. To do this, the current medication administration and distribution process was fully documented to determine a baseline in workload complexity. Then a new mobile medication center was installed to allow nurses easier access to patient medications while traveling on the floor, and the medication administration and distribution process was

remapped to demonstrate where process complexities were reduced and nurse workflow is more efficient. A similar study showed that the time nurses spend gathering medications and supplies can be dramatically reduced through this type of system (see Braswell & Duggar, 2006); however, they did not directly investigate the impact on the nursing process. Thus, this research is presented to document the impact of this technology on the nursing workflow at a regional hospital, and as an expansion on the work begun by Braswell and Duggar.

Methodology

This qualitative case study used a prospective, exploratory method of direct observation to identify and examine the work processes involved in medication administration. The focus of observation was on the nursing tasks, material and information flows, communication, variations and staff developed work-arounds associated with medication administration. For this project, a medical-surgical unit was chosen for study, since previous research has shown that as many as 67% of a hospitals' medication administration errors are associated with the typical Medical-Surgical patient's medication complexity (Madegowda, Hill, & Anderson, 2007).

Research Team

An interdisciplinary research team of industrial engineering (two PhD students and one faculty member) and nursing (one masters student, three bachelors students, and one faculty member) formed the core project investigators. The team also incorporated additional input from hospital administration (Director of Patient Care Services, chief nursing administrator, and unit nurse manager), pharmacy, and a medical technology vendor.

Participants

All nurses working in the medical-surgical unit during the morning shift were invited to participate. They were then separated into three categories based on their experience level: less than five years, between five and fifteen years, and more than fifteen years experience. All of the nurses who participated in the study were full time employees at the facility where observations were made.

Facility

The participating facility is an outlying facility of a larger regional hospital system. It is an 80 bed hospital that is recognized as a teaching facility in the area. The hospital relocated to a new facility during the study. Due to the number of dramatic physical layout and procedural changes that followed the move, all new baseline data were collected at the new facility in order to ensure consistency for comparison with post-implementation data. For example, the new facility utilizes an alcove model floor plan, in which a small nursing workspace exists between every two rooms with dedicated patient medication drawers located in that workspace.

Data Collected

A number of data types were collected during each round of observations, in addition to the time (and task steps) spent preparing, administering and documenting the medications given to each patient. These data included: current patient census, number of patients assigned to each nurse, number of medications administered to each patient, technology used to administer and document medication administration, and distance traveled (number of steps taken) during the medication administration process. Additional information was recorded about any barriers to process flows which were encountered, such as medication not being available, orders being changed, bar coding technology not working, unrelated interruptions, etc.

Results and Discussion

The baseline process data was collected over 14 sessions during the 7am medication round. Of these sessions, 5 were RNs with less than 5 years of experience, 4 were with RNs with at least 5, but less than 15 years of experience, and the remaining 5 sessions were with RNs with at least 15 years of experience. During the baseline data collection, the average daily patient census was 27 patients, but census during data collection did range from only 18 patients in the unit up to 36 patients, which is a dramatic range in patient load. The number of patients assigned to the participant averaged at about 5 patients. Data collection was done once with the participant only having 3 patients, and sometimes up to as many as 6 patients, but five patients was by far the more typical patient load for the participants observed.

The time taken for the morning medication round was approximately two hours on average (1 hr and 56 min-average, 29 min standard deviation), and ranged from as low as 1 hour and 11 minutes to 2 hours and 48 minutes. The distance walked during the morning medication round was on average 857 steps, or approximately 565 yards, (a standard deviation of 511 steps, or 338 yards), resulting in an average of 441 steps each hour (a standard deviation of 200 steps per hour). (All time and distance data reported corresponds to data collected in the new hospital. As this building was designed specifically with nursing workflows in mind, e.g. an alcove model with patient specific medication drawers, these numbers are considered lower than what would be expected in a traditional hospital.)

As just indicated, there was a large variability in the distance walked during medication administration, but contrary to expectations, it did not seem to be related to the nurse's level of experience. Rather it seemed to be more highly related to external factors, such as printers being out of toner or running out of paper, illustrating the high impact that the environment has on individual processes.

Since medication administration was the focus of this study, the number and types of medications given to each patient were recorded. On average, the patients assigned to participating RNs received about seven (7) medications during this first morning medication round. One patient was observed to receive 19 medications, while others received as few as one or two. Most medications were in the pills or IVs, but other types included intramuscular, subcutaneous, liquids, powders, crèmes, or patches.

Process Charts to Illustrate Workflow

One method of data organization and analysis that was utilized to convey information about workflow and process inefficiencies was that of the process chart. (See Figure 1 for an illustration of this method.) This method facilitated discussion of the process between the engineering and nursing disciplines. Of particular interest were steps which involved transportation, delays and interruptions. By creating process charts of the observations, patterns of inefficiencies and process barriers emerged that could be addressed in future phases of this work.

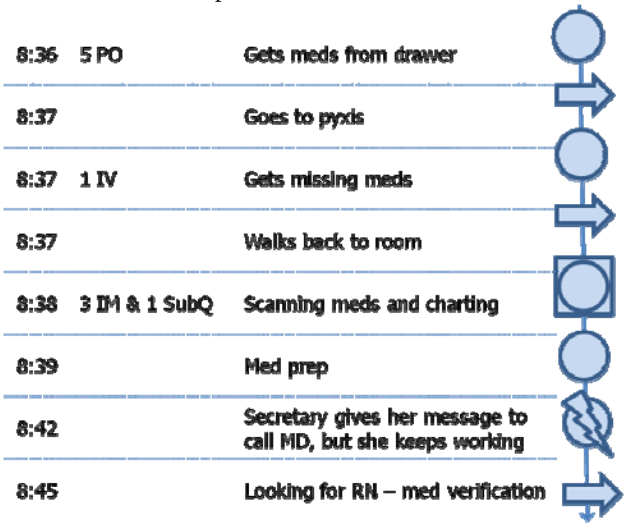

Figure 1: Example Process Chart of Workflow

Process Complexity and Barriers to Workflow

In addition to inspecting each medication to ensure the correct medicine and dosage (recognition for one specific reference out tens of thousands of possibilities), the nursing medication administration process was complicated by constant multitasking and needing to maintain an awareness of evolving situations (through patient assessment). Furthermore, the process of interacting with the patients rarely occurred in a strictly predictable linear manner. Often, the nurse would go into a room to give a patient his/ her medication, only to have the patient request a different beverage (e.g. apple juice) causing the nurse to go back down the hall to retrieve the beverage. At other times, the patients would make personal requests, such as wanting their hair brush or lotion from purse. Each of these instances are part of the patient care process, but do interrupt the process flow of administering medication.

More importantly, for studying process complexity, was an investigation into the barriers to process flows which were encountered, such as medications not being available, orders being changed, preliminary assessment data (e.g. glucose levels) not being complete or charted, bar coding technology not working, unrelated interruptions, etc. While each of the aforementioned occurrences were observed during this study, interruptions and medications not being available (or provided) at point of care, were the two chosen for further investigation.

Interruptions

Nurses were interrupted while preparing and administering medication for a variety of reasons. Some of the most common interruptions were being paged, having a Certified Nursing Assistant (CAN) stop by to notify the nurse of a patient's current vital assessment (e.g. blood pressure and glucose levels), or when another nurse needed someone to verify a medication dose or witness "wasting" a remaining medication. Other frequent interruptions came from the family members of patients, asking questions or requesting assistance (such as needing help moving the patient to the bathroom or letting the RN know that an IV pump was beeping.)

While some of these interruptions would be considered *justifiable interruptions* that are necessary for task coordination and patient care, other types of interruptions that break into tasks for non-urgent or less important issues could be considered a form *avoidable interruptions*, a form of process waste. It is important to distinguish both the importance and urgency of the new information to be transferred or interjected task (Garrett, 2007).

As the focus of this study was on the process of medication administration, interruptions were noted with general context, but high levels of detail were not recorded. Thus only preliminary analysis of the frequency of interruptions could be pulled from the current study. (Future work intends to investigate the classification of interruptions, their frequency, and apparent impact on process.) During this initial project phase, nurses were interrupted just over six times on average (a standard deviation of 2.97) while doing the morning medication rounds. When the number of interruptions was compared with the duration of the medication round for that specific morning, we found that on average nurses were interrupted approximately every 19 minutes, although the interruptions were never evenly spaced throughout the observed period.

Wasted Transportation

A second area that was examined in more detail was that of wasted transportation. This was classified as transportation that did not directly add value to the patient's care. (Transport waste was also viewed as

transportation that could / should be eliminated through future process and design changes, and thus was seen as a diagnostic tool for improving process flow.)

Before this study it was unknown what proportion of a nurse's transportation acts were value added to patient care vs. waste. While still considered a very preliminary finding, due to the small sample size and unique facility design, approximately 40% of transportation (walking) activities were considered waste. On average, more than four trips (average of 4.15 with a standard deviation of 1.82) to just the medication room (pyxis) were observed during each round. The four trips per round does not include going to the supply room to replenish materials that should have been available, nor searching for missing information. Future technology and process redesigns should be carried out with the reduction or eliminate of these key areas of waste in mind.

Lessons Learned

Methodological

The first lessons learned during this project involved using the process of direct observation to collect data "in the field". In fast-paced environments it can be difficult to keep up with the task flow, but it is very important to not let details such as context slip. In fact, in this research the most important data that was collected included "context" information to help explain why things happened, and what else was going on at the same time. This context information was crucial when going back to code the data for interruptions and wasted transportation acts.

A second lesson learned was the recognition that data recording "styles" vary dramatically between disciplines. Industrial engineers tended to write "everything down" that they could in the limited time, but were constrained by the task pace and having less initial understanding of the process observed. On the other hand, nurses tended to write fewer steps (lumping things together), because they were so familiar with the process. This led to some difficulty in making direct comparisons between the collected data. We expect to have a broader understanding of the actual medication administration process once all of these differences are examined fully. However, for the mean time the results presented in this paper are primarily driven by the data collected by the industrial engineers.

Impact of Facility and Unit Layout

During the initial study period, the hospital and staff transitioned from an older facility into a brand new hospital which both interrupted and delayed any possibly data collection and analyses. In addition, since the unit layout at the two facilities were dramatically different, data collected at the initial site would not be comparable with data collected at the new facility. Therefore, data collection was restarted after moving into the new hospital.

The unit layout directly affects distance traveled. The original facility was laid-out like a typical institutionalize "hall model" with a single nursing station in the center of the unit. This nursing station is where most nurses returned in order to complete documentation, and served as a communication and coordination hub for the floor. The new hospital is an innovatively designed environment built to facilitate nursing workflows, reducing (but not eliminating) the need for an improved / localized patient medication system. (The new hospital utilized a nursing alcove design, where a small nursing workstation with locked drawers for patient medications was situated between every two rooms.) Thus we do not expect as dramatic a difference between the pre and post-technology implementation as we would in a more traditional facility, like the one where the study was originally planned.

General

Nursing staff are generally frustrated by the time and complexity, frequency of order changes, and number of policies / procedures that they must learn and continually adapt to. Also, they are discouraged by their inability to know "everything" about the variety and dosages of medications they administer, and the technology that is "sold" on the basis of improving safety and reducing errors. RN staff nurses want to study work processes to identify opportunities to improve efficiency and reduce risk; however, managers and staff at the micro-system level often do not have the influence, tools, or knowledge to engage in experimentation related to process re-engineering on their own or within their scheduled hours.

Possible Impact of Technology

Mobile or individual patient drawer medication systems without capacity for floor stock and schedule II medications interrupt workflow and create unnecessary waste in process steps as the nurse must return to the medication room to retrieve the medicine from pyxis. Implementation of individual mobile medication carts that can be stocked with all forms of medications and supplies would reduce the time spent retrieving medications and supplies from the medication dispensing room. Phase Two of this project introduces a new type of medication distribution carts to the study facility. These carts are being tested to see if their implementation will have the expected reduction in distribution time and number of process steps in the medication administration process

Phase Two: Technology Deployment

A new mobile medication system (MedCenter, from Sabal Medical, Inc.) is being tested to see its impact on the nursing workflow during medication administration (see Figure 2). We expect to see a reduction in distribution time and number of process steps in medication administration. MedCenter is being loaned to the facility on a trial basis for the purpose of this study.

Figure 2: MedCenter- Mobile Medication Unit

MedCenter is a secured, mobile medication cart that has 108 locations to store patient specific medications and floor stock. The MedCenter system includes formulary management and inventory control software along with the ability to interface with most electronic medication documentation systems.

The MedCenter technology supports JCAHO's National Hospital Safety Goals through improving the accuracy of patient identification (medication cannot be dispensed without verifying patient ID). The system can only be accessed by personnel with stored biometric data, and the patient selected must be verified by bar code before medication is accessible. The MedCenter unit rotates a tray system so only one verified medication is available at a time (shown in Figure 2).

Phase 2: Methodology

The general methodology used in phase 2 was the same as was used in phase 1, but now the observed nurse used the MedCenter (not alcove drawers) for the medications of each of her patients. Slight modifications were made to the data collection form (new columns were added) to improve tracking of interruptions and wasted transportation.

Phase 2: Initial Impressions

Both pharmacy and nursing staff have been accepting of the new technology and amenable to using it during this trial period. The most dramatic impact of transitioning to using the MedCenter cart technology is on pharmacy processes. Pharmacy now needs to stock the medication cart with medications that had been previously stored in pyxis, and also needs to create additional patient specific trays sorted by administration time, when previously the patient's entire days medication were kept together in the alcove drawers.

There are some additional features that will not be available during this trial period that will be available at a later time. For example, nurses have expressed that they would like to see touch screen capabilities added. MedCenter is able to be used with a touch screen, but that its software cannot interface with the electronic record system currently in place at this hospital. Given that this technology is being used on a trial basis, it was infeasible to develop additional software to enable this interface; but this will be possible for anyone wanting to implement the product long-term.

Phase 2: Results

Data collection and analysis are still underway for this phase second phase, but are expected to be available for report during the SHS 2009 conference.

One key feature is that all types of medications and supplies now available "at the bedside," including narcotics, PRN, IV solutions, etc. The initial impression is that the need to travel to / from the medication room may be completely eliminated with this product, since the number of missing medications drops to zero when you have a highly engaged pharmacy in the process (the process efficiency is more dependent on pharmacy now). While we expect to see less transportation waste post-implementation, until we finish analyzing the results of this study that is yet to be proven.

Conclusion

Once the final analysis is complete we will have a better understanding of how this mobile medication technology impacts the efficiency and process of medication administration. As the project currently stands, the average time and distance traveled during the morning medication round has been determined, although it is recognized that both of these variables would be closely dependent on the facility layout. (Substantial differences were noticed between the original facility and the new facility where the research project was finally conducted.)

Barriers to process flows such as medications not being available, preliminary assessment data not being complete or unrelated interruptions were also examined. It is hoped (and expected) that the new MedCenter cart will be instrumental in reducing the amount of wasted transportation during the medication administration process. (However, it is also anticipated that this type of technology would have a more dramatic impact in a facility with a more traditional layout.) We hope to determine whether our results are transferable to other facilities, and will be testing this at additional locations; but do anticipate needing to create adjustments to the findings to compensate for facility layout.

The hospital will have both quantitative and qualitative evidence to use when deciding what type of new technology to invest in to simplify processes which we believe will both increase efficiency and facilitate a decrease in errors. The medical technology company will also be able to use these results to improve the effectiveness of their product. In the end, the interdisciplinary approach and collaboration between industrial engineering and nursing, with an emphasis on

human factors engineering techniques, has proven to be very beneficial in this research. We believe that the key to process simplification entails using the practice of human factors engineering to build additional (non-human) resilience into the healthcare delivery system

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Biographical Sketch

Sandra K. Garrett, Ph.D. is an Assistant Professor of Industrial Engineering at Clemson University in South Carolina. She received her PhD and MS degrees in Industrial Engineering from Purdue University, and her BS in Industrial Engineering from Clemson University. Her research in human factors engineering has taken a holistic, cross-disciplinary approach, exploring theoretical issues in information flow and knowledge development within complex environments, team coordination and healthcare systems engineering. Sandra has been working in healthcare systems for over 5 years with experience in both outpatient and hospital settings, as well as working with state and local public health department. Sandra's second primary research application area is focused on disaster mitigation, response and recovery.

Janet B. Craig, RN, DHA is an Assistant Professor in the School of Nursing at Clemson University. Her work there has focused on nursing leadership roles and responsibilities for quality and safety in the health system, end-of-life care and policy, racial disparities in health care, and improving health through community collaboratives. Additionally, as an Extramural Program Officer at Health Sciences South Carolina, she focuses on interdisciplinary clinical re-engineering, infection control, and medication safety strategic initiatives, an effort that is designed to take quality improvement research to the bedside.