A COMPARISON OF DISPENSING ERROR DETECTION METHODS FOR THE

DEPARTMENT OF DEFENSE

Except where reference is made to the work of others, the work described in this thesis is my own or was done in collaboration with my advisory committee. This thesis does not include proprietary or classified information.

_____

Achilles J. Hamilothoris

Certificate of Approval:

_____	_____
Elizabeth A. Flynn Professor Pharmacy Care Systems	Kenneth N. Barker, Chair Professor Pharmacy Care Systems
_____	_____
Robert E. Thomas Professor Industrial and Systems Engineering	George T. Flowers Interim Dean Graduate School

A COMPARISON OF DISPENSING ERROR DETECTION METHODS FOR THE DEPARTMENT OF DEFENSE

Achilles J. Hamilothoris

A Thesis

Submitted to

the Graduate Faculty of

Auburn University

in Partial Fulfillment of the

Requirements for the

Degree of

Master of Science

Auburn, Alabama
August 9, 2008

A COMPARISON OF DISPENSING ERROR DETECTION METHODS FOR THE DEPARTMENT OF DEFENSE

Achilles J. Hamilothoris

_____
Signature of Author

_____
Date of Graduation

THESIS ABSTRACT

A COMPARISON OF DISPENSING ERROR DETECTION METHODS FOR THE DEPARTMENT OF DEFENSE

Achilles J. Hamilothoris

Master of Science, August 9, 2008
(B.S., Rutgers University, 1995)

66 Typed Pages

Directed by Kenneth N. Barker

Medication error rates in pharmacies range from 0.2% to 10% and there are several detection methods in which these rates are determined. The observation and self report methods for detecting medication errors are described and compared at a Department of Defense (DoD) facility.

Over a period of 20 days, 3,293 prescriptions were studied using the observation method. These prescriptions were later reconciled against pharmacy prescription and computer data in order to identify dispensing medication errors by categories of errors.

The observation method detected 35 errors compared to zero reported by the presently utilized self-report method at this facility during the study period. In addition, when results were extrapolated, significantly different types of errors were detected by each method. The DoD should consider utilizing the observation method as its primary method for detecting dispensing errors.

APA style used

Microsoft Word 2003 used

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

INTRODUCTION

General Problem Area

A study by Flynn et al. (2003) reported that dispensing error rates, detected by the observation method in 50 ambulatory pharmacies ranged from 0.2% to 10%. Even if the conservative number of 1% were used, a projected 30 million errors would occur each year in the United States. In addition the study reported that 6.5% of these errors were found to be clinically significant, meaning having a high potential for serious patient harm. No such dispensing error study using the observation method has been conducted in a Department of Defense (DoD) healthcare facility and published.

There are several ways in which medication dispensing errors have been detected and an error rate compiled. Flynn, et. al. (2002) conducted a study in which the observation, chart review and incident report (self report) methods were compared in 36 hospitals and skilled nursing facilities in two states. The results of the study revealed that the observation method was better at detecting the most common categories of medication errors. Out of a total of 457 errors confirmed by a research pharmacist, 300 of 457 were detected by the observation method, 17 of 457 by chart review and only 1 of 457 by incident report.

The DoD presently uses the incident report method as its primary mode of detecting medication errors. After the incident reports are filled out, they are entered into MEDMARX, a central internet-based database that was designed to report, track and help

users detect trends in medication errors by using a standardized-entry form and allowing anonymous error data comparisons between the facilities enrolled.

Though not well-known, the DoD is responsible for fully 52% of the outpatient pharmacy error data reported by MEDMARX, which is commonly used as reflecting U.S. pharmacies.

The main goal of this study is to compare the medication error detection method now used by the Department of Defense (DoD) and compare it with the observation method with regard to the validity and reliability of the results obtained, and thus address the question "How does the present method for detecting prescription dispensing medication errors used by the DoD compare with the observation method?"

Review of the Literature

The literature search and review covered previous studies and their outcomes related to the research question. The search covered areas ranging from all outpatient pharmacy practice settings to specific comparison studies of the observation method and incident report techniques for detecting medication errors. The purpose of the literature review was to gain a broad background in the areas that relate to the research question, to understand the standard terminology and notations found in the literature and to identify individuals recognized as experts in the field in order that they may be contacted. In addition, the literature review was done to explain the significance and need to conduct the study, and to explain the rationale for the study.

The following databases and sources were used to conduct the literature search:

- Ovid Full Text Journals

- Cochrane Controlled Trials Register (CCTR)
- Cochrane Database of Systematic Reviews (CDSR)
- MEDLINE (1950 to present)
- CINAHL (1982 to present)
- MEDLINE In-Process & Other Non-Indexed Citations (1950 to present)
- PSYCINFO (1806 to present)
- Abstracts from national and international pharmaceutical and medical conferences
- Thesis/dissertation abstracts
- Contacts with researchers/personnel recognized as experts on this subject

The following terms were used to conduct the literature search:

- Key words:
  - "error"
  - "adverse"
  - "event"
  - "ade"
  - "a.d.e."
  - "misadventure"
  - "miss"
  - "medication"
  - "observation"
  - "incident"
  - "detection"
  - "self"
  - "method"
  - "MEDMARX"
- Key words were then cross-linked ("and" Boolean search) to the terms:
  - "outpatient"
  - "ambulatory"
  - "civilian"
  - "retail"
  - "military"
  - "dod"

- "d.o.d."
- "defense"
- "USAF"
- "Air Force"
- "Army"
- "Navy"
- "chain"
- "independent"
- "pharmacy"
- "community"
- "category"
- "categories"
- "dispensing"

Medication Errors

Barker & McConnell (1962) defined a medication error as the administration of the wrong medication or dose of medication, drug, diagnostic agent, chemical, or treatment requiring the use of such agents, to the wrong patient or at the wrong time, or the failure to administer such agents at the specified time or in the manner prescribed or normally considered as accepted practice.

The American Society of Health-System Pharmacists (1993) defined a medication error as any preventable event that may cause or lead to inappropriate medication use or patient harm, while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems including: prescribing; order communication; product labeling, packaging, and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use.

The United States Pharmacopoeia is the sponsor of MEDMARX, a national internet-based medication error reporting and prevention program. MEDMARX (2007) defines a

medication error as any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in control of the health care professional, patient or consumer. Such events may be related to professional practice, health care products, procedures and systems, including prescribing; order communications; product labeling, packaging and nomenclature; compounding; dispensing; distribution; administration; education; monitoring; and use.

The American Society of Consultant Pharmacists (1997) believe that all pharmacists involved in the medication use process have a responsibility to develop and participate in continuous quality improvement programs for preventing medication errors in pharmacies and long-term care facilities. The evaluation of existing processes and establishment of effective system controls should involve pharmacists in collaboration with other health care professionals, providers of care, and consumers of medications.

Dispensing Errors

There have been very few studies conducted on dispensing errors in an ambulatory pharmacy setting (community/outpatient/chain/independent/mail/military/HMO/etc.).

In a study to measure the effects of illumination levels on dispensing errors at an Army outpatient pharmacy, Buchanan (1991) defined a prescription dispensing error as a new, non-controlled-drug prescription deviating in one or more ways from the prescriber's written orders as shown on the patient's outpatient prescription. He found a dispensing medication error rate of 2.6-3.8% using a direct observation method.

In 1995, Allan et al. reported a 24% dispensing error rate involving high-risk medication prescriptions filled by disguised patients at 100 chain pharmacies. In a 2007 study conducted in a similar fashion to the 1995 study, Flynn found that when a pharmacy was

presented with a prescription of any one of five high-risk medications for filling, the overall dispensing error rate was 22%, which was very similar to the 24% error rate reported by her group 12 years previously, suggesting that dispensing accuracy has not improved much over the past 12 years.

In 2003, Flynn et al. conducted a nationwide observational study of 50 ambulatory pharmacies and detected an overall error rate of 1.7%, with 6.5% of these errors being considered clinically significant (meaning having a high potential for serious harm or injury). Flynn defined a dispensing error as a discrepancy between the prescriber's interpretable written order and the filled prescription (including written modifications made by the pharmacist pursuant to contact with the prescriber or in compliance with pharmacy policy). The definitions of the dispensing error categories used were as follows:

- Wrong drug: A medication that is different from what the prescriber wrote on the prescription order or, for refill prescriptions, what is printed on the prescription label.
- Wrong strength: A dosage unit containing an amount of medication that is different from what the prescriber specified is dispensed without an adjustment to the dosing instructions to the patient.
- Wrong dosage form (correct drug): The form of the medication used to fill the prescription is different from what the prescriber wrote on the prescription order. Examples of this type of error include filling a prescription with an enteric-coated tablet when it was not ordered as such and using a sustained-release product when one was not ordered.

- Wrong quantity*:* The number of dosage units or the volume of a product was different from what the prescriber ordered. Unless the observer could see a difference in the number of solid oral dosage forms without counting on a tray, we assumed that the correct quantity was used. Liquid measures were included if it was possible to observe the volume dispensed. If the quantity or volume of liquid could not be determined, the prescription was classified as "no error" if there were not errors in any other categories.
- Wrong prescription label information (excluding instructions): Defined to include one or more of the following deviations from any one of the federal or state requirements for label contents:
    - Name and address of dispenser (pharmacy).
    - Serial number of prescription.
    - Date of prescription or date of filling.
    - Name of prescriber.
    - Name of patient, if stated in the prescription order.
    - Drug name.
    - Drug strength (if more than one strength was available).
    - Quantity dispensed.
    - Expiration date.
    - Manufacturer or distributor.
- Wrong label instructions: The directions on the prescription label deviated in one or more ways from what was prescribed, except for changes made based on good pharmaceutical practice. (Note that auxiliary label information included on the

package by the pharmacist that was not required by the physician was not evaluated in this study.) For example, if "for 14 days" was added at the end of the directions for an antibiotic that was prescribed to be taken for a complete course of therapy, an error was not counted. However, if the physician wrote "for 14 days" on the prescription order and this was omitted from the label instructions, a wrong label instruction error was counted.

- Omission: Failing to dispense a prescribed medication.
- Wrong time: A medication was packaged in blister pack locations that were different from what was conveyed on the prescription (e.g., a medication was placed in the bubble for bedtime doses instead of the one for dinner doses).
- Deteriorated drug: A medication that had passed its expiration date was used to fill a prescription or a prescription was filled with a medication that was stored in a location not in accordance with the manufacturer's recommendations (e.g., outside a refrigerator).

Error Detection Methods

There are several ways in which medication errors have been detected and an error rate compiled.

Schneider (2002) presented nine workshop vignettes on medication error detection methods in hospitals. These nine methods ranged from the voluntary reporting method, to chart review method, to the observation method, to using various computer-assisted-information technology methods. He concluded by stating that no single method offers a comprehensive measure of medication safety, but rather a combination of methods needs to be used.

In an inpatient hospital setting, Flynn, et. al. (2002) conducted a study in which the observation, chart review and incident report (self report) methods were compared in 36 hospitals and skilled nursing facilities in two cities. Results of the study revealed that the observation method was far better at detecting the most common categories of medication errors. Out of a total of 457 errors confirmed by a research pharmacist, 300 of 457 were detected by observation method, 17 of 457 by chart review & 1 of 457 by incident report. In a study comparing two error detection methods in an outpatient mail order pharmacy, Varadarajan (2008) found a significant difference in the type of errors detected by the two methods. The observation method was significantly better at detecting dispensing errors compared to the incident report method.

The DoD presently uses the incident report method as its primary mode of detecting medication errors. Therefore, the observation and incident report methods will be discussed in further detail.

Allan and Barker (1990) defined an incident report as a term used to designate the official written legal report of a medication error as documented by hospital staff. Schneider (2002) reported that on a national scale, the incident report method is a good way of identifying emerging problems before they result in harm and detecting events that are relatively rare in individual institutions. Other strengths include the minimal resources needed for data collection and that the capture of problems is perceived and done by front- line practitioners. Limitations of the incident report method include the fact that incident reporting is passive and reporter dependent. Staff must also be aware that an error has occurred and be given the time and proper motivation to complete the reports.

In addition, staff may be reluctant to complete and submit the reports due to fear of management taking disciplinary action. These limitations may prevent reporting.

In comparison, the observation method overcomes many of these limitations. Flynn et al. (2003) reported the following advantages of the observation method over the incident report method:

- Knowledge of the error by the person involved is not required (they are often not aware that an error has been made).
- Willingness to report the error is not a factor (there is no threat of disciplinary action as a result of recording the error using observation).
- Remembering to report errors is not required.
- Ability to communicate errors is not required.
- Selective perception of the nurse or pharmacist is not involved (they may only believe it is necessary to report serious errors).

Limitations of the observation method include:

- Special training is needed for observers to conduct data collection.
- Devoting an employee to conduct the observation may impose a greater strain on financial and personnel resources.
- The observation method needs to be conducted over periods of time and thus may cause fatigue of the observers.

Another concern of the observation method is that because the observer may be in the vicinity of the individuals being observed, the individuals being observed may in fact make more or less errors due to being observed. Numerous studies have shown that this is an unimportant concern. Barker (1966) found that when observing nurses

administering medications, the observer did not have an effect on the error rate as determined by exit interviews with the nurses and comparisons of the individual nurse daily error rates over the study period duration. Flynn (2003) compared the error rates of prescriptions filled prior to the observer's arrival to the error rates during the study period, and found no significant difference. Kerlinger and Lee (1999) also wrote that as long as the observation is done in an unobtrusive and nonjudgmental manner, the subject adapts quickly to an observer's presence and the subject acts as they usually act. Dean and Barber (2001) also found that the observation of nurses at a United Kingdom hospital to include tactful interventions by the observers, did not significantly affect the medication administration error rate.

Significance

Extrapolating the error rates from Flynn's 2003 nationwide study of 50 pharmacies to the 20 million outpatient prescriptions filled annually at the 76 DoD healthcare facilities worldwide would mean that the real rate of errors is probably not 3,600 errors per year, but closer to 340,000 errors. That would be 94 times higher than the present amount reported by the DoD. Extrapolating using an error rate somewhere between Buchanan's 3.8% and Flynn's 22% error rate would mean the occurrence of over one million errors per year.

This situation calls for further research to develop an evidence-based database in an effort to learn how to increase patient safety.

Adding significance to this study is the uniqueness of a DoD pharmacy when compared to traditionally studied 'civilian' pharmacies. Active duty DoD personnel that receive

medications from DoD pharmacies have jobs that may be quite different from their civilian pharmacy customer counterparts. Thus, the impact of being on the receiving end of a medication dispensing error may be much higher or severe.

For example an individual that may be on active flying status such as a bomber or fighter pilot must follow strict rules and regulations for issues pertaining to medications. Medications are categorized and classified according to such things as their side effect profile and lingering effects. Many medications are listed on a "Do Not Fly" list (list confidential) meaning medical experts have determined that flying status personnel cannot perform their normal duties while taking or experiencing the secondary effects of such medications. If for example a pilot is prescribed and takes a medication deemed 'safe' to take while flying and a medication dispensing error occurs in which a "Do Not Fly" medication is dispensed, the consequences could be catastrophic.

Choate (2006) reported an incident that occurred during a mission involving a B-1 bomber. In that incident, the co-pilot landed the plane without lowering the landing gear in the proper condition, causing over $7.9 million dollars in damage and injuries to the crew. The subsequent investigation report stated that the co-pilot took a "go-pill" ninety minutes prior to the landing, but the co-pilot had never taken that medication before nor was cleared to take that medication.

Other examples of active duty individuals may include aircraft maintainers, Personnel Reliability Program (PRP) individuals or Security Forces (SF) personnel. PRP individuals have similar and even additional restrictions to the flying status individuals mentioned previously, due to the nature that PRP personnel work directly with nuclear weaponry. SF personnel are entrusted with guarding bases, entrances, crowds, missile

silos, gates, weapons, personnel, airframes, etc. Thus, any unintended medication dispensing error causing impaired judgment or side effects has the capacity to produce grave effects that extend far beyond the scope of the individual patient involved. Sneeder (2001) reported that of a survey of 214 USAF aircraft maintainers, 26 said that they received medications that made them drowsy after seeing a medical provider, and 19 (65%) returned to their normal jobs while they were still feeling the drowsiness effects of the medications.

Active duty personnel have responsibilities that to include weaponry, mid-air refueling operations and combat zone tactical operations to name a few. In addition to the individual and airframe being at increased risk, armaments and ordinances being carried may produce secondary effects if they are either used inappropriately on civilian or allied forces or if involved in any accidents. O'Neil (2003) reported that during a friendly fire incident in a hostile combat zone, a "go-pill" was identified as a contributing factor to the incident. In that incident, a fighter jet delivered ordinance onto allied forces, causing four fatalities.

Scope

The subjects to be studied were identified by querying military leaders in Washington, D.C. on potentially good locations to conduct the study. Two locations were selected based upon their size, mission, military importance, representativeness and error reporting rate of the facility. Once these locations were identified, the commanders of these locations were interviewed by the researcher. The researcher described the rationale and the procedures of the study and how the results will be used. Both

commanders welcomed the researcher to visit and perform the study at their locations. Due to time constraints, only one location was used for data collection. The location that was selected had the greater number of flights with the most dangerous weapon systems.

Concepts Defined

Department of Defense Pharmacy - An outpatient-military pharmacy listed on the TRICARE Pharmacy Benefits website.

Medication error - Mistakes occurring at any stage in the process of ordering or delivering a medication. Medication errors can occur at any stage in the drug ordering, dispensing and administration processes. (Varadarajan, 2005)

Outpatient Prescription Dispensing-Error Rate - The numerator was the number of prescriptions containing one or more errors (not the total number of errors discovered) and the denominator was the opportunity for error. (Buchanan, 1991) The results of the equation are then multiplied by one hundred to obtain the percent of prescriptions in error.

Pharmacist - An individual currently licensed by any state board of pharmacy to practice pharmacy as demonstrated by the presence of a copy of the pharmacist's license renewal in the pharmacy. (Buchanan, 1991)

Incident report - The official written legal report of the medication error, as demonstrated by the presence of the report in the Pharmacy and the presence of a corresponding entry in the MEDMARX online database.

Problem Statement

1. The first objective was to explore and describe the dispensing medication error rates in a DoD outpatient pharmacy using and comparing the results obtained by the observation method and the existing incident report method.
2. The second objective of the study was to explore and describe the errors in categories detected by the incident report method and reported to MEDMARX, compared to the errors in comparable categories detected by the observation method.
3. The third objective of the study was to explore the present cumulative MEDMARX database of results by category, compared to the cumulative MEDMARX database of results by category where the DoD data resembled the results found by observation.

Research Questions

1. Will the error rates detected by the observation method and incident reports, be significantly different?
2. Will the error rates detected by the observation method and incident reports, be significantly different, by error category type?

3. How do the top three categories of errors as reported in the cumulative MEDMARX database compare to the top three categories detected by observation?

Research Hypotheses

H_0 - The error rates detected by the observation method and incident reports are not significantly different.

H_1 - The error rates detected by the observation method and incident reports are significantly different.

H_0 - The error rates detected by the observation method and incident reports by error category type are not significantly different.

H_2 - The error rates detected by the observation method and incident reports by error category type are significantly different.

H_0 - The top three types of errors in the cumulative MEDMARX database of results by category are the same as the top three types of errors in the cumulative MEDMARX database of results by category if the DoD data resembled the results found in this study.

H_3 - The top three types of errors in the cumulative MEDMARX database of results by category are not the same as the top three types of errors in the cumulative MEDMARX database of results by category if the DoD data resembled the results found in this study.

Operational Definitions

Prescription - An order for a medication for a patient by a physician, either handwritten or typed and handed in directly to the pharmacy by the patient or representative, or electronically transmitted to the pharmacy by the physician.

Prescriber - A currently licensed prescriber as documented by a copy of their state license or via check with the state's board's list of prescribers.

Opportunity for error – The total number of prescriptions inspected for accuracy by each pharmacist and checked by the observer during study hours.

Medication dispensing error - Any deviation between the prescriber's prescription, either handed in or transmitted electronically to the pharmacy (including documented modifications made by the pharmacist pursuant to contact with the prescriber or in compliance with pharmacy policy), and the filled prescription that is ready for delivery to the patient.

Medication dispensing error rate - The number of prescriptions containing at least one error divided by the total opportunities for error (total number of prescriptions checked by the pharmacist and reviewed by the observer during the study hours) and then multiplied by 100.

The following operational definitions are for the observation method error categorization types:

Wrong drug - A medication that is different from what the prescriber wrote on the prescription order.

Wrong strength - A dosage unit containing an amount of medication that is different from what the prescriber specified is dispensed without an adjustment to the dosing instructions to the patient. (Flynn et al. 2003)

Wrong dosage form (correct drug) - The form of the medication used to fill the prescription is different from what the prescriber wrote on the prescription order. Examples of this type of error include filling a prescription with an enteric-coated tablet when it was not ordered as such and using a sustained-release product when one was not ordered. (Flynn et al. 2003)

Wrong quantity - The number of dosage units or the volume of a product was different from what the prescriber ordered. (Flynn et al. 2003)

Wrong prescription label information (excluding instructions) - to include one or more of the following deviations from any one of the federal or state requirements for label contents: (Flynn et al. 2003)

- Name/address of pharmacy
- Date of Rx or date of filling
- Name of patient
- Drug strength
- Expiration date
- Rx number
- Name of prescriber
- Drug name
- Quantity dispensed
- Manufacturer

Wrong label instructions - The directions on the prescription label which deviated in one or more ways from what was prescribed, except for changes made based on good pharmaceutical practice. (Note that auxiliary label information included on the package by the pharmacist that was not required by the physician was not evaluated in this study.) For example, if "for 14 days" was added at the end of the directions for an antibiotic that was prescribed to be taken for a complete course of therapy, an error was not counted. However, if the physician wrote "for 14 days" on the prescription order and this was omitted from the label instructions, a wrong label instruction error was counted. (Flynn et al. 2003)

Omission - Failing to dispense a prescribed medication. (Flynn et al. 2003)

Wrong time - A medication was packaged in blister pack locations that were different from what was conveyed on the prescription (e.g., a medication was placed in the bubble for bedtime doses instead of the one for dinner doses). (Flynn et al. 2003)

Deteriorated drug - A medication that had passed its expiration date was used to fill a prescription or a prescription was filled with a medication that was stored in a location not in accordance with the manufacturer's recommendations (e.g., outside a refrigerator). (Flynn et al. 2003)

The following operational definitions are for the incident report method error categorization types:

Deteriorated product - A product in which the physical or chemical integrity may have been compromised by improper storage, light exposure, temperature, improper container type, etc. (MEDMARX, 2008)

Drug prepared incorrectly - Incorrect preparation / formulation of a drug product, e.g., incorrectly reconstituted or diluted. (MEDMARX, 2008)

Expired product - A product with an expiration date beyond the date by which policies/procedures direct the removal of the product from stock. (MEDMARX, 2008)

Extra dose – A duplicate dose administered at a different time. Note: Dose administered after order was discontinued is considered an *Unauthorized drug*. (MEDMARX, 2008)

Improper dose/quantity - Any dose or strength that differs from the prescribed dose or strength. Includes incorrect quantity (e.g., tablets, vials) dispensed. (MEDMARX, 2008)

Mislabeling - Product labeled incorrectly.

Omission error - Failure to administer an ordered dose; excludes patient's refusal and clinical decision (contraindication) or other reason (e.g., patient sent for test) not to administer. (MEDMARX, 2008)

Prescribing error - An incorrectly prescribed or authorized order (written or verbal). (MEDMARX, 2008)

Unauthorized/wrong drug - Medication that was not authorized by a legitimate prescriber was dispensed and/or administered. Note: Select 'Wrong Patient' when ordered for, dispensed for, or administered to the wrong patient. (MEDMARX, 2008)

Wrong administration technique - Inappropriate / improper technique used in the administration of a drug, includes incorrectly activating a drug administration system and inappropriately crushing tablets. (MEDMARX, 2008)

Wrong dosage form - A dosage form dispensed / administered other than that ordered by the prescriber. (MEDMARX, 2008)

Wrong patient - A product ordered for, dispensed for, or administered to the wrong patient. (MEDMARX, 2008)

Wrong route - Use of wrong route of administration of the correct drug, e.g., intravenous instead of intramuscular. (MEDMARX, 2008)

Wrong time - A scheduled dose administered outside a facility's acceptable predetermined time interval. (MEDMARX, 2008)

In addition to the observation method and incident report error categorization type definitions mentioned previously, the following will be used during categorization of error types:

Other - A medication dispensing error that does not fit into any of the other defined categories of errors.

METHODOLOGY

Design

The study was an exploratory study.

Population

The target population of this study was the prescriptions dispensed by the pharmacists working at the selected DoD outpatient pharmacy. The exact name and location of the pharmacy is omitted due to confidentiality requirements. The list of pharmacies that were available to be studied was accessed online from the DoD outpatient pharmacy website.

Sampling

The researcher was trained in the observation method by a research PhD Pharmacist. The researcher then observed 3,334 prescriptions as they were being filled in the normal workflow process, which included barcode verification at each step. The researcher observed the prescriptions after they were checked by a pharmacist and prior to dispensing to the patients. The minimum target of 3,000 prescriptions was determined by the researcher and the study committee members based upon the individual facility error data reporting rate history.

Pilot study

The pilot study for observation of dispensing errors took place at the sample DoD outpatient pharmacy on February 14, 2008. Prior to start of the pilot study, the researcher was introduced to the pharmacy staff. The researcher then downloaded a medication usage report from the pharmacy computer indicating the top 273 drugs dispensed by that pharmacy based on prescription count. The researcher then took this report and entered in the tablet/capsule identification marks from prescription stock bottles, making an imprint library in an effort to ease the reconciliation steps that would be completed later in the study. This information was then organized and saved in Microsoft Excel, 2003. The purpose of the pilot study was to test all procedures, equipment, data collection, download information/accessibility and data transport steps. Fifty new prescriptions with the exclusion of controlled substance prescriptions were observed by the researcher utilizing the observation method after they have had the final check completed by the pharmacist.

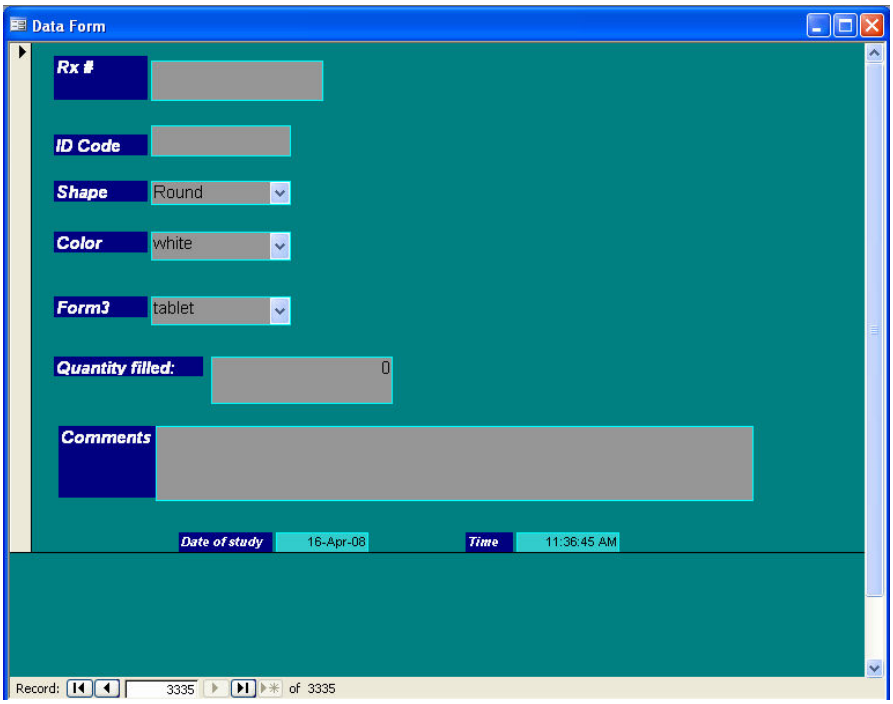
The researcher was blinded to all information from the label except the prescription number and date, by utilizing a cutout overlay of the prescription label that only allowed the date and prescription number to be viewed.

The researcher was also blinded to any other information that might make him aware of the error. He did not reconcile the information collected until after the data had been collected. If he was aware of the error, he would have had to have it corrected, which would have affected the comparison of error detection methods.

The researcher used Microsoft Access, 2003 to document the prescription number, dispensing date and time, prescription content identification information (i.e., tablet

imprint codes, inhaler active ingredients, liquid concentration, etc.), shape, color, dosage form, quantity (if less than 10) and any additional comments for each of the 50 prescriptions observed during the pilot study.

Figure 1: Screenshot of Microsoft Access, 2003 Data Collection tool.



The researcher took digital photographs of the front and back of every prescription observed for reconciliation after the observations took place. At first, a Real Digital 100K SnakeCam (Model# E02MUL) camera was used, but due to poor resolution issues identified after taking 5 pictures, a Sony Cybershot camera 5000K (Model# DSC-P10) was used instead.

The researcher also downloaded all prescription file information for the 50 prescriptions observed during the study period and all MEDMARX entry information for the previous

12 months into Microsoft Excel 2003 for reconciliation after completion of the pilot study.

No errors were identified during the reconciliation period which occurred the evening after data collection. Two issues were identified and corrected in regards to the data collection procedures. The first issue (which was mentioned previously) was in regards to the camera that the researcher was utilizing to capture the prescription images. Due to inadequate digital resolution with the SnakeCam, it was decided to switch cameras and utilize the researcher's Sony Cybershot camera for the study.

The second issue was in regards to the Microsoft Access, 2003 data collection tool. Due to a duplicate entry noted in the tool, it was decided to modify the program so that a duplicate scan of the same prescription number would trigger a popup message to warn that this was a duplicate entry.

Data Collection Techniques

The observation of dispensing errors took place at the sample DoD outpatient pharmacy from February 15, 2008 to March 14, 2008 (a total of 20 observation days). The hours of observation varied depending on workflow but typically lasted Monday through Friday from 0900 to 1600 with regular 30-60 minute lunch and 5 minute anti-fatigue breaks. No data was collected on February 18, 2008 and March 11, 2008 due to holiday or minimally-manned training days. New prescriptions with the exclusion of controlled substance prescriptions were observed by the researcher utilizing the observation method after they have had the final check completed by the pharmacist.

The researcher was blinded to all information from the label excluding the prescription number and date, by utilizing a cutout overlay of the prescription label that only allowed the date and prescription number to be viewed.

The researcher was also blinded to any other information so that he was not immediately aware of any errors committed, as he did not reconcile the information collected until 30 days after the data had been collected. This was to allow the staff at the pharmacy and patients time to detect errors committed and complete the incident reports.

The researcher used Microsoft Access, 2003 (see Figure 1) to document the prescription number, dispensing date and time, prescription content identification numbers (i.e., tablet imprint code), shape, color, dosage form, quantity (if less than 10) and any additional comments for each of the 3,334 prescriptions observed.

The researcher also took electronic images front and back of every prescription observed for reconciliation of the data 30 days later, utilizing a Sony Cybershot Model# DSC-P10 camera.

The researcher also downloaded all prescription file information for the 3,334 prescriptions observed during the study period and all MEDMARX entry information for the previous 12 months onto Microsoft Excel 2003 for reconciliation 30 days later.

Observation accuracy was optimized by creating an environment in which there were no other work responsibilities or demands on the researcher such as answering questions from individuals or answering telephone calls. The researcher was able to focus on that one task and worked at his own pace with no other time or workload constraints

During the reconciliation period that occurred 30 days after data collection, the data was analyzed to identify any missing information. The reconciliation of the data collected

took place in an isolated locked room in which there were no interruptions or distractions. Images were first randomly checked for completeness and legibility of resolution. Also, all data fields were double-checked for completeness and any anomalies. In addition, all findings were double and cross-checked with the various data backup files in order to rule out any false findings. It was noted that 41 images were either missing or illegible. Therefore, these prescriptions were not counted during the reconciliation period, which left 3,293 observations in the study. A medication identification program was also utilized to aid in identification of tablet/capsule/etc. information and also randomly verify 10% of the imprint library created previously (Micromedex Identidex, 2008).

During reconciliation, the prescription content information data, electronic images and computer files were reconciled to identify any errors that were detected by the observation method.

Light levels were also measured in the storage, pick-up, filling and checking areas of the pharmacy prior to data collection using an International Light Radiometer/Photometer (Model IL1350 SN2048).

Figure 2: Workflow of the Pharmacy.

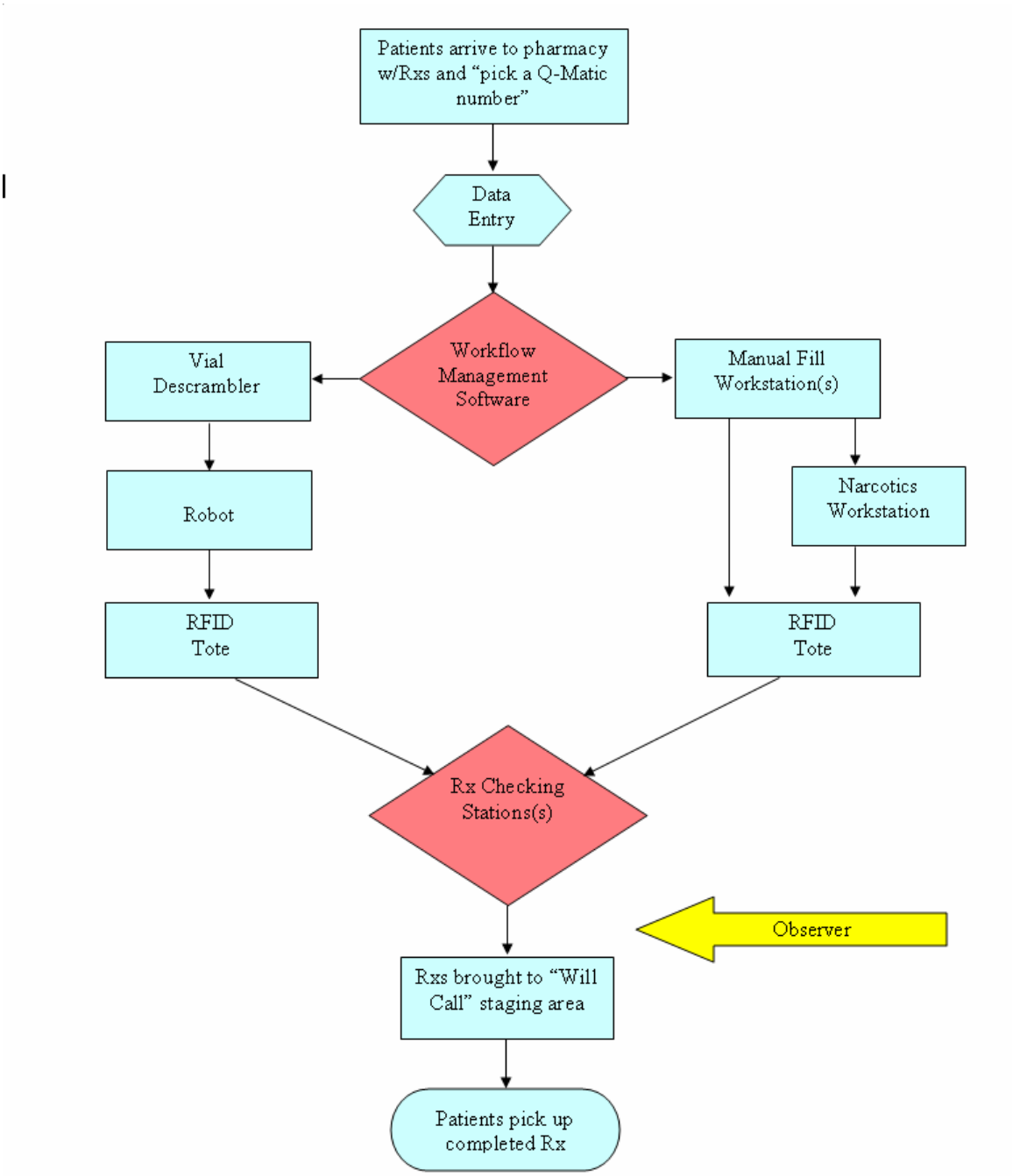
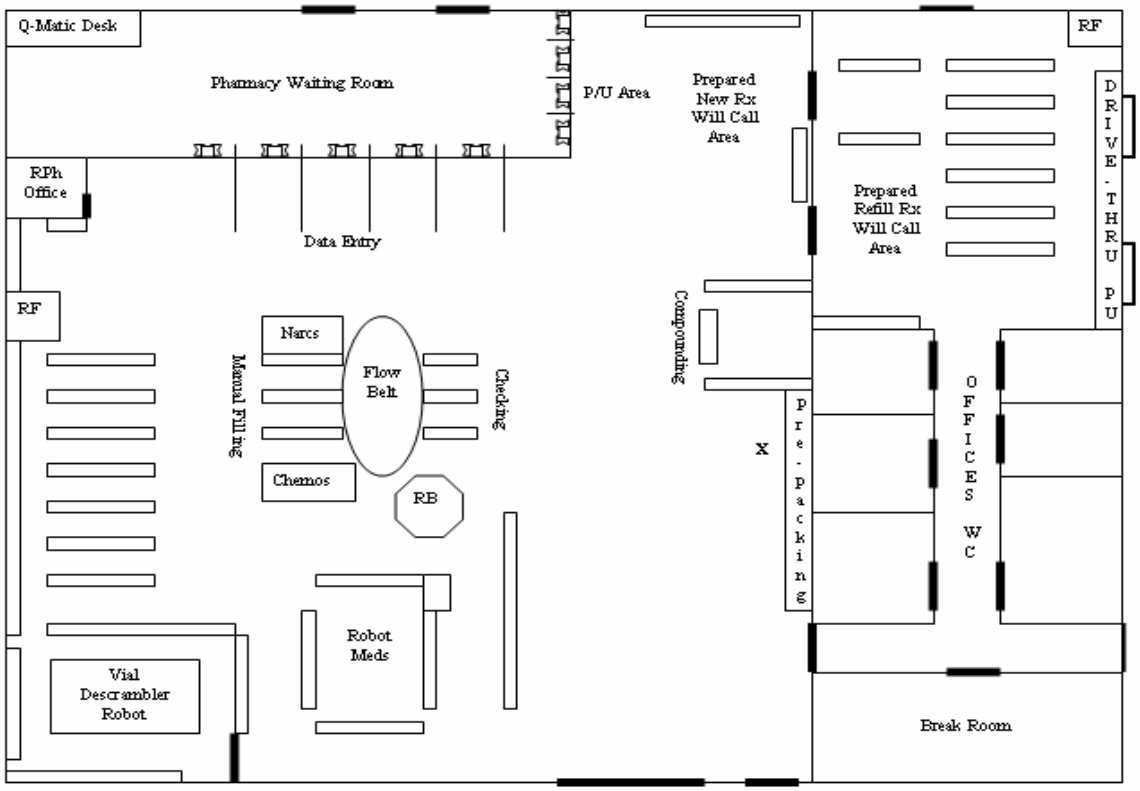


Figure 3: Pharmacy Layout ("x" indicates observer).



Statistical Hypotheses and Tests

Chi Square Analysis (Independent samples Chi Square test) utilizing the more conservative Yates' continuity correction was used to compare the error types and the total errors as detected by Observation and Incident Reports, using a software tool for Chi Square (Preacher, 2003). Alpha was set at 0.05. The results were verified with a second Chi Square analysis tool (GraphPad, 2008).

RESULTS

Data

A total of 5,984 new prescriptions were filled at the pharmacy being observed during the study data collection period of 15 February 2008 to 14 March 2008. The researcher observed 3,334 of these prescriptions, or 55.7%. Forty-one, or 1.2% of these observed prescriptions were excluded from the study due to not being able to find the original prescription in order to take a digital image for later reconciliation. One of the reasons for the missing prescriptions may have been that the pharmacy utilized a manual system for filing the original hardcopy prescriptions. Therefore, a total of 3,293 prescriptions were included in the final study, which was 55% of the total prescriptions dispensed for the study. An average of 315 prescriptions were filled per day and of these 176 were observed.

Figure 4: Observed prescriptions by date.

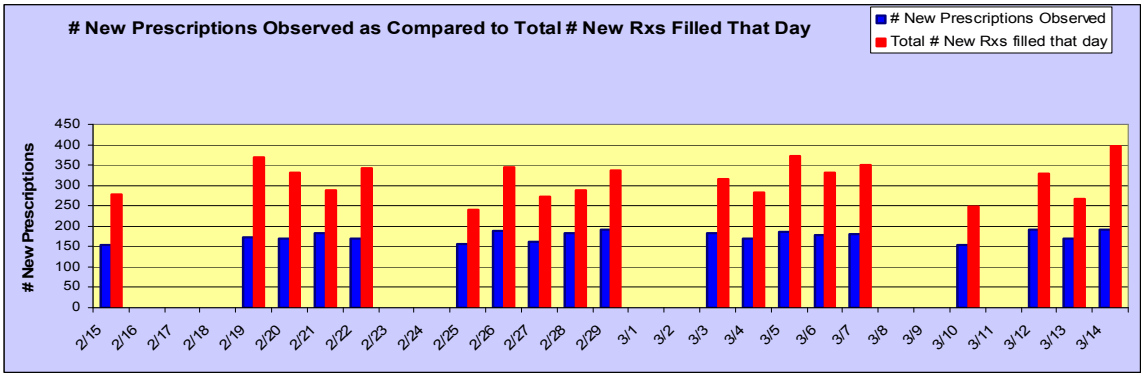
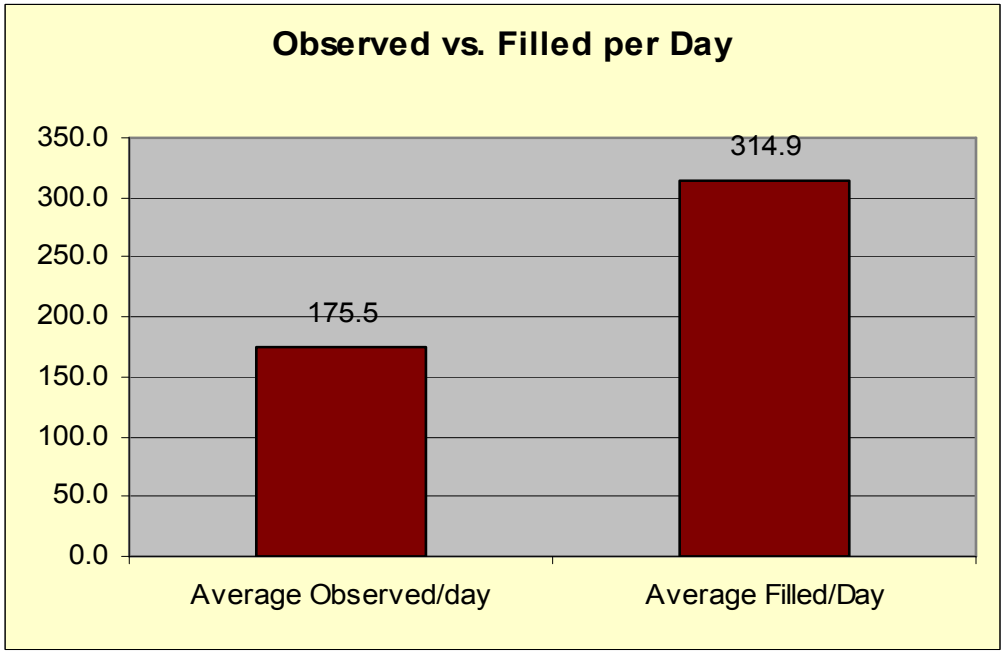


Figure 5: Average of Prescriptions Observed.



Errors Detected by the Observation Method

A total of 35 prescriptions errors were detected by the observation method.

Figure 6: Breakdown of error types detected by the observation method, using the MEDMARX error type category definitions.

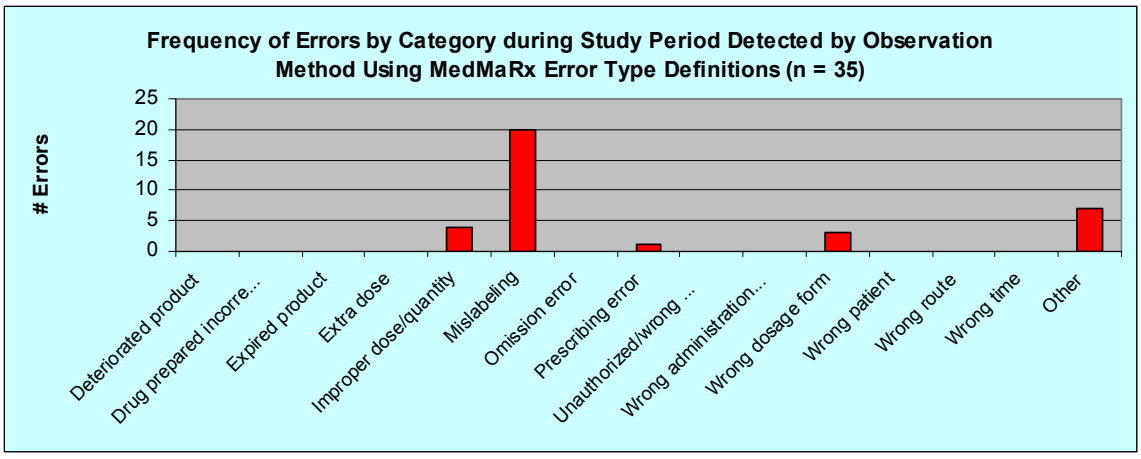
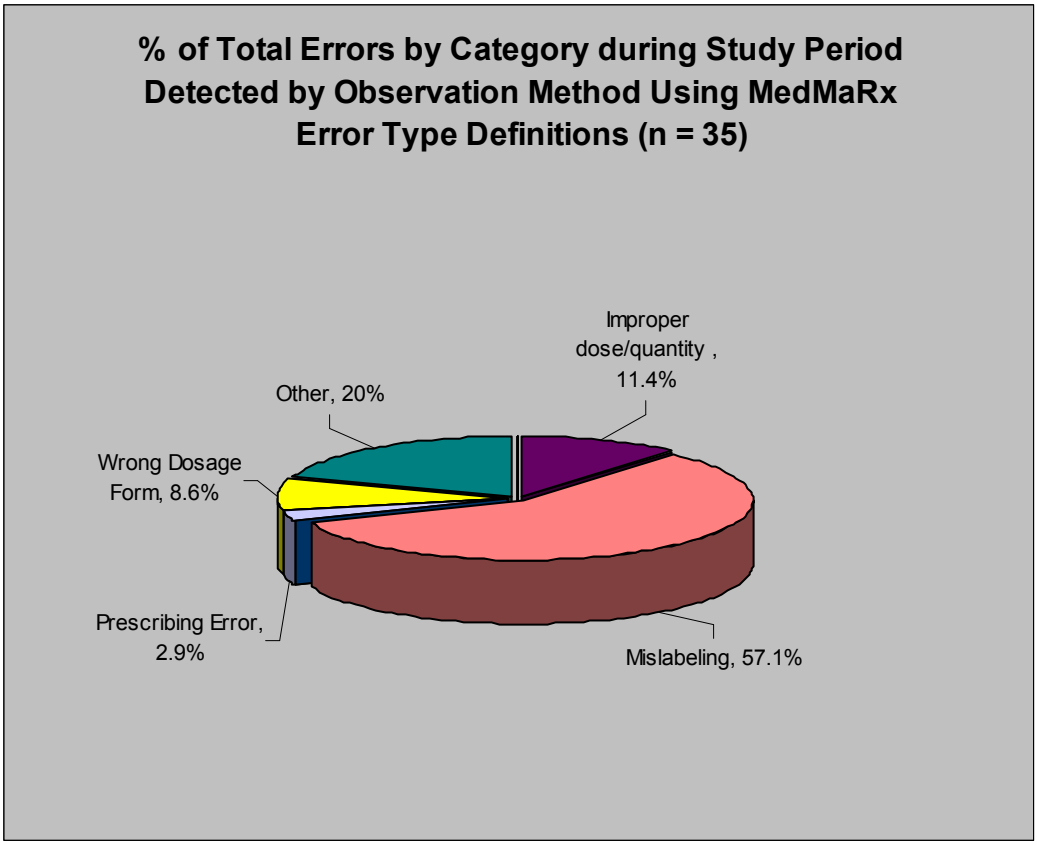


Figure 7: Breakdown of error type percentages for errors detected by the observation method, utilizing the MEDMARX error type definition.



The most frequently occurring error was Mislabeling (N = 20, 57%), followed by "Other" types of error (N = 7, 20%), followed by Improper Dose/Quantity (N = 4, 11%), Wrong Dosage Form (N = 3, 9%) and Prescribing Error (N=1, 3%).

Figure 8: Breakdown of error types detected by the observation method, using the Observation Method error type category definitions.

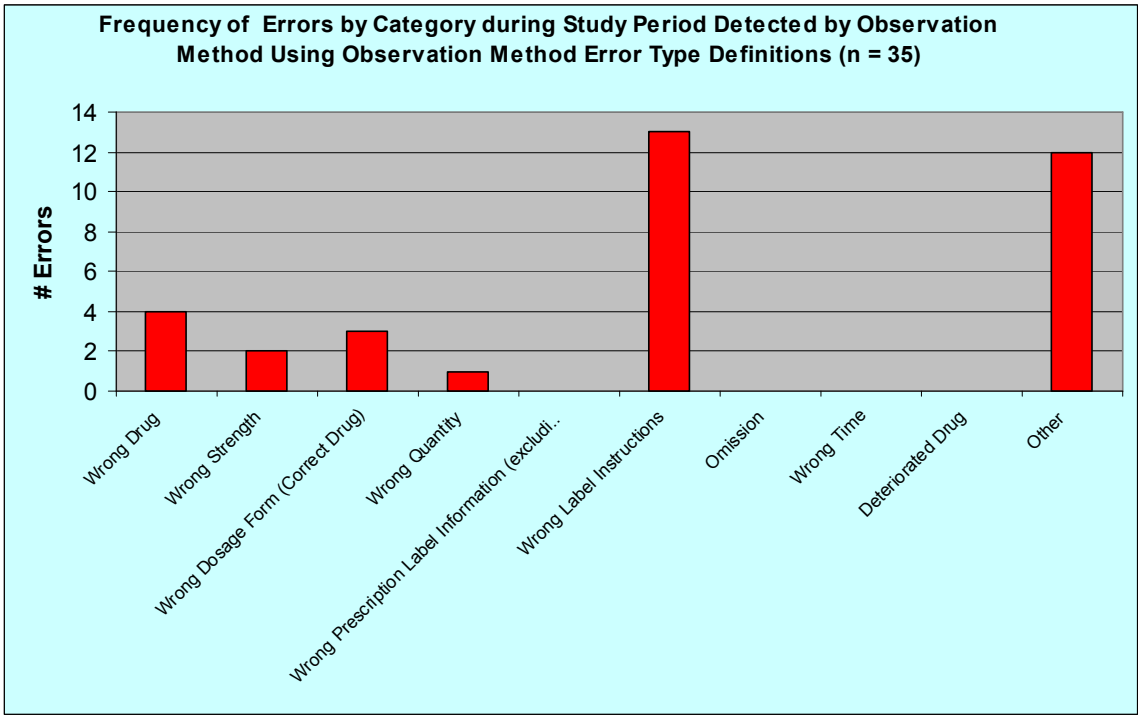
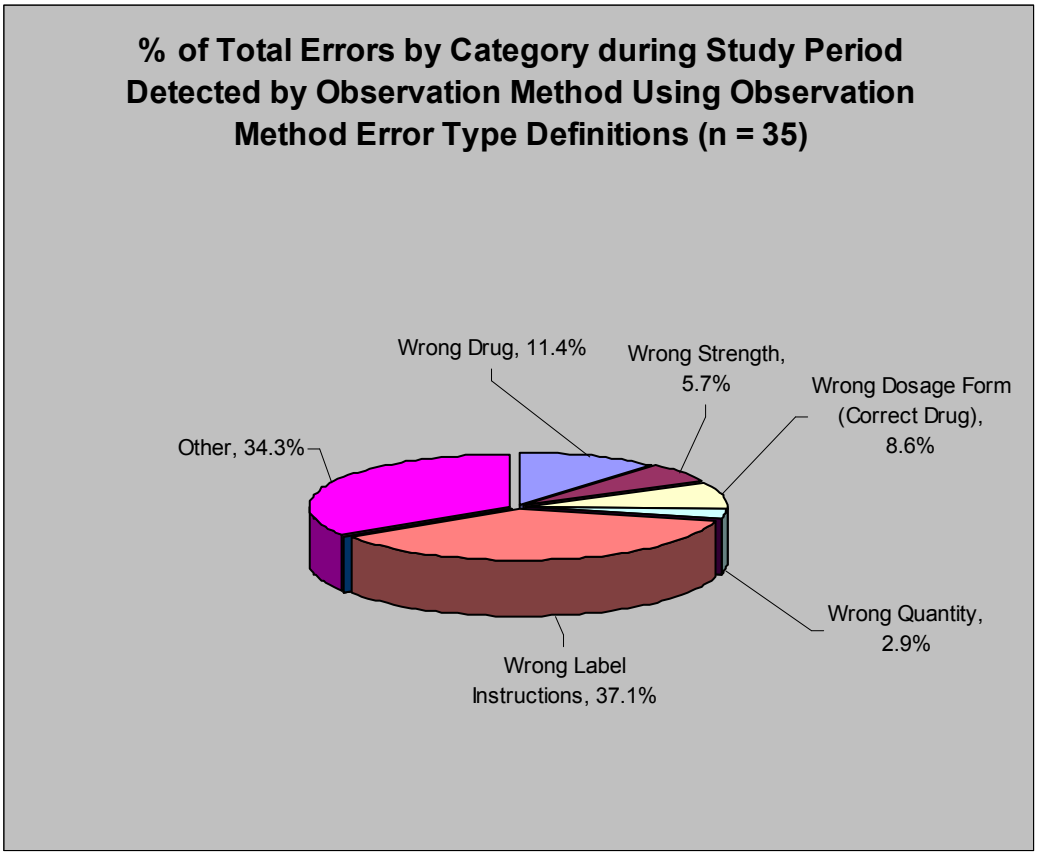


Figure 9: Breakdown of error type percentages for errors detected by the observation method, utilizing the Observation Method error type definition.



The most frequently occurring error was Wrong Label Instructions (N = 13, 37%), followed by "Other" type of error (N = 12, 34%), followed by Wrong Drug (N = 4, 11%), followed by Wrong Dosage Form (correct drug) (N = 3, 9%), followed by Wrong Strength (N = 2, 6%) and Wrong Quantity (N = 1, 3%).

The total amount of errors detected by the observation method during the study period, excluding the "Other" category of error types, was 23. This gave a total error rate of 0.70% utilizing the Observation Method based upon the 3,293 prescriptions included in the study.

Errors Detected by the Incident Report Method

There were no errors detected by the Incident Report Method for the 3,293 prescriptions included in the study. There were also no errors detected for the 41 prescriptions that were excluded from the sample. This gave an error rate of 0 utilizing the Incident Report Method.

The previous one year's worth of error data reported by the pharmacy to MEDMARX was analyzed. Out of a total of 81, 632 new prescriptions filled, 70 errors were detected. This gave an error rate of 0.09%

Table 1: Breakdown of previous one year error data reported by facility to MEDMARX.

	Self Reported Previous 1 Year (21 Feb 07 - 21 Mar 08)	% of Errors
Deteriorated product		
Drug prepared incorrectly		
Expired product		
Extra dose		
Improper dose/quantity	35	50.0%
Mislabeling	2	2.9%
Omission error		
Prescribing error		
Unauthorized/ wrong drug	12	17.1%
Wrong administration technique		
Wrong dosage form		
Wrong patient	21	30.0%
Wrong route		
Wrong time		
Total Errors	70	100.0%
Rxs Filled / Observed	81,632	
Error Rate	0.09%	

The most commonly reported error for the previous year time frame was Improper Dose/quantity (N = 35, 50%), followed by Wrong Patient (N = 21, 30%) followed by Unauthorized/wrong drug (N = 12, 17%) and Mislabeling (N = 2, 3%).

Table 2: Comparison of one year facility MEDMARX data to study sample Observation Method data using MEDMARX error category definitions. (Note: "Other" types of errors detected during the sample period are not included and "Wrong patient" errors were not evaluated in this study)

	Self Reported Previous 1 Year (21 Feb 07 - 21 Mar 08)	% of Errors	Observation Method During Sample Period	% of Errors	Errors Observed Extrapolated to One Year
Deteriorated product					
Drug prepared incorrectly					
Expired product					
Extra dose					
Improper dose/quantity	35	50.0%	4	14.3%	99
Mislabeling	2	2.9%	20	71.4%	496
Omission error					
Prescribing error			1	3.6%	24
Unauthorized/ wrong drug	12	17.1%			
Wrong administration technique					
Wrong dosage form			3	10.7%	75
Wrong patient	21	30.0%			
Wrong route					
Wrong time					
Total Errors	70	100.0%	28	100.0%	694
Rxs Filled / Observed	81,632		3,293		81,632
Error Rate	0.09%		0.85%		0.85%

Twenty-eight dispensing errors were detected by the observation method out of 3,293 prescriptions observed during the sample period (error rate = 0.85%). The data in the right column indicate that the errors occurring per year are not 70 as presently indicated with the self report method (incident reports, MEDMARX), but 694 if the observation method results were extrapolated.

Light levels in the pharmacy

Table 3: Pharmacy light levels

Pharmacy Area	Light Level (ft/candle)
Storage Area 1	67
Storage Area 2	73
Storage Area 3	80
Pick-Up Area 1	54
Pick-Up Area 2	71
Pick-Up Area 3	76
Filling Area 1	93
Filling Area 2	97
Filling Area 3	109
Checking Area 1	94
Checking Area 2	108
Checking Area 3	126

Light levels in the pharmacy ranged from a low of 54 ft/candles in the Pick-Up Area 1 section to 126 ft/candles in the Checking Area 3 section. Buchanan in 1991 reported that the rate of prescription-dispensing errors was associated with the level of illumination. He went on to report that the lowest prescription-dispensing error rate occurred at the 146 foot-candles illumination level compared to the 102 and 46 foot-candles illumination levels.

Present cumulative MEDMARX database of results by category, compared to the cumulative MEDMARX database of results by category if the DoD data resembled the results found in this study

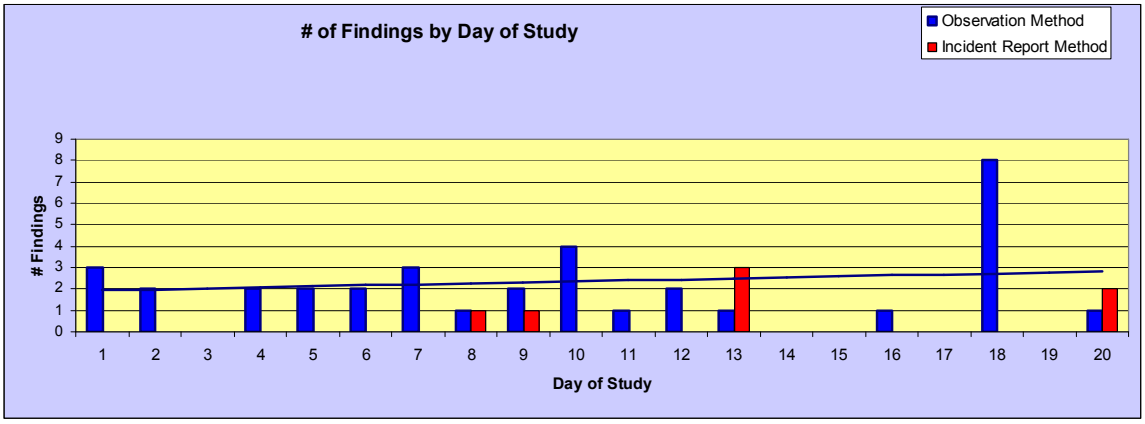
Table 4: Ranking of % Error Type categories for Non-DoD Facilities, DoD Facilities, Total MEDMARX of Non-DoD and DoD Facilities and Total MEDMARX for Non-DoD and DoD if DoD % Error Type Contributions resembled % Error Types found in this study (using MEDMARX definitions)

	National MEDMARX Rate DoD Only	National MEDMARX Rate Non-DoD Only	Total MEDMARX Rate Using Self Report Method	Total MEDMARX Rate with DoD Using Observation Method
Deteriorated product				
Drug prepared incorrectly				
Expired product				
Extra dose				
Improper dose/quantity	2	2	2	2
Mislabeling				1
Omission error				
Prescribing error	1	1	1	
Unauthorized/ wrong drug		3	3	
Wrong administration technique				
Wrong dosage form	3			
Wrong patient				
Wrong route				
Wrong time				
Other				3

Seventy-five percent of the errors reported to MEDMARX fall within the top three % Error Categories. The top three % Error Categories reported to MEDMARX by DoD facilities were Prescribing Error, Improper Dose/quantity and Wrong Dosage Form. The

top three % Error Categories reported to MEDMARX by Non-DoD facilities were Prescribing Error, Improper Dose/quantity and Unauthorized/wrong drug. The top three % Error Categories reported cumulatively to MEDMARX were Prescribing Error, Improper Dose/quantity and Unauthorized/wrong drug. If the DoD % Error Categories were replaced with the data observed in this study at this facility, the top three categories for the cumulative MEDMARX results would be Mislabeling, Improper Dose/quantity and Other.

Figure 10: Number of Errors Detected by Day of Study, Both Methods



Errors detected by the Observation Method occurred linearly across the twenty day sample period. The seven incident reports that were reported during the sample period involved prescriptions excluded from the study.

Analysis

Chi Square Analysis (Independent samples Chi Square test) utilizing the more conservative Yates' continuity correction was used to compare the error types and the total errors as detected by Observation and Incident Reports, using an electronic software tool for Chi Square (Preacher, 2003). The results were verified with a second Chi Square analysis tool (GraphPad, 2008).

Comparison of numbers of errors detected by each method

Table 5: Statistical analysis of numbers of errors detected by the Incident Report method compared to numbers of errors detected by Observation Method.

	Yates Chi Square Value	Degrees of Freedom	Significance
Total errors Detected by each Method	25.918	1	0.0001

There was a statistically significant difference in the total number of errors detected by the observation method during the sample period compared to the total number of errors detected by the incident report method during the sample period.

Comparison of error types using MEDMARX error type category definitions

Table 6: Statistical analysis of sample period incident report data compared to previous one year data.

Error Type	Yates Chi Square Value	Degrees of Freedom	Significance
Improper dose/quantity	1.6	1	0.2053
Mislabeling	0.147	1	0.7018
Unauthorized/ wrong drug	0.134	1	0.7146
Wrong patient	2.018	1	0.1554
Total Errors	0.314	1	0.5754
Rxs Filled	1.365	1	0.2427

There was no statistically significant difference in the types of incident report errors reported during the sample period compared to the previous one year data. There was also no statistically significant difference in the amount of prescriptions filled.

Table 7: Statistical analysis of sample period observation method data compared to previous one year data.

Error Type	Yates Chi Square Value	Degrees of Freedom	Significance
Improper dose/quantity	2.714	1	0.099
Mislabeling	421.578	1	0.0001
Prescribing Error	5.706	1	0.0169
Unauthorized/ wrong drug	0.484	1	0.487
Wrong Dosage Form	50.77		0.0001
Wrong patient	0.126	1	0.722
Total Errors	102.29	1	0.0001

There was a statistically significant difference in three types of errors detected by the observation method during the sample period compared to the previous one year data, specifically, Mislabeling, Prescribing Error and Wrong Dosage Form error types.

Table 8: Statistical analysis of sample period incident report data compared to sample period observation method data.

Error Type	Yates Chi Square Value	Degrees of Freedom	Significance
Improper dose/quantity	4.72	1	0.03
Mislabeling	26.239	1	0.0001
Wrong Dosage Form	2.996	1	0.083
Wrong patient	0.923	1	0.337
Total Errors	20.341	1	0.0001

There was a statistically significant difference in two types of errors detected by the observation method during the sample period compared to errors detected by the incident report method during the sample period, specifically, Improper dose/quantity and Mislabeling error types.

Comparison of error types using Observation Method error type category definitions

Table 9: Statistical analysis of sample period incident report data compared to previous one year data.

Error Type	Yates Chi Square Value	Degrees of Freedom	Significance
Wrong Drug	1.049	1	0.3058
Wrong Strength	0.513	1	0.4738
Wrong Dosage Form (Correct Drug)	0.147	1	0.7018
Wrong Quantity	0.001	1	0.9739
Wrong Prescription Label Information (Excluding Instructions)	0.001	1	0.9739
Wrong Label Instructions	0.849	1	0.3567
Total Errors	0.314	1	0.5754
Rxs Filled	1.365	1	0.2427

There was no statistically significant difference in the types of incident report errors reported during the sample period compared to the previous one year data.

Table 10: Statistical analysis of sample period observation method data compared to previous one year MEDMARX data using observation method definitions.

Error Type	Yates Chi Square Value	Degrees of Freedom	Significance
Wrong Drug	20.565	1	0.0001
Wrong Strength	3.947	1	0.047
Wrong Dosage Form (Correct Drug)	28.512	1	0.0001
Wrong Quantity	0.2	1	0.655
Wrong Prescription Label Information (Excluding Instructions)	0.242	1	0.6227
Wrong Label Instructions	88.446	1	0.0001
Total Errors	102.29	1	0.0001
Rxs Filled	1.446	1	0.2291

There was a statistically significant difference in four types of errors detected by the observation method during the sample period compared to errors detected by the incident report method during the previous year, specifically, Wrong Drug, Wrong Strength, Wrong Dosage Form (Correct Drug) and Wrong Label Instructions error types.

Table 11: Statistical analysis of sample period incident report data compared to sample period observation method data.

Error Type	Yates Chi Square Value	Degrees of Freedom	Significance
Wrong Drug	1.214	1	0.271
Wrong Strength	1.214	1	0.271
Wrong Dosage Form (Correct Drug)	2.996	1	0.083
Wrong Quantity	0.092	1	0.762
Wrong Prescription Label Information (Excluding Instructions)	0.578	1	0.447
Wrong Label Instructions	20.834	1	0.0001
Total Errors	20.341	1	0.0001

There was a statistically significant difference in one type of error detected by the observation method during the sample period compared to errors detected by the incident report method during the sample period, specifically, Wrong Label Instructions.

Discussion

The results of this study support the results found in previous studies comparing the observation method to several other dispensing error detection methods. The observation method detects more than 9 times the errors, when the results of this study are extrapolated to a one year period. There was a statistically significant difference in the additional errors detected by the observation method compared to the presently used incident report method. There was also a statistically significant difference in many of

the types of errors detected by the two different methods, without regards to what error type category definitions were used. In addition, there was a difference in the top three error categories for cumulative MEDMARX data if the DoD results were substituted with the results found in this study. In other words, if one were to substitute the DoD data submitted to MEDMARX to compile the national MEDMARX error data, with the data observed in this study, the national MEDMARX error data would be different. Not only does the self-report method (incident report, MEDMARX) data understate the results, their data misleads by pinpointing the highest error categories as being Prescribing Error, Improper Dose/quantity and Unauthorized/wrong drug, instead of Mislabeling, Improper Dose/quantity and Other.

The DoD should consider utilizing the observation method as the primary error detection method which detects 9 times as many errors (statistically significant) as the incident report method, which should be retained for its ability to detect rare events and additional subjective details about errors made visible by the significance of their impact on the patient.

In addition, the lighting levels measured in all parts of the process were below the levels found by Buchanan to be effective in reducing medication errors. Improving the lighting levels in the pharmacy is recommended as a relatively inexpensive way to reduce dispensing errors. (Buchanan, 1991)

Suggestions for further research include exploring why the dispensing medication error rate detected in this study is below the error rates published in other outpatient studies

Limitations

There are several limitations to this study. First, small sample size will be a limitation in trying to generalize to all other DoD and similar outpatient pharmacies. Although most DoD pharmacies are quite similar, some are clearly not. For example, there are facilities that may be much busier and have larger operations than others due to the populations and catchment area they serve. While these larger and busier facilities have additional staff and resources in order to handle the increased workload, other factors such as average age of the population served, may be different and therefore introduce additional variables. Take for instance a large facility in a heavy retirement area of the Southeast United States compared to a small remote facility in the Northern mid-section of the country. The retirement area facility may have a much higher average patient age and therefore the associated issues of increased average prescription count per patient and more complex drug-regimen profile per patient compared to the small remote facility's patients. While the workload rate may be the same at both facilities, the more complex patient population at the Southeast facility may have different variables that may be associated with a different dispensing error rate and/or profile. A second limitation is the researcher waited 30 to 40 days for data collection in an effort to allow the facilities' incident report method ample time to detect and report any errors. Even with this waiting period, some errors may have been identified and reported after this time period. A third limitation is that the pharmacists that agree to have the study done at their location may believe that their pharmacy has no problems or is better than other pharmacies. Any error rate calculated at such a pharmacy may be lower than what occurs at other pharmacies, even though this may not be significant in the case in this study due to the military's open

willingness to cooperate with the researcher from the start and the military's constant efforts to report all medication errors in order to improve overall system processes. A fourth limitation is that the researcher did not include refills or controlled substances in the study sample. Other researchers that have studied refills though reported that there is no statistically significant difference. A fifth limitation is that the data collection time period was selected based upon the availability and schedule of the researcher. Comparison of the facility's error reporting rate and profile of the actual data collection time period to the previous year's data indicate no statistically significant difference.

Conclusion

During a 20 day period, a total of 3,293 prescriptions were examined to detect dispensing errors by two different methods. During this time period, an observation method adapted for DoD use detected 35 dispensing errors, while the self-report system currently relied upon to detect dispensing errors detected--none. Thus, the true accuracy of the method currently used by the DoD is unknown, but it was at least 35 times poorer than the observation method implemented for this study. Though the rate of dispensing errors detected was low compared to those detected in ambulatory pharmacies outside the military, the significance of dispensing errors involving those who routinely fly the planes armed with the weapons of mass destruction was underscored when prescription medications were implicated in the crash of the B-1 bomber pictured in the results. To truly minimize the risk of such errors requires a dispensing error monitoring system of the highest validity and reliability, which today appears to be the observation method used in this study. Replication of this study is recommended.

REFERENCES

Flynn, E. A., K. N. Barker, et al. (2003). National observational study of prescription dispensing accuracy and safety in 50 pharmacies. *Journal of the American Pharmaceutical Association,* 43(2): 191-200.

Flynn, E. A., K. N. Barker, et al. (2002). Comparison of methods for detecting medication errors in 36 hospitals and skilled-nursing facilities. *American Journal of Health-System Pharmacy,* 59(5): 436-46.

Nosek, R.A., McMeekin, J., Rake, G.W. (2005). *Standardizing Medication Error Event Reporting in the U.S. Department of Defense.* Retrieved 10/19/07 from: http://www.ahrq.gov/downloads/pub/advances/vol4/Nosek.pdf

American Society of Health-System Pharmacists. ASHP Guidelines on Preventing Medication Errors in Hospitals. *Am J Hosp Pharm*. 1993; 50:305-14.

MEDMARX Medication Error Definition. *MEDMARX Medication Error User Orientation Manual.* Retrieved 9/19/07 from: http://www.medmarx.com/help/000Reference/010.html

American Society of Consultant Pharmacists (1997). *Statement on Preventing Medication Errors in Pharmacies and Long-term Care facilities.* Retrieved 9/19/07 from: http://www.ascp.com/resources/policy/upload/Sta97-Med%20Errors.pdf

Buchanan, T., Barker, K., Gibson, T., Jiang, B., Pearson, R. (1991). Illumination and Errors in Dispensing. *American Journal of Hospital Pharmacy,* 48, 2137-2145.

Allan, E. L., K. N. Barker, et al. (1995). Dispensing errors and counseling in community practice. *American Pharmacy,* NS35(12): 25-33.

Brian Ross (2007). ABC News 20/20. Rhonda Schwartz and Avni Patel, *Pharmacy Errors: Unreported Epidemic?* American Broadcasting Company. Retrieved 10/19/07 from http://abcnews.go.com/Video/playerIndex?id=3003647

Schneider PJ. Measuring Medication Safety in Hospitals: Introduction. *American Journal of Health-System Pharmacy.* December 1, 2002 2002;59(23):2313-2314.

Varadarajan, R. (2008). An Exploratory Study and Comparison of Two Error Detection Methods in a Mail Order Pharmacy Serving Correctional Facilities. *Journal of the American Pharmacists Association,* In press.

Barker, K. N., Flynn, E. A., Pepper, G. A. (2002). Observation method of detecting medication errors. *American Journal of Health-System Pharmacy,* 59(23): 2314.

Barker, K.N., Kimbrough, W.W., Heller, W.M. (1966). *A Study of Medication Errors in a Hospital.* University of Arkansas.

Kerlinger, F.N. (2000). *Foundations of Behavioral Research.* USA: Earl McPeek.

Dean, B., Barber, N. (2001). Validity and reliability of observational methods for studying medication administration errors. *American Journal of Health-System Pharmacy.* 58(1):54-59.

Choate, T. Levesque, S. (2006). *Amphetamine's prescribed use defended by Air Force, M.D.* Abilene Reporter News. Retrieved 11/15/07 from: http://www.globalsecurity.org/military/library/policy/navy/misc/NAVMEDP-6410.pdf

B-1 Bomber Crash Picture (2008). Retrieved 6/9/08 from: http://images.google.com/imgres?imgurl=http://warisboring.com/wp/content/uploads/2008/04/singles06b1bellyflop.GIF&imgrefurl=http://warisboring.com/3Fp%3D1030&h=445&w=950&sz=217&hl=en&start=9&um=1&tbnid=aE929uaYuq1jM:&tbnh=69&tbnw=148&prev=/images%3Fq%3Dbomber%2Bal-udeid%2Bcrash%2Bpic%26um%3D1%26hl%3Den%26rls%3Dcom.microsoft:en-US%26sa%3DN

Sneeder, B. (2001). Medication And Aircraft Maintainers - causes of airplane mishaps. *Flying Safety,* June 2001.

United States. *Summary of Facts: Tarnak Farms Friendly Fire Incident Near Kandahar, Afghanistan, 17 Apr 2002*. Retrieved 11/15/07 from: http://www.centcom.mil/CENTCOMNews/Reports/Tarnak_Farms_Report.htm

O'Neill, T. (2003) *US pilots blame drug for Canadian bombing*. Sunday Business Post On-line. Retrieved 11/15/07 from: http://archives.tcm.ie/businesspost/2003/01/19/story334330.asp

TRICARE Outpatient Pharmacy list. *Pharmacy Benefit Overview*. Retrieved 9/19/07 from: http://www.tricare.mil/pharmacy/bene_info.cfm

University of Kansas Department of Psychology. *Preacher Chi Square Analysis Tool.* Retrieved 4/18/07 from http://www.psych.ku.edu/preacher/chisq/chisq.htm

GraphPad Software. *Chi-Square Contingency Table.* Retrieved 4/18/07 from http://www.graphpad.com/quickcalcs/contingency1.cfm

APPENDIX. LIST OF FINDINGS

#	Prescribed Drug	Finding	MEDMARX Category	Observation Method Category
1	Nitroglycerin 0.4mg pump spray	Directions on Rx: 0.4 s/l prn cp. Labeled as 1-2 sprays under the tongue as needed for chest pain	Mislabeling	Wrong label instructions
2	Glyburide 5mg	Directions on Rx: 2 tabs a.c. bid. Label did not include "before meals"	Mislabeling	Wrong label instructions
3	Simvastatin 40mg	Directions on Rx: 1 po qhs. Labeled as "1 by mouth every evening for cholesterol"	Mislabeling	Wrong label instructions
4	Naphcon-A	Directions on Rx: 1-2 gtts each eye bid for 30 days. Label did not include "for 30 days"	Mislabeling	Wrong label instructions
5	Bactroban cream	Bactroban ointment dispensed with comment written "ointment per profile"	Other	Other
6	Zpak	Quantity for 2. Only 1 dispensed with no documentation.	Improper dose/quantity	Wrong Quantity
7	Hydrochlorothiazide 25mg	Directions on Rx: 1 po QD. Labeled as "Take one tablet every day tablet by mouth every day"	Mislabeling	Wrong label instructions
8	Calcium 500 w/Vit D 250	Dispensed with Calcium 500 w/Vit D 200	Improper dose/quantity	Wrong strength
9	Synthroid 75mcg	Directions on Rx: 1 tab QD. Labeled as "Take 1 tab roid"	Mislabeling	Wrong label instructions

10	Miralax	Directions on Rx: 17gm po qday prn x 1 month. Label did not include "for 1 month"	Mislabeling	Wrong label instructions
11	Anusol HC cream	Directions on Rx: Apply PR TID. Labeled as "Apply to Affected areas 3 times a day"	Mislabeling	Wrong label instructions
12	Methotrexate 2.5mg	Contents of patient's bottle were folic acid 1mg tablets	Mislabeling	Wrong Drug
13	Folic acid 1mg	Contents of patient's bottle were methotrexate 2.5mg tablets	Mislabeling	Wrong Drug
14	Loratadine 10mg	Directions on Rx: 1 daily. Labeled as "Take 1 tablet by mouth QD*"	Mislabeling	Wrong label instructions
15	Efudex cream	Directions on Rx: Apply bid for 2-4 weeks or until erosion occurs. Labeled as "Apply to affected areas twice a day for 2 to 4 weeks or until all gone"	Mislabeling	Wrong label instructions
16	Fosamax +D 70mg/5600IU	Filled with Fosamax +D 70mg/2800IU	Improper dose/quantity	Wrong strength
17	Buffered asa 81mg	Filled with asa 81mg enteric coated	Wrong dosage form	Wrong dosage form
18	Clonidine 0.1mg	Directions on Rx: 1 qam, 2 qpm. Labeled as "Take one take one tablet in the morning *PO every morning then take two tablets by mouth every evening"	Mislabeling	Wrong label instructions
19	Hytrin 10mg "Dispense as Written"	Filled with generic	Mislabeling	Other
20	Nortriptylline 10mg	Contents of patient's bottle were omeprazole 10mg capsules	Mislabeling	Wrong Drug
21	Omeprazole 10mg	Contents of patient's bottle were nortriptylline 10mg capsules	Mislabeling	Wrong Drug
22	Loratadine 10mg orally disintegrating	Filled with non-disintegrating loratadine	Wrong dosage form	Wrong dosage form

23	Zocor 40mg	Directions on Rx: 1 po hs. Labeled as "Take one tablet every day"	Mislabeling	Wrong label instructions
24	Synthroid 0.5mg	Filled with Synthroid 0.05mg	Prescribing error	Other
25	Metoprolol 50mg	Directions on Rx: 1 ½ tab bid. Labeled as "Take ½ tablet by mouth twice a day"	Improper dose/quantity	Wrong label instructions
26	Bupropion 100mg	Filled with Bupropion 100mg SR	Wrong dosage form	Wrong dosage form
27	Bentyl 20mg "Dispense as Written"	Filled with generic	Mislabeling	Other
28	Cardura 8mg "Dispense as Written"	Filled with generic	Mislabeling	Other
29	KDUR 20mEq	Directions on Rx: 1 po QD with ½ written over the "1" in 1 po QD. Labeled as "Take ½ tablet by mouth every day"	Other	Other
30	Zocor 10mg	Wrong patient information in computer and on label	Other	Other
31	Wellbutrin 150mg	Wrong patient information in computer and on label	Other	Other
32	Claritin 10mg	Wrong patient information in computer and on label	Other	Other
33	Hydrochlorothiazide 25mg	Wrong patient information in computer and on label	Other	Other
34	Zetia 10mg	Wrong patient information in computer and on label	Other	Other
35	Claritin 10mg "Dispense as Written"	Filled with generic	Mislabeling	Other