MEDICATION ERRORS PRE AND POST IMPLEMENTATION OF AN ADMIN-RX BARCODE ENABLED MEDICATION ADMINISTRATION SYSTEM

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Dedicated to LaVonda Ballard

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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ABSTRACT

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Medication errors have been extensively explored in the literature but the impact of information technologies (IT) on these errors has not. This study evaluated the impact of the implementation of a barcode enabled medication administration system on medication errors in an acute care hospital. Medication errors were measured for a four month period pre and post implementation of the Admin-Rx system using web-based event reports filed by hospital staff. Medication errors were analyzed per 1000 patient days by total event reports filed, number of actual errors made, and category of error by stage in the medication process where the error occurred (ordering, transcribing, dispensing, and administration). There were no significant differences detected from pre implementation to post implementation, though some trends were noted. The actual number of medication errors was higher post implementation while the number of medication error event reports was higher pre implementation. The number of errors in the administration stage was lower post implementation. The implementation of barcoding at the bedside would be expected to impact errors at this stage of the medication process. Transcription errors accounted for a greater percentage of the errors post implementation than pre implementation. These findings suggest the impact of barcode technology on the entire medication administration process warrants further research and focus.

CHAPTER ONE: INTRODUCTION

Introduction to Medication Errors

Medication administration is a core nursing function in the hospital setting. A basic nursing tenet taught in nursing schools is the "five rights" of medication administration to lessen the chances of making medication errors by ensuring that the right medication is given in the right dose to the right patient via the right route at the right time. Despite this tenet ingrained in every nurse, medication administration errors continue to occur in health care. These errors may be due to human error or to system problems.

Medication errors can occur at any point in the medication administration process, from the ordering by the physician, transcribing by the nurse or unit clerk, dispensing by the pharmacist, or administering by the nurse or respiratory therapist. In the manual medication process, there are back ups in place for catching errors in the early stages of the process, as pharmacists may identify ordering or transcription errors during the dispensing stage or nurses may identify dispensing errors during the administration stage. The administration stage, when the nurse or respiratory therapist actually delivers the medication to the patient by giving him/her a pill, liquid, injection, or intravenous infusion, is the most vulnerable stage because it does not have a back up for catching errors unless an information technology solution is put in place to provide support to the nurse or respiratory therapist at the point of medication administration. One such solution is a barcode enabled medication administration system, such as the Admin-Rx system by McKesson.

Importance of Preventing Medication Errors

Medical errors account for 44,000 -98,000 deaths per year according to the Institute of Medicine's "To Err is Human" report (1999). As many as 7,000 deaths a year are estimated to be caused by medication errors (Phillips, Christenfeld & Glynn, 1998). Leape et al (1991) found that 3.7 % of the patients they studied had disabling injuries caused by medical treatment and the most common type of adverse event identified was from drug complications (19%).

Lisby, Nielson and Mainz (2005) studied medication errors in Denmark and noted that errors were detected in 43% of the opportunities for errors. Opportunities for errors include doses given or omitted as well as unordered drugs. Medication errors can range from causing no detectable harm to the patient to causing disability or death.

Phillips, Christenfeld and Glynn (1998) investigated medication errors which caused death by examining U.S. death certificates for the ten year period of 1983 to 1993. They found that the inpatient deaths which occurred due to medication errors showed a 2.37-fold increase for that time period.

Leape et al (1995) performed a system analysis of medication errors that caused Adverse Drug Event (ADEs) or represented potential ADEs. An ADE is an injury caused by a medication. Their analysis found that 39% of errors occurred in the ordering stage of the medication process and nearly half of those errors were detected and intercepted by nurses or pharmacists prior to reaching the patient. On the other hand, 38% of the errors occurred in the administration stage of the medication process, but only 2% of those errors were intercepted before reaching the patient.

Knowledge Gap

The topic of medication errors is well studied but the impact of information technologies (IT) on these errors is yet to be thoroughly evaluated. Computerized Physician Order Entry systems have received attention regarding the impact they have on medication errors, especially in order entry as the issues of illegibility and transcription errors can be remedied through computerization.

Barcode enabled technology has broken free from its roots in the supermarket and is being employed in medication administration systems in health care. The nurse can employ barcode technology to scan both the medication to be administered and the patient who is to receive the medication in order to provide a back up for error checking at the point of medication administration. This technology can be used to confirm that the right medication is reaching the right patient at the right time in the right dose and via the right route. The system can also be integrated with the pharmacy system to check for patient allergies and laboratory test results that may contraindicate the medication.

The theory behind barcode enabled medication administration systems suggest they should have a profound and positive impact on the rate of medication errors in the hospital setting. If, as noted by Leape et al (1995), 38% of errors in the medication process happen at the point of administration but only 2% of those are intercepted before reaching the patient, then an IT solution that confirms the patient, medication, dose, time, and route prior to administration should be effective in reducing administration errors. However, evaluation of the impact of these systems must be conducted to ensure the implementation of an IT solution has the desired impact upon the system to which it is applied.

CHAPTER TWO: BACKGROUND

Related Research

Low and Belcher (2002) examined medication errors twelve months pre and post implementation of a Bar Code Medication Administration (BCMA) system on two medical-surgical units in a government hospital. Medication errors were measured for twelve months pre implementation and 12 months post implementation. Only the month of actual implementation was omitted from the study. Data on pre implementation errors were collected from incident report forms while post implementation errors were gathered from the nurse as well as from data generated from the BCMA log. No statistical difference was noted between the pre implementation and post implementation medication error rates, though the findings did show an increase of 18% in the error rate per 1,000 doses following implementation of the BCMA system. With the use of two separate methods of measurement pre and post implementation, the ability to interpret these results is limited.

A prototype for a barcode medication administration system was developed at the Eastern Kansas Health System beginning in 1992. This prototype became the basis for the Department of Veterans Affairs' (VA) BCMA system which has since been implemented in all of the VA medical centers nationwide. The Colmery-O'Neil VA Medical Center reported an 86.2% improvement in their medication error rate between 1993 (the final year of their totally manual system) and 2001 with the BCMA system. Though "no medication errors have occurred as a result of BCMA", the VA does experience errors as a result of the system not being used as intended such as when nurses employ "workarounds" (Johnson et al, 2002).

Poon et al (2006) studied the effects of implementing bar code technology in the pharmacy on dispensing errors and potential ADEs. Three different pharmacy processes were studied to determine the impact of bar code technology on each area: carousel fill, which stocked the semi-automated medication cabinets used on the nursing units, two-day fill, which stocked a two day supply for patient-specific drawers in the nurses' medication carts, and alternate zone, which dispensed medications not accommodated in the carousel (including high-risk intravenous medications). Four measures were taken pre and post implementation of the bar code system: target dispensing errors, all dispensing errors, target potential ADEs, and all potential ADEs (target refers to those errors and potential ADEs "that bar code technology was specifically designed to address"). Findings showed a decrease in target dispensing errors by 85%, a decrease in all dispensing errors by 36%, a decrease in target potential ADEs by 74%, and a decrease in all ADEs by 63%.

Poon et al (2006) found that, along with positive results from initiating bar code technology, untoward effects were also noted. In the alternate zone fill process in the pharmacy, the rate of ADEs actually increased 2.4 fold after bar coding was initiated. The dangers of over reliance on technology was cited by the authors as a concern in this study. Evaluation of the new technology led investigators to identify areas for process and software improvements which resulted in work-flow design changes in the alternate zone fill process.

Patterson, Cook, and Render (2002) investigated potential side effects of introducing bar code technology for medication administration. A cross-sectional observational study was conducted before and after implementation of BCMA in VA

hospitals. Five unintended side effects were identified that could create new paths for ADEs. Nurses were surprised by automated actions of the new system, such as medications being automatically removed from the "to give" list without the nurse's awareness. Communication and coordination became degraded between nurses and physicians as a computerized process replaced a more familiar manual process, such as the replacement of a paper medication administration record with an electronic one. This change required computer access on the part of the physician to see a record that was previously readily available on paper. Another side effect was nurses worked around safety features in order to decrease their workload when busy, such as typing in the patient identification rather than scanning. The other two side effects observed were a difficulty in deviating from the routine and the alteration of priorities to place more emphasis on monitored activities (such as giving higher priority to giving a medication on time since timeliness was monitored rather than appropriating that priority to a more critical need).

Current Understanding

The manual medication administration process consists of the nurse utilizing paper medication administration records (MAR) to determine which medications are due to be given to which patients at what times. The nurse would have to consult the MAR for each patient to plan his/her medication administration work flow.

Several challenges are manifested in this manual system. The nurse may encounter difficulty locating the MAR on each patient because if it is in the patient's chart, another practitioner could be in possession of the chart while the nurse is trying to locate it and if it is at the patient's bedside, then the nurse must go to each patients' room

to determine when medicines are due. Another challenge for the nurse is keeping up with each patient's medication allergies. Prior to administering a medication, the nurse is responsible for ensuring the patient has no known allergy to that medication by looking up the patient's known allergies on the medical record. The nurse must then manually confirm the "5 Rights" of medication administration prior to the patient actually receiving the dose. While the nurse is following the medication administration process for all assigned patients, s/he must also deal with numerous interruptions and demands from patients, visitors, physicians, and co-workers. Failure at any step in the manual process can result in a medication error with potentially dangerous consequences.

The implementation of a barcode enabled medication administration system involves a complete process change in the way nurses give medications. In the manual system, nurses determine the medication administration times based upon the physician order. With the barcode system, this process moves to the pharmacy so that the administration times can be standardized and integrated into the electronic system. Another major change for the nurse is the replacement of the paper MAR with an electronic "to give" list the nurse uses to guide herself/himself in identifying the medications that are due to which patients.

The new process for the nurse with the barcode enabled system is to consult the "to give" list, scan a patient's wristband to confirm the correct patient, scan the barcode on the medication to confirm the correct medication, dose, and time, and then select the route (intravenous, by mouth, etc.). If the system does not notify the nurse of any alarms (such as "wrong patient", "allergy", "wrong time", etc.), the nurse administers the dose

and confirms the patient received the medication (which documents the administration in the electronic system).

In order to initiate the barcode enabled medication administration system, a myriad of process and technological changes must take place in an organization. The hospital's pharmacy system may have to be upgraded to be compatible with the barcode system, all medications must be packaged with barcodes, the entire pharmacy inventory must be cataloged in the system with the accompanying barcode, computers and barcode scanners must be installed on the nursing units, a wireless network must be in place if wireless scanners are to be used, all of the infrastructure must be installed, integrated, and tested, and policies and procedures must be written to guide the organization through the new processes.

Nurses and pharmacy staff must then be trained on the new system. Nurses need to know how the patient is profiled in the electronic system and how medications are administered with the barcode process. They must be trained in both process and procedure and be given a realistic vision of how their daily routine and patient care will be affected by the new system. Nurses must also be trained in how to use the scanning equipment and how to address failures in the system, such as wristbands or medications that won't scan.

The major changes in the medication administration process of going from a manual system to a barcode enabled system result in opportunities for both success and failure. If staff do not use the barcode system as intended and instead employ "workarounds", the safety features of the system can be circumvented and an increase in medication errors can result from the conversion to an electronic system. Informatics

research can be employed to evaluate the impact of applying an IT solution to the medication administration process.

Research Question

The research question for this study was "What is the impact of the implementation of a barcode enabled medication administration system such as Admin-Rx on the incidence of medication errors in an acute care hospital?" There were two hypotheses. Hypothesis 1: total medication errors would decrease post implementation of Admin-Rx. Hypothesis 2: medication errors in the administration category would decrease while medication errors in the ordering, transcribing, and dispensing categories remained unchanged post implementation of Admin-Rx.

CHAPTER THREE: METHODS

Materials and Instruments

The site of the study was St. Mary's Medical Center in Evansville, Indiana. The source of data was the Medication Event Details Report by Department from the Peminic web-based event reporting system at St. Mary's. Each medication error event report was entered into the system by the individual encountering and recognizing the error (for example, nurse or pharmacist). Each event detail report consisted of the location of the error (nursing unit, etc), the date and time of the event, the type of event (medication error), classification of event (for example, the error reached the patient), and a narrative description of the event. A separate event report was generated for each untoward event noted. The Medication Event Details Report provided to the researcher covered the pre implementation four month period of October, 2005 to January, 2006 and the post implementation four month period of August through November, 2006. A new computerized pharmacy system was implemented in February, 2006 and because of myriad of changes this entailed for the pharmacy staff, February and March were excluded from the pre implementation data collection period. The four month period immediately following implementation (April – July) was deemed an adjustment period for working out system problems for nursing and pharmacy staff and was not included in the measurement.

Subjects

Human subject clearance was obtained for the study through the Indiana University and the St. Mary's Medical Center Internal Review Boards. Patient identifiers, except for medical record numbers, were removed from the reports prior to acquisition by

the researcher. The researcher's job position in the Quality Department of the study hospital allowed her access to view the medical records of any patient in the facility for quality based information. The medical records were viewed by the researcher only if the description in the event report was insufficient to determine the number or category of errors described in the event report and only the Medication Administration Records, Physician Orders, and Nurses Notes were viewed to collect the missing data on medication errors. Each event report was assigned a study number and no patient specific data was collected. No attempt was made to connect the event report to the reporter involved.

The study sample for the pre implementation measurement was 100% of the event reports for medication errors that occurred during the four month pre implementation study period of October, 2005 through January, 2006. The study sample for post implementation measurement was 100% of the event reports for medication errors that occurred during the four month post implementation study period of August through November, 2006.

Procedures

The researcher obtained the Medication Event Details Report by Department (location error occurred) for both the pre implementation and post implementation time periods from the Risk Management Department at St. Mary's (for only those departments whose Admin-Rx go-live date was April 4, 2006). Medication errors were measured pre and post implementation of the Admin-Rx medication administration system. Each event report was coded as pre or post implementation and the medication error was categorized by the stage in the drug ordering-administration process where the error occurred as

"ordering", "transcribing", "dispensing", or "administration". These categories were based upon the four stages used by Leape et al. (1995) in their analysis of adverse drug events: "(1) physician ordering, (2) transcription and verification, (3) pharmacy dispensing and delivery, and (4) nurse administration to the patient."

The categories were defined for this study as follows: (1) ordering was the process of the physician writing the medication order or the nurse writing the physician's telephone or verbal orders, (2) transcription was the process of scanning the order to pharmacy and entering the order on the paper Medication Administration Record prior to implementation of Admin-Rx and verifying and entering the order in the pharmacy computer system post implementation, (3) dispensing was the process of filling the medication order in the pharmacy and delivering it to the nursing unit, and (4) administration was the process of giving the medication to the patient either orally or parenterally.

Each of the categories was coded. Pre implementation errors were given two codes, a "1" for pre implementation and a second number to designate the pre implementation category as follows: ordering = "11", transcribing = "12", dispensing = "13" and administration = "14". All post implementation errors were coded with a "2: and the category codes were "21" for ordering, "22" for transcribing, "23" for dispensing and "24" for administration.

Reliability of the category groupings was established through the use of two coders. The researcher was the primary coder and categorized every medication error as ordering, transcribing, dispensing or administration. A second coder, a Health Informatics Specialist at the study facility then coded a sample of 25 medication errors and interrater

reliability was measured by comparing the categorizations of the primary coder with those of the secondary coder for consistency. An interrater reliability value of 95% was determined to be considered acceptable for this study.

Errors that resulted from more than one category were evaluated using two different methods. First each error was counted in every applicable category; that is, if pharmacy dispensed the wrong medication and the nurse gave that medication, that medication error would be counted in both the dispensing and the administration categories thus tabulating each "opportunity for error". The results from this method of analysis are shown in the tables labeled "Medication Errors – All Categories". Next, the errors that resulted in more than one category were coded by the earliest category applicable. In the example noted above, only the dispensing error would be counted as it was the earliest stage at which an error occurred. The results from this method of analysis are shown in the tables labeled "Medication Errors – Earliest Category". Finally, each medication error was coded as an "actual error" (an error that reached the patient) or as a "near miss" (an error that was intercepted before reaching the patient).

Data Analysis

Descriptive statistics were employed to describe the results for medication errors both actual and near misses by total and by category pre and post implementation of Admin-Rx. Total medication errors pre and post implementation were reported by month per 1000 patient days. Statistical analysis methods utilized in this study include descriptive statistics (Mean, Standard Deviation) and the two-sample two-sided *t*-test.

t-test For Independent Groups

The *t*-test For Independent Groups is used to test the difference between means for two groups based the same variable. A key assumption of the *t*-test is that the variances of the two groups are homogenous. "Levene's Test for Equality for Variances" provides critical information to the researcher as to whether the variances of the two groups are heterogeneous or homogenous.

Details Concerning the t-test For Independent Groups

The statistical package, SPSS Version 14, was utilized in the analysis of the data. Based on the assumptions of the *t*-test for Independent Groups, it was appropriate to utilize this statistical test to determine if there were any significant differences between the means of the pre and post implementation medication errors and if there were any significant differences between the means of each category pre and post implementation. The small sample size could be a limitation for using the t-test in this study; therefore a nonparametric test, the Mann-Whitney U Test, was also performed to detect differences between the pre and post implementation groups.

CHAPTER FOUR: RESULTS

Overview

Analysis was performed on five aspects of the data: the number of medication error event reports pre and post implementation of Admin-Rx, the number of medication errors identified in those event reports pre and post implementation, the number of medication errors by category counting all categories that apply to each error, the number of medication errors by category only counting the earliest stage in the medication process in which an error occurred, and the interrater reliability of the coding definitions. The significance of the number of event reports was explored because of the impact of a single event report upon the actual medication errors for post implementation. An event report could describe an administration error that resulted in a single medication error, such as one missed dose, or it could describe a transcription error that resulted in multiple medication errors, such as a physician order sheet that wasn't sent to pharmacy resulting in many missed doses over several days. One event report in the post implementation period tied to a transcription error resulted in 39 medication errors (accounting for 30% of all post implementation medication errors). This event involved a sheet of physician's orders that did not reach the pharmacy for three days. The order sheet contained multiple medication orders involving starting, stopping, or changing eight different medications. The impact this single event had on skewing the results of the medication error analysis was explored in this study. Analysis of the actual number of medication errors was performed twice, once including the above mentioned event and once excluding it as an outlier. The results of both analyses will be described in order to demonstrate what effect, if any, this outlier had upon the statistical significance of the findings.

Interrater analysis was performed to test the reliability of the category definitions. There were 25 randomly selected medication error event reports coded by the researcher and the Health Informatics Specialist for the earliest stage in the medication process in which the error occurred. The 25 event reports resulted in 67 medication errors. The two coders agreed on the category for 64 of those errors for a 95.5% interrater reliability value, which meets the desired value of 95% determined prior to the onset of the study.

Findings

The first analysis completed was a comparison of the event reports pre and post implementation of Admin-Rx. Pre implementation there were 95 event reports filed. Of those 95, 6 event reports were excluded as non-medication errors either because the event report described an Adverse Drug Reaction (ADR) rather than a medication error or because the researcher was unable to determine if the event described was actually a medication error due to lack of clarity of the description of the event in the Medication Event Details Report. Of the 89 event reports attributed to medication errors, 4 (4.5%) were classified as "Near Miss" since the errors were caught before reaching the patient. Post implementation of Admin-Rx, there were 78 event reports filed. Of those 78, 3 event reports were excluded as non-medication errors for the same reasons as noted above. Of the 75 event reports attributed to medication errors, 5 (6.7%) were classified as "Near Miss" while 70 actually reached the patient. See Table 4.1.

The pre and post implementation event reports were analyzed to determine their rate per 1000 patient days. Near misses were included as well as actual errors in this analysis of medication error event reports per 1000 patient days. The pre implementation rate of medication error event reports was 4.84 per 1000 patient days while the post

implementation rate was 4.38 per 1000 patient days. See Table 4.2. These rates were subjected to a 2-sided *t*-test for independent groups and found not to be statistically significant (p=.230). See Appendix A.

	Pre Implementation of Admin-Rx	Post Implementation of Admin-Rx
Event Reports	95	78
Exclusions (Not Medication Errors)	6	3
Medication Error Event Reports	89	75
Distribution by Month: Month 1	19	18
Month 2	21	17
Month 3	26	21
Month 4	23	19
Mean By Implementation Period	22.25	18.75
Standard Deviation By Implementation Period	2.99	1.71

Table 4.1 Medication Event Reports Distribution

Pre Implementation		Post Implementation	
Month	Med Error Event Reports / 1000 Patient Days	Month	Med Error Event Reports / 1000 Patient Days
October 2005	4.32	August 2006	4.36
November 2005	4.47	September 2006	4.05
December 2005	5.72	October 2006	4.81
January 2006	4.87	November 2006	4.28
Mean	4.84	Mean	4.38
Standard Deviation	0.63	Standard Deviation	0.32

Table 4.2 Medication Error Event Reports Per 1000 Patient Days

The number of medication errors was compared pre and post implementation. The 89 pre implementation event reports resulted in 119 errors (either actual or near misses). The 75 post implementation event reports resulted in 130 errors when the outlier (1 event report with 39 errors) was included and 91 errors when the outlier was excluded. The medication error rate was calculated per 1000 patient days and was 6.48 pre implementation, 7.59 post implementation when the outlier was included, and 5.31 without the outlier. See Table 4.3. These rates were subjected to a 2-sided *t*-test for independent groups and found not to be statistically significant (with outlier, p=.643, without outlier, p=.275). See Appendices B and C. The medication error rates pre and post implementation were also subjected to the nonparametric Mann-Whitney U Test and there was no statistical significance noted between the two groups.

Pre Implementation			Post Implementation				
Month	# Med. Errors	Med. Error Rate/1000 Patient days	Month	# Med. Errors		Med. Error Rate/1000 Patient days	
Oct 05	23	5.22	Aug 06	60 (with Outlier)	21 (without Outlier)	14.54 (with Outlier)	5.09 (without Outlier)
Nov 05	23	4.89	Sep 06	20		4.77	
Dec 05	35	7.70	Oct 06	29		6.64	
Jan 06	38	8.04	Nov 06	21		4.73	
Mean	29.75	6.48	Mean	32.5	22.75	7.59	5.31
St. Dev.	7.89	1.64	St. Dev.	18.77	4.19	4.67	0.90

Table 4.3 Medication Error Distribution and Rates Per 1000 Patient Days

Next, the medication errors were analyzed by category based upon the stage in the drug ordering-administration process where the error occurred. These stages were entitled “ordering”, “transcribing”, “dispensing”, and “administration” and were defined in the

methods section of this paper. The analysis by category of error was performed in two ways. First, all categories identified in an error were counted to give a total of all opportunities for error. This method of analysis accounted for all of the stages in which a medication error was affected. For example, if a medication error was made in

Month	Ordering	Transcribing	Dispensing	Administration	Unable to Determine
Pre Implementation:					
Oct 2005	3	4	5	18	1
Nov 2005	1	7	1	18	0
Dec 2005	1	12	6	30	1
Jan 2006	2	6	13	32	0
Totals	**7**	**29**	**25**	**98**	**2**
Mean	**1.75**	**7.25**	**6.25**	**24.5**	**0.50**
St. Dev.	**0.96**	**3.40**	**4.99**	**7.55**	**0.58**
Post Implementation with Outlier:					
Aug 2006	1	44	4	16	0
Sep 2006	3	9	2	15	1
Oct 2006	1	8	1	22	0
Nov 2006	1	7	0	14	0
Totals	**6**	**68**	**7**	**67**	**1**
Mean	**1.50**	**17.00**	**1.75**	**16.75**	**0.25**
St. Dev.	**1.00**	**18.02**	**1.71**	**3.59**	**0.50**
Post Implementation without Outlier:					
Aug 2006	1	5	4	16	0
Sep 2006	3	9	2	15	1
Oct 2006	1	8	1	22	0
Nov 2006	1	7	0	14	0
Totals	**6**	**29**	**7**	**67**	**1**
Mean	**1.50**	**7.25**	**1.75**	**16.75**	**0.25**
St. Dev	**1.00**	**1.71**	**1.71**	**3.59**	**0.50**

Table 4.4 Number of Medication Errors by Category including all Opportunities for Errors

the transcription stage, such as the wrong order was entered into the pharmacy computer system, and then the nurse confirmed the order and gave the medication even though the order was incorrect, the error would be counted once in the transcription stage for each dose affected and once in the administration phase for each dose affected. In this example, if the wrong order was entered in the pharmacy system and the nurse administered one dose of the wrong medication, the total categories counted would be two, one transcription error and one administration error. If the error described above were identified by the nurse when she confirmed the order and s/he did not administer the incorrect medicine, than only one opportunity for error would be counted, i.e., the transcription error and the event would be identified as a "near miss". Table 4.4 depicts the number of medication errors by category where all opportunities for error were counted. There were three medication errors the researcher was unable to determine a stage for due to inadequate information provided in the event report.

The medication error rate for all categories was calculated per 1000 patient days by month and by study period both pre and post implementation (See Table 4.5) and was found to be 0.38 for "ordering" pre implementation and 0.35 for "ordering" post implementation. These rates were subjected to a 2-sided *t*-test for independent groups and found not to be statistically significant (p=.873). See Appendix D.

The outlier described earlier in the results occurred in the transcription stage so the error rate for "transcribing" was calculated with and without the outlier. The rate for "transcribing" pre implementation was 1.58 and post implementation was 3.97 with the outlier and 1.69 without the outlier. These rates were subjected to a 2-sided *t*-test for

independent groups and found not to be statistically significant (with outlier, p=.345, without outlier, p=.795). See Appendix E and F.

The error rate for the "dispensing" stage was 1.36 pre implementation and 0.41 post implementation. These rates were subjected to a 2-sided *t*-test for independent groups and found not to be statistically significant (p=.149). See Appendix G.

Month	Ordering	Transcribing	Dispensing	Administration	Unable to Determine
Pre Implementation:					
Oct 2005	0.68	0.91	1.14	4.09	0.23
Nov 2005	0.21	1.49	0.21	3.83	0.00
Dec 2005	0.22	2.64	1.32	6.60	0.22
Jan 2006	0.42	1.27	2.75	6.77	0.00
Mean	**0.38**	**1.58**	**1.36**	**5.33**	**0.11**
St. Dev.	**0.22**	**0.75**	**1.05**	**1.58**	**0.13**
Post Implementation with Outlier:					
Aug 2006	0.24	10.67	0.97	3.88	0.00
Sep 2006	0.72	2.15	0.48	3.58	0.24
Oct 2006	0.23	1.83	0.23	5.04	0.00
Nov 2006	0.23	1.58	0.00	3.15	0.00
Mean	**0.35**	**3.97**	**0.41**	**3.91**	**0.06**
St. Dev.	**0.24**	**4.41**	**0.42**	**0.81**	**0.12**
Post Implementation without Outlier:					
Aug 2006	0.24	1.21	0.97	3.88	0.00
Sep 2006	0.72	2.15	0.48	3.58	0.24
Oct 2006	0.23	1.83	0.23	5.04	0.00
Nov 2006	0.23	1.58	0.00	3.15	0.00
Mean	**0.35**	**1.69**	**0.41**	**3.91**	**0.06**
St. Dev.	**0.24**	**0.40**	**0.42**	**0.81**	**0.12**

Table 4.5 Medication Error Rate Per 1000 Patient Days by Category Including all Opportunities for Errors.

The error rate for the "administration" stage was 5.33 pre implementation and 3.91 post implementation. These rates were subjected to a 2-sided *t*-test for independent groups and found not to be statistically significant (p=.180). See Appendix H.

Finally, the medication errors were analyzed by category based on the earliest stage in the drug ordering-administration process where the error occurred. For example, if an error occurred in the transcription stage that also resulted in a dispensing or administration error, only the transcription stage was counted. This method of analysis was undertaken due to the diverse processes involved for the medication transcribing through administration stages between pre and post implementation of Admin-Rx. One of the biggest changes for nursing was the transfer from a paper Medication Administration Record (MAR) to an electronic MAR. Pre implementation, if an order was transcribed incorrectly to the MAR, the nurse could find that error when she compared the paper MAR to the written orders. However, with the electronic MAR, the nurse is provided with an electronic "To Do" list of medications due to be given. If the order did not reach the pharmacy for order entry, there was nothing to show up on the "To Do" list for the nurse to compare with the order. Therefore, the earliest identified stage for the medication errors was analyzed to determine any significant differences between pre and post implementation. See Table 4.6 for the number of medication errors by the earliest stage identified.

The medication error rate by earliest category was calculated per 1000 patient days by month and by study period both pre and post implementation (see Table 4.7). The medication error rates for the "ordering" stage and the "transcribing" stage for earliest category identified were identical to the rates noted previously when all

categories were counted. The error rate for the "dispensing" stage pre implementation when counting only the earliest stage was 1.31 pre implementation and 0.41 post implementation. These rates were subjected to a 2-sided *t*-test for independent groups and found not to be statistically significant (p=.178). See Appendix I.

Month	Ordering	Transcribing	Dispensing	Administration	Unable to Determine
Pre Implementation:					
Oct 2005	3	4	4	11	1
Nov 2005	1	7	1	14	0
Dec 2005	1	12	6	15	1
Jan 2006	2	6	13	17	0
Totals	**7**	**29**	**24**	**57**	**2**
Mean	**1.75**	**7.25**	**6.00**	**14.25**	**0.50**
St. Dev	**0.96**	**3.40**	**5.10**	**2.5**	**0.58**
Post Implementation with Outlier:					
Aug 2006	1	44	4	11	0
Sep 2006	3	9	2	5	1
Oct 2006	1	8	1	19	0
Nov 2006	1	7	0	13	0
Totals	**6**	**68**	**7**	**48**	**1**
Mean	**1.50**	**17.00**	**1.75**	**12.00**	**0.25**
St. Dev.	**1.00**	**18.02**	**1.71**	**5.77**	**0.50**
Post Implementation without Outlier:					
Aug 2006	1	5	4	11	0
Sep 2006	3	9	2	5	1
Oct 2006	1	8	1	19	0
Nov 2006	1	7	0	13	0
Totals	**6**	**29**	**7**	**48**	**1**
Mean	**1.50**	**7.25**	**1.75**	**12.00**	**0.25**
St. Dev.	**1.00**	**1.71**	**1.71**	**5.77**	**0.50**

Table 4.6 Number of Medication Errors by Earliest Category Identified

The medication error rate for the "administration" stage when counting only the earliest stage was 3.10 pre implementation and 2.80 post implementation. These rates were subjected to a 2-sided *t*-test for independent groups and found not to be statistically significant (p=.668). See Appendix J.

Month	Ordering	Transcribing	Dispensing	Administration	Unable to Determine
Pre Implementation:					
Oct 2005	0.68	0.91	0.91	2.50	0.23
Nov 2005	0.21	1.49	0.21	2.98	0.00
Dec 2005	0.22	2.64	1.32	3.30	0.22
Jan 2006	0.42	1.27	2.75	3.60	0.00
Mean	**0.38**	**1.58**	**1.31**	**3.10**	**0.11**
St. Dev.	**0.22**	**0.75**	**1.07**	**0.47**	**0.13**
Post Implementation with Outlier:					
Aug 2006	0.24	10.67	0.97	2.67	0.00
Sep 2006	0.72	2.15	0.48	1.19	0.24
Oct 2006	0.23	1.83	0.23	4.35	0.00
Nov 2006	0.23	1.58	0.00	2.93	0.00
Mean	**0.35**	**3.97**	**0.41**	**2.80**	**0.06**
St. Dev.	**0.24**	**4.41**	**0.42**	**1.29**	**0.12**
Post Implementation without Outlier:					
Aug 2006	0.24	1.21	0.97	2.67	0.00
Sep 2006	0.72	2.15	0.48	1.19	0.24
Oct 2006	0.23	1.83	0.23	4.35	0.00
Nov 2006	0.23	1.58	0.00	2.93	0.00
Mean	**0.35**	**1.69**	**0.41**	**2.80**	**0.06**
St. Dev.	**0.24**	**0.40**	**0.42**	**1.29**	**0.12**

Table 4.7 Medication Error Rate Per 1000 Patient Days by Earliest Category Identified

The medication error rate for each category was subjected to the Mann Whitney U Test and no statistical significance was noted between the pre and post implementation

groups for any of the categories. Since there were no differences in the conclusions drawn in the significance testing, in the results the *t*-test will be reported because it is more interpretable (i.e., means and standard deviations versus ranks).

CHAPTER FIVE: DISCUSSION

Explanation of Outcomes

Statistical analysis of medication error events, rates, and categories failed to render any statistically significant results in this study. However, several trends were identified pre to post implementation of Admin-Rx. The rate of medication error event reports was higher pre implementation (see Figure 5.1). The rate of medication errors was also higher pre implementation when the outlier was removed, but higher post implementation when the outlier was included in the calculations (see Figure 5.2). The rate of errors in the administration stage (the stage that the implementation of barcoding at the bedside would be expected to have the greatest impact on errors) was lower post implementation (see Figure 5.3).

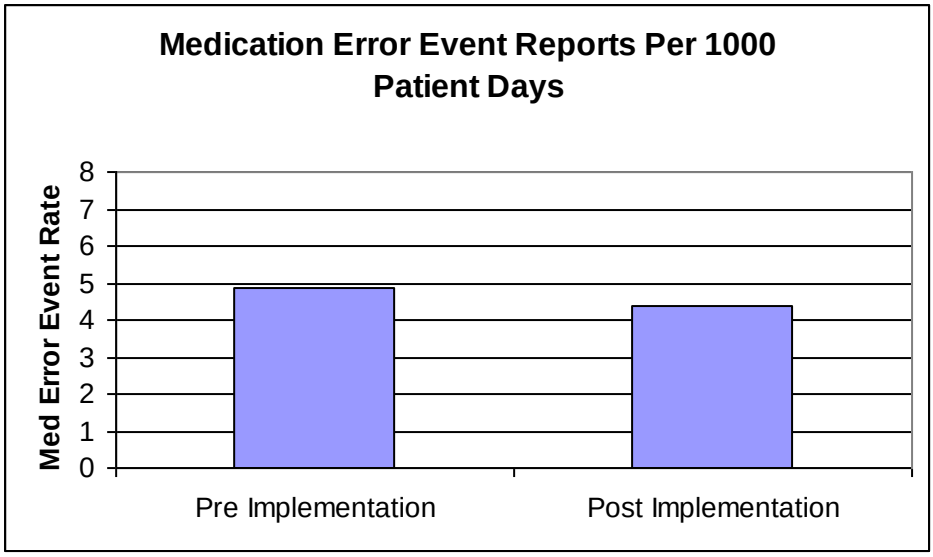

Figure 5.1

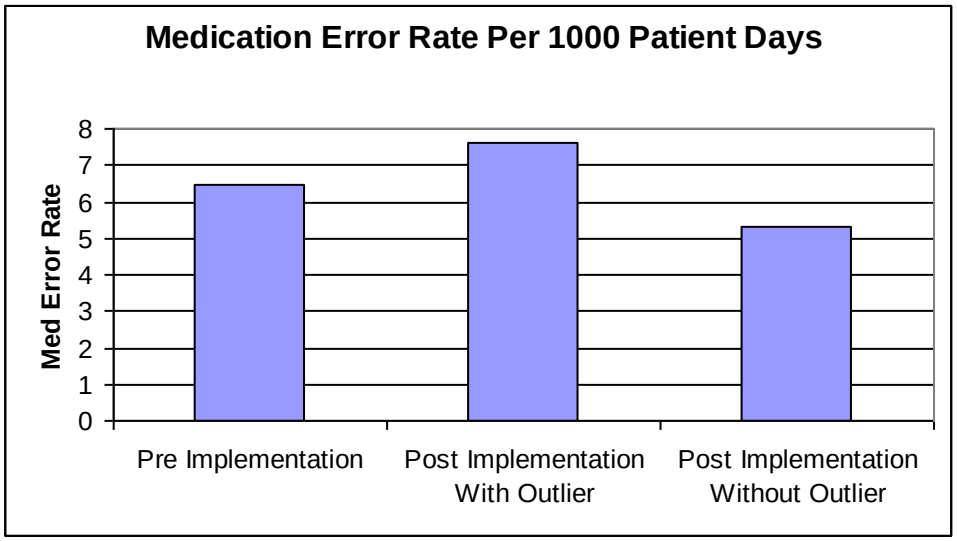

Figure 5.2

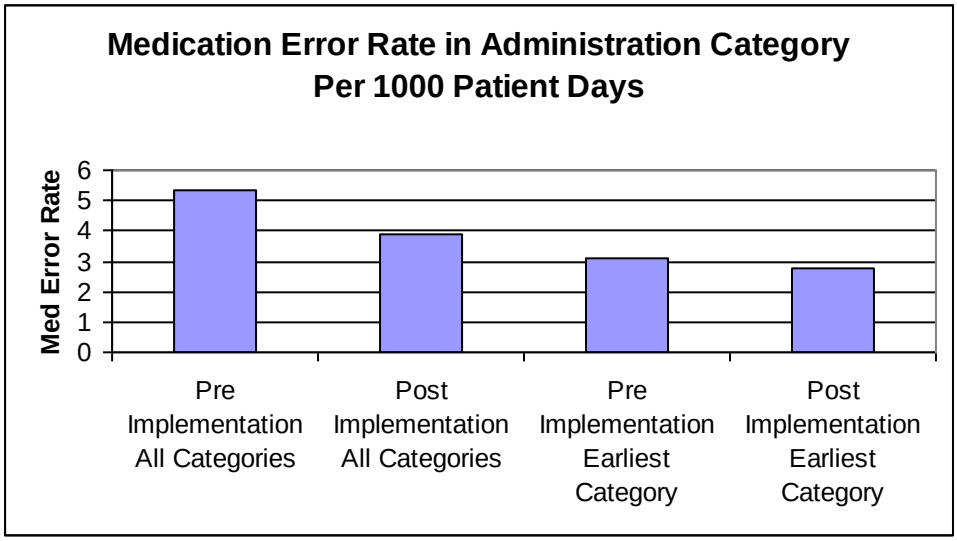

Figure 5.3

Transcription errors accounted for a greater percentage of errors post implementation than pre implementation. When all categories of each error were counted, transcription errors accounted for 18% of the errors pre implementation, 46% of the errors post implementation when the outlier was included, and 26% of the errors post implementation when the outlier was excluded. When only the earliest category of each

error was counted, transcription errors accounted for 24% of the errors pre implementation, 52% of the errors post implementation when the outlier was included, and 32% of the errors when the outlier was excluded (see Figure 5.4).

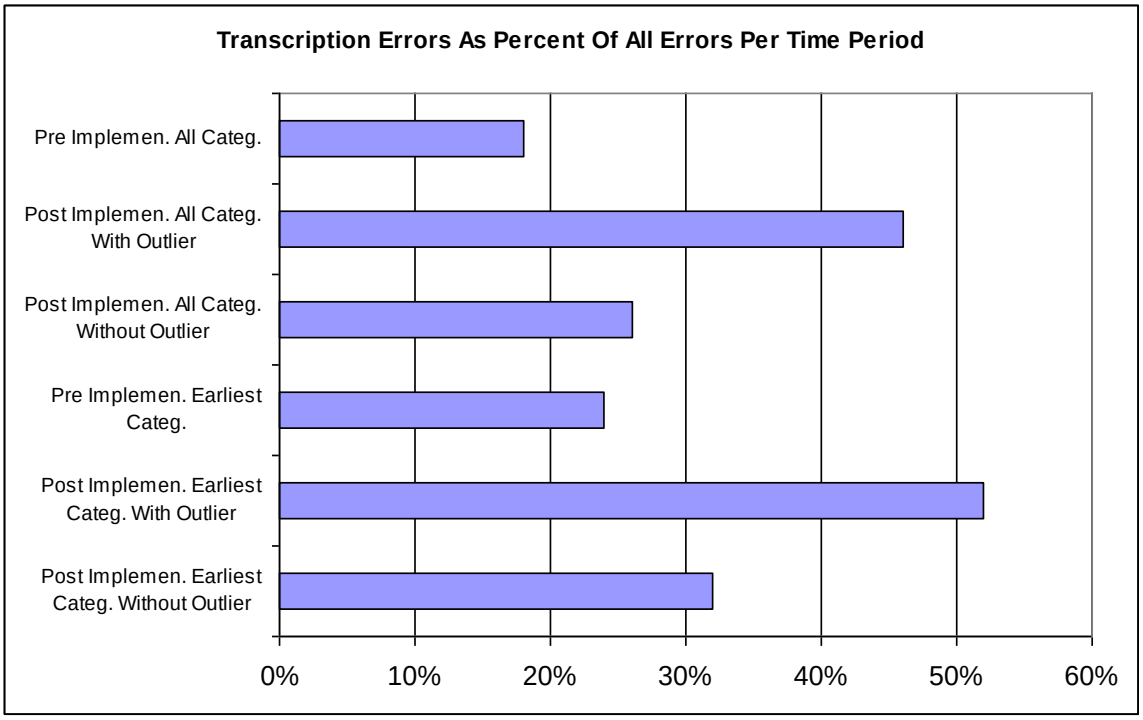

Figure 5.4

Numerous factors may account for these results. The implementation of Admin-Rx resulted in many process changes for nursing, respiratory care, pharmacy, and information services. In addition, six weeks prior to the Go Live of Admin-Rx, a new computerized pharmacy system was implemented. The pharmacy staff had a limited time to adjust to their new system prior to the implementation of Admin-Rx. Greater strain was placed on pharmacy resources as staff learned two new systems is a short period of time and then had to take on the burden of entering all of the medication orders into the computer system with Admin-Rx.

One of the biggest changes for nursing was the transfer from a paper Medication Administration Record (MAR) to an electronic MAR. Pre implementation, nurses and respiratory therapists were working with a paper MAR and the pharmacy was not inputting all medication orders into the computer system. Post implementation, medication administration was based upon an electronic MAR. The changes were massive for nursing, respiratory care, pharmacy, and information services.

Implications of Results

The results of this study have several implications for the evaluation of the implementation of a barcode enabled medication administration process. The increase of the percentage of errors being transcription errors post implementation suggests that special focus should be placed on this process during Admin-Rx implementation. Some transcription errors were the result of the physician order not being placed in the appropriate location in the chart, some from failure of the scanning process from the nursing unit to pharmacy, and some from the incorrect order being entered or omitted by the pharmacist. Each of these avenues of error has different causes that must be investigated in order to minimize transcription errors. The first could be the result of inadequate communication between physician and staff or the failure of having a standardized process for order flagging on all units. The second could be the result of technical failures, inattention, or inadequate training of staff. The third could be the result of too high of volume, too many interruptions, or inattentiveness regarding the pharmacy staff. All of these avenues for transcription errors must be addressed in order to maximize the patient safety benefits of implementing the Admin-Rx system.

Another implication from this study is the lack of a statistical significance in the decrease of errors in the administration stage. Admin-Rx is intended to assist the nurse or respiratory therapist in ensuring the "5 rights" of medication administration when the system is used as intended. However, administration errors will still occur if the order is confirmed without the nurse or respiratory therapist checking the order to be sure it has been entered in the system correctly, if medications are selected on the screen rather than scanned in, and if the patient's armband is not scanned prior to administration of the medication. Some administration errors in this study were the result of the failure of syringe pumps to be started. It is unknown if these errors were due to human or mechanical failure, but the point is Admin-Rx cannot solve all administration issues and staff must be alert to other sources of error if the patient safety benefits of Admin-Rx are to be fully realized.

Summary of Discussion

The researcher expected to find that Admin-Rx had significantly decreased the number of medication errors post implementation and that administration errors would decrease while ordering, transcribing, and dispensing errors remained the same. These expectations were not realized in this study. While administration errors did decrease, they did not do so significantly and transcription errors increased as a percentage of errors rather than remaining unchanged.

CHAPTER SIX: CONCLUSION

Limitations

This study is reliant upon a self-reporting adverse event data collection system. Research suggests that medication errors that are self-reported tend to be under-reported. Grasso, Genest, Jordan and Bates (2003) compared medication errors from record review with those that were self-reported. They found that while 2,194 medication errors were detected through a chart review, only 9 of those errors were self-reported (0.41%). Even though the current study collected data from the same cultural system (St. Mary's) both pre and post implementation, the concerns for under-reporting in a self-reporting system should be considered a limitation of this study.

Another limitation is the lack of standardized units of measure for medication error studies. This study defined four categories of medication errors and excluded adverse drug reactions. Lisby, Nielsen and Bates (2005) defined five categories of errors (ordering, transcription, dispensing, administration, and discharge summaries) and excluded adverse drug reactions from their study. Leape et al. (1995) focused on adverse drug events and evaluated how many were due to errors, classifying errors into basically the same four stages as the current study. Depending on the researcher's definition of how medication errors were measured, differing results can be obtained.

Descriptions of two of the medication error events in this study lacked sufficient details to determine if these medication error events resulted in more than one missed or wrong dose and the researcher could not determine how many doses were affected by the error. Each of these two medication error events occurred in the post implementation period and was accounted for as a single dose. The inability of the researcher to

determine if more doses were involved in these two events is seen as a limitation of this study.

Another limitation of the study is the scope of information about medication errors that was available. The current system for capturing data on medication errors does not include the severity of errors nor whether the errors are attributable to human or system errors. Therefore, conclusions cannot be drawn as to the effect the implementation of BCMA had on the severity of medication errors or the performance of systems in place within the organization.

This study took place at a single facility on medical surgical and intensive care units. It was also limited to a relatively short period of time, namely four months pre and four months post implementation. It is unknown how the results would be affected by a longer study period or how they would generalize to other institutions or nursing units.

The sample size for this study was small. Essentially, the unit of analysis was the monthly total or rate of medication errors. This resulted in a restricted sample size and reduced statistical power, which may account for lack of statistical significance. A larger sample size, including 12 months pre and post implementation data collection would not only increase the power, but would yield information about longer term trends in the data post implementation of BCMA.

Future Research

Further research is needed to explore the relationship of the implementation of a barcode enabled medication administration system and its effect on transcription errors. Which factors would have the greatest impact on decreasing transcription errors: further training for unit clerks, more resources for pharmacy personnel, or consistent processes

for flagging orders on the unit? Additional research is also needed to investigate the impact of the barcode system on the administration stage of the medication process, such as what factors are contributing to the continuation of administration errors following implementation of the barcode system.

Computerized Physician Order Entry (CPOE) is a safety recommendation by the Leapfrog Group (www.leapfroggroup.org) and may address many of the transcription errors noted in this study. Further research is needed to explore the effects of implementing CPOE along with BCMA on medication errors.

Summary

Medication errors decreased in the administration stage of the medication process but increased in the transcription stage from pre to post implementation of the Admin-Rx system. In order to maximize the patient safety benefits of implementing an IT solution for medication administration, every stage of potential errors must be analyzed for areas of weakness and targeted for process improvement.

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APPENDICES

Appendix A: Medication Error Event Rate *t*-test

Group Statistics

	Pre or Post Implementation	N	Mean	Std. Deviation	Std. Error Mean
Med Error Event Rate	Pre Implementation	4	4.8450	.62783	.31391
	Post Implementation	4	4.3750	.31838	.15919

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Med Error Event Rate	Equal variances assumed	1.331	.293	1.335	6	.230	.47000	.35197	-.39124	1.33124
	Equal variances not assumed			1.335	4.447	.246	.47000	.35197	-.46966	1.40966

Appendix B: Medication Error Rate With Outlier *t*-test

Group Statistics

	Pre of Post Implementation	N	Mean	Std. Deviation	Std. Error Mean
Medication Error Rate	Pre Implementation	4	6.4625	1.63671	.81836
	Post Implementation	4	7.6700	4.66588	2.33294

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Medication Error Rate	Equal variances assumed	2.706	.151	-.488	6	.643	-1.20750	2.47231	-7.25703	4.84203
	Equal variances not assumed			-.488	3.727	.653	-1.20750	2.47231	-8.27442	5.85942

Appendix C: Medication Error Rate Without Outlier *t*-test

Group Statistics

	Pre of Post Implementation	N	Mean	Std. Deviation	Std. Error Mean
Medication Error Rate	Pre Implementation	4	6.4625	1.63671	.81836
	Post Implementation	4	5.3075	.90282	.45141

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Medication Error Rate	Equal variances assumed	8.432	.027	1.236	6	.263	1.15500	.93460	-1.13189	3.44189
	Equal variances not assumed			1.236	4.671	.275	1.15500	.93460	-1.29928	3.60928

Appendix D: Ordering Error Rate *t*-test

Group Statistics

	Pre of Post Implementation	N	Mean	Std. Deviation	Std. Error Mean
Ordering Error Rate	Pre Implementation	4	.3825	.22066	.11033
	Post Implementation	4	.3550	.24338	.12169

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Ordering Error Rate	Equal variances assumed	.034	.859	.167	6	.873	.02750	.16426	-.37443	.42943
	Equal variances not assumed			.167	5.943	.873	.02750	.16426	-.37536	.43036

Appendix E: Transcribing Error Rate All Opportunities With Outlier *t*-test

Group Statistics

	Pre of Post Implementation	N	Mean	Std. Deviation	Std. Error Mean
Transcribing Order Rate	Pre Implementation	4	1.5775	.74759	.37380
	Post Implementation	4	4.0575	4.41450	2.20725

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Transcribing Order Rate	Equal variances assumed	6.045	.049	-1.108	6	.310	-2.48000	2.23868	-7.95785	2.99785
	Equal variances not assumed			-1.108	3.172	.345	-2.48000	2.23868	-9.39091	4.43091

Appendix F: Transcribing Error Rate All Opportunities Without Outlier *t*-test

Group Statistics

	Pre of Post Implementation	N	Mean	Std. Deviation	Std. Error Mean
Transcribing Order Rate	Pre Implementation	4	1.5775	.74759	.37380
	Post Implementation	4	1.6925	.39736	.19868

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Transcribing Order Rate	Equal variances assumed	.982	.360	-.272	6	.795	-.11500	.42332	-1.15082	.92082
	Equal variances not assumed			-.272	4.570	.798	-.11500	.42332	-1.23471	1.00471

Appendix G: Dispensing Error Rate All Opportunities *t*-test

Group Statistics

	Pre of Post Implementation	N	Mean	Std. Deviation	Std. Error Mean
Dispensing Error Rate	Pre Implementation	4	1.3550	1.04952	.52476
	Post Implementation	4	.4200	.41577	.20789

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Dispensing Error Rate	Equal variances assumed	1.228	.310	1.657	6	.149	.93500	.56444	-.44613	2.31613
	Equal variances not assumed			1.657	3.919	.174	.93500	.56444	-.64499	2.51499

Appendix H: Administration Error Rate All Opportunities *t*-test

Group Statistics

	Pre or Post Implementation	N	Mean	Std. Deviation	Std. Error Mean
Med Error Opportunity Rate	Pre Implementation	4	5.3225	1.57838	.78919
	Post Implementation	4	3.9125	.80917	.40459

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Med Error Opportunity Rate	Equal variances assumed	10.328	.018	1.590	6	.163	1.41000	.88686	-.76006	3.58006
	Equal variances not assumed			1.590	4.475	.180	1.41000	.88686	-.95257	3.77257

Appendix I: Dispensing Error Rate Earliest Stage *t*-test

Group Statistics

	Pre of Post Implementation	N	Mean	Std. Deviation	Std. Error Mean
Dispensing Error Rate	Pre Implementation	4	1.2975	1.07130	.53565
	Post Implementation	4	.4200	.41577	.20789

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Dispensing Error Rate	Equal variances assumed	1.588	.254	1.527	6	.178	.87750	.57458	-.52844	2.28344
	Equal variances not assumed			1.527	3.884	.204	.87750	.57458	-.73681	2.49181

Appendix J: Administration Error Rate Earliest Stage *t*-test

Group Statistics

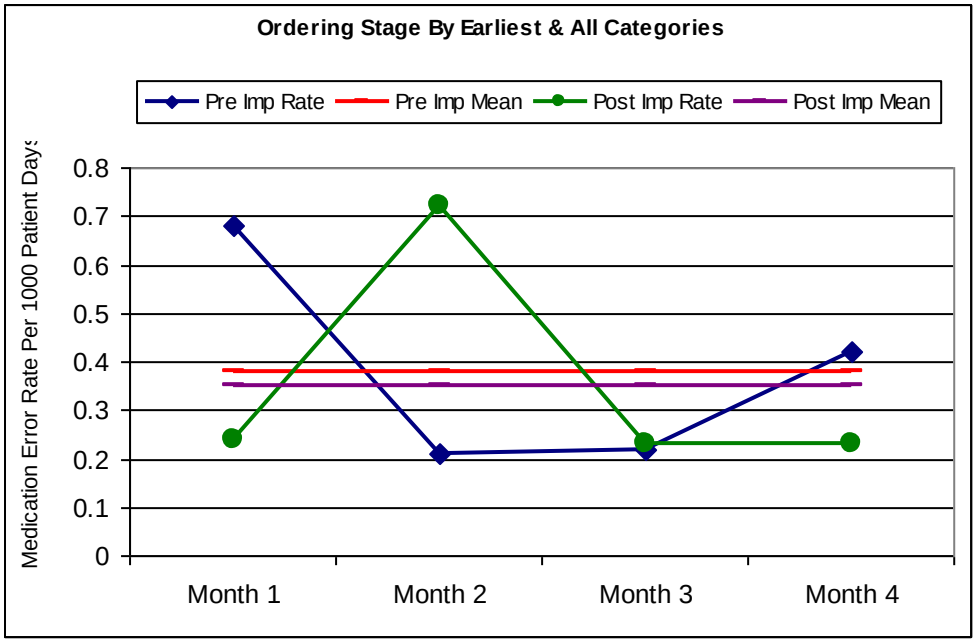
	Pre or Post Implementation	N	Mean	Std. Deviation	Std. Error Mean
Administration Error Rate	Pre Implementation	4	3.0950	.47057	.23528
	Post Implementation	4	2.7850	1.29454	.64727

Independent Samples Test

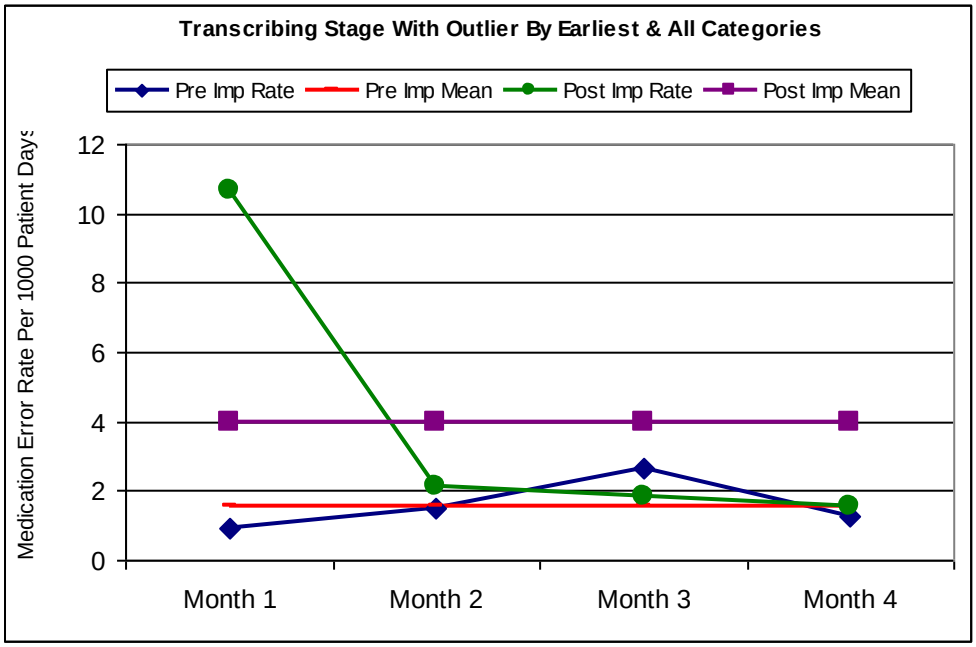
		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Administration Error Rate	Equal variances assumed	1.325	.293	.450	6	.668	.31000	.68871	-1.37520	1.99520
	Equal variances not assumed			.450	3.779	.677	.31000	.68871	-1.64703	2.26703

Appendix K: Graphical Displays of Table Data

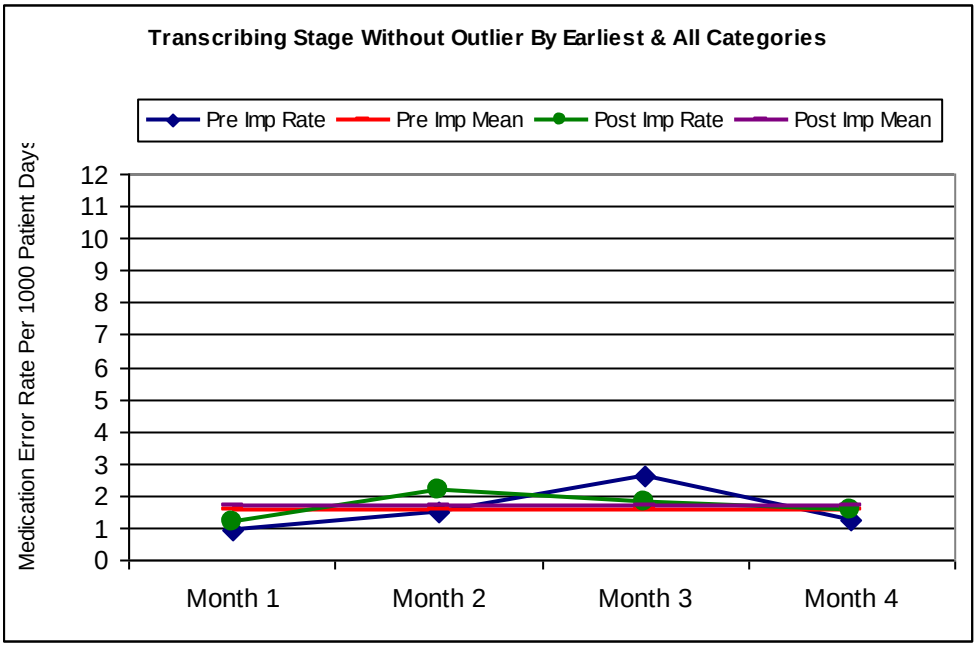
Appendix K1: Ordering Stage By Earliest & All Categories



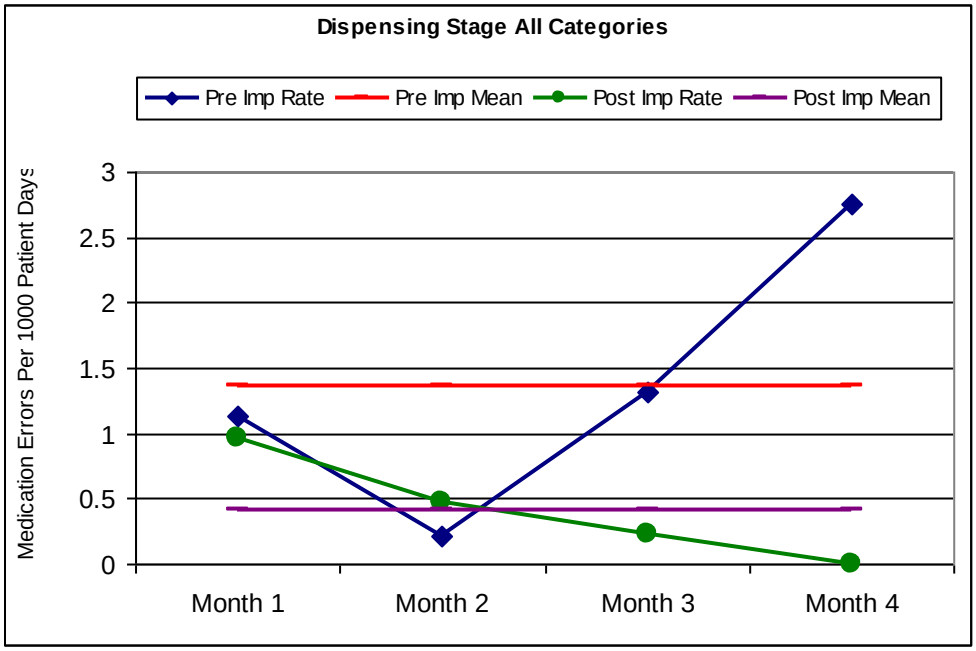
Appendix K2: Transcribing Stage With Outlier By Earliest & All Categories



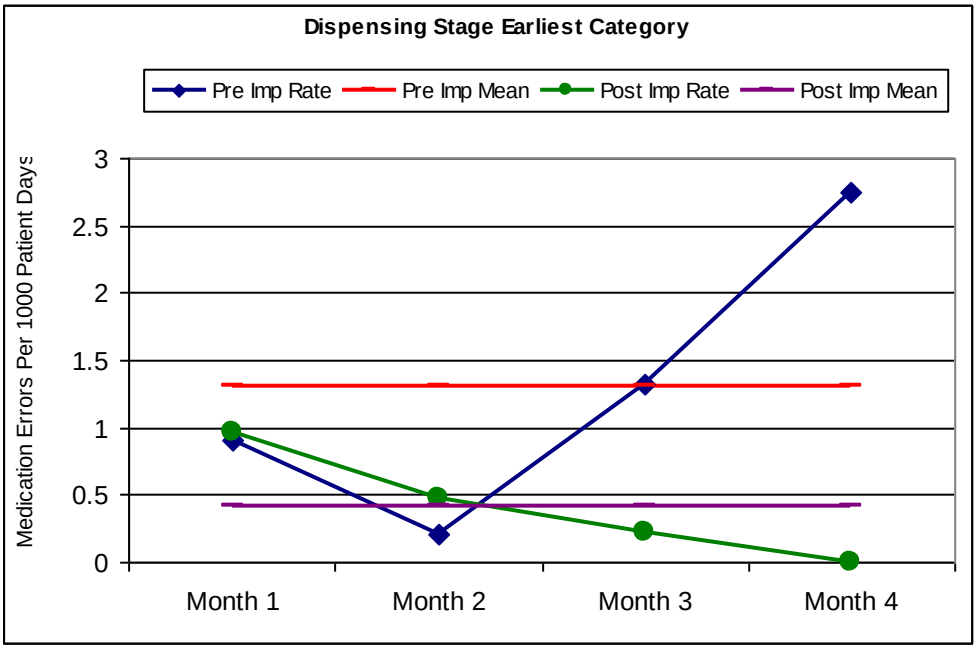
Appendix K3: Transcribing Stage Without Outlier By Earliest & All Categories



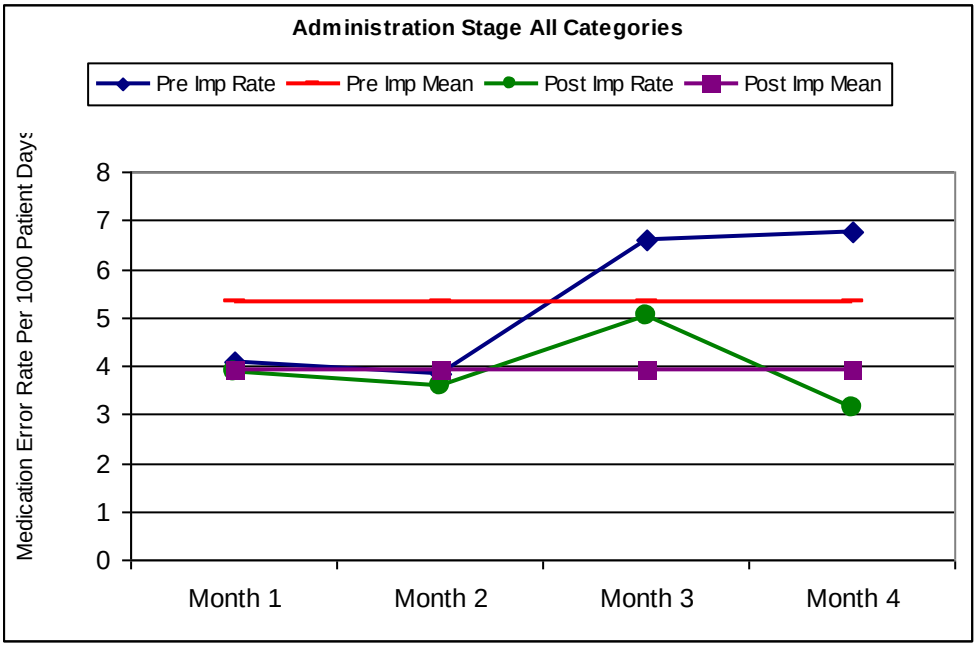
Appendix K4: Dispensing Stage All Categories



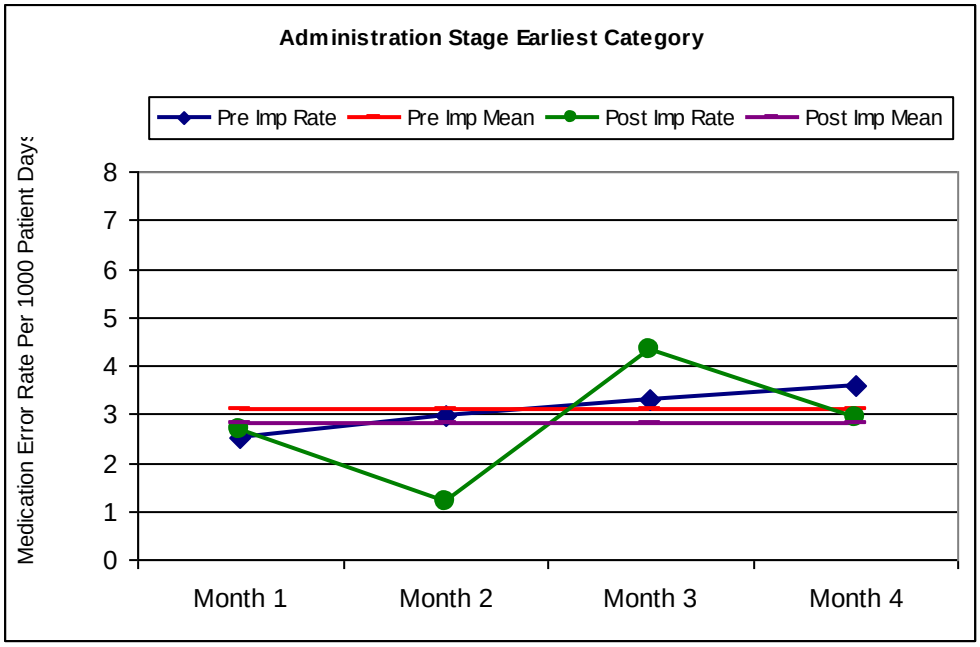
Appendix K5: Dispensing Stage Earliest Category



Appendix K6: Administration Stage All Categories



Appendix K7: Administration Stage Earliest Category



CURRICULUM VITAE

Karen Varda

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2205 Herbert Avenue
Evansville, IN 47714 USA

Education

Master of Science in Health Informatics, Expected May 2007
School of Informatics, Indiana University Purdue University at Indianapolis (IUPUI)
Thesis: Medication Errors Pre and Post Implementation of an Admin-Rx Barcode Enabled Medication Administration System
Advisor: Anna McDaniel

- Medication Errors Pre and Post Implementation of an Admin-Rx Barcode Enabled Medication Administration System is the study that focused on the effect of the implementation of a medication administration IT solution on the prevalence of medication errors at an acute care hospital.

Master of Science in Health Services Administration, May 1989
University of Evansville, Evansville, Indiana

Bachelor of Science in Nursing, May 1979
University of Evansville, Evansville, Indiana

Research Interests

- Effectiveness of implementation of IT solutions for improving healthcare processes

Professional Experience

Health Informatics Specialist, Quality Department, St. Mary's Medical Center, Evansville, IN
Sep 2004 – May 2007

- Facilitated integration of data, information, and knowledge to support patients, clinicians, and other providers in their decision-making through the use of information structures, information processes, and information technology.

Quality Improvement Analyst, Quality Department, St. Mary's Medical Center, Evansville, IN
Aug 2001 – Sep 2004

- Performed functions of data gathering and verification, database management, coordinating medical staff and hospital quality issues, and providing quality education.

Adjunct Faculty, University of Evansville, Evansville, IN
Aug 2001 – Dec 2001

- Taught graduate course in Health Care Research and Design.

Quality Clinical Analyst, Quality Department, St. Mary's Warrick, Boonville, IN
Jan 2000 – Mar 2001

- Coordinated medical staff and hospital quality issues as well as educational courses.

Quality Clinical Coordinator, Quality Department, Welborn Baptist Hospital/St. Mary's, Evansville, IN
Jun 1998 – Jan 2000

- Coordinated medical staff and hospital quality issues.

Birthplace Staff Nurse, Newborn Nursery, Welborn Baptist Hospital, Evansville, IN
Jun 1979 – Jun 1998

- Provided and supervised patient care in the Newborn Nursery and developed, coordinated, and published a research study investigating the timing of the newborn bath and infant temperatures.

Clinical Nursing Instructor, Indiana Vocational Technical College, Evansville, IN
1991 – 1993

- Increased teaching skills as a clinical instructor in obstetrics for the Associate Degree Nursing program.

Publications, Professional Presentations

2006 Presentation entitled "Admin-Rx Failure Mode Effect Analysis" at the Region 7 meeting of the Indiana Association For Healthcare Quality.

2005 Presentation with Sharon Milligan, RN, entitled "Racing For Quality: The Informatics Edge" at the Indiana Association For Healthcare Quality Annual Education Conference in Indianapolis, Indiana.

2000 Varda, K., & Behnke, R. (2000). The Effect of Timing of the Initial Bath on Infant Temperature. Journal of Obstetrical, Gynecological, and Neonatal Nursing, 29 (1), 27-32.

Memberships and Awards

2001-07 Indiana Association For Healthcare Quality Board of Directors
2005 Service Award – Indiana Association For Healthcare Quality
1997 Sigma Theta Tau – Omicron Psi Chapter
1992 "Outstanding Achievement in Nursing Practice" Award – Welborn Baptist Hospital
1989 Phi Kappa Phi Honor Society