EVALUATING THE IMPACT OF IMPLEMENTING CLINICAL INFORMATION SYSTEMS

by

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A dissertation submitted to the faculty of The University of Utah in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

Department of Medical Informatics
The University of Utah
May 2006
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ABSTRACT

The implementation of clinical information systems across the healthcare community has been declared as a necessary element to improve the quality and access to patient care. As part of that process, it is imperative that researchers evaluate the impact of implementing these systems to ensure that the desired outcomes are being achieved. This dissertation comprises three scholarly projects that specifically explore the issues surrounding the impact of implementing these systems across various healthcare environments.

The first project involves the development of a conceptual framework to be used as a tool to guide researchers as they consider how to evaluate the impact of implementing clinical information systems. The framework was developed through literature reviews and feedback from a panel of informatics experts. The final version of the framework encompasses three elements of impact (human, technological, financial) that can be considered at four levels of granularity (individual, institutional, trans-organizational, trans-national).

The second project focuses on evaluating the impact of implementing a new pharmacy information system. Qualitative and quantitative techniques were used to evaluate the productivity of pharmacists as they entered medication orders in the old versus the new system. Overall, pharmacists’ productivity was the same across the two systems with the exception that they perceived that they were slower entering orders in the new system.
The third project is a case study exemplifying the financial impact of replacing a disparate set of pharmacy systems with an enterprise-wide electronic health record. In the post-implementation environment a multidisciplinary team identified problems with the process of applying unit conversions to medications prior to billing submission, which temporarily resulted in significant financial losses. This study provides a real-world example of issues that were encountered and the subsequent steps that were taken to rectify the problems as they were discovered.

In summary, all of these projects have been undertaken to further the growth and development of the evaluation processes that are necessary as we strive toward integrated information transfer and improved patient care processes.
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ACKNOWLEDGEMENTS

As I come to the end of this chapter in my academic journey my attention turns toward giving thanks and appreciation to those who have encouraged me to achieve this goal. Starting with my academic mentors these people have been the key drivers in providing me with the skills, the confidence and the vision to pursue my own fulfilling research path. I would like to thank Heidi Dobson, who was my undergraduate thesis advisor; Dr. Daniel Casey, who was my employer as a researcher with the Veterans Administration; Joan Ash, who was my graduate thesis advisor at OHSU; and finally Nancy Staggers who has chaired my PhD committee here at the University of Utah. Each of these individuals has enabled me to achieve personal growth within each of these chapters of my life forming foundational layers of strength and encouragement to pursue this end goal of a PhD in medical informatics.

Next, I would like to thank the National Library of Medicine for providing me with the means and opportunity to contribute to the enhancement of the field of medical informatics. I would also like to thank the other members of my PhD committee who have individually spent a great deal of time and effort throughout the completion of my projects; Scott Evans, Brad Farr, James Jorgenson, and Olivia Sheng.

Finally, to my family who has stood by me with unwavering support as I have made my way through this process. With sound advice and continual belief in my ability to overcome any obstacles they ensured that I would be able to see this journey through. Thank-you, thank-you, thank-you.
CHAPTER 1

INTRODUCTION
1.1 Objectives

In recent years hospitals and healthcare facilities have begun to feel the pressure to introduce integrated clinical information systems (CIS’s).¹ This initiative has been driven by the desire to improve patient safety and patient outcomes while also bringing escalating healthcare costs under control. Pressures have been mounting from various groups: the government with the introduction of Health Insurance Portability and Accountability Act, industry with the initiatives set forth by the Leapfrog group, and consumers. As a result, these interest groups have ensured that the question is no longer whether or not computerized systems should be implemented, but when.

Consequently, the need to evaluate the impact of implementing these systems is becoming even more essential. Unfortunately, more often than not, healthcare facilities focus on setting aside the appropriate resources to purchase and implement systems and leave little time and effort for evaluation. In part, this is because there are always competing information technology (IT) projects; however, evaluations within the field of healthcare have also been overlooked due to the difficulty of identifying what to measure. Unlike banking and other industries that use discrete metrics, such as direct cost savings, people have argued that determining what to target, with respect to how IT impacts medicine, is far more challenging.² The goal of this dissertation is to focus attention on the need for impact evaluations, to develop a tool to encourage their undertaking, and to provide two examples of impact evaluations that can be shared with others enabling them to undertake best practices in their local environments.
1.2 Rationale and Significance

The development of clinical information systems and the automation of medical records has been a vision of many informaticaists for the past four decades. Just this last year, the power of these systems to improve patient safety and patient outcomes finally reached public awareness when the federal government publicly endorsed greater use of these systems as a means to improve patient care throughout our nation. In the advent of the national publicity campaigns and the increased attention being raised, one might expect that CIS implementations would be on the rise; however, recent studies suggest that the adoption rates of these systems are still progressing relatively slowly given their purported potential to improve care.

There are many reasons for the slow adoption rates across the nation, varying from the need to overcome cultural norms within the healthcare community to a lack of financial incentives to implement these systems. However, I would also argue that adoption rates have been slow due to the lack of comprehensive evidence conveying how these systems have impacted the environments and institutions in which they have been placed. Without enough documented measurements and evaluations of these systems, I believe that the adoption rate of these systems will persist in a progressively slow manner.

Therefore, the focus of my dissertation has been to raise the awareness that impact evaluations play an important role in providing helpful information to others as they consider how to implement systems in their local environments. As part of that process I developed a conceptual framework to evaluate the impact of implementing clinical information systems. Up to this point, few conceptual frameworks have been developed
within the field of informatics and, as has been demonstrated in other disciplines, they can serve as helpful tools as evaluators try to make sense of the vast amounts of information that can be gathered. Subsequent to the development of the conceptual framework, I focused my attention on an evaluation study that helped validate my framework. Finally I conducted a financial impact evaluation as these studies have typically been difficult to quantify and I believe the there is a need to attempt these evaluations when possible. Overall, in order to increase the adoption rates of these systems and improve our understanding of their impact we need to provide convincing evidence of accountability, effectiveness, and positive outcomes from implementations. The three projects that were undertaken as part of this dissertation provide a lasting contribution toward achieving that goal.

1.3 References


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CHAPTER 2

A CONCEPTUAL FRAMEWORK FOR EVALUATING THE IMPACT OF IMPLEMENTING CLINICAL INFORMATION SYSTEMS

Danielson E, Staggers N

J Am Med Inform Assoc 2005 (submitted)
2.1 Abstract

Although some excellent models have been developed to evaluate the impact of implementing clinical information system, a comprehensive framework to evaluate impact is not yet available. The development of this conceptual framework was undertaken to address that gap. The Danielson CIS Impact Framework facilitates identification of impact areas, potential confounding variables and it encourages a systematic approach for researchers, leaders and implementers to use as they conduct evaluations.

The framework was developed in several steps: an extensive literature review from medical and business databases was conducted, the retrieved items were categorized into distinct elements and subelements, and finally levels of granularity were added for greater clarity and generalizability across studies. Using affinity diagrams, the first author inductively derived distinct elements and subelements for the impact of clinical information systems. Unique elements and levels emerged and a visual depiction was created.

The Danielson CIS Impact Framework is composed of three elements of impact (Human, Technological, and Financial), their respective subelements, and four levels of impact (Individual, Institutional, Trans-organizational, Trans-national). Evidence for the development and emergent designations of the elements and levels are explained, and an actual study design is presented.

The Danielson CIS Impact Framework is a new tool to guide researchers, system implementers, leaders, and educators as they design and conduct clinical system impact studies.
2.2 Introduction

In recent years healthcare facilities have begun to feel the pressure to introduce integrated clinical information systems (CISs). This initiative is driven by government initiatives, industry groups such as Leapfrog, and by consumers as means to improve patient safety and reduce escalating health care costs. Consequently, the need to evaluate the impact of these implemented systems is becoming even more essential. However, evaluations within healthcare have been relatively sparse due to the cost to conduct studies, the necessary time commitment, and the difficulty of identifying elements of import. Unlike banking and other industries that are able to use discrete metrics, such as direct cost savings, authors have argued that determining what to target, with respect to how IT impacts medicine is far more challenging. Having a comprehensive framework of systems impact could help reduce this challenge.

2.3 Background and Significance

Although few excellent models exist for certain areas of CIS impacts, a comprehensive framework is not yet available. As in other fields, models are simplified frameworks designed to illuminate the specifics of complex processes whereas the goal of a framework is to provide an all-inclusive vision of a topic from a broader more theoretical level. Thus, the framework described here can help guide researchers, systems implementers and leaders in the design of CIS impact studies. Also, informatics educators may find the framework useful to organize evaluation study content for courses and student understanding. This framework should be used at the inception of an evaluation as a means to help determine a study’s focus, identify confounding variables early in design, and encourage evaluators to employ consistent methods of conveying
impact results so that future studies could be better compared. The subsequent steps that are necessary to undertake in the research process, such as research and evaluation methods, have been well documented and discussed by others in the field.\textsuperscript{7,8} Therefore, these issues fall outside of the scope of this framework. Finally, a visual depiction of this framework was developed as a means to provide evaluators with another tool to help organize ideas surrounding evaluations of systems impact. It has been demonstrated that visual representations of complex issues, such as systems impact, have the potential to enhance peoples' ability to make sense of complex issues and aid them as they clearly identify how to synthesize these issues in a new way.\textsuperscript{9}

The goal of this framework is, then, to represent the breadth of systems impact and help evaluators consider the wide array of possible variables. Using this framework, researchers and implementers will be able to: 1) identify elements and levels of impact to evaluate in particular situations, 2) identify related and potential confounding impact variables, 3) build a resource of information that they can benchmark against internally, 4) effectively communicate the results of their experiences with others. Finally, this framework should help organize broader study comparability. Cross-comparative analyses of CIS impact evaluations, whether positive, negative or neutral, are necessary and will become more feasible by using an organizing framework as means to convey study results in a consistent manner.

\textbf{2.4 Formulation of the Danielson CIS Impact Framework}

The content of the framework was derived through literature reviews and the structure was derived though careful consideration of how other models and partial frameworks were developed.\textsuperscript{16,11} Development occurred in four steps: a literature review,
the use of affinity diagrams to categorize impact articles into basic elements, further subcategorization of the elements into subelements and finally the formulation of these unique ideas and elements into a visual depiction with associated levels of granularity.

The literature review returned over 150 articles from medical and business databases. Affinity diagrams were used to categorize these articles into impact elements. As described by iSixSigma, this methodology is often used as a means to discover meaningful groups of ideas within a raw list, which lets themes emerge rather than having preordained categories. From this process, the following foundational elements of impact emerged: Human, Technological, and Financial. They are depicted in a triangular shape, as this shape is conducive to allowing the core elements of impact to interrelate based upon the particular setting and the chosen variables of interest. Further division of the elements into subelements was necessary to provide greater specificity of impact areas as depicted in Figure 2.1. The elements and subelements of the framework are discussed in the subsequent section and supporting evidence for their designation is provided. Articles were chosen as exemplars to illustrate the potential breadth and depth of each element.

2.5 Framework Description

2.5.1 Human element

The impact that information systems have on the human element of the healthcare industry is by far the largest and most complex part of this framework. Not only are the roles of the various stakeholders diverse, i.e., patients, providers and administrators, but they also have different perceptions and expectations of what an information system
Figure 2.1. The Danielson framework for CIS system impacts
should do for them. Both Kaplan and Lorenzi have been leaders in the field of people and organizational issues (POI)\textsuperscript{13-15} emphasizing that successful informatics projects depend more upon POI issues than on the technology itself. Concepts that these authors stressed, along with categories derived through affinity diagrams, were used to help define the sub elements of this portion of the framework. Each subelement will be discussed in further detail and they are as follows: communication, workflow, workload, patient safety, and psychosocial issues.

2.5.1.1 Communication

Researchers have tried to understand how implementing a CIS can impact communications from various perspectives. For example, Patel and Kaufman used a cognitive science methodology to develop sociometric analyses of e-mail communications,\textsuperscript{16} and Coiera argued that it is imperative to understand the clinical communication space in order to model the common ground between a system and human users.\textsuperscript{17}

Other authors have stressed that evaluating how communications are affected by a CIS implementation is “mission critical” to ensure proper patient care.\textsuperscript{18} For example, in one study researchers determined that the introduction of a provider order entry system improved communications between ordering physicians and pharmacists, but, nurses felt the opposite because they were less involved in the ordering process than previously.\textsuperscript{19} These issues can become critically important during implementations and evaluators should be reminded that communication is a bidirectional exchange and impact evaluations will be most useful when multiple perspectives are taken into account.
2.5.1.2 Workflow

Analyzing how workflow patterns change as a result of a new system implementation is becoming more important within the field of informatics. These analyses can help determine if any major disruptions occur within workflow patterns. As Wil van der Aalst (2004) recently described, “Workflow technology has become a mature tool for designing, supporting and monitoring administrative processes. In fact, the focus is now shifting from process automation to process diagnosis and improvement.” CIS workflow impacts include changes to roles and responsibilities, policies and procedures, and overall organizational culture. Process maps and workflow diagrams serve as critical tools that help researchers understand how core processes are impacted over time, determine where bottlenecks occur, and enable them to streamline processes affected by the implementation.

For example, in one study setting researchers were interested in evaluating how the implementation of a new digital radiography system into an Emergency department would impact workflow. They found that the new system changed the bottleneck in work processes from waiting for the films to be returned, to waiting for patients to be positioned for the procedure. In a second example, in Hawaii, the workflow patterns of physicians and administrators were significantly streamlined with the implementation of a CIS that networked information across clinics located on various islands. These examples demonstrate that evaluating how processes change and specifically identifying how peoples’ workflow is impacted can crucially affect the ultimate success or failure of an implementation.
2.5.1.3 Workload

CISs often impact both workflow and workload, including productivity, efficiency and subsequent timesaving for the end-users of the systems. Consequently, evaluations in this area are not uncommon. Frisse provides an exceptional analogy regarding the importance of understanding how technology impacts workload as it pertains to the field of medicine.

Wal-Mart, Amazon.com, and other organizations make effective use of technology by putting their resources where value can be obtained, through better control of their inventory...the inventory of clinical medicine is time and the value gained by information technology may be to allocate the precious resource more judiciously. (p.366)

Workload studies are particularly important when a system has the potential to impact productivity negatively. For example, with CPOE systems, timing studies can be conducted to confirm or deny if productivity is affected by a CIS implementation. In fact, in some cases researchers who have performed these studies have been able to determine that little extra time was required, even suggesting that providers might save time.

2.5.1.4 Patient safety and patient care

A great deal of attention currently is geared toward improving patient safety and patient outcomes. The placement of these issues within the human element of this framework focuses on how a CIS can enhance a caregiver’s ability to make clinically appropriate decision in a timely manner. The two focal areas of interest within this sub-element are: curbing errors including adverse drug events (ADEs), and improving clinical decision making often through the use of clinical decision support systems (CDSSs).
Bates and Guwande described two ways in which information technology can reduce error rates: 1) by facilitating a more rapid response after an adverse event has occurred, and 2) by tracking and providing feedback about adverse events. The information technology systems that have been developed to achieve these goals strive to provide clinicians with pertinent information at the point of care as a means to improve outcomes. Currently there is a great need for evaluators to follow through and determine if in fact positive patient outcomes are being achieved as a result of these system implementations. For example, Evans et al. demonstrated the use of an antibiotic assistant program significantly decreased the number of ADEs, antibiotic susceptibility mismatches, and the incidence of excess drug dosing and Bates demonstrated a 55% reduction in serious medication errors with the use of a CPOE system.

2.5.1.5 Psychosocial

The last area within the human element encompasses sociotechnical and psychosocial issues. Sociotechnical issues refer to interactions between people and technology; more specifically how people use technology to perform tasks. Psychosocial issues tie into this concept by including the emotions that users feel as a result of having to use technological solutions. Some commonly addressed psychosocial issues include attitude, perception, satisfaction, and user acceptance. For instance, Embi et al. conducted an excellent impact evaluation in this area by focusing on how a computerized physician documentation system impacted physicians’ perceptions. Physician’s perceptions ranged from improved documentation availability to decreased confidence in document accuracy. Researchers concluded that the results of the
evaluation would help them assess impacted areas and further enable them to determine
the best strategies to address these issues.

2.5.2 Technological element

This element is broken into two subelements: 1) System quality and 2) Information quality. These two subelements are part of a six category framework developed by Delone and McLean to evaluate successful management information systems and has been adapted to this framework to evaluate the technological impact of CIS implementations in general.

2.5.2.1 System quality

The concept of system quality relates to how well a system is able to process information and the basic characteristics of the system itself. Evaluation of impact areas that would fall under this category include system response time, availability/downtime, security, reliability and rigidity. These issues tend to be highly quantifiable and easy to track via error logs, audit trails and the use of simple software programs that can be embedded into system architectures. Response times and system availability are of particular interest to end-users because time delays directly affect their ability to accomplish their work. Therefore, setting up the appropriate error logs and tracking measures can be critically important in understanding the impact of a CIS implementation.

2.5.2.2 Information quality

Issues that are part of this category relate to input and output criteria: accuracy (correctness and completeness of information), relevance, and formatting issues. The
underpinnings of these outcomes rely heavily on strides that are being made in the areas of programming, standards, knowledge management, database management, data warehousing, and reporting tools. Authors who focus their research efforts in this area\textsuperscript{32-33} found that the variability across CPR studies is often due to differences in study design, in types of data studied, and in the CPRs themselves, concluding that standardized reporting and assessment of information quality is especially needed.

\textbf{2.5.3 Financial element}

Financial constraints continue to be felt across the healthcare industry, reinforcing the need to understand business costs, investments, and the potential revenue streams. Healthcare is faced with greater amounts of variability and uncertainty as compared to other service industries,\textsuperscript{34} but both cost and quality impacts still need to be evaluated as a means to justify the financial investment of systems implementations.\textsuperscript{35}

Traditional ROI assessments have been controversial within healthcare because of the complexity of patient care and the difficulty in translating the benefits of an IT investment in this area directly to a positive ROI. Still, ROI calculations can serve as a common denominator for comparing investment opportunities if returns can be quantified, the investment resources fully estimated, and the investments are amenable to comparison in similar terms.\textsuperscript{34} The goal in discussing ROI is not to suggest that these studies should be conducted in every instance but rather to recommend that financial data should be gathered and quantified when appropriate. These same precepts apply to research efforts that involve cost-benefits analyses as well.

There are three main areas where financial impact can be identified: supplies, labor, clinical efficiency.\textsuperscript{36} Administrative efficiency was also added to the framework, as
CIS implementations can cause changes in this area which are inextricably connected to the financial well-being of any healthcare facility.

### 2.5.3.1 Supplies

Evaluating how the implementation of a CIS can financially impact the use of supplies ranges from the intuitive to the less obvious. For example, facilities converting from a paper-based record system to a computerized system are likely to see an intuitive savings by decreasing the amount of paper purchased. Whereas, a facility that implements a medication/inventory management system may have to consider how they will see cost savings in a host of less obvious ways. For example, the number of misplaced, lost, or stolen items may be reduced but these cost savings may go unnoticed unless they are being tracked. Since supply expenses account for roughly 25 to 35% of hospital spending, it has been suggested that inventory management systems have the potential to save as much as 8 to 14% of that total.\(^\text{36}\) This represents a significant impact with respect to financial savings and institutions could benefit from the knowledge as to whether or not these savings can actually be achieved. Savings could also be seen from better management of the storage and retrieval of inventory, which other service industry leaders, like Wal-Mart, have capitalized upon for years in order to maintain profitability.\(^\text{37}\) For example, Community Hospital of Central California enjoyed almost a 20% supply cost savings after they converted to a pathway-based supply management system in their operating rooms by using just-in-time inventory management. The resultant changes included the use of fewer suppliers, greater utilization and standardization of products, reduced inventory, and more space, leading to reduced overall costs.\(^\text{38}\)
2.5.3.2 Labor

Commonly tracked labor issues include changes to staff overtime, staff ratios, staff mix (full-time, part-time, agency), and productivity. Although the last item has been discussed in the human element section of this framework, changes in an employee’s productivity can also be converted to a dollar amount as well. Although this information can be helpful for benchmarking purposes, converting productivity into dollar values rarely amounts to changes in FTE.\textsuperscript{30} This is due to the fact that time saved doing one task is generally reallocated to the completion of other tasks. Also, FTE reductions in clinical care may be off-set by increases in IT and system support personnel.

2.5.3.3 Administrative and clinical efficiency

Administrative efficiencies refer to the ability to streamline processes associated with the billing and charge capture aspects of the CIS implementation. For example, Taylor et al.\textsuperscript{35} described how changes to a hospitals’ ADT system can impact the ability to increase bed utilization rates, decrease accounts receivable days, and increase bad debt processing rates. Clinical efficiencies refer to the impact that system have on the overall patient care process and how the changes have the capability to financially affect the institution as well. With respect to the area of clinical efficiency, translating these changes into financial terms is more difficult than capturing administrative efficiencies. Surrogate metrics however, can be used to shed light on potential cost savings as they relate to some the aspects of clinical care.

Three of the most common surrogate metrics that have been used to evaluate how clinical efficiencies can be converted into financial impact are length of stay (LOS), test ordering/reordering, and the use of costly medications.\textsuperscript{40} First, LOS calculations can be
readily converted in monetary terms when CISs are implemented and even small reductions in LOS metrics can result in significant financial benefits for an institution. Tierney et al. determined that the impact of implementing a CPOE system resulted in a reduced mean length of stay of .89 days or $887 savings in charges per admission. Second, by providing clinicians with accurate up to date information about tests that have been ordered and their status, providers are less likely to reorder the test again unnecessarily. Third, Tierney et al. also demonstrated that by displaying the costs of tests to physicians the number tests ordered and the costs per test were significantly reduced.

Another way in which clinical efficiencies can be identified involves evaluations in facilities that have implemented CDSSs. In one institution, the introduction of a CDSS alerted physicians of a medication shortages while providing alternative ordering pathways, resulting in a $35,552 annualized cost savings for the institution. Financial impacts that guide clinicians to order formulary drugs, as opposed to expensive alternatives, have also demonstrated significant financial savings as have CISs that enable evaluators to other track surrogate metrics such as ADEs, transcription errors, compliance rates, and preventative care measures.

2.6 Levels of Granularity Within the Danielson Framework

Another defining feature of impact evaluations is that they take place at different levels of granularity: individual, institutional, trans-organizational, and trans-national. Due to the broad spectrum of stakeholders and the varying degrees to which systems are integrated, specifying the level of impact helps further designate the scope and perspectives involved in an evaluation study. Including these levels makes this
framework more robust as suggested by others. The four levels of granularity are represented by concentric rings as seen in Figure 1. These rings are placed within the bounds of the triangular structure to signify that system implementations can result in impact pervading across all four levels of granularity depending upon extent of the implementation and the focus of the evaluation.

2.6.1 Individual level

The most accessible and readily studied level starts with the most granular: the individual. The individual level is defined by evaluations that study a particular group whose results are too specific to generalize to an entire institution. Take for example the situation where a hospital chooses to evaluate how the implementation of a CPOE system impacts their Emergency Department (ED). An individual human impact study might involve evaluating how ED physicians’ attitudes toward the CPOE system change once the system has been implemented. These results can be very insightful but they cannot be generalized to represent the attitudes of all doctors working in the hospital.

2.6.2 Institutional level

Institutional level impact evaluations focus on outcomes that are applicable to the organization as a whole. Evaluations at this level are more likely to be conducted as separate modules of systems are integrated to create enterprise-wide solutions. For example, 7 years after implementing the HELP system LDS Hospital evaluators surveyed over 1300 nurses and physicians to extrapolate what their attitudes were toward the system. With a high response rate, the results from the survey provided a useful institutional level representation of attitudes toward the CIS system.
2.6.3 Trans-organizational level

Common impact studies at the trans-organizational level are likely to include evaluations of community, public and national healthcare issues. These evaluations may use information from disparate systems and which makes studies at this level increasingly challenging. Examples of some of the studies that have taken place at this level include community health initiatives such as tracking influenza outbreaks and national initiatives to thwart bioterrorism using biosurveillance systems.\textsuperscript{47}

2.6.4 Trans-national level

The last level of impact involves evaluations that take place trans-nationally. Although few evaluations are currently conducted at this level, it is included within this framework as the trend toward globalization increases and trans-national health initiatives become increasingly important to evaluate. Some examples include evaluations of telemedicine and systems that have been developed to track pandemics like HIV/AIDS.\textsuperscript{48}

2.7 Initial Validation of the Framework

This framework underwent initial validation of face and content validity when it was assessed by a panel of 5 business and medical informatics experts. The panel's first recommendation was to provide supporting evidence for each element, subelement and level as a means to justify their significance within the framework. The second recommendation was to provide a visual depiction of the entire framework to increase clarity and overall ease of use. Finally, the panel recommended that the framework undergo subsequent validation by directly applying it to the development of an impact evaluation, as described below.
An actual study is presented here to illustrate the usefulness of the framework and how it guided researchers through design, determination of confounding variables, and clear identification of the variables of interest at the appropriate level. The first step was to consider what type of system was being implemented and determine what elements of impact would undergo the greatest foreseeable changes within the context of the implementation. The next step was to determine the appropriate level of granularity that will be studied within the evaluation protocol. Based upon these findings, researchers chose elements and levels of interest while maintaining awareness of the remaining impact areas. These remaining areas represented the issues that researchers needed to control for in the study and helped identify the potential confounders that could have influenced study results.

A large academic medical center in the West recently installed an enterprise-wide, integrated clinical information system. One of the main institutional goals of the new system was centered on replacing a legacy stand-alone pharmacy system with a new pharmacy module that was part of the integrated enterprise-wide solution. The immediate goal of the implementation was to replicate the functionality of the legacy system while providing future potential for expansion to other modules such as CPOE. With these goals in mind, implementers, administrators and end-users were particularly concerned with how the people and processes associated with the implementation were going to be impacted. The inpatient central pharmacists were well adapted to the old system and they entered as many as 1,700 orders each day during the day shift. Because of the national shortage of pharmacists, any negative impact to pharmacists could be disastrous. Therefore, based upon the resources available and the system goals, researchers chose to
study issues associated with the Human element of impact at the Individual level of granularity.

By clearly identifying the focal element of interest at the appropriate level, researchers could then use the framework to drill down to the specific subelements that they wanted to evaluate. This particular transition focused on two subelements of human impact: workload and psychosocial issues. More specifically, the focus was to understand how the system implementation would impact the workload of the pharmacists, i.e., changes in productivity, as well as understanding the impact that it would have on the pharmacists’ perceptions of the system as it pertained to their workload.

The researchers also used the framework to identify potential confounding variables across the other areas of the framework. Within the technological portion of the framework differences in medication order entry speed pre- and postimplementation might be affected if there were differences in technical devices, the network, databases or information quality. However, in this case, the network and devices remained unchanged throughout the transition to the new system.

Other potential confounding variables included the fact that the backend databases did change; however, I/O time and screen changes were not substantially different as determined by the IT department prior to go-live. With respect to information quality, it was noted that individual departments had decided to change the design of their order sets and changes were made to the software formatting to accommodate these changes. Therefore, pre- and postassessments of order-sets were not comparable and they were excluded from the study.
Within the context of this implementation issues associated with the financial element of impact helped raise awareness of confounding variables to consider throughout the study. Although there were some labor changes (some pharmacy technicians went on maternity leave), these changes were not a result of the system implementation itself. This system implementation did not affect any changes to supplies nor did it appear to affect any administrative or clinical efficiencies that would be associated with the outcomes of this study. In summary, the use of Danielson's framework helped researchers in the initial steps of targeting what to evaluate, determining what variables to control, and in the identification of potential confounding variables within the study.

2.8 Discussion

For clarity, the elements and subelements of this framework have been presented in isolation although overlap across the framework is certainly possible. In fact, evaluations across multiple dimensions are encouraged to help provide a more complete understanding of how CISs impact the healthcare industry. For example, Mekhjian et al\textsuperscript{49} used pre-and postcomparisons to evaluate the benefits of implementing a CPOE system in conjunction with an electronic medication administration records system at both the institutional level and trans-organizational levels. Authors focused on two of the core elements, human and financial using time-and-motion studies to determine productivity and workload and they used LOS and cost data across institutions to determine administrative efficiencies within the financial element of impact. Depending upon the resources and setting of each individual implementation different elements and levels of impact are possible to study. The use of this framework helps evaluators
determine what issues they face within an implementation and it allows for greater clarity as they strive to evaluate each aspect to the fullest.

2.9 Conclusions

This framework can aid researchers and implementers as they evaluate CIS impact and guide the development of the study criteria by enabling researchers to identify several elements: what data are needed, what factors to control for, and what factors may represent confounding variables. By raising awareness of these items from the beginning of the evaluation process, researchers will have a greater opportunity to develop appropriate study methodologies, control for confounding variables and present robust reliable results of their impact evaluations within and across organizations. The framework may also facilitate cross-comparative assessments by acting as an organizing mechanism for the consistent portrayal of study variables and results.

2.10 References


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CHAPTER 3

EVALUATING THE IMPACT OF IMPLEMENTING AN INTEGRATED PHARMACY SYSTEM ON PHARMACISTS' PRODUCTIVITY IN AN ACADEMIC MEDICAL CENTER'S CENTRAL PHARMACY

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Am J of Health Sys Pharm 2005 (submitted)
3.1 Abstract

The purpose of the study in this chapter is to evaluate changes in pharmacists’ productivity as they entered orders in a stand-alone pharmacy system versus an enterprise-wide vendor-based solution.

A time and motion methodology was employed to quantitatively evaluate the impact of implementing the new system with respect to changes in pharmacists’ productivity. Pharmacists working in an academic medical center’s central pharmacy were timed as they entered orders pre-and postimplementation and comparisons were made by the following medication order entry types: “All” medication orders per patient (n=293 pre; n=280 post), “New” single orders (n=112 pre; n=86 post), and “Discontinued” single orders (n=17 pre; n=18 post). Qualitative techniques were also used to capture how the implementation of the new system impacted the pharmacists’ perceptions of their productivity.

From the quantitative portion of the study, there was no significant difference in pharmacists’ productivity when entering All medication orders. However, pharmacists were significantly faster (26%) in processing New single medication orders in the old system as compared to the new whereas the data suggest that they could enter Discontinued orders quicker in the new system. Results from both the qualitative portion revealed that the pharmacists’ perception of the new system encompassed both positive and negative impacts of the implementation. Positive impacts included the perception that certain processes (accessing patient records, reactivating medications and accessing other patient specific information) were easier with the new system. However, the predominant
perceived impact was that the pharmacists felt as if the new system had negatively affected their productivity.

This study demonstrated that this was a successful implementation that lay the foundational framework for the rest of the vendor based system to build upon. The initial goals of the implementation were met with little to no repercussions in productivity and the organization was one step closer to realizing future benefits from an integrated solution.

3.2 Introduction

The implementation of integrated clinical information systems (CISs) in healthcare organizations has become a recognizably important initiative to improve patient safety and patient outcomes while constraining escalating healthcare costs. In order to achieve this goal, healthcare facilities have been forced to assess what type of CIS architecture they can support with three simplified models to consider; a home-grown solution, an integrated/interfaced best-of-breed solution, or an enterprise-wide vendor-based solution. Although there are pros and cons to each of these options, organizations must choose the most appropriate solution based upon their available resources, capabilities, and long-term strategic plan.

Currently, many healthcare facilities are opting to implement an enterprise-wide vendor-based solution as a means to achieve the goals of an integrated CIS while minimizing the overall perceived risk to their institution. Some of the reasons include a lack of qualified in-house staff to develop, support, and maintain home grown solutions; a lack of expertise to interface disparate systems; or the fact that single vendor-based solutions may provide more cost-effective pricing structures to an institution.
Regardless of the underlying issues surrounding the selection of an enterprise-wide solution, all institutions that select this option will face hurdles throughout the implementation process. Intrinsically system implementations require the understanding that current hospital practices will change and therefore challenges associated with the transition process will arise. \(^{55}\)

In order to better understand the changes that take place during this transition process, it is imperative that researchers evaluate the impact of implementing a new CIS. \(^1\) Evaluating the impact of the system can provide useful information to the institution in a multitude of ways depending upon the chosen focus of an evaluation. For example, some impact evaluations can reveal if the goals of an implementation are being met, expose any discrepancies between real versus perceived impacts, identify areas that may need improvement, or provide information to others as they consider implementing similar systems in their respective environments.

3.3 Rationale and Purpose for the Study

3.3.1 The systems

The Information Technology Service (ITS) Department of a large academic medical center in the West developed a strategic plan to have an integrated computer solution for all clinical applications throughout their facility. Over a period of several months, and with extensive evaluation, an enterprise-wide vendor based solution was selected.
3.3.1.1 Preimplementation

The preimplementation pharmacy information system was a DOS-based medication order entry system that was used in the central pharmacy for over 10 years. It was a character-based user interface with menu and table driven command prompts. It was designed by a company that was acquired by the Cerner Corporation in 1993 and can still be supported as a stand-alone product (although it is no longer profiled as a featured Cerner solution). This system was interfaced to a limited number of other systems such as the admission discharge and transfer (ADT) system for direct patient information identification, and to the billing system. Other core hospital information systems could be accessed by logging into separate software applications, which were also accessible to the pharmacists via the same thin-client terminals.

3.3.1.2 Postimplementation

The postimplementation pharmacy information system was developed by the Cerner Corporation as part of their initiative to develop an enterprise-wide integrated solution. This new system has a graphical user interface with a medication order entry system that is directly integrated with the rest of the hospitals core clinical information systems. During the initial phase of the implementation this system was linked to laboratory, clinical documentation and ADT modules with subsequent links to take place to the radiology, electronic medication administration record (e-MAR), and computer prescriber order entry modules (CPOE) as they were implemented.

Within the context of impact evaluations, many institutions have reported on the changes that take place as a result of transitioning from a paper-based solution to a computerized solution.\textsuperscript{56-60} However, there is a paucity of literature discussing some of
the impacts associated with the replacement of one system with another and this replacement will become more common with pharmacy applications. This type of transition has particular relevance during an era of system to system upgrades from stand-alone solutions, that have been hand picked by individual departments, to an enterprise-wide vendor-based solution, that will directly connect to the rest of the organization's core clinical information system. As more facilities make the decision to implement an enterprise-wide solution there is a greater need to analyze these experiences and share the results with others for a better understanding of this paradigm. Therefore, this situation provided the opportunity to evaluate and report upon the impact of replacing a stand-alone solution with an enterprise-wide solution.

Another relevant issue related to this system to system upgrade involved switching user interfaces. Interface design can play an integral role in the overall success or failure of an implementation and recognizing issues related to these interface changes can be insightful. The two interfaces involved in this situation were a character user interface (CUI) in the older legacy system and a graphical user interface (GUI) in the new system. Many studies have been conducted to compare and contrast differences between these two interfaces although the results across studies have produced variable results. Some of the generally accepted principles that have emerged are that command-line users initially have more difficulty learning how to use the system but data entry can be faster since users are only required to use a keyboard. In contrast, GUIs are said to be more intuitive to the end-users regardless of previous ability but data entry may be slower because users are required to use a mouse, which requires point and click data entry, as well as keyboard. Although these may be the generally accepted trends when
comparing these two interfaces the evidence is not conclusive and questions still arise as to whether productivity of end-users predictably differs between the two.\textsuperscript{64-66} Therefore within the context of this system implementation, since pharmacists and administrators did not want the new system to negatively impact productivity, evaluators focused on determining if the productivity of the end-users would be affected by the introduction of the new system.

3.3.2 Conceptual framework and hypotheses

In order to determine appropriate variables to measure within this paradigm (i.e. replacing a stand-alone solution with an enterprise wide solution) a conceptual framework of systems impact was used. The framework was developed by E Danielson and it conceptualizes three basic elements of impact that can be affected by a CIS implementation: human, technological, and financial (currently under review). The framework also designates four levels of granularity that can be impacted; individual, institutional, trans-organizational, trans-national (Figure 2.1). The specific identification of these characteristics, elements and levels, within this impact evaluation helped facilitate a clear study focus and greater ease of comparability across impact evaluations as they are reported.

Based upon the resources available and some of the basic tenets of this phase of the clinical information system (CIS) implementation, researchers chose to study issues associated with the human element of impact at the individual level of granularity. In this case, the main institutional goals of implementing the new system were centered on replacing the legacy stand-alone pharmacy system with a new pharmacy module that was part of an integrated CIS. The immediate goal of the implementation was to replicate the
same functionality of the legacy system while providing the future potential to improve processes and patient care via the integrated enterprise-wide solution. Particular attention was geared toward ensuring that the new system did not overstress the current pharmacy staff and in the advent that it did administrators wanted to have the evaluative results available to create another position if necessary. During an era of pharmacist shortage, these issues and the concern over potential staffing issues that might arise as a result of the implementation gave rise to the desire to obtain appropriate information that would enable informed decisions to occur.67

As mentioned previously with these goals in mind, implementers, administrators and end-users were mainly concerned with how the people and processes associated with the implementation were going to be impacted. Within the human element of impact, the framework further subcategorized this element into five subelements: communication, workflow, workload (which includes productivity), patient safety issues, and psychosocial issues (which include peoples’ perceptions). In order to address some of the questions and concerns surrounding this particular transition from one system to another, two subelements of human impact were selected: workload and psychosocial issues. More specifically, the focus was to understand how the system implementation would impact the workload of the pharmacists, i.e., changes in productivity, as well as understanding the impact that it would have on the pharmacists’ psychosocial perceptions of the system as it pertained to their workload. Subsequently, two study hypotheses were generated as means to focus on these issues: (1) central pharmacists’ productivity during medication order entry will be significantly different (higher or lower) between the stand-alone legacy system and the enterprise-wide system; (2) central pharmacists’ perceptions
of their productivity as related to medication order entry will be different between the two systems.

Whether the findings from this study were positive or negative, determining the impact of transitioning from a stand-alone solution to a vendor-wide integrated solution provides useful information both internally as well as externally to researchers in general. Internally, study outcomes will allow implementers to determine if the initial goals of the system implementation were met. It will also allow them to set appropriate expectations with respect to the impact that the system has on workers’ productivity and to make necessary modifications to the system or work processes if necessary. Externally, with the likelihood of enterprise-wide vendor-based solutions proliferating, this study will help fill the void with respect to the paucity of literature available describing a system to system implementation. This study will also serve as an example of the potential impacts that can occur during this type of implementation and will provide other researchers with ideas as to how they can ensure positive outcomes as they implement these systems in their particular settings.

3.4 Methodology

3.4.1 Setting and subjects

The institutional review board of the academic medical center approved this study in the spring of 2003. The study took place in the central pharmacy of the medical center which is a 400 bed tertiary care teaching hospital. The go-live date for the new pharmacy system took place in May of 2003 in a cut-over implementation style. The subjects for the study consisted of all six fulltime dayshift central pharmacists. All of the pharmacists had
worked in the central pharmacy for more than 5 years with a relatively consistent 5 day a week work schedule.

Throughout the implementation the overall medication ordering process within the central pharmacy remained the same: orders were faxed to the central pharmacy from all floors and units throughout the hospital, the pharmacists pulled the orders sequentially as they were received and they would begin entering the orders into the CIS. All front-end as well as backend components of the system architecture also remained the same across the length of the study, i.e., same thin clients, operating system, servers, databases, and network speed, which helped ensure excellent internal validity to the study and the findings.

3.4.2 Quantitative methodology: time and motion study

A time-series methodology was chosen to quantitatively measure pharmacists’ productivity with respect to the medication order entry process pre and post implementation. Productivity was defined as the total amount of time required to enter an individual patient’s medication order into the pharmacy system. Benchmark data were collected one month prior to the new systems go-live during the second week of April 2003. Each day a trained observer shadowed one of the six pharmacists in the morning from (7am until 12pm) and timed them with a stopwatch as medication orders were entered. Timing began as soon as a pharmacist accessed a patient’s record on the computer and ended with the last keystroke that completed the medication order entry process. Total elapsed time as well as the number and type of medication orders were recorded on daily log-sheets, which were transferred to computerized spreadsheets each night. The collection of specific medication order types was decided upon from feedback
provided by the pharmacists as well as previously published literature. The basic medication order designations collected were: all, new, and discontinued. Although order-sets were also identified as a separate type of medication order to consider, ultimately they were excluded from this study due to the fact that individual departments took the initiative to create new potentially more complex order-sets in the post-implementation setting. Therefore, these orders were not included as a means to preserve consistency across the pre and post implementation setting.

The postimplementation review process followed the exact same protocol and the same six pharmacists were observed. Evaluators chose a 6 month postimplementation review interval to allow initial “bugs” in the system to be corrected and to allow the pharmacists enough time to feel comfortable with the new application.

3.4.3 Qualitative methodology: observations and focus group

3.4.3.1 Observations

Direct observations were used as means to qualitatively capture pharmacists’ perceptions of their productivity. The observer played a passive role and recorded issues that arose with respect to the medication order entry process as well as pharmacists’ verbal comments regarding their perceptions of the system. This approach was used as a means to capture unanticipated relevant issues that pertained to the pharmacists’ perceptions of the system in a non-obtrusive format. The goal was to capture each respondent’s views and perceptions in his or her own words while obtaining clarification only when necessary. The observations and pharmacists’ comments were recorded on the same daily log-sheet as the time and motion study and then transferred into a computerized summary sheet each night.
3.4.3.2 Focus group

A focus group was also conducted with the same six pharmacists 1-year post implementation of the new system. A moderator was used to introduce general topics related to the implementation while enabling the subsequent discussion to flow freely from the pharmacists as they discussed how they felt about the system. The moderator then listened and recorded the feedback generated during these conversations. The goal in using a multimethod approach within the qualitative portion of this study helped in the process of triangulation, which is an approach used to verify the reliability and validity of the qualitative results. The purpose of triangulation within this context was to confirm findings obtained during the observation periods as they converged with issues discussed during the focus group session to reduce the intrinsic biases associated with these qualitative techniques when presented alone. The results from the time and motion study were also revealed at the end of the focus group session as a means to gain further insight from the pharmacists and to give them feedback on quantitative outcomes of the study.

The results from the observations and focus group session are discussed in tandem as the combined results were used to triangulate and verify reliable themes that emerged with respect to the impact of the implementation on pharmacists’ perceptions of the system. Themes were initially identified from the focus group session by considering the internal consistency of the discussion and the frequency and specificity of certain ideas. Results from the observations and pharmacists’ direct quotations were then used to verify the themes and validate that they were representative of the pharmacists’ perceptions.
3.4.4 Statistical analysis

Order entry comparisons were made by medication order type (all, new, discontinued). To account for the correlation structure in the data, where order times within the same pharmacists would be more alike than between pharmacists, a random effects linear regression model was fitted to the data. The Shapiro-Wilk test for normality of the data was used to determine that the original data was severely skewed. Due to the fact that the untransformed data violated that normality assumption of the regression model with a p value of less than .001 for both variables a log transformation of the original data was performed, normalization was achieved and regression analyses were conducted. All statistical calculations were performed using Intercooled Stata 9.0 statistical software.

3.5 Results

3.5.1 Time and motion study

The pharmacists were observed for a combined total of 17 hours during the pre-implementation time period of which they spent a total of 7.5 hours specifically entering medication orders. During that time, 293 patient records were accessed and a total of 635 medications orders were entered (often with multiple medications orders entered for each patient). Postimplementation, pharmacists were observed for over 19 hours during which pharmacists spent 8.5 hours entering medication orders. During that time a total of 280 patients records were accessed and total of 585 medication orders were entered.

The results from timing the medication order entry process are broken down by the following medication types: All medication orders (n= 293 pre; n=280 post), New single medication orders (n= 112 pre; n=86 post), and Discontinued single medication
orders (n = 17 pre; n = 18 post). Table 3.1 shows the median difference in the time it took the pharmacists to enter the orders based upon medication order type. Results from the analysis of “all” medications, the time it takes the pharmacists to enter all medication orders for a patient, revealed that there is no significant difference in median order entry time between the two systems (p = .53). These results demonstrate that there was no significant difference in the overall amount of time it took the pharmacists to process the faxed medication orders for each patient.

When the medication orders were analyzed by “new single” and “discontinued single” order types, differences in the pharmacists’ productivity between the two systems were revealed. Based on the estimated medians from the log transformed regression model the new single medications were entered in the old system 26% faster (95% CI, 3%-43%) than the new system with the following median order entry times: pre-implementation 54 seconds, postimplementation 66 seconds (p = .026). Results from the median order entry times for the discontinued single orders suggested that the pharmacists were more productive in the new system (roughly 43% faster). Although this

Table 3.1. Pharmacists’ median medication order-entry time pre- and postimplementation

<table>
<thead>
<tr>
<th>Medication type</th>
<th>Pre</th>
<th>Post</th>
<th>p-value (two tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All</td>
<td>99 [88, 110]</td>
<td>100 [88, 111]</td>
<td>.530</td>
</tr>
<tr>
<td>New single</td>
<td>54 [45, 62]</td>
<td>66 [56, 76]</td>
<td>.026</td>
</tr>
<tr>
<td>Discontinued</td>
<td>38 [26, 49]</td>
<td>26 [15, 38]</td>
<td>.033</td>
</tr>
</tbody>
</table>

p < .05 for difference between median order entry times using a random effects linear regression model
trend is tenable, it should be noted that the sample size of discontinued single orders was not sufficiently powered to conclude the statistical probability of this outcome.

3.5.2 Observations and focus group

The results from the qualitative portion of the study revealed that the pharmacists had both positive and negative perceptions of the new system implementation. In the following section, each theme is described, key findings are highlighted and representative comments and observations are provided as supporting evidence.

3.5.2.1 Positive perceived impacts of the system implementation

3.5.2.1.1 Finding patients in the new system is quicker. The pharmacists felt as if they could find patients within the new system faster and easier than the old system. Notes taken during the observation period confirmed these sentiments. In the old system pharmacists had to select the appropriate patient based upon one patient characteristic; either a patient’s medical record number or the patient’s name. However, problems often arose as medical record numbers could be difficult to read off of the faxed medication order sheets or there could be multiple patients with the same name staying in the hospital. In these situations pharmacists would have to call to find out more patient information or guess which name was correct and read through the chart to verify that indeed the medication orders matched the profile of the patient and their clinical history. With the new system, the correct patient could be found using multiple patient characteristics. For example, the pharmacists could search for a patient based upon the floor or unit the order was coming from, by patient name, by medical record number, or
by financial account number. From the focus group session it was reiterated that all of the pharmacists appreciated the ability to identify the right patient using these new features.

3.5.2.1.2 Tracking the medications. The pharmacists felt as if it was easier for them to accurately track a medication order’s history in the new system. They could easily identify who accessed a patient’s record, who had entered or modified a medication order, and at what times. This information was helpful as it provided a more complete patient history further enabling them to fill appropriate medications for the patients in a timely manner. Although the old system had some of the same functionality, the layout and ease with which this information was assimilated were not as readily accessible. The information was stored on multiple screens and the pharmacists needed to navigate through multiple menus to derive the same information.

3.5.2.1.3 Discontinuing and reactivating medications. The pharmacists appreciated the fact that the new system allowed them to copy and paste medications as a means to discontinue them or easily reactivate them in one step. From the observations this feature was noted to be particularly useful in the situation where patients needed to discontinue their medications prior to surgery and then postoperatively have the same medications reactivated. With the new system’s graphical user interface, pharmacists could simply highlight all of the appropriate medications, discontinue or reactivate them and be done. Whereas, with the legacy character user interface system each item needed to be changed in sequential steps individually.

3.5.2.1.4 Direct access to other systems is helpful. The pharmacists felt that having direct access to other patient specific information was helpful. A quote from one of the pharmacists supported this notion when she said, “The laboratory data is quick and
easy to lookup (in the new system) and is especially useful when I am ordering something like Vitamin K.” In that situation she was referring to the need to check laboratory data to prevent the possibility of an adverse drug event if the patient’s laboratory values were not within appropriate levels. Although the pharmacists did not access other information systems too frequently they all appreciated the fact that they did not have to log in and out of separate applications in order to access other patient specific information.

3.5.2.2 Negative perceived impact of the new system

3.5.2.2.1 Pharmacists’ productivity. In lieu of the positive impacts noted above, the most dominant theme that was vocalized by all of the pharmacists was that they felt as if they were slower and less productive with the new system as opposed to the old one. From the outset there was concern that they were not going to be able to enter orders as quickly for various reasons: issues associated with interface changes, the fact that they were going to have to learn how use a new system, and they liked the old system that they originally had. Some of the comments made during that preimplementation phase support these sentiments such as “the system we have now is so fast and easy I don’t see how the new system can be better.” Or “I can enter the orders without even looking at my hands, but we have been told that with the new system we are going to have to use a mouse thing.” During the postimplementation phase the pharmacists continued to feel as if they were not as productive with very frank comments like “we are much much slower with this (new) system.” Or “this (new) system is way worse.”

At the end of the focus group session, the results from the time and motion study were also revealed to the pharmacists. They were all surprised by the result that there was
no significant impact on their overall productivity between the two systems. A roundtable discussion followed as a means to figure out why their perceptions were different than the actual timed results of the study. Issues raised during this session are considered in the discussions section of this manuscript. Overall, the results from this portion of the study helped confirm that the second hypothesis of this study is true; the pharmacists’ perceptions of the two systems differed revealing both positive and negative impacts as a result of the system implementation.

3.6 Discussion

This study demonstrates that the replacement of a stand-alone pharmacy information system with an integrated pharmacy system is a complex process with multiple impact outcomes. From the most general assessment of the medication order entry process, there was no significant difference in the pharmacists’ productivity as it related to their ability to process each patients faxed orders. This was an important outcome to determine in an era where medication order entry and medication turn around times need to be kept to a minimum. Therefore, from the first portion of the study others contemplating a similar system to system transition might infer that there would be little impact on workers productivity. As we know central pharmacists work in a stressful environment where streamlining work processes and improving efficient work practices have become imperative and any disruptions can have significant repercussions as delays in medication ordering, distribution, and dissemination can snowball into affecting the quality of patient care and patient outcomes. As a global outcome, results from this portion of the study revealed that that this implementation did not appear to affect the overall productivity of the pharmacists.
That being said, upon further analysis of more specific medication order types (new single and discontinued single) this study also revealed that actual changes in the pharmacists' productivity could be detected between the two systems. These finding are of particular importance as they help explain why the perceptions of the pharmacists were so different from the global outcome that their productivity had not changed. From the results comparing the pharmacists’ ability to process the new single medication orders, we determined that they were able to enter orders 26% faster (i.e., 12 seconds faster) in the old system as compared to the new one. Extrapolating this point a bit further, we know that on average 1100 medication orders are processed in the central pharmacy during the day shift, of those about 1/3 are new single medication orders which means that each of the 6 pharmacists processes about 60 new single medication orders per day. Considering the 12 second median time differential to enter a new single medication order between the two systems, the accumulative affect is that it takes each pharmacist roughly 12 minutes longer per day to enter these orders in the new system. Not only is the time differential empirically statistically significant but it helps to explain why the pharmacists’ perception, with respect to their productivity, was negatively affected by the new system implementation.

Subsequent research needs to be conducted to determine specifically why the pharmacists were slower with the new system but the following explanations are possibilities to pursue as derived from the qualitative portion of the study. One of the most basic explanations involves the difference in interfaces between the two systems, keyed entry may have been quicker as compared to the need to point and click multiple times with the new system. Another possibility involves the fact that the pharmacists
might be accessing other information resources that are connected to the new system, i.e. labs and radiology modules as a means to validate the need and appropriateness of the new medication activation.

With respect to the discontinued medication data trends suggest that the pharmacists were quicker with the new system. As the pharmacists discussed in the qualitative portion of the study, they found that the process of discontinuing and reactivating medications in the new system was easier. Although the pharmacists were generally referring to the ability to highlight and modify multiple medications with greater speed, the same principle applied to the process of discontinuing a single medication as well. The process changed from the need to flip through multiple screens to discontinue a medication in the old system to one screen flip and one mouse click in the new system. However, due to the uncommonness of entering a single discontinued order, this increase in productivity when processing these orders was not sufficient enough to override the aforementioned decrease in productivity that the pharmacists felt with respect to entering orders in general.

Other factors are also important to consider in order to gain further understanding as to why the pharmacists perceived that they were less productive with the new system. In this situation one of the key factors that should be discussed involves the fact that this study took place in a real-world setting as opposed to a simulated environment. As Anderson points out, in real practice settings information systems are complex involving not only information technology but the organizational environment, both of which are dynamic and changing over time. Although the researchers tried to ensure internal validity with respect to the order entry process, in this situation other organizational
changes took place within the central pharmacy between the pre-implementation and post-implementation evaluation periods that were not able to be preemptively controlled. The workflow of the pharmacists themselves did not change over the course of the study though workflow changes did occur with respect to support staff and pharmacy technicians. One of the results of these role and responsibility changes affected how incoming calls were handled in the pharmacy. As a consequence, it appeared that the pharmacists were more likely to be interrupted while entering medication orders during the post-implementation evaluation period. Research has shown that interruptions that take place during cognitively complex tasks, like medication ordering, disrupt a person’s working memory. These disruptions force individuals to redirect and re-prioritize their focus and their perceptions with respect to task completion suffer. Therefore, in this case, the increased number of phone interruptions that occurred in the post-implementation environment may have negatively influenced the pharmacists’ perceptions of their productivity.

Another factor that may have influenced the pharmacists’ perceptions of their productivity pertained to some of the fundamental aspects of the implementation itself. In this situation, the pharmacists realized that this transition from their stand-alone legacy system to the new system was not going to offer them any initial benefit in relation to their ability to get their work done. As Stead and Lorenzi point out, it is important to relay how a new system is going to add value to the end-users to ensure their commitment to achieving the overall vision of improving the patient care process. During this phase of the implementation, a lot of the focus was channeled on the short term inconveniences, such as having to learn how to use a new interface, as opposed to
the long term vision of implementing an integrated solution to streamline processes, enhance communication and ultimately improve patient care. As Vogel points out, gaining value from the IT investment, specifically with respect to productivity, hinges upon how well technology is deployed and how willing an organization is to address necessary changes in business processes as a means to realize true value. In this situation, one of the key methods that could have been used to alleviate the development of negative perceptions would have been to involve the pharmacists a lot earlier in the implementation process. Early involvement of leadership and decision making responsibilities allows the end-user to feel as if they have influence and control over the process. Research has shown that small concessions like these can go a long way toward gaining better end-user acceptance of a new system, improving work processes, and achieving positive psychosocial outcomes. This is especially true when you are taking away a system that users are fond of and replacing it with a system that was chosen by administrators. As Ash et al. discovered, “A recipe for failure seems to be the imposition on clinicians of a system that will help the hospital but not help them.” Therefore, involving the end-users in the process of building trust and confidence that the new system is being implemented to improve clinical care will help in gaining a positive perception of the system overall.

In general, this study demonstrated that understanding the impact that a system implementation can have on productivity is a complex set of interactions. Even though the quantitative results of an evaluation can appear straightforward it is important to break them down and consider them in tandem with some of the psychosocial elements of impact as a means to decipher greater clarity of some of the subtle discrepancies in the
results. Impact evaluations that utilize a multimethod evaluation approach are more likely to enable researchers to accurately assess the impact of the implementation, draw the right conclusions, and share ideas with others as a means to avoid some of the same potential pitfalls.

3.7 Study Limitations

There were limitations in this study. The data were collected only at one institution and there were a limited number of pharmacists to observe. Only six fulltime pharmacists worked in the central pharmacy during the day. This small number was a limiting factor in relation to the generalizability of this study. In order to overcome this limitation each subject was observed for an extensive period of time as a means to increase the sample size of medication orders entered and appropriate statistical modeling was run to ensure the validity of the quantitative results.

In addition to these limitations, it is also acknowledged that the individual researcher-observer was aware of the study hypotheses. Although this individual did not have a vested interest in a particular outcome, it is possible that biases were introduced during the data collection or analysis phase of this study.

3.8 Future Research

Future research opportunities include continued assessment of pharmacists’ perceptions as the rest of the enterprise-wide solution is implemented. For example, it is possible that the pharmacists’ perceptions of the system may continue to change as additional modules, like the e-MAR and CPOE, go-live and operations become more streamlined. Another option would be to evaluate some of the other elements of impact
that are part the conceptual framework that was used to help guide this study, such as the financial or technological impact of implementing the enterprise-wide solution. The more information that is gathered across various elements and levels of granularity, the more robust the evaluation of this systems impact will become. Many facilities are looking to implement enterprise-wide vendor-based solutions in the future and the more information that we can share the more accurately we will be in setting and achieving appropriate expectations.

3.9 Conclusions

The paradigm of replacing a stand-alone solution with integrated enterprise-wide solutions is anticipated to produce positive impacts throughout the healthcare industry. This study represents a small piece of the necessary evaluation process to make sure that these goals are being met. In this case all forms of potential impacts were recognized within this phase of the implementation process; positive, negative and no impact at all. Ultimately, this was a successful implementation that helped lay the foundational groundwork for the rest of the enterprise-wide solution to be built upon and it demonstrates that care should be taken when designing and evaluating system implementations to ensure that accurate impacts are recognized. This process will enable necessary modifications to the system or the implementation process to take place, and effective conveyance of research outcomes to occur as a means to improve the odds of successful implementations in the future.

3.10 References

1. IOM committee calls for complete revamping of health care system to achieve better quality. Qual Lett Healthc Lead 2001; 13:14-5.


CHAPTER 4

ENSURING SUCCESSFUL REIMBURSEMENT AFTER IMPLEMENTING A NEW PHARMACY INFORMATION SYSTEM

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Am J of Health Sys Pharm 2006 (submitted)
4.1 Problem

Pharmacy departments are facing the need to introduce new information systems or upgrade current ones as a means to improve the continuity of patient care, safety, and outcomes. During the implementation of these new systems it is not only important to ensure that clinical outcomes such as patient safety and quality of care are maintained or improved upon, but it is also imperative that pharmacy departments address the complex issues associated with the financial impact of implementing these systems. Through firsthand experience, the focus of this chapter is to illuminate some of the financial issues that one healthcare organization faced as they transitioned from an architecture of multiple disparate pharmacy systems to an integrated enterprise-wide solution.

4.2 Background

At the time of this project a large academic teaching hospital in the West decided to purchase an enterprise-wide Electronic Health Record (EHR) to replace their existing systems. This decision was based on the desire to streamline processes, improve the quality of patient care and reduce their overall healthcare expenditures throughout the institution. As part of this process, various modules of the EHR are being implemented over a five-year period with the ultimate goal of an integrated single vendor solution with provider order entry and seamless access to a patient’s entire medical record. In order to achieve this end, one of the foundational layers was the computerized pharmacy module. As a key revenue center for the institution, this module needed to be carefully evaluated to ensure that accurate charge capture would be retained.

The overall structure of the pharmacy system included 3 hospitals, 2 clinic satellite pharmacies and 11 retail pharmacies. Multiple pharmacy information systems
were utilized to accommodate the local needs of the individual pharmacies throughout the organization. All of these systems then funneled their information through a home-grown intermediary database that was used to format the information for transmission to the billing system. Figure 4.1 provides a simplified version of how this complex set of systems and processes from medication ordering through billing was achieved in the preimplementation environment as compared to the postimplementation environment.

System A was the primary system used for processing inpatient medication orders, System B encompassed the use of medication dispensing devices placed throughout the hospital units and clinics to accommodate both inpatient and outpatient high volume medication orders, and finally System C was a retail pharmacy system that had been modified to handle two outpatient satellite pharmacies needs (the eye center and the cancer institute.) All three of these systems were customized to some extent over the years to accommodate the requirements of the end-users in each of the local environments. In order to transfer the ordered medication information from these three disparate systems to the financial billing and accounting system in the appropriate format for reimbursement, a home-grown intermediary database had been developed. The database was created by the central pharmacy manager in charge of finance and billing.

The intermediary system was created to address a crucial gap in processing capabilities between the disparate pharmacy systems and the billing system. This system was an integral part of preprocessing of medication orders before they were transferred to
Figure 4.1. Comparison of pre- and postimplementation system architectures
System A = inpatient, System B remote dispensing units, System C modified retail outpatient
the billing department for over 10 years. Throughout that time, complex algorithms were programmed into the system to handle issues between the pharmacy department and patient accounting that had evolved over time. Not only had the complexity of the organization grown, but legislative mandates, such as the Balanced Budget Act of 1997,\(^1\)\(^3\) had forced specific modifications to the medication ordering and reimbursement processes to take place.\(^4\) Some of the primary functions that the intermediary system achieved were: detecting appropriate inpatient or outpatient billing status, rectifying date of service discrepancies, reformatting medication orders for reimbursement by third party payers (especially relating to maintenance of Medicare reimbursement codes and unit conversions), and auditing the orders to ensure that reimbursements were within reasonable limits. This solution had worked well in handling of the evolving needs of time; however, problems associated with this system were on the horizon. Namely, the pharmacy manager who created and maintained the system wanted to retire and the university had decided to implement the enterprise-wide EHR.

Within the pharmacy department, these decisions represented the opportunity to replace two of the pharmacy systems, System A and System C, with the new EHR solution and to completely eliminate the intermediary system. Although this was a seemingly good time to decrease the complexity of the medication ordering/reimbursement process, there were significant difficulties to overcome: no one but the single pharmacy manager understood exactly what the program that he had developed did, the application was written in dBase II which most programmers had abandoned years before, and this manager was retiring so there was very little time to understand the complexity of his algorithms.
With these issues in mind and an impending pharmacy system implementation imminent, the objective of this project was to analyze the financial impact of new system implementation to ensure that charge capture was retained. The evaluation took place in two phases, a preimplementation assessment and a postimplementation assessment. Both phases will be discussed as a means to understand how evaluators attempted to understand the financial impact of the implementation, to identify what financial issues arose, and to reveal what evaluators, implementers and hospital personnel did to rectify the financial repercussions.

4.3 Analysis and Resolution

In order to ensure that the financial integrity of the pharmacy department’s billing practices would be retained, evaluators wanted to ensure that charges for ordered medications would be comparable in both system architecture environments. The approach that was taken in both phases of the evaluation focused on tracing the high cost/high volume medications through the various systems to the billing department.

4.3.1. Phase 1: preimplementation assessment

Prior to the implementation of the new EHR pharmacy module, a team of data analysts and data warehousing experts was assembled to assess how the high-cost high-volume medications charges were being assigned. The goal was to be able to compare the same medications charges before and after the new system was implemented to validate the charge process. Using available resources and the data from each of the individual systems, which was stored in the university’s data warehouse, attempts were made to retrace how medication charges were determined. Due to the fact that the charges were
being traced through the systems retrospectively, evaluators had to work backward through the systems from the billing system back to the pharmacy system of origin. After months of trying various data-mining techniques, including complicated table joins, data reformatting, and fuzzy logic to reverse engineer how the charges were ascribed, it became apparent that reliably concluding how the charges were derived was impossible. The following issues address the reasons for the inability to retrace the medication information based on the data that had been collected and stored in the databases.

First, data elements had many-to-many relationships between medications and charge codes meaning that the same charge codes were used for multiple medications and vice-versa. Second, multiple variable names were used to describe the same data elements across the various systems and these data elements were stored in various data formats which made linking the same data elements across the systems difficult. Third, broadly defined codes were used, such as “Miscellaneous” and dummy codes, when people needed to manually determine the charges or override the system-derived charges. Finally, one of the most important medication charge files was stored in the intermediary dBase II program which was never incorporated into the data warehouse. Unfortunately this was only discovered after the analysis had begun.

Analyzing these issues in conjunction with basic database theory demonstrated how fundamental principles of data capture and storage were violated in this situation. In a desideratum for controlled medical vocabularies, 12 points were outlined specifying data standards that should be adhered to as a means to ensure that data stored across multiple databases can be useful for multiple purposes. The 12 tenets are listed in Table 4.1, and in this situation the following three principles were not followed leaving data
Table 4.1. Summary of Cimino’s desideratum

<table>
<thead>
<tr>
<th>Desideratum I: Content</th>
<th>The vocabulary must seek to provide breadth and depth of content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The content should be expressed at the most basic level i.e., atoms versus molecules</td>
</tr>
<tr>
<td></td>
<td>A formal methodology for content development is needed</td>
</tr>
<tr>
<td>Desideratum II: Concept Orientation</td>
<td>The unit of symbolic processing is the concept and each concept in the vocabulary should have a single, coherent meaning</td>
</tr>
<tr>
<td></td>
<td>Concepts should be non-vague, non-ambiguous, and non-redundant</td>
</tr>
<tr>
<td>Desideratum III: Concept Permanence</td>
<td>A concept’s meaning cannot change and it cannot be deleted from the vocabulary</td>
</tr>
<tr>
<td>Desideratum IV: Meaningless Concept Identifiers</td>
<td>Concepts typically have unique identifiers (codes) and these should be non-hierarchical to allow for later relocation and for multiple classification</td>
</tr>
<tr>
<td>Desideratum V: Polyhierarchy</td>
<td>Allow concepts to be located across multiple classifications</td>
</tr>
<tr>
<td></td>
<td>Example: diseases of the liver which also involve the kidney</td>
</tr>
<tr>
<td>Desideratum VI: Formal Definitions</td>
<td>Structured and controlled (not narrative) concepts Support understanding and future maintenance</td>
</tr>
<tr>
<td></td>
<td>Represented through relationships within the vocabulary</td>
</tr>
<tr>
<td>Desideratum VII: Reject &quot;Not Elsewhere Classified&quot;</td>
<td>Traditional classifications have rubrics that include NOS, NEC, Unspecified, Other, Misc</td>
</tr>
<tr>
<td></td>
<td>whose meaning may change over time as new concepts are added to the vocabulary. These are not appropriate for recording data in an electronic health record</td>
</tr>
<tr>
<td>Desideratum VIII: Multiple Granularities</td>
<td>Different users require different levels of expression for different purposes</td>
</tr>
<tr>
<td></td>
<td>Uncertainty is allowed, imprecision is not (we must be precise about our uncertainty).</td>
</tr>
<tr>
<td>Desideratum IX: Multiple Consistent Views</td>
<td>Although there may be multiple views of the hierarchy required to support different functional requirements and levels of detail, these must be consistent</td>
</tr>
<tr>
<td>Desideratum X: Representing Context</td>
<td>There is a crucial relationship between concepts within the vocabulary and the context in which they are used. Cimino defines 3 types of knowledge:</td>
</tr>
<tr>
<td></td>
<td>Definitional - how concepts define one another</td>
</tr>
<tr>
<td></td>
<td>Assertional - how concepts combine</td>
</tr>
<tr>
<td></td>
<td>Contextual - how concepts are used</td>
</tr>
<tr>
<td></td>
<td>A grammar is needed to show appropriate concept usage and what is sensible to say</td>
</tr>
<tr>
<td>Desideratum XI: Graceful Evolution</td>
<td>Vocabularies must be designed to allow for evolution and change, to incorporate new advances in healthcare and to correct errors</td>
</tr>
<tr>
<td>Desideratum XII: Recognize Redundancy</td>
<td>Where the same information can be expressed in different ways</td>
</tr>
</tbody>
</table>
aggregation and information retrieval across the systems unfeasible: concept orientation, concept permanence, reject not elsewhere classified. In order to rectify these issues the following steps would need to have taken place. First, each medication would need to have been linked to a specific charge code to establish a “one-to-one” relationship in the database, which would overcome the problems associated with concept ambiguity. Second, a standard format for the data elements would need to be agreed upon across the various systems and the codes once established could not be reused. Third, the use of “Miscellaneous codes” for manually derived charges should have been formalized into a structured coded algorithm or explicitly documented to allow others to recreate the charges as well. In summary the processes that were in place in the preimplementation environment did not provide a gold standard that could be used for comparison purposes. Essentially, the pharmacy manager had assumed the role of the gold standard in the preimplementation environment but after careful review of the charges in the postimplementation environment the institution discovered that he was only manually correcting about 50% of the medications accurately. Thus, there was no “gold standard” for charge comparison. In order to rectify this situation, institutions should develop formalized processes with documentation to ensure that more than one person can accurately verify and audit the charge assignment process.

It should be noted that individually, each of the systems worked well for the desired use within each of the local environments; however, at the institution-wide level, the information across the systems had not been standardized to achieve a greater purpose and usefulness. This is a common problem when legacy systems are part of an institution’s system architecture and each of these systems represents an “information
silo” making it difficult to attain enterprise-wide informational content and knowledge.
Although the goals of the first phase of financial analysis were not able to be achieved using the resources in the preimplementation environment, this portion of the evaluation raised the awareness that careful attention with respect to charge capture was going to be necessary in the postimplementation environment.

4.3.2 Phase 2: postimplementation assessment

Implementation of the new system occurred in May of 2003 and at the time things appeared as if everything was going very smoothly: clinically, the pharmacists were enjoying seamless access to laboratory and results review information (which were the other two modules that were also implemented at that time), and financially very few charges were being “kicked-out” of the billing system for reconciliation before being sent for reimbursement. It was assumed that the new system and the interfaces were working properly until the Patient Accounting Office (PAO) started to receive the reimbursements for the medication charges. Roughly 6 months after the system had been implemented they determined that there were numerous patient accounts that were being reimbursed at significantly lower rates than they were in the pre implementation environment. More specifically they determined that in one month alone the pharmacy department was losing approximately $170,000 in revenue which over the course of the year would amount to over $2 million dollars. To put this in context, with annual gross inpatient pharmacy revenue over $70 million, the possibility of losing $2 million in billable charges would have resulted in a 2% reduction in gross revenue over the course of a year, an noticeable impact which no pharmacy department would want to persist.
Immediately after the problem was identified a multidisciplinary team was assembled to address the issues. Department heads from pharmacy, billing and finance, patient accounting, information technology services, and supply chain management were brought together to spearhead the problem. Subsequently, people from the finance and billing departments started the process of analysis by identifying which charts were being reimbursed at a low percentage of their overall medication charges. From there, the supply chain management people chose to approach the problem using the Pareto Principle, also known as the 80/20 rule. They decided to focus their immediate attention toward the medications that had formerly been their highest grossing revenue medications that were now being reimbursed at less than 3%.

Based on this subset of patient accounts, one and half year’s worth of patient chart data was manually analyzed and the patients with the lowest overall medication reimbursement were further assessed. Slowly trends in the low reimbursement patient accounts started to emerge: outpatient accounts, the individuals were often cancer patients, and their chemotherapeutic agents were rarely being reimbursed correctly. With this information, experts from charge capture, billing, and the information technology department took over further elucidating what the problems were and identifying how to incorporate the necessary technical modifications into the systems to rectify the situation.

What became apparent was that the new system that had been implemented was not capable of reformatting medications for appropriate third-party billing and therefore reimbursements had decreased. This was glaringly apparent with respect to Medicare reimbursement for chemotherapeutic agents as they are very costly and their coding standards need to be updated frequently. The information in Table 4.2 exemplifies how
Table 4.2. Prescription unit conversion for Medicare reimbursement

<table>
<thead>
<tr>
<th>Rx Name</th>
<th>Billing Detail</th>
<th>Dispense Detail</th>
<th>Without Unit Conversion</th>
<th>With Unit Conversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Darbepoetin</td>
<td>1mcg</td>
<td>25mcg 40mcg 60mcg 100mcg 200mcg 300mcg</td>
<td>$3</td>
<td>$78  $124  $186  $310  $620  $930</td>
</tr>
<tr>
<td>Bevacizumab</td>
<td>10mg</td>
<td>100mg 400mg</td>
<td>$55</td>
<td>$549  $2,197</td>
</tr>
<tr>
<td>Oxaliplatin</td>
<td>5mg</td>
<td>50mg 100mg</td>
<td>$70</td>
<td>$700  $1400</td>
</tr>
<tr>
<td>Pemetrexed</td>
<td>10mg</td>
<td>500mg</td>
<td>$40</td>
<td>$2,000</td>
</tr>
</tbody>
</table>

the lack of unit conversions within the systems as the patients charges were submitted to Medicare resulted in significant underpayment. For example, the drug Darbepoetin is dispensed for administration according to logical dosing for patients ranging from 25mcg to 300mcg as singular quantity. In contrast, Darbepoetin needs to be billed in single mcg units and subsequently multiplied by $3 to determine the appropriate total billable charge. Without the unit conversion multiplier the hospital was being reimbursed $3 for a 25mcg dose as opposed to the correct billable amount of $78. The same was true for a 300mcg dose; the hospital was being reimbursed only $3 for this dose as opposed to the correctly converted billable amount of $930 resulting in a $927 loss in revenue reimbursement for this single medication alone.

After detecting how the pharmacy department's billing had become corrupted, discussion ensued with the vendor to understand how the issues could be rectified. According to the vendor, there would not be a solution to this problem until the next version's release, which at the time was over one year away. Therefore, the information
technology staff in conjunction with people from charge master, pharmacy and the billing departments developed a solution to program the unit conversions into the billing system interface. This process took over 6 months to complete, as every single medication had to be evaluated and then integrated into the existing system.

As a result, the medication reimbursements have now been rectified, and it has become one individual’s full-time responsibility to maintain and update these unit conversions in the charge master files as necessary. An auditing process has also been formalized to verify that the new system is working correctly. At this point, the auditing process is still performed manually by randomly selecting patients’ records and assessing them to make sure that the charges billed and the reimbursements received are within reasonable limits. Eventually, the university wants to automate this process, allowing them to quickly verify that their medication cost accounting throughout the institution is accurate.

4.4 Discussion

Many studies have described successful hospital information system implementations, but few studies have discussed specific issues that are unique to the pharmacy medication ordering/reimbursement process. As demonstrated through this experience, it is crucially important that administrators and implementers have a thorough understanding of their internal systems and processes as well as an understanding of the vendor side limitations of a product in order to make sure that gaps in the information transfer do not occur. Fortunately, in this situation, the university was able to identify the problems, create a workable solution, and recoup the financial losses from the bills that were initially submitted incorrectly. More importantly, the goal in sharing this experience
is to help others avoid some of the same pitfalls. The following lessons learned and recommendations should serve as helpful reminders for others to consider as they prepare to implement a new pharmacy system in their own environments.

The first issue relates to the importance of understanding the people and the politics of a particular setting. In this situation political difficulties became apparent when the implementation team attempted to decipher the functionality that had been programmed into the intermediary system. Over time, the intermediary system had developed into a very complex proprietary system that no one else understood and it was difficult for anyone, including its developer, to articulate exactly how it worked. Therefore, again no gold standard for charges was present.

To overcome the difficulty in extracting the logic built into the system, it may have been useful to use process-modeling techniques as an organizational tool. Through the use of data flow diagrams and business process redesign methods, a better understanding of the functional capabilities of the intermediary system might have been achieved. These methods can also help people visually see what the necessary data elements are, identify how these elements need to be modified and elucidate some of the idiosyncratic inefficiencies that may have been part original processes. This process may also have allowed the system developer to feel included in the system conversion alleviating his feelings of losing control over an area which he had maintained for so long.

The second issue involves the difficulties associated with coordinating multidisciplinary teams and making sure that the crucial problem areas have been addressed and that appropriate expectations are met within the given implementation
timeline. Although months of interdisciplinary meetings, product analyses and configuration testing took place, some key pieces of the testing were not adequately addressed in a timely manner. For example, individual “unit tests” were performed to ensure individual module functionality, but the processing of more complex patients and medication profiles across the systems was not fully assessed. Due to time constraints and pressures to stay on track with the implementation schedule, in this situation trade-offs between speed of testing and the quantity of medications that could be tested prior to the implementation needed to be made. One approach would have been to prioritize the testing of the medications, starting with the high-cost high-volume medications first, then test scenarios requiring special charging to be defined across the systems, leaving the low-cost low-volume medications to be tested last. This strategy may have helped set expectations for the members of interdisciplinary team helping them to understand the importance of completing certain tasks within the time constraints of the implementation timeline.

The third issue relates to the difficulties in managing vendor promises and relations. Although the vendor promised that adequate reporting and tracking metrics would be available with the EHR by the time of implementation, in fact this was one of the first times the vendor had tried to interface their EHR with such a large billing system and the necessary software for reporting did not exist. One way to avoid this situation is to require vendors to demonstrate in the testing phase of the implementation how their software works with institution specific information. At this stage if it is apparent that the necessary software is still not available it may give the institution time to create an intermediate solution. Another good idea to avoid this situation is to maintain close
contact with other institutions that have undergone an implementation with the same vendor. The more real-world advice solicited from those who have gone through a similar implementation the more likely an institution will be able to prepare for potential pitfalls and hold vendors to their contractual agreements.

The last recommendation is to create a formalized auditing process. As mentioned previously, at this point this is still a manual process at the university but a team of people is working toward automating this procedure. The goal is to create accountability at each stage of the medication information transfer between the systems allowing the institution to perform cost accounting and validation of the overall reimbursement process.

4.5 Conclusion

In an era of increasing pressures to implement integrated pharmacy information system, it is imperative that implementers take the time to evaluate the overall impact of this process. Due to the inherent complexity between processing medication orders and receiving appropriate reimbursement from third-party payers, special care should be taken to clearly understand the transfer of information across various systems to ensure that gaps in the information transfer and formatting do not go unnoticed.

4.6 References


CHAPTER 5

DISCUSSION
5.1 Summary

The hope in undertaking these three projects, which have focused on evaluating the impact of clinical information systems, is to raise the awareness that evaluation is a critical part of improving the quality of our systems and improving the way in which they impact the environments where they are placed. The projects undertaken for this dissertation contribute toward this goal by examining the current state of evaluations, building a tool to encourage evaluations to take place, and providing two real-world examples of evaluations that are pertinent to issues facing implementers today. Without evaluation we do not have a way of measuring what has worked, determining what has been challenging or sharing lessons learned with others who are also trying to achieve the vision of an integrated clinical information system.

Clearly there have been promising successes throughout the field of medical informatics and systems implementations; however, there have also been plenty of hurdles and barriers to overcome and we must develop innovative approaches to evaluating the system impacts as they vary across different medical settings. The field of medical informatics has not only realized that systems are crucial elements toward improving the continuity and quality of patient care but that these systems must be carefully assessed to make sure that the desired outcomes of their implementation are being achieved. In my view evaluation is crucial to these efforts: it strengthens accountability, improves the quality of operations, and informs strategy, policy, and resource allocation for the future.
5.2 Limitations

There were some inherent limitations to the studies conducted for this dissertation. With respect to the first project, although the conceptual framework was developed iteratively with continual feedback from subject area experts, it was primarily developed by one individual who may have introduced personal biases into the underlying structure. In order to overcome any potential biases, efforts were made to have outside reviewers confirm, expand upon, and critique each area to ensure that subject areas were complete and comprehensive. Still, the framework is subject to further expansion and validation as more feedback is received.

Limitations intrinsic to the two subsequent evaluation studies include that fact that both took place within the same academic medical center which may influence the generalizability of the results. Although academic medical centers have unique elements specific to their environment, the areas of impact that were studied, methodologies used and the suggestions made regarding how the implementation could be improved upon are applicable to any environment undertaking a system implementation. Therefore, although the outcomes may be different across various settings when conducting similar impact evaluations, the information revealed in these studies will help others as they consider what to prepare for within their local environments.

5.3 Future Directions

As clinical information systems become more commonplace throughout the healthcare industry, over time the challenges that we discover today may no longer apply to the environments in which systems are placed in the future. However, my goal in creating a conceptual framework to evaluate systems impact was to provide a tool that
will endure over time as researchers contemplate what to study today while also making it generalizable enough to address what issues may be pertinent to study in the future. In order to achieve this goal, the framework as discussed here in Chapter 2 is still subject to user feedback and future validation studies. The development of the framework has been an iterative process that incorporated feedback from potential users, subject experts, and editorial board critics. As the framework achieves greater exposure, undoubtedly more feedback will be generated and modifications will continue to be made. At this point the majority of our evaluations are taking place at the individual and institutional levels of granularity as depicted in the framework. However, as technology continues to breakdown logistic barriers across the world, my hope is that impact evaluation will begin to be conducted at the trans-organizational and trans-national levels of granularity as well.

With respect to the future directions associated with Chapter 3’s productivity evaluations, it would be prudent to evaluate changes in productivity as subsequent modules of the enterprise-wide solution are implemented. Results from this study were helpful in identifying how the pharmacists were affected by first phase of the system implementation which was conducted at the individual level of impact. Subsequently impact evaluations of the pharmacists would also be useful to conduct at the next crucial juncture of the enterprise-wide implementation, which involves the introduction of a provider order entry system. There is a nationwide push to implement provider order entry systems throughout the healthcare industry, and evaluating the impact on pharmacists will help improve our understanding of the overall complexity of the process.
Finally, I would like to discuss future directions as related to my last project involving an attempt to evaluate the financial impact of a CIS implementation. Although this last project was wrought with difficulties, I feel strongly that this is an area we as informatacists must make a bigger effort to evaluate. I am not a proponent of forcing every implementation to be subjected to a return on investment analysis (as I do not think that they are applicable in most situations), but I think that we need to at least try to measure how these systems are financially impacting our healthcare industry. This is an area that I hope to personally pursue as I would argue that we need to provide more insight into accountability and financial impacts as we move forward with more system implementations. As I learned from my project undertaking, a financial impact evaluation is a very complex and frustrating process within a healthcare setting, but I am a strong believer that as we implement more systems that allow us to better track and manage information that it is our duty to attempt to justify our investments.

In the near future, the primary focus of impact evaluations will be to provide evidence supporting that the purported benefits of these systems are realizable. These evaluations studies will continue to take place primarily at the individual and institutional levels of impact due to the current state of system implementations. In the advent that the present trends of implementing enterprise-wide solutions continues, it will be important to evaluate the unique aspects of these integrated solutions as compared to other paradigms to ensure that the intended goals of this architecture are being achieved. Over time, with increasing interoperability between organizational systems, impact evaluations should expand to include trans-organizational and trans-national levels of evaluation. Evaluations at these less granular levels will help us ensure that we are make the most of
our clinical information systems as the inevitable progression toward integrations and the globalization of healthcare will continue.