EVALUATION OF PHARMACIST WORK ACTIVITIES BEFORE AND AFTER IMPLEMENTATION OF COMPUTERIZED PROVIDER ORDER ENTRY

by

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STATEMENT OF THESIS APPROVAL

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ABSTRACT

Computerized provider order entry (CPOE) is proposed to improve overall delivery of health care by increasing medication safety, decreasing cost, and improving efficiency of health care providers. As the health care industry continues to incorporate information technology into daily operations, the impact on provider work activities will be important to evaluate. Existing literature on health information technology implementation has predominantly come from internally developed programs that were designed specifically for the institution in which they reside.

The University of Utah Hospital is a 450-bed academic health care center that implemented a commercially available CPOE system. The objective of this study was to evaluate the impact of CPOE implementation on decentral and central pharmacist work activities as measured by a work sampling evaluation.

Participants used the Divilbiss Electronics JD-7 Random Reminder for data collection in order to assess the proportion of time each pharmacist spent on itemized work activities. The data collection form was organized according to Clinical, Professional, and Technical work activities. Data were collected before CPOE implementation in April 2009 and 6 months after implementation in November 2009. Data were summed by category and evaluated as nonparametric data using chi-square analysis. Results demonstrated significant

changes in the Professional (16.7% vs. 56.8%, $p<0.001$) and Technical work activities (56.8% vs. 11%, $p<0.001$) performed by central pharmacists due to CPOE implementation. The improved efficiency of order verification may allow for administrators to reduce pharmacist staff or use increased available pharmacist time to expand pharmacy services. Decentral pharmacist overall work activities demonstrated minimal change. However, time spent on education increased after CPOE (6% vs. 10.8%, $p<0.001$). The increase in education time is consistent with the mission of the academic medical center.

Reporter bias was possible due to a perception that the study was evaluating individual participants. However, assurance that no data would be associated with any individual, the nearly 6 months between sampling periods, and the large number of observations limited this potential bias. This study provided the pharmacy department with a better understanding of pharmacy work activities and the impact of CPOE on pharmacists' daily work activities.

Dedicated to the pharmacists at the University of Utah Hospital
for their support and participation in this thesis and to Laura Miars, my favorite pharmacist.

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CHAPTER 1

INTRODUCTION

The health care delivery process is a complex system with many opportunities for error. Multiple providers are involved in the care process for each patient. The complexity of the health care system makes it challenging to provide safe and efficient care. Health information technology (HIT) has been proposed to improve both safety and efficiency. HIT systems are available for many of the steps in the health care delivery process. These systems will continue to evolve and impact the delivery of care.

The medication order process is error prone and involves many members of the health care team. Computerized provider order entry (CPOE) may make the process safer and more efficient. CPOE requires the provider to electronically enter a medication order instead of manually handwriting an order. The electronic order represents a significant change in the medication order process. This change in process may reduce errors at the time of order entry, but it may also impact the work activities of other providers involved in medication order processing.

The introduction of CPOE may impact all providers involved in medication order processing, including pharmacists. Prior to CPOE implementation, pharmacists may be responsible for transcribing the written medication order into

the electronic pharmacy information system. A new method of order entry may also impact the time pharmacists spend on various work activities. Therefore, this thesis will evaluate the impact of CPOE on pharmacists' work activities.

CHAPTER 2

REVIEW OF LITERATURE

Health information technology continues to evolve, and new developments may significantly change the delivery of health care. Health care administrators and professionals will need to evaluate the impetus for implementing new health information technology while considering the impact on patient care and provider work activities.

Health Information Technology

The Office of the National Coordinator for Health Information Technology was formed in 2004 through an executive order by President George W. Bush in order to promote and develop the use of health information technology (HIT) in the United States.[1] The position was not legislatively established and funded until the American Recovery and Reinvestment Act of 2009, designating $19.2 billion over ten years to be spent on increasing HIT. The Office of the National Coordinator for Health Information Technology received $2 billion to distribute as grants and loans, which is a significant increase from the previous average of $60 million in annual funding.[2] The remaining $17.2 billion was designated to be used as incentives for physicians and hospitals to implement new health technology.

In addition to financial incentives, the federal government will try to increase HIT by reducing Medicare and Medicaid reimbursement to physicians and hospitals that are not using health technology in a “meaningful” way by 2015, although the term “meaningful” was left undefined in the legislation.[2,3] The Congressional Budget Office predicted that funding will increase hospital HIT adoption to 55% of hospitals by 2014, compared to an estimated 25% of hospitals in 2009.[4]

As the motivation to implement new technology increases, hospitals and physicians will need to consider many different components of HIT. New technologies are aimed at streamlining the transfer of information at each step of the health care delivery process. One way to look at involved components is to follow the general pathway of information through the delivery of a health care practice, specifically the medication order process as outlined in the provider-patient HIT pathway outlined in Figure 2.1.

Patient Assessment

The medication order process begins with the provider conducting a patient assessment. A necessary component of each patient assessment is the patient’s health record. As described by Dumitru,[5] an electronic health record (EHR) can be used to maintain a patient’s personal medical history, including documentation of previous provider visits, medication history, and previous test results. Electronic health records allow patient information to be available to multiple providers within a health system, which allows for increased level of continuity in the care provided. The electronic medication administration record

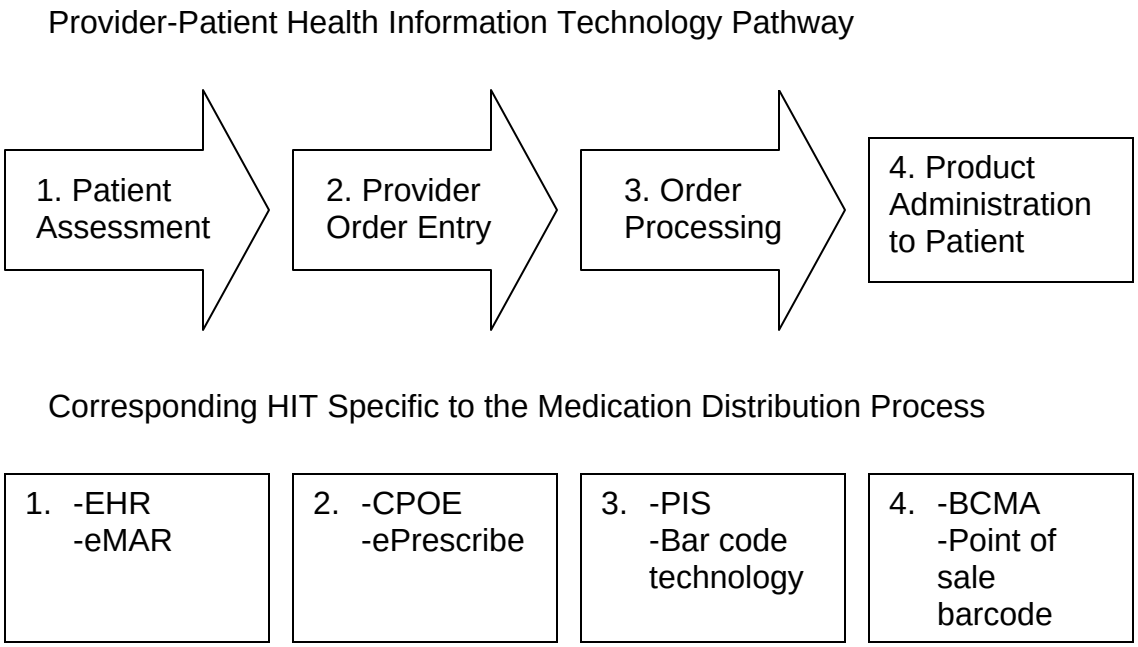

Figure 2.1. Overview of the Provider-Patient HIT Pathway
EHR – Electronic health record
eMAR – Electronic medication administration record
CPOE – Computerized provider order entry
PIS – Pharmacy information system
BCMA – Bar code medication administration

(eMAR) is utilized in the inpatient setting to monitor timing and frequency of medication use. A nurse uses the eMAR to record the dose and time that a specific drug is administered to a patient. This allows all providers caring for the patient to review the dose and time of administration for each medication the patient receives.

Provider Order Entry

After patient assessment, a provider can order a medication for the patient. Computerized physician or provider order entry (CPOE) is technology that streamlines the physician order process. Providers can order a medication, laboratory test, or other procedure through an electronic ordering system.

Relative to medications, a provider can also order a specific medication, dose, frequency, and outline parameters for administration within a single order. Medication orders may be custom built by the provider one medication at a time or orders may also be constructed within the order system as order sets. Order sets may include multiple medication orders that can be entered at one time. For example, all or most patients may receive the same medication orders after surgery. Therefore, a postoperation order set may be constructed in order to allow a provider to quickly enter standard postoperation medications. ePrescribing provides physicians with the ability to send prescriptions electronically to outpatient pharmacies.

Order Processing

The medication order is sent to an inpatient or outpatient pharmacy after the provider enters the order. Then, the pharmacy uses a pharmacy information system (PIS) to process the order. The PIS allows pharmacists to track a patient's medication history, prescription refills, allergies, and other pertinent pharmacy data. Bar-coding technology, similar to that used in a grocery store, may be used throughout product procurement, preparation, dispensing, and administration. Pharmacies may also use bar coding to ensure that the drug is the right product for the right patient. Pharmacy technicians and pharmacists may scan the product's bar code and scan a patient-specific bar code located on the patient label. Bar code technology can alert the individual whether the medication matches the patient's medication label or if there is a discrepancy between the

two bar codes. This process requires that all medications and all patient labels have bar codes that specifically identify the product or patient.

Product Administration to the Patient

After patient assessment, entry of the medication order, and order processing, the prepared medication is administered to the patient. In the inpatient setting, medication is directly administered or given to the patient as one dose to self administer. The outpatient pharmacy will most commonly dispense multiple doses of the medication packaged in vials. Bar code medication administration (BCMA) uses bar code technology in the inpatient setting to scan and verify the right drug and patient. The individual administering the medication will scan the bar code on the medication package and a patient-specific bar code on the patient's wrist band. This is done at the patient's bedside. Point of sale bar coding verifies the right prescription is being dispensed when a patient picks it up at an outpatient pharmacy.[5] Once again, the individual dispensing the medication to the patient will scan a bar code on the medication product label and a patient-specific bar code on the patient's receipt. The bar code system will notify the provider if bar codes do not match.

Adoption of Health Information Technology in the United States

Many HIT systems and their role in the medication order process have been explained. Implementing multiple HIT systems will require adequate planning and coordination. The United States (US) lags behind multiple countries abroad that have implemented national HIT plans, such as Germany and the United Kingdom.[6] Some foreign countries are able to implement technology

nationwide due to support from a national health plan or system. US hospitals decide independently which information technology systems they wish to implement and in which order due to the lack of a national health system. Some foreign countries have chosen to implement HIT in order to standardize information available to providers. Standardization is also proposed to increase efficiency and safety in the delivery of health care. In the US, numerous health policy organizations, including the Institute of Medicine (IOM),[7] the Leapfrog Group,[8] and the Agency for Healthcare Research and Quality (AHRQ),[9] have advocated for the adoption of HIT. The IOM report on medication errors has noted that HIT is a potential solution to preventing many of the medical errors that cause harm.[7] The Leapfrog Group and the AHRQ have promoted HIT as a tool that can improve both quality of care and provider compliance relative to national quality measures. One example of quality improvement would be to increase health care safety, as well as to ensure appropriate care and use of medical best practices.[7-9] One specific piece of HIT that has been supported by all three groups is computerized physician or provider order entry (CPOE).

Computerized Provider Order Entry

CPOE is an integral component in the development of health information technology. CPOE has been proposed to improve overall delivery of health care by increasing medication safety,[10-22] decreasing cost,[17,19,22-25] and improving efficiency of health care providers.[19,22,25-31] As previously described relative to the health care delivery process outline in Figure 2.1, CPOE allows health care providers to write orders electronically in the inpatient or outpatient setting. Use

of CPOE instantly changes the medication ordering process for all health care professionals involved in the health care delivery process. As CPOE is implemented in hospitals across the nation, it will also be important to evaluate both intended and unintended consequences that may coincide with the use of new technology.[32-39]

CPOE systems have been in existence since the 1970s. Many early systems were internally developed products that were tailored to meet one institution's needs. The Regenstrief Insititute of the University of Indiana (Wishard Memorial Hospital), Brigham and Women's Hospital, Vanderbilt University, and the LDS Hospital have all been credited with developing and studying early CPOE systems.[40,41] The Veterans Health Administration internally developed a CPOE system that Veterans Affairs hospitals implemented in the early 1980s.[42] As CPOE implementation has increased in more recent years, most hospitals have implemented commercially developed vendor-based programs.[40] However, few US hospitals are estimated to have CPOE in place.

Current estimates of CPOE use vary due to differing definitions of utilization. A survey conducted by Ash et al.[43] in 2002, found that only 9.6% of US hospitals have a CPOE program in place and in use; more recent estimates concluded that approximately 15-17% of hospitals utilize CPOE.[40,44] In 2007, Leapfrog reported that 11% of Leapfrog member hospitals used CPOE for at least 75% of inpatient medication orders. In 2008, the Leapfrog group changed its annual survey methodology to evaluate the presence of appropriate clinical decision support as part of their definition of "CPOE use." All hospitals

participating in the survey subjected their CPOE systems to Leapfrog testing. The 2008 survey reported that only 7% of hospitals met Leapfrog's CPOE criteria.[45] Of all US hospitals at present, only large academic medical centers are considered to be most likely to have implemented CPOE compared to their non-academic counterparts.[44,46,47]

Existing literature on HIT implementation has predominantly come from evaluations of internally developed programs. In a systematic review of the impact of HIT on internal operations, approximately 25-33% of the studies came from four institutions[48] and 92% came from academic medical centers.[49] Commercial products may have less customization compared to products developed by individual hospitals. However, while custom products may be readily adapted to local practices, commercial products may cause adopters to modify current practice in order to incorporate new systems. As more vendor-based products become available, it is necessary to evaluate the consistency of benefits between internally developed programs and commercial products.[40,48,50]

Medication Safety of Computerized Provider Order Entry

The 2000 IOM report To Err Is Human: Building a Safer Health System[51] highlighted the impact of medication errors on patient safety. Since that report was issued, the IOM published Preventing Medication Errors: Quality Chasm Series[7] which included many recommendations relative to avoidance of medication errors and prevention of adverse drug events (ADEs) through CPOE utilization. One analysis of medication errors and ADEs at each phase of the medication ordering process found that 49% of medication errors occurred during

the ordering phase. Another 14% of events were identified during the medication order transcription process.[52] The most common type of error was incorrect dosing, which accounted for 28% of all medication errors.[53] CPOE improved medication safety by increasing accuracy during the ordering phase, eliminating transcription errors, potentially providing clinical decision support to reduce dosing errors including drug-allergy checking, providing formulary decision support, and duplicate therapy verification at the initiation of the physician order process.[50] Three years after these studies were published, Schiff et al. stated, "Physicians should never again write a prescription."[54]

Early studies of CPOE and medication errors evaluated the custom built systems used by individual hospitals. Bates et al.[10] published a prominent article in 1998 that evaluated CPOE and medication errors. This study included two critical care units, two medical units, and two surgical units. The use of CPOE and inclusion of a pharmacist on medical teams reportedly decreased serious medication errors from 10.7 events per 1,000 patient-days to 4.86 events per 1,000 patient-days (55% reduction, $p=0.01$).[10] Another study by Bates et al.[11] evaluated CPOE that included clinical decision support software. The study demonstrated an 81% reduction in medication errors ($p<0.0001$), excluding missed-dose medication errors. The number of missed doses increased from 169 to 329, a 51.4% increase ($p<0.0001$). The authors attributed the increase in missed doses to changes in pharmacy staffing. The authors also noted that the nursing staff may have expected CPOE to drastically improve timely medication

delivery. This increase in expectation may have resulted in the nurses reporting more missed doses after CPOE implementation.

As CPOE has developed, more studies were published that supported the positive impact of CPOE on medication safety. CPOE decreased dosing errors,[12,15] transcription errors,[19] and overall medication errors.[16,21,55] CPOE primarily reduced errors at the ordering phase of the medication process. Error prevention at the administration phase may not occur without other forms of HIT, such as eMAR or bedside bar code medication administration.[37] While the majority of studies are positive, other studies had neutral[24] or negative results.[56] Han et al.[56] reported an increased mortality rate in pediatric patients within the first 5 months following CPOE implementation. The authors noted that CPOE cannot be associated as the cause of increased mortality; however, they discussed several possible explanations for the negative result. Notably, Han et al.[56] stated that administration of antibiotics and select critical medications was delayed due to the centralization of pharmacy services following CPOE. Also, electronic order entry caused providers to spend more time ordering medications at the time of patient admission when many critical evaluations regarding patient status are made. Another study involving pediatric patients showed no change in overall mortality between the 13 months prior and the 13 months after CPOE implementation.[57]

Reviews of CPOE studies have concluded that medication errors were measured differently between studies, different CPOE systems were measured, and few randomized controlled trials exist.[13,14,17,20,49] However, these reviews

provided an insight regarding trends found relative to the impact of CPOE on medication errors. Reckmann et al.[20] reviewed studies that specifically evaluated prescribing errors in the inpatient setting. Four pediatric studies demonstrated fewer overall medication errors, fewer antibiotic dosing errors, fewer chemotherapy errors, and fewer continuous intravenous (IV) order errors.[12,15,58,59] Three studies evaluated CPOE in an adult intensive care unit,[21,26,60] and six studies took place in adult general medical or surgical wards.[18,61-65] Reckmann's review reported positive results from seven studies and negative results from two studies. Evans et al.[26] found an increase in errors related to incorrect infusion rates, discontinued orders that remained on the active medication profile, and incorrect selection of IV diluent and diluent volume. However, the Evans et al. study was conducted in 1996 and may not reflect modern CPOE programs.[26] The other negative study measured self-reported medication errors to determine whether an increase in medication errors per discharge day was related to the use of CPOE. The authors noted that the increase may have been due to a lack of integration between CPOE and the hospital's pharmacy information system (PIS). Another explanation was related to whether an increased reporting rate was caused by increased vigilance following the introduction of the new system.[65] Reckmann et al.[20] and Koppel et al.[38] also introduced a list of new medication errors related to CPOE such as inaccurate product selection or incorrect dosage form selection (Table 2.1). This list demonstrated the potential for new types of medication errors attributed to CPOE.

Table 2.1 Identified Medication Errors Related to CPOE[a]

Medication Errors Related to CPOE
Selection of an inappropriate dosage form
Selecting an incorrect medication product
Incorrect dose, frequency, or formulation from a dropdown menu
Incorrect use of default doses
Missed drug allergies
Duplicate medication orders
Discontinued medications remaining on the active medication list
Incorrect IV diluents or volume selected
Assumed Dose Information
Immediate and give as needed medications not given or canceled properly
Antibiotic renewal failure
Postsurgery “suspended” medication order
Unclear logon and logoff
System failures during CPOE downtime

[a]Adapted from Reckmann et al.[20] and Koppel et al.[38]

Financial Impact of CPOE

The financial impact of CPOE has varied between studies. Total costs have included annual maintenance costs and initial implementation costs which can be quite large. Potential cost savings may come from reduced adverse drug events, improved efficiency of providers, and improved clinical decision support to reduce unnecessary tests.[17] A 1993 study by Tierney et al.[22] demonstrated a decrease in overall costs with a decreased length of stay of 0.89 days; however, the decreased length of stay was not statistically significant. The study concluded an estimated annual savings of $3 million for the institution.

Mekhjian et al.[19] found cost savings in specific units of care, but no significant overall cost savings. Stone et al.[24] reduced annual costs by eliminating eleven ancillary positions after CPOE implementation. Personnel in the eliminated positions were primarily responsible for transmitting previously written orders to nursing, radiology, and laboratory personnel. A time-and-motion study in a hospital with 50 pharmacists estimated a significant reduction in pharmacist time, resulting in an annual savings of over $2 million for the hospital.[25]

Kaushal et al.[23] performed a return on investment analysis of an internally developed CPOE system over a 10-year period. Total costs were estimated to be $11.8 million, including development of the system. The total cost savings over 10 years was $28.5 million, a net savings of $16.7 million (Table 2.2). In addition to the basic CPOE system, specific clinical decision support programs such as renal dosing guidelines and guidance for high cost drugs were integrated

Table 2.2 CPOE Related Cost Savings Over a Ten-Year Period[a]

Cost Saving Method	Total Estimated Cost Savings (millions)
Renal Dosing Guidance	$6.3
Nurse Time Utilization	$6
Specific or High Cost Drug Guidance	$4.9
ADE Prevention	$3.7
Laboratory Charge Display and Redundant Laboratory Warning	$1.9
Panic Laboratory Alert	$1.8
Intravenous to Oral Guidance	$1.1
ADE Monitor	$1
Automated Medication Summary at Discharge	$0.6
Physician Time Utilization	$0.6
Radiology Indications	$0.4
Elderly Dosing Guidance	$0.1
Specific Drug Level Guidance	$0.1

[a]Adapted from Kaushal et al.[23]

into the system. The clinical decision support capability accounted for the majority of the cost savings. Additional savings were attributed to a reduction in nurse and physician time utilization. This custom built system allowed the institution to implement clinical decision support that met the individual hospital's needs, but a commercially available product may lack the flexibility of a custom system and may not be able to reproduce the same cost savings.

Impact on Clinical Workflow

CPOE significantly changes the medication ordering process. Therefore, CPOE should also be expected to change the work of health care professionals involved in the process. These changes may impact workflow, work activities, or workload. A survey of representatives from 178 US hospitals reported that 87% of participants ranked workflow concerns to be a "moderate to very important issue."[34] While CPOE is proposed to introduce efficiencies, it is also important to evaluate the changes across the interdisciplinary health care team.

Taylor et al.[25] found that pharmacists were spending 60% of their time on written medication order processes prior to CPOE implementation. After CPOE implementation pharmacists spent 20% of their time on the medication order process. Taylor et al.[25] also reported that each nurse saved 20 minutes per shift with CPOE. Another time-and-motion study found no change in pharmacist time spent on medication orders.[27] However, Wietholter et al.[28] reported the time spent on pharmacist order-processing decreased from 31 minutes to 3 minutes on each medication order ($p<0.0001$).

Physician time on medication orders increases with CPOE. A time-and-motion study found medical interns increased the time they spent writing orders by 5.5 minutes per patient ($p<0.0001$).[22] Another study evaluated the time spent by physicians per order and found that handwritten orders took 20 seconds compared to 55 seconds for computerized orders.[26] Therefore, it is possible to assume that a CPOE system may increase the workload of medication ordering for physicians.

Medication turnaround times have consistently improved with the implementation of CPOE, with results ranging from 23% to a 92% reduction.[19,28-31] This improvement in efficiency could significantly impact patient care by getting medications to the patient in a more timely manner. Improved medication turnaround could also improve nurse satisfaction by reducing the nurse's waiting time for medications. Medication waste could also potentially be reduced by avoiding preparation of products that may be discontinued during a prolonged turnaround time.

Unintended Consequences of CPOE

Hospitals have encountered unintended consequences from CPOE implementation, such as the new types of medication errors shown in Table 2.1. For example, selection of an inappropriate dosage form may be an error that was previously minimized because the pharmacist verifying the order may be more familiar with available products. With CPOE, the dosage form may be automatically selected by the ordering system. A pharmacist may not intuitively check to see that the proper dosage form was properly selected.

CPOE also impacts the culture and interactions with a health care team and organization. Physicians may perceive CPOE and clinical guidelines included in the system as a threat to their autonomy. Health care administrators often make the final decision to implement CPOE, and providers may see CPOE as unnecessary or may feel that their input was not adequately solicited prior to implementation. This may create tension between individuals selecting a CPOE product and the people who use the product daily.[33] Campbell et al.[36] discussed potential issues surrounding health system overdependence on technology. Providers may assume that they are using the system correctly and that the system is always working correctly. This may cause all providers to be less cautious when making or verifying an order. Also, a CPOE failure or system downtime could disrupt practice as well as increase risk of errors. Health care providers have also noticed errors occurring due to system workarounds. For example, providers may have difficulty entering an order exactly how they would like. The provider may then enter free text orders within a CPOE order that contradicts the order sentence.[39] These potential consequences of CPOE are important to monitor as hospitals implement a new system.

Methods of Work Measurement

Given the situation described above, institutions should evaluate changes in health providers' work in order to assure that negative consequences are not introduced into an already error-prone system. Numerous methods of work measurement are available to assess the impact of CPOE. The methods for work measurement include subjective evaluation, direct time study, standard time

data, statistical data, and work sampling.[66] Subjective evaluation requires a participant to estimate the time spent on a specific activity using previous experience. This method may be affected significantly by reporter bias. A direct time study employs an observer to monitor a subject and record the time spent on work activities. While accurate, a direct time study requires the resources necessary to employ an observer and inefficiently observes one participant at a time. The observer is unable to differentiate between multiple cognitive work activities that may appear to be the same activity. This limitation also prevents researchers from obtaining data on pharmacists' cognitive work activities, such as verifying a medication order, reviewing a patient's medical history, or performing a medication reconciliation. These activities may all appear the same but are very different tasks.

The standard time data method evaluates the time needed to accomplish a task and multiplies the average time by the frequency that the task is performed. The equation provides an estimate of total time spent on a designated work activity. The statistical data method uses the frequency of tasks completed per time to produce an average time per work activity. Statistical data and standard time data methods provide only estimates of work activities. These measurement methods are useful when measuring standardized, repetitive tasks such as during manufacturing or dispensing.

Work sampling uses a large number of random observations to evaluate the proportion of time spent on different work activities. This method provides an efficient way for one observer to accurately assess multiple participants' work

activity.[66-69] This is crucial for researchers evaluating an intervention that impacts all workers in a department, such as the implementation of CPOE. Pharmacists perform several cognitive functions as part of their daily activities. When participants in work sampling studies record the activity they are participating in at time of each random observation, researchers can obtain data on several cognitive functions and differentiate between these functions.

University of Utah Health Care Medication Ordering Process

In 2007, the University of Utah decided to implement CPOE. Prior to CPOE implementation, University Hospital used a Cerner-based electronic health record (EHR), electronic medication administration record (eMAR), and pharmacy information system (PIS) as outlined in Figure 2.1. Each patient had a paper-based medical chart that contained daily progress notes, provider orders, outside institution records, and other select patient information. The PIS was fully integrated with the eMAR. Each patient care unit had commonly used medications and controlled medications available in automated dispensing machines (ADMs).

Pre-CPOE Implementation Medication Order Process

The pre-CPOE medication order process is illustrated in Figure 2.2. A provider initiates the medication order process by writing an order in the patient chart. The chart is then placed on a designated “orders only shelf” accessible to the health unit coordinator. The unit coordinator takes the order out of the chart and electronically faxes the order to the pharmacy. The pharmacy receives the

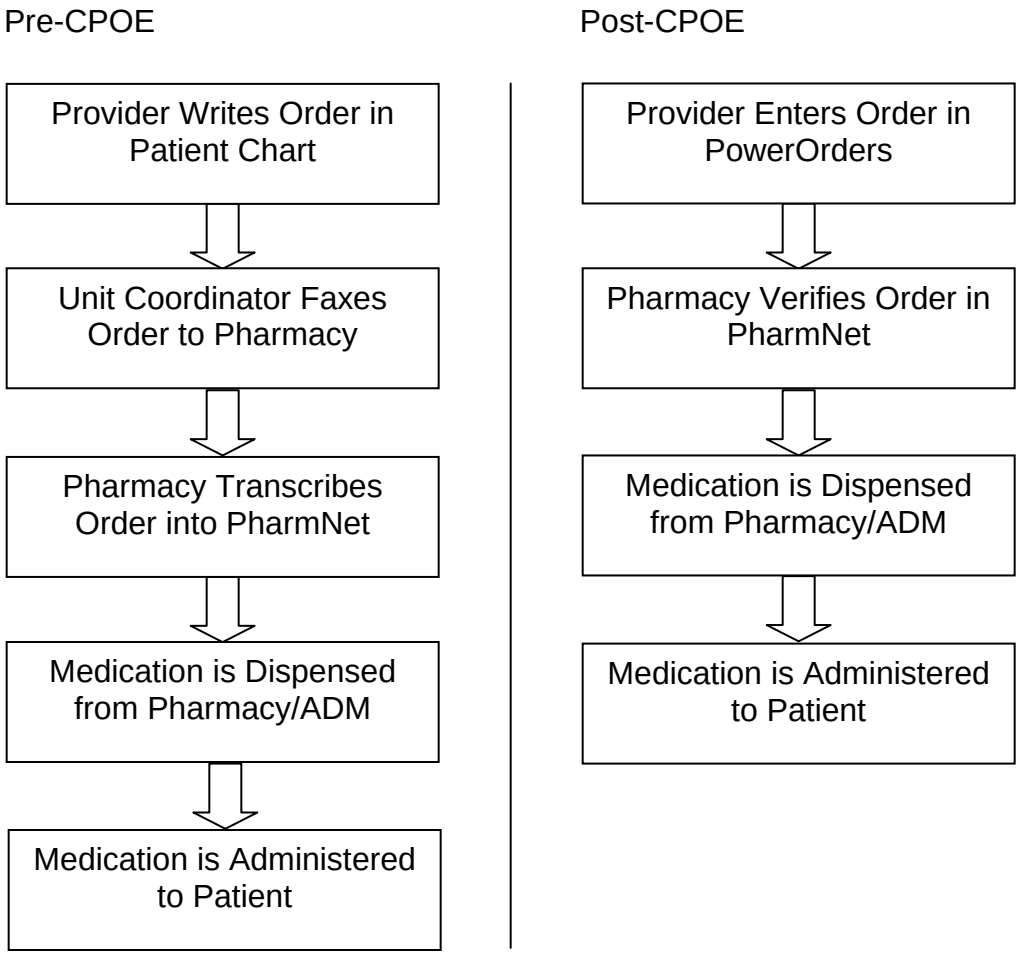

Figure 2.2 The Medication Order Process Pre- and Post-CPOE
ADM – Automated dispensing machine

order via fax on a system called Omnilink. Pharmacists then have access to an electronic copy of the order, the PIS, and the patient's eMAR/EHR on dual screens. It is the pharmacists' responsibility to transcribe the order from the written copy to the electronic system. The medication is then dispensed from the central pharmacy or the ADMs before the product is administered to the patient.

Post-CPOE Implementation Medication Order Process

In May 2009, University Hospital implemented the Cerner CPOE product known as PowerOrders.® CPOE significantly changed the medication order process as illustrated in Figure 2.2. The provider enters the order electronically, and the order is sent directly to the pharmacy for verification. After the pharmacist verifies the order, the medication is dispensed in the same manner as pre-CPOE. CPOE entirely removes the unit coordinator from the process.

University Hospital may benefit from implementing CPOE; however, many effects of CPOE are still unknown. The process shift will impact the work load, workflow, and work activities of health care providers who are involved in medication ordering, distribution, and administration. It will be important to evaluate the process shift so pharmacy and health care administrators will be better prepared to adapt pharmacy services to a CPOE-operated medication order process.

Statement of the Problem

The medication order process will change with CPOE. The impact of CPOE implementation on pharmacist work activities is unknown. Therefore, a

work sampling evaluation to assess work activities pre- and post-CPOE implementation will be designed.

References

1. Brailer DJ. National Coordinator for Health Information Technology; Development and Adoption of a National Health Information Network. *Federal Register.* November 4 2004;69(219):65599-65601.

2. Steinbrook R. Health care and the American Recovery and Reinvestment Act. *N Engl J Med.* Mar 12 2009;360(11):1057-1060.

3. The American Recovery and Reinvestment Act of 2009. H.R.1. 2009. http://thomas.loc.gov/cgi-bin/bdquery/z?d111:h.r.00001.

4. Estimated Effect on Direct Spending and Revenues of Title IV of Division B of the American Recovery and Reinvestment Act of 2009 (Public Law 111-5): Health Information Technology.2009.

5. Dumitru D. *The Pharmacy Informatics Primer*. Bethesda, MD: American Society of Health-System Pharmacists; 2009.

6. Anderson GF, Frogner BK, Johns RA, Reinhardt UE. Health care spending and use of information technology in OECD countries. *Health Aff (Millwood).* May-Jun 2006;25(3):819-831.

7. Institute of Medicine. *Preventing Medication Errors: Quality Chasm Series*. Washington, D.C.: The National Academies Press; 2007.

8. The Leapfrog Group. Factsheet: computerized provider order entry. 2008:1-3. http://www.leapfroggroup.org/media/file/FactSheet_CPOE.pdf. Accessed January 4, 2010.

9. Agency for Healthcare Research and Quality. Computerized provider order entry. July 2009. http://healthit.ahrq.gov/portal/server.pt?open=514&objID=5554&mode=2&holderDisplayURL=http://prodportallb.ahrq.gov:7087/publishedcontent/publish/communities/k_o/knowledge_library/key_topics/health_briefing_02062006010308/computerized_provider_order_entry.html. Accessed January 18, 2010.

10. Bates DW, Leape LL, Cullen DJ, et al. Effect of computerized physician order entry and a team intervention on prevention of serious medication errors. *JAMA.* Oct 21 1998;280(15):1311-1316.

11. Bates DW, Teich JM, Lee J, et al. The impact of computerized physician order entry on medication error prevention. *J Am Med Inform Assoc.* Jul-Aug 1999;6(4):313-321.

12. Cordero L, Kuehn L, Kumar RR, Mekhjian HS. Impact of computerized physician order entry on clinical practice in a newborn intensive care unit. *J Perinatol.* Feb 2004;24(2):88-93.

13. Eslami S, de Keizer NF, Abu-Hanna A. The impact of computerized physician medication order entry in hospitalized patients--a systematic review. *Int J Med Inform.* Jun 2008;77(6):365-376.

14. Kaushal R, Shojania KG, Bates DW. Effects of computerized physician order entry and clinical decision support systems on medication safety: a systematic review. *Arch Intern Med.* Jun 23 2003;163(12):1409-1416.

15. Kim GR, Chen AR, Arceci RJ, et al. Error reduction in pediatric chemotherapy: computerized order entry and failure modes and effects analysis. *Arch Pediatr Adolesc Med.* May 2006;160(5):495-498.

16. King WJ, Paice N, Rangrej J, Forestell GJ, Swartz R. The effect of computerized physician order entry on medication errors and adverse drug events in pediatric inpatients. *Pediatrics.* Sep 2003;112(3 Pt 1):506-509.

17. Kuperman GJ, Gibson RF. Computer physician order entry: benefits, costs, and issues. *Ann Intern Med.* Jul 1 2003;139(1):31-39.

18. Mahoney CD, Berard-Collins CM, Coleman R, Amaral JF, Cotter CM. Effects of an integrated clinical information system on medication safety in a multi-hospital setting. *Am J Health Syst Pharm.* Sep 15 2007;64(18):1969-1977.

19. Mekhjian HS, Kumar RR, Kuehn L, et al. Immediate benefits realized following implementation of physician order entry at an academic medical center. *J Am Med Inform Assoc.* Sep-Oct 2002;9(5):529-539.

20. Reckmann MH, Westbrook JI, Koh Y, Lo C, Day RO. Does computerized provider order entry reduce prescribing errors for hospital inpatients? A systematic review. *J Am Med Inform Assoc.* Sep-Oct 2009;16(5):613-623.

21. Shulman R, Singer M, Goldstone J, Bellingan G. Medication errors: a prospective cohort study of hand-written and computerised physician order entry in the intensive care unit. *Crit Care.* Oct 5 2005;9(5):R516-521.

22. Tierney WM, Miller ME, Overhage M, McDonald CJ. Physician inpatient order writing on microcomputer workstations: effects on resource utilization. *JAMA.* 1993;269(3):379-383.

23. Kaushal R, Jha AK, Franz C, et al. Return on investment for a computerized physician order entry system. *J Am Med Inform Assoc.* May-Jun 2006;13(3):261-266.

24. Stone WM, Smith BE, Shaft JD, Nelson RD, Money SR. Impact of a computerized physician order-entry system. *J Am Coll Surg.* May 2009;208(5):960-967; discussion 967-969.

25. Taylor R, Manzo J, Sinnett M. Quantifying value for physician order-entry systems: a balance of cost and quality. *Healthc Financ Manage.* Jul 2002;56(7):44-48.

26. Evans KD, Benham SW, Garrard CS. A comparison of handwritten and computer-assisted prescriptions in an intensive care unit. *Crit Care.* 1998;2(2):73-78.

27. Pitre M, Ong K, Huh JH, Fernandes O. Thorough planning and full participation by pharmacists is key to MOE/MAR success. *Healthc Q.* 2006;10 Spec No:43-48, 44.

28. Wietholter J, Sitterson S, Allison S. Effects of computerized prescriber order entry on pharmacy order-processing time. *Am J Health Syst Pharm.* Aug 1 2009;66(15):1394-1398.

29. Jensen J. The effects of Computerized Provider Order Entry on medication turn-around time: a time-to-first dose study at the Providence Portland Medical Center. *AMIA Annu Symp Proc.* 2006:384-388.

30. Niazkhani Z, Pirnejad H, Berg M, Aarts J. The impact of computerized provider order entry systems on inpatient clinical workflow: a literature review. *J Am Med Inform Assoc.* Jul-Aug 2009;16(4):539-549.

31. Wess ML, Embi PJ, Besier JL, et al. Effect of a Computerized Provider Order Entry (CPOE) System on medication orders at a community hospital and university hospital. *AMIA Annu Symp Proc.* 2007:796-800.

32. Ash JS, Sittig DF, Campbell E, Guappone K, Dykstra RH. An unintended consequence of CPOE implementation: shifts in power, control, and autonomy. *AMIA Annu Symp Proc.* 2006:11-15.

33. Ash JS, Sittig DF, Dykstra R, Campbell E, Guappone K. The unintended consequences of computerized provider order entry: findings from a mixed methods exploration. *Int J Med Inform.* Apr 2009;78 Suppl 1:S69-76.

34. Ash JS, Sittig DF, Poon EG, Guappone K, Campbell E, Dykstra RH. The extent and importance of unintended consequences related to computerized provider order entry. *J Am Med Inform Assoc.* Jul-Aug 2007;14(4):415-423.

35. Campbell EM, Sittig DF, Ash JS, Guappone KP, Dykstra RH. Types of unintended consequences related to computerized provider order entry. *J Am Med Inform Assoc.* Sep-Oct 2006;13(5):547-556.

36. Campbell EM, Sittig DF, Guappone KP, Dykstra RH, Ash JS. Overdependence on technology: an unintended adverse consequence of computerized provider order entry. *AMIA Annu Symp Proc.* 2007:94-98.

37. FitzHenry F, Peterson JF, Arrieta M, Waitman LR, Schildcrout JS, Miller RA. Medication administration discrepancies persist despite electronic ordering. *J Am Med Inform Assoc.* Nov-Dec 2007;14(6):756-764.

38. Koppel R, Metlay JP, Cohen A, et al. Role of computerized physician order entry systems in facilitating medication errors. *JAMA.* Mar 9 2005;293(10):1197-1203.

39. Singh H, Mani S, Espadas D, Petersen N, Franklin V, Petersen LA. Prescription errors and outcomes related to inconsistent information transmitted through computerized order entry: a prospective study. *Arch Intern Med.* May 25 2009;169(10):982-989.

40. Classen DC, Avery AJ, Bates DW. Evaluation and certification of computerized provider order entry systems. *J Am Med Inform Assoc.* Jan-Feb 2007;14(1):48-55.

41. Ozdas A, Miller RA. Care provider order entry (CPOE): a perspective on factors leading to success or to failure. *Yearb Med Inform.* 2007:128-137.

42. Brown SH, Lincoln MJ, Groen PJ, Kolodner RM. VistA--U.S. Department of Veterans Affairs national-scale HIS. *Int J Med Inform.* Mar 2003;69(2-3):135-156.

43. Ash JS, Gorman PN, Seshadri V, Hersh WR. Computerized physician order entry in U.S. hospitals: results of a 2002 survey. *J Am Med Inform Assoc.* Mar-Apr 2004;11(2):95-99.

44. Jha AK, DesRoches CM, Campbell EG, et al. Use of electronic health records in U.S. hospitals. *N Engl J Med.* Apr 16 2009;360(16):1628-1638.

45. The Leapfrog Group. Leapfrog Hospital Survey Results: 2008. 2009:1-10. http://www.leapfroggroup.org/. Accessed January 4, 2010.

46. Cutler DM, Feldman NE, Horwitz JR. U.S. adoption of computerized physician order entry systems. *Health Aff (Millwood).* Nov-Dec 2005;24(6):1654-1663.

47. Yu FB, Menachemi N, Berner ES, Allison JJ, Weissman NW, Houston TK. Full implementation of computerized physician order entry and medication-related quality outcomes: a study of 3364 hospitals. *Am J Med Qual.* Jul-Aug 2009;24(4):278-286.

48. Chaudhry B, Wang J, Wu S, et al. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. *Ann Intern Med.* May 16 2006;144(10):742-752.

49. Weir CR, Staggers N, Phansalkar S. The state of the evidence for computerized provider order entry: a systematic review and analysis of the quality of the literature. *Int J Med Inform.* Jun 2009;78(6):365-374.

50. Kuperman GJ, Bobb A, Payne TH, et al. Medication-related clinical decision support in computerized provider order entry systems: a review. *J Am Med Inform Assoc.* Jan-Feb 2007;14(1):29-40.

51. Institute of Medicine. *To Err Is Human: Building a Safer Health System*. Washington, D.C.: The National Academies Press; 2000.

52. Bates DW, Cullen DJ, Laird N, et al. Incidence of adverse drug events and potential adverse drug events. Implications for prevention. ADE Prevention Study Group. *JAMA.* Jul 5 1995;274(1):29-34.

53. Leape LL, Bates DW, Cullen DJ, et al. Systems analysis of adverse drug events. ADE Prevention Study Group. *JAMA.* Jul 5 1995;274(1):35-43.

54. Schiff GD, Rucker TD. Computerized prescribing: building the electronic infrastructure for better medication usage. *JAMA.* Apr 1 1998;279(13):1024-1029.

55. Lykowski G, Mahoney D. Computerized provider order entry improves workflow and outcomes. *Nurs Manage.* Feb 2004;35(2):40G-H.

56. Han YY, Carcillo JA, Venkataraman ST, et al. Unexpected increased mortality after implementation of a commercially sold computerized physician order entry system. *Pediatrics.* 2005;116:1506-1512.

57. Del Beccaro MA, Jeffries HE, Eisenberg MA, Harry ED. Computerized provider order entry implementation: no association with increased mortality rates in an intensive care unit. *Pediatrics.* Jul 2006;118(1):290-295.

58. Vaidya V, Sowan AK, Mills ME, Soeken K, Gaffoor M, Hilmas E. Evaluating the safety and efficiency of a CPOE system for continuous medication infusions in a pediatric ICU. *AMIA Annu Symp Proc.* 2006:1128.

59. Potts AL, Barr FE, Gregory DF, Wright L, Patel NR. Computerized physician order entry and medication errors in a pediatric critical care unit. *Pediatrics.* Jan 2004;113(1 Pt 1):59-63.

60. Colpaert K, Claus B, Somers A, Vandewoude K, Robays H, Decruyenaere J. Impact of computerized physician order entry on medication prescription errors in the intensive care unit: a controlled cross-sectional trial. *Crit Care.* Feb 2006;10(1):R21.

61. Franklin BD, O'Grady K, Donyai P, Jacklin A, Barber N. The impact of a closed-loop electronic prescribing and administration system on prescribing errors, administration errors and staff time: a before-and-after study. *Qual Saf Health Care.* Aug 2007;16(4):279-284.

62. Donyai P, O'Grady K, Jacklin A, Barber N, Franklin BD. The effects of electronic prescribing on the quality of prescribing. *Br J Clin Pharmacol.* Feb 2008;65(2):230-237.

63. Voeffray M, Pannatier A, Stupp R, Fucina N, Leyvraz S, Wasserfallen JB. Effect of computerisation on the quality and safety of chemotherapy prescription. *Qual Saf Health Care.* Dec 2006;15(6):418-421.

64. Oliven A, Michalake I, Zalman D, Dorman E, Yeshurun D, Odeh M. Prevention of prescription errors by computerized, on-line surveillance of drug order entry. *Int J Med Inform.* Jun 2005;74(5):377-386.

65. Spencer DC, Leininger A, Daniels R, Granko RP, Coeytaux RR. Effect of a computerized prescriber-order-entry system on reported medication errors. *Am J Health Syst Pharm.* Feb 15 2005;62(4):416-419.

66. Rascati KL, Kimberlin CL, McCormick WC. Work measurement in pharmacy research. *Am J Hosp Pharm.* Oct 1986;43(10):2445-2452.

67. Capuano T, Bokovoy J, Halkins D, Hitchings K. Work flow analysis: eliminating non-value-added work. *J Nurs Adm.* May 2004;34(5):246-256.

68. Doty LA. *Work Methods and Measurement for Management*. Albany, NY: Delmar Publishers; 1989.

69. Aft LS. *Productivity Measurement and Improvement*. Reston, Virginia: Reston Publishing Company; 1983.

CHAPTER 3

METHODS

Study Design and Procedures

This thesis is an observational study designed to assess the proportion of time spent by pharmacists on various work activities before and after CPOE implementation using work sampling methodology. The study was classified as a quality assessment and development project, and was approved by the University of Utah Institutional Review Board (IRB_00033313).

The initial phases of the study included design of pharmacist work sampling forms. Work activities were divided into Clinical, Professional, Technical, and Other categories based on previous work in this institution (Table 3.1).[1-5] Specific activities within each classification were initially developed by the investigators and sent to all inpatient pharmacists for evaluation. Work activity definitions were evaluated with pharmacist input to ensure inclusion of all daily activities. The work sampling forms included an itemized list of the selected work activities with definitions and a table used to record work samples (Appendix A).

Divilbiss Electronics JD-7 Random Reminder pagers were used to collect data gathered at random intervals according to the observation schedule outlined

Table 3.1 Pharmacist Work Activity Definitions

Work Activity	Definition
Clinical	Participating in direct patient care
Professional	Performing nonclinical activities required by law, hospital policy, or accrediting body
Technical	Other activity pertaining to pharmacy but not considered Clinical or Professional
Other	Personal time, idle time, time spent on this study, burn unit orders, and undefined time

in Table 3.2. This method of work activity sampling was used and validated in previous studies at the University of Utah[1-5] and outside institutions.[6-8] The Random Reminder pagers were set to emit a predetermined number of random notifications per hour. At each notification (audible or vibrating as selected by the pharmacist), participants placed a mark on the data collection sheet corresponding to the activity he or she was involved in at the time of the notification. Data sheets were collected in a secure collection box at each pharmacy satellite or the central pharmacy. Completed work sampling sheets were only viewed by the investigators. Participants were not identifiable by the data collection sheets. Each participant was given his or her Random Reminder pager and work activity sheet prior to starting their shift.

Prior to implementation of the study, an electronic form and hard-copy letter of explanation were given to personnel participating in the study

Table 3.2 Estimated Number of Observations by Pharmacist Position

Pharmacist Position	Pharmacists/Shift	Notifications/Hour	Anticipated Shifts Studied	Estimated Observations Pre-CPOE	Estimated Observations Post-CPOE
Central Pharmacist Day	3	8	21	1344	1344
Central Pharmacist Swing	3	8	21	1344	1344
Central Midnight	2	8	14	896	896
Decentral Shifts					
Medical & Surgical	2	4	14	448	448
Internal Medicine	1	4	7	224	224
Cardiology	1	4	5[a]	160	160
Intermediate Care Unit	1	4	5[a]	160	160
Medical Intensive Care Unit	1	4	7	224	224
Neurology/Neurosurgery	1	4	5 or 7[b]	160	224
Neurocritical Care Unit	1	4	7	224	224
Surgical Intensive Care Unit	2 or 1[c]	4	12[c]	768	768

[a]No weekend pharmacist [b] No weekend pharmacist in pre-CPOE phase [c]Two weekday, one weekend pharmacist

(Appendix B). The letter included instruction on the use of the Divilbiss Electronics JD-7 Random Reminder and the work activity sheet. In-person education was given to participants at the time that pagers were distributed. Random Reminder pagers and work activity sheets were kept in participating units throughout the study. The primary investigator and information technology pharmacists were available for contact via pager throughout the study to address any concerns from participants. Data were collected before and after computerized provider order entry (CPOE) implementation (Figure 3.1). Each sampling period included five weekdays and two weekend days, and assessed work activities of day, evening, and night shift pharmacists.

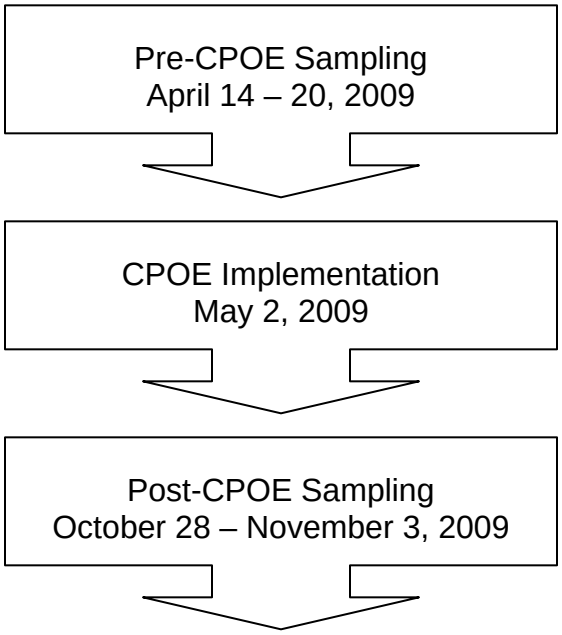

Figure 3.1. Project Timeline

Participant Selection Criteria

Pharmacists included in this study consisted of University Hospital centralized and decentralized inpatient pharmacy staff. The decentralized staff included those participating on rounding and nonrounding services (Table 3.2). All participants were asked to sign a letter of consent prior to participation. No personal information was collected on data sheets, and all data collection sheets were kept secure by the primary investigator.

Number of Observations

The number of observations desired to reach adequate power is determined by the equation:[1,2]

$$N = [4a^2p(1-p)]/I^2$$

where a =1.96 or 1.645 for the 95% or 90% confidence interval, I = 0.025 or 0.05 for a selected sampling error of 2.5% and 5%, and p = the proportion of time believed to be spent on the activity of greatest research interest. This study based the number of observations required for evaluation on the estimated proportion of time that pharmacists spent in Clinical work activities. The estimated proportion of Clinical activities time was 0.25 based on previous studies conducted at the University of Utah[1]; therefore, p = 0.25 for this study. Accounting for a confidence interval of 95% (a = 1.96) and an allowable sampling error of 2.5% (I = 0.025), the study needed at least 4610 observations of pharmacist work activities. In order to obtain an adequate number of observations, study methods were based on obtaining 20% more observations

than were required to be collected (Table 3.2). Therefore, central pharmacists were measured at a rate of eight notifications per hour, and decentral pharmacists were measured at a rate of four notifications per hour. All pharmacist shifts were anticipated to be eight hours and thirty minutes in length.

Statistical Methods

Descriptive statistics were used at the completion of each phase to assess the reported proportional distribution of work activities. A chi-square test was used to test for statistically significant differences relative to potential changes in work activities between the pre- and post-CPOE periods.

References

1. Nickman NA, Guerrero RM, Bair JN. Self-reported work-sampling methods for evaluating pharmaceutical services. *Am J Hosp Pharm.* Jul 1990;47(7):1611-1617.

2. Nickman NA, Guerrero RM, Bair JN. Number of observations in workload sampling. Letter. *Am J Hosp Pharm.* 1990;47:2466.

3. Nickman NA, Schneider JK, Knick KA. Work activities at an ambulatory care pharmacy with an integrated model of pharmacy practice. *Am J Health Syst Pharm.* Feb 15 1996;53(4):397-402.

4. Guerrero RM, Nickman NA, Bair JN. Work activities of pharmacy teams with drug distribution and clinical responsibilities. *Am J Health Syst Pharm.* Mar 15 1995;52(6):614-620.

5. Guerrero RM, Nickman NA, Jorgenson JA. Work activities before and after implementation of an automated dispensing system. *Am J Health Syst Pharm.* Mar 1 1996;53(5):548-554.

6. Guarisco S, Oddone E, Simel D. Time analysis of a general medicine service: results from a random work sampling study. *J Gen Intern Med.* May 1994;9(5):272-277.

7. Murray MD, Loos B, Tu W, Eckert GJ, Zhou XH, Tierney WM. Effects of computer-based prescribing on pharmacist work patterns. *J Am Med Inform Assoc.* Nov-Dec 1998;5(6):546-553.

8. Rascati KL, Kimberlin CL, Foley PT, Williams RB. Multidimensional work sampling to evaluate the effects of computerization in an outpatient pharmacy. *Am J Hosp Pharm.* Sep 1987;44(9):2060-2067.

CHAPTER 4

RESULTS

Results summarizing the work sampling evaluation conducted over two 1-week study periods are outlined in Table 4.1.

Number of Observations Obtained

Initially, data collection was planned in order to obtain 3584 observations from 56 central pharmacy shifts during the pre-CPOE and post-CPOE study periods. However, due to some pharmacists not participating in the study, a total of 2828 observations (88.4% of anticipated observations during 50 shifts) in central pharmacy were reported pre-CPOE and 2781 observations (85.2% of anticipated during 51 shifts) were reported post-CPOE.

For the decentral pharmacists, the study was designed to observe 1984 observations pre-CPOE and 2048 observations post-CPOE. Total number of anticipated observations differed between the pre- and post-CPOE period due to changes in decentral pharmacist weekend staffing (Table 3.1); specifically, a neurology pharmacist shift was added to the weekend staffing schedule after CPOE. Two decentral pharmacist shifts were not covered in both study periods and one shift was not observed due to a pager malfunction. This resulted in a total of 1832 observations (95.4% of anticipated during 60 shifts) of decentral

Table 4.1 Number of Shifts and Observations Expected and Obtained

	Central Pharmacist		Decentral Pharmacist	
	Pre-CPOE	Post-CPOE	Pre-CPOE	Post-CPOE
Observations	2828	2781	1832	1785
(% of Anticipated)	(88.4%)	(85.2%)	(95.4%)	(91.4%)
Shifts	50	51	60	61
(% of Anticipated)	(89.3%)	(91.1%)	(96.8%)	(95.3%)

pharmacist activities reported pre-CPOE and 1785 observations of activities (91.4% of anticipated during 61 shifts) reported post-CPOE.

Comparison of Central Pharmacist Work Activities Before and After CPOE

Central pharmacists reported 9.9% of their time was spent on Clinical activities before CPOE was implemented (Table 4.2). This was not significantly different from the 10.1% of time designated as Clinical after CPOE implementation ($p=0.732$). The proportion of Professional work activity increased from 16.7% to 56.8% of total time ($p<0.001$). Overall, time spent on Technical work activities decreased from 56.8% to 11% ($p<0.001$). The pre-CPOE sample reported 16.6% of time spent on Other work activities compared to 22.1%, a significant increase ($p<0.001$). Examples of Other work activities included personal time, idle time, or other time spent on activities that were not included in the work activity definitions.

Table 4.2 Comparison of Work Activities Pre- and Post-CPOE

Work Activity	Central Pharmacist		P-value	Decentral Pharmacist		P-value
	Pre-CPOE % (n)	Post-CPOE % (n)		Pre-CPOE % (n)	Post-CPOE % (n)	
Clinical	9.9% (279)	10.1% (282)	0.732	68.7% (1259)	66.4% (1185)	0.133
Professional	16.7% (473)	56.8% (1579)	<0.001	17.2% (316)	17.7% (316)	0.719
Technical	56.8% (1607)	11% (305)	<0.001	3.1% (56)	2% (36)	0.047
Other	16.6% (469)	22.1% (615)	<0.001	11% (201)	13.9% (248)	0.008
Study total	100% (2828)	100% (2781)		100% (1832)	100% (1785)	

Two central pharmacist Clinical work activities significantly differed between the two study periods (Table 4.3). Pre-CPOE data indicated that 4.4% of time was spent on medication therapy review. This proportion decreased to 2.4% in the post-CPOE sample ($p<0.001$). The proportion of pharmacist intervention time increased from 3.1% in the pre-CPOE sample to 5.2% in the post-CPOE sample ($p<0.001$). Clinical consultation time occurred at a similar frequency between the samples (2.3% vs. 2.3%, p=NS). Medication reconciliation time occurred 0.04% pre-CPOE and 0.29% post-CPOE. No time was spent on medical rounds in either study period.

Table 4.3 Central Pharmacist Clinical Work Activities Pre- and Post-CPOE

Clinical Work Activity	Pre-CPOE % (n)	Post-CPOE % (n)	p-value
Total	9.9% (279)	10.1% (282)	0.732
Pharmacy Intervention	3.1% (89)	5.2% (144)	<0.001
Medication Therapy Review	4.4% (125)	2.4% (67)	<0.001
Medication Reconciliation	0.04% (1)	0.29% (8)	0.02
Medical Rounds	0% (0)	0% (0)	NS
Clinical Consultation	2.3% (64)	2.3% (63)	NS
Study total	100% (2828)	100% (2781)	

Time spent on order verification increased the most between the pre- and post-CPOE samples (Table 4.4, 10.4% vs. 44.8%, p<0.001). Time spent on education also increased significantly (2% vs. 6%, p<0.001), while time spent on pharmacy operations work activity, such as department meetings or hospital committee meetings, increased slightly but significantly from 4.4% to 6% (p=0.007). Time spent on medication dispensing and telephone activity decreased after CPOE implementation (Table 4.5). Medication dispensing decreased from 51.2% in the pre-CPOE group to 7.8% (p<0.001) in the post-CPOE group. Telephone activity time decreased from 5.7% to 3.2% (p<0.001).

Time spent on Other work activities increased between the pre- and post-CPOE study periods, primarily in the personal and idle work activity categories (Table 4.6). The proportion of personal time available significantly increased from 7.3% to 10.6% (p<0.001). Idle time also increased from 4.8% to 8.6% (p<0.001). The proportion of time spent on burn unit orders decreased; however, pharmacists reported less than 1% of work activities fit this category (0.74% vs. 0.04%, p<0.001) during both study periods. No significant difference was found in the work activities of “other” (1.9% vs. 1.6%, p=0.46) or “this study” (1.9% vs. 1.3%, p=0.05) work activities.

Comparison of Decentral Pharmacist Work Activities Before and After CPOE

Decentral pharmacists reported the majority of observed time as Clinical, but there was no difference in the proportion of Clinical activity reported in either of the two study periods (Table 4.2). The pre-CPOE sample reported 68.7% of

Table 4.4 Central Pharmacist Professional Work Activities Pre- and Post-CPOE

Professional Work Activity	Pre-CPOE % (n)	Post-CPOE % (n)	p-value
Total	16.7% (473)	56.8% (1579)	<0.001
Order Verification	10.4% (293)	44.8% (1246)	<0.001
Education	2% (56)	6% (167)	<0.001
Operations	4.4% (124)	6% (166)	0.007
Study total	100% (2828)	100% (2781)	

Table 4.5 Central Pharmacist Technical Work Activities Pre- and Post-CPOE

Technical Work Activity	Pre-CPOE % (n)	Post-CPOE % (n)	p-value
Total	56.8% (1607)	11% (305)	<0.001
Medication Dispensing	51.2% (1447)	7.8% (216)	<0.001
Telephone	5.7% (160)	3.2% (89)	<0.001
Study total	100% (2828)	100% (2781)	

Table 4.6 Central Pharmacist Other Work Activities Pre- and Post-CPOE

Other Work Activity	Pre-CPOE % (n)	Post-CPOE % (n)	p-value
Total	16.6% (469)	22.1% (615)	<0.001
Personal Time	7.3% (205)	10.6% (295)	<0.001
Idle Time	4.8% (135)	8.6% (238)	<0.001
Burn Unit Orders	0.74% (21)	0.04% (1)	<0.001
Other	1.9% (53)	1.6% (45)	0.46
This Study	1.9% (55)	1.9% (36)	0.05
Study total	100% (2828)	100% (2781)	

time as Clinical compared to 66.4% (p=0.133) post-CPOE. Professional work activities were similar during both study periods. Decentral pharmacists reported 17.2% of time as Professional in the first study period and 17.7% (p=0.719) in the second study period. Technical activity time decreased slightly between the two groups. Overall time spent on Technical activities decreased from 3.1% to 2% (p=0.047). The pre-CPOE sample reported 11% of time as Other work activities compared to 13.9% (p=0.008).

The only significant change in the Clinical work activities was the pharmacist intervention activity (Table 4.7). The time spent on this activity decreased from 10.7% to 7.7% (p=0.002). Decentral pharmacists reported similar amounts of time spent on medical rounds (11% vs. 10.8%, p=0.837), medication reconciliation (9% vs. 8.1%, p=0.343), and clinical consultation (6.5% vs. 7.2%, p=0.384). Medication therapy review accounted for the largest proportion of time, and was similar pre- and post-CPOE (31.5% vs. 32.5%, p=0.497).

All three Professional activities measures demonstrated significant changes (Table 4.8) pre- and post-CPOE. Order verification and pharmacy operations activity decreased significantly between pre- and post-CPOE (5.1% vs. 2.6%, p<0.001 and 6.2% vs. 4.3%, p=0.01 respectively). The proportion of education time increased following the implementation of CPOE (6% vs. 10.8%, p<0.001).

With regard to Technical activities, the medication dispensing function decreased from 2.7% to 1.6% (Table 4.9, p=0.016). The telephone function accounted for less than 1% of total decentral pharmacist time and did not

Table 4.7 Decentral Pharmacist Clinical Work Activities Pre- and Post-CPOE

Clinical Work Activity	Pre-CPOE % (n)	Post-CPOE % (n)	p-value
Total	68.7% (1259)	66.4% (1185)	0.133
Pharmacy Intervention	10.7% (196)	7.7% (137)	0.002
Medication Therapy Review	31.5% (577)	32.5% (581)	0.497
Medication Reconciliation	9% (165)	8.1% (145)	0.343
Medical Rounds	11% (202)	10.8% (193)	0.837
Clinical Consultation	6.5% (119)	7.2% (129)	0.384
Study Total	100% (1832)	100% (1785)	

Table 4.8 Decentral Pharmacist Professional Work Activities Pre- and Post-CPOE

Professional Work Activity	Pre-CPOE % (n)	Post-CPOE % (n)	p-value
Total	17.2% (316)	17.7% (316)	0.719
Order Verification	5.1% (93)	2.6% (46)	<0.001
Education	6% (109)	10.8% (193)	<0.001
Operations	6.2% (114)	4.3% (77)	0.01
Study Total	100% (1832)	100% (1785)	

Table 4.9 Decentral Pharmacist Technical Work Activities Pre- and Post-CPOE

Technical Work Activity	Pre-CPOE % (n)	Post-CPOE % (n)	p-value
Total	3.1% (56)	2% (36)	0.047
Medication Dispensing	2.7% (50)	1.6% (28)	0.016
Telephone	0.33% (6)	0.45% (8)	0.559
Study Total	100% (1832)	100% (1785)	

significantly change between pre- and post-CPOE (0.33% vs. 0.45%, p=0.559).

The time spent on the activity defined as “This Study” increased from 0.38% to 1.3% (p=0.002) after CPOE implementation (Table 4.10). The activity defined as other increased from 1.4% to 2.4% (p=0.03). The proportion of time reported as personal time did not significantly change after CPOE implementation (5.2% vs. 6.2%, p=0.203). The time spent on idle work functions (3.9% vs. 4%, p=0.874) and burn unit orders (0.11% vs. 0%, p=0.163) were also similar between the two samples.

Table 4.10 Decentral Pharmacist Clinical Work Activities Pre- and Post-CPOE

Other Work Activity	Pre-CPOE % (n)	Post-CPOE % (n)	p-value
Total	11% (201)	13.9% (248)	0.008
Personal Time	5.2% (95)	6.2% (110)	0.203
Idle Time	3.9% (71)	4% (71)	0.874
Burn Unit Orders	0.11% (2)	0% (0)	0.163
Other	1.4% (26)	2.4% (43)	0.03
This Study	0.38% (7)	1.3% (24)	0.002
Study Total	100% (1832)	100% (1785)	

CHAPTER 5

DISCUSSION

Analysis of Central Pharmacist Observations

Central pharmacist proportion of time spent on Professional and Technical work categories demonstrated the greatest changes after CPOE implementation. This change was due primarily to the definitions of medication dispensing and order verification. The 43.4% decrease in the medication dispensing activity appeared to account for the 34.4% increase in order verification (Table 5.1). Time spent on order verification and medication dispensing functions may be added together to include the primary functions of central pharmacists, specifically the act of processing a provider's order. When order verification and medication dispensing work activities were combined, there was a decrease in the proportion of time after CPOE implementation, 61.6% versus 52.6%. This 9% difference in time spent may account for the 3.3% increase in personal time, the 3.8% increase in idle time reported by participants, or the 4% increase in the education work function.

While the time spent on Clinical work activities did differ significantly, the changes in pharmacist intervention and medication therapy review may provide meaningful insight to changes in work activity. The 2.1% increase in pharmacist interventions may be due to an increase in pharmacists making CPOE-related

Table 5.1 Analysis of Central Pharmacist Medication Dispensing and Order Verification

Work Activity	Pre-CPOE % (n)	Post-CPOE % (n)	p-value
Medication Dispensing	51.2% (1447)	7.8% (216)	<0.001
Order Verification	10.4% (293)	44.8% (1246)	<0.001
Combined	61.6% (1740)	52.6% (1462)	

interventions (Table 5.2). Also, the pre-CPOE medication order process allowed central pharmacists to electronically send medication orders that required intervention to the decentral pharmacists for follow up. This process was not available in CPOE and may have led to central pharmacists making more interventions. However, the data collection form was not designed to capture the specific type of pharmacy intervention, such as dosage correction or drug interaction. The type of intervention was not included in the study because it may have complicated the work sampling by introducing a more specific work activity that would require more in depth interpretation by the participant.

Pharmacists spent less time on the medication therapy review function after CPOE. This may be due to an increase in efficiency of the activity. Prior to CPOE, the pharmacist would evaluate a written order and enter the order into the pharmacy information system before or after reviewing a patient's medication regimen. With CPOE, the new medication order appears as a part of the

Table 5.2 Analysis of Central Pharmacist Clinical Activities

Work Activity	Pre-CPOE % (n)	Post-CPOE % (n)	p-value
Pharmacy Intervention	3.1% (89)	5.2% (144)	<0.001
Medication Therapy Review	4.4% (125)	2.4% (67)	<0.001

medication regimen that allows the pharmacist to quickly review the appropriateness of therapy. However, there are no measures or documentation that ensures medication therapy review was performed to the same degree on every patient. Medication therapy review is assumed to be completed by every pharmacist as part of their job responsibilities.

Analysis of Decentral Pharmacist Observations

Decentral pharmacists are not primarily responsible for medication dispensing or order verification. Therefore, CPOE was not anticipated to significantly impact decentral pharmacist work activities. Time spent on Clinical work activities did not significantly change. Pharmacist intervention time decreased by 3% (10.7% to 7.7%). This decrease may be due a reduction in errant medication orders sent from central pharmacists as described in the previous section. The decrease may also reflect the reduction of interventions made due to illegible medication orders. Decentral pharmacists did not spend additional time on medical rounds after CPOE implementation as may have been anticipated.

Decentral pharmacists reported a decrease in time spent on order verification. While this is not a primary responsibility of the decentral pharmacist, this may be due to either an increased efficiency of order verification or the improved efficiency of central pharmacists to verify more medication orders. Decentral pharmacists reported an increase of 4.8% in time spent on education. This resulted in over 10% of total time spent in education alone post-CPOE. Notably, patient education was included in the clinical consultation activity rather than education because patient education was determined to fit the direct patient care criteria defined by Clinical work activities.

Limitations of the Study

One limitation of this study was reporter bias. It is possible that participants may have inaccurately reported their work activities due to a perceived perception that the study was evaluating an individual participant. However, all participants were assured that data collected would be kept confidential and would not be associated with any individual. Also, the nearly 6 months between sampling periods limited the ability of the pharmacist to recollect data submitted during the previous study period. The number of observations collected would require participants to make a concerted effort to report false data.

Another limitation was the variability between different pharmacists when interpreting defined work activities. Prior to each study period, the work activity definitions were distributed and explained to all potential participants. Definitions were developed in conjunction with pharmacists to encompass all work activities

and to be easily identifiable. Also, several pharmacists participated in the study as both decentral and central pharmacists. This potentially increased the validity of work definition interpretation and narrowed potential differences between the central and decentral pharmacist groups. The study design could have included the same participants in both study periods in order minimize variation in reporting. However, this may have limited application of study results to those individual participants rather than all pharmacists that fulfill the decentral and central pharmacy position.

The study site also underwent significant construction in between the two sampling periods. Several of the decentral pharmacists were also working on new patient care units during the second study phase. Changes in environment may have impacted the proportion of time spent on some work functions. Also, the initial number of planned observations was intended to combine observations of both central and decentral pharmacists. The dramatic difference between the two pharmacist groups resulted in an analysis completed as separate groups. This decreased the power of the decentral pharmacist sample size, but the decentral pharmacist results may still be analyzed with a 90% confidence interval with a 5% sampling error. However, the central pharmacist sample was sufficient to meet the desired 95% confidence interval with a 2.5% sampling error. Pharmacy administration’s analysis of the results was not significantly changed by the change in statistical power. Analysis was not adjusted for multiple comparisons as data was considered to be nonparametric in nature.

Finally, medication safety was not evaluated in this study. The quality of

pharmacist work as measured by identification and prevention of medication errors cannot be assessed with these study results.

Impact of the Results at the University of Utah Hospital

The results of this study allowed pharmacy administration and pharmacists to identify baseline and changes in work functions after CPOE implementation. Central pharmacist observations revealed a reduction in overall time spent processing provider orders. Administrators may evaluate this change as an opportunity to reduce central pharmacist staffing patterns. The adjustments in central pharmacy staffing may result in reduced labor expenses or redeployment of pharmacists to expand other clinical services.

Prior to the study, administrators and pharmacists could only estimate the proportion of time spent on work activities that occupied a pharmacist's work day. For example, decentral pharmacists participated in medication therapy review nearly one-third of the time. This work function had been identified as an area for efficiency improvement. Also, 10% of decentral pharmacists time was spent in education after CPOE. Education is a part of the pharmacy department's mission, and the study allowed administrators to estimate the amount of time spent fulfilling this mission.

Considerations for External Application of the Study Data

The results of this study may allow pharmacy administrators across the country to anticipate some of the changes observed with CPOE implementation. Results may also be used to address pharmacists' concerns regarding the

introduction of CPOE. The results may also be useful to hospitals considering CPOE, but several factors unique to the University of Utah Hospital must be considered.

The pharmacy staffing model at the University of Utah gives decentral pharmacists limited responsibility for medication order processing. Decentralized pharmacists in other hospitals may have more responsibility for this function and should anticipate greater changes after implementing CPOE. Potential changes could allow decentral pharmacists to expand their existing clinical services. Pharmacy departments that share medication order processing between decentral and central pharmacists may realize a greater potential to decrease central pharmacy staffing.

The results of this study can only be applied to a similar CPOE system with similar functionality. The University of Utah Hospital has not implemented clinical decision support as part of the CPOE system at this time. Clinical decision support software will further change the order process at the point of order entry. This may impact the frequency and type of pharmacy interventions made. Clinical decision support may also create an overreliance on technology. Pharmacists may verify orders at a quicker pace based on the assumption that decision support alerts would prevent most problems.

Conclusion

CPOE systems have improved medication safety, reduced health care costs, and improved health provider efficiency. This study provided pharmacy administrators and staff with a better understanding of pharmacist work activities

and the impact of CPOE on pharmacists' daily work. CPOE significantly impacted the proportion of time pharmacists spent on several activities at the University of Utah. This study also provided data for the department to evaluate when considering how to distribute and utilize hospital resources.

APPENDIX A

PHARMACIST WORK SAMPLING CLASSIFICATIONS

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Pharmacist Work Sampling Classifications

Clinical: Pharmacist participating in patient care

- Medical Rounds: includes all clinical activities during rounds (excludes order entry)
- Medication Reconciliation: Performing medication reconciliation (communicating directly with the patient, patients' pharmacy, caregiver/family member, or outside health center); verifying a medication reconciliation performed by a pharmacy intern/student
- Clinical Consultation: Answering drug information question from another health care provider or patient; providing patient education
- Pharmacy Intervention: Making a therapeutic recommendation; intervening with a physician, nurse, or other health care provider regarding use, timing, monitoring, or administration of a medication; reconciling problem orders in Omnilink/sent up from central pharmacy; therapeutic interchange
- Medication Therapy Review: Reviewing a patient's medication profile, performing pharmacokinetic calculations on a medication regimen, reviewing patient information from electronic or paper chart, identification of medication problem

Professional: **Pharmacist performing non-clinical activities required by law, hospital policy, or accrediting body (i.e. Joint Commission)**

- Order verification: Checking medications that have been filled by technicians/interns (includes cartfill and medications for technician to take to floors); verify orders entered into computer; taking/writing a verbal order from a licensed health care professional; clarifying transcription errors
- Education: Training/educating pharmacy resident, student, or intern; participating in staff development, grand rounds, health care in-service; clinical literature search or reading to develop personal knowledge; working on research projects
- Operations: Department meetings; scheduling; work e-mails/communication

Technical: **Other activity pertaining to pharmacy but not considered clinical/professional**

- Medication Dispensing: Filling medication orders; entering orders into the computer; compounding medication; printing an extra label for a lost/missing dose
- Telephone: Using the telephone for issues regarding medication dispensing (not drug information questions); requesting medication from central pharmacy

Other:

- Personal time: Meals; restroom; breaks
- This study
- Idle time: Talking with co-workers; personal internet; transit between units while not on rounds

Pharmacy Work Sampling Data Sheet

Unit: Shift: Date: Pager #: Time in/out: /

Work Activity	Please Check a Box for Each Activity															Total
Medical Rounds																
Medication Reconciliation																
Clinical Consultation																
Pharmacy Intervention																
Medication Therapy Review																
Order Verification																
Education																
Operations																
Medication Dispensing																
Telephone																
Personal																
Idle																
This Study																
Other																

Define “Other” activities:

Comments:

APPENDIX B

INSTRUCTIONS FOR PARTICIPANTS IN THE WORK SAMPLING STUDY

Instructions for Participants in the Work Sampling Study

The objective of this study is to evaluate the effect of computerized physician order entry (CPOE) on workflow. Many methods are available to measure workflow. This study will use random work sampling in order to efficiently and accurately assess changes in workflow. Work sampling will be completed using the Random Reminder pagers. The pagers can be set to vibrate or beep depending on the participants' preference. Each pager is programmed to randomly beep or vibrate a predetermined amount per hour. The amount of notifications per hour will vary based on the unit and shift being assessed. The time that separates each notification may vary throughout the day.

Each participant will have a data collection sheet that includes a list of work activities and definitions of those work activities. These data collection sheets will be available in the participating units throughout the study. Participants will not be identified on the data collection sheets.

This study will be conducted in two phases. The first phase will be completed prior to CPOE implementation. This phase will provide baseline work sampling information. The second phase of data collection will occur 6-8 months following CPOE implementation. The information from both phases will be compared in order to assess the impact of CPOE.

Daily Instructions for Participants in the Work Sampling Study

1. Before beginning your shift, obtain your pager and data collection sheet.
2. Review the work definitions to familiarize yourself with the terms used.
3. Fill in the top of the data collection sheet with the unit, shift, date, and pager number. Each pager is assigned a number in order to help the investigators identify malfunctioning pagers.
4. Turn your pager on at the beginning of your shift. The pager may be set to silent (vibrate) or beep. The silent vibration setting may be preferred as the beep may be missed easily. Record the time that you turn the pager on at the top of the data collection sheet.
5. At each notification, make a check mark in a box corresponding to the activity that best matches what you were doing when the notification occurred. If you are participating in an activity that does not correspond with any activity listed, mark "other" and write the activity in the designated area.
6. Record your work activities throughout the day, including lunch, breaks, meetings, etc.