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Occurrence of Dispensing Errors and Efforts to Reduce Medication Errors at the Central Arkansas Veteran's Healthcare System

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Abstract

Background: Medical errors have received national attention in the past few years, largely due to the Institute of Medicine's (IOM) 1999 report, which found that over one million injuries and nearly 100 000 deaths occur annually in the US as a result of medical errors.

Purpose: The purpose of this study was to examine the type and severity of dispensing errors reported by pharmacy services at the Central Arkansas Veteran's Healthcare System from October 1997 through September 2001 and to examine the efforts implemented by the Central Arkansas Veteran's Healthcare System to reduce overall medication-related errors.

Methods: Dispensing error reports for the Central Arkansas Veteran's Healthcare System were obtained for October 1997 to September 2001. Dispensing errors were tabulated in the Statistical Package for the Social Sciences (SPSS) according to the pharmacy section, type of error (wrong drug, wrong dose, wrong patient and 'other') and severity of error (minor, significant, major and unrated). Data were explored using descriptive statistics, χ^2, independent sample *t*-tests and Pearson's correlation. Information on error reduction efforts was obtained from pharmacy administrative services.

Results: A total of 82 dispensing errors were reported from eight different pharmacy sections for the time period examined. Errors included 31 wrong drugs, 21 wrong doses, 24 wrong patients and six 'other' errors. The number of errors, according to severity, included 29 unrated, 30 minor, 21 significant and two major errors. Both major errors were due to wrong drug selection. In total, the highest number of errors occurred at the North Little Rock Ambulatory Care Pharmacy (39 errors) and the Little Rock Ambulatory Care Pharmacy (24 errors).

Wrong drug and wrong dose dispensing errors were not significantly different among the pharmacy sections. Wrong patient selection was significantly different among pharmacy service sections. Wrong patient selection, wrong drug, and wrong dose were all significantly correlated with unrated severity, minor severity, and significant severity. Significant correlations were also found between wrong drug, wrong dose and wrong patient selection. There were no significant correlations between wrong patient selection and major severity, or other errors. χ^2 analysis found significant differences in expected frequency among errors for wrong drug, wrong dosage, wrong patient and other errors. Significant differences

were also found in expected frequencies between unrated, minor, significant and major errors.

Discussion: Although the major dispensing errors were not statistically different according to pharmacy services sections and not significantly correlated with any other categories, they both involved the selection of the wrong drug, which was also the most common error. In contrast, the selection of the wrong patient, the second most common error, was statistically different among pharmacy sections and was significantly correlated with all other dispensing type and severity of error except major severity and other errors.

Conclusion: Focusing error reduction efforts on selection of the correct drug and correct patient would likely yield the best results in reducing dispensing errors since these errors combined accounted for 55 (67.1%) of the 82 reported errors.

Background

Medical errors have received national attention in the past few years, largely due to the Institute of Medicine's (IOM) 1999 report, "To Err is Human: Building a Safer Health System."[1] The IOM report found that over one million injuries and nearly 100 000 deaths occur annually in the US as a result of medical errors.[2] Seven thousand of these deaths were attributable specifically to medication errors.[3] The annual cost of medical errors is estimated to be $US37.6 billion[3] (2001 values) while adverse drug events are thought to be responsible for $US2 billion of this total (2002 values).[4]

The Harvard Medical Practice Study, a cornerstone of the IOM report, found a 3.7% rate of iatrogenic injury among hospitalised patients and suggested that one-third of these adverse events were unpreventable.[2] This report found that the remaining two-thirds of errors were errors in treatment and should be amenable to prevention through sound methods of error reduction.[2] This is consistent with the US Pharmacopeia (USP), which reported a 3% error rate that included omissions, incorrect doses and the wrong drug as the top three causes of medication errors while insulin, heparin and morphine were the top three drug products associated with errors that were reported to the USP.[5]

Flynn et al.[4] defined a medication error as any discrepancy between the prescriber's interpretable medication order and what was administered to a patient. Errors included omission, wrong drug, wrong dose, extra dose, wrong route, wrong form, wrong technique and wrong time. Bates et al. defined an adverse drug event as any injury resulting from a medical intervention relating to a drug.[6] The USP defines a medication error as "any preventable event that may cause or lead to inappropriate medication use or patient harm while the drug is in control of the healthcare professional, patient or consumer".[7] Regardless of the definition chosen, medication errors can occur at any stage of the drug delivery process, i.e. prescribing, transcribing, dispensing and administration.

Various aspects of medication errors have been studied including the incidence per medical speciality,[8] types of drugs most often linked to errors,[9] time of day and shift work effects[10,11] and calculation skills and incidence of error.[12,13] System problems leading to medication errors have also been examined.[14,15] Leape et al.[14] have identified sixteen systems failures, which lead to medication errors. These systems failures are now being addressed with initiatives using General Systems Theory and Quality Improvement to examine problems and recommend solutions aimed at improving the rate of medication errors.[16]

The adverse drug event prevention study showed that 49% of errors occurred in the drug ordering stage (prescribing), 11% in transcription, 14% in dispensing and 26% in administration. The most frequent errors in the drug prescribing stage were wrong dose, wrong frequency, wrong drug and known allergy.[14,17] Errors were more likely to be prevented in the early stages of the delivery process. Forty-two percent of prescribing errors and 37% of dispensing errors were prevented, but none of the administration errors were prevented.

Flynn et al.[4] compared methods for detecting medication errors in 36 hospitals and skilled-nursing facilities. They evaluated 12 methods of collecting medication errors. These included: (i) direct observation of medication administration; (ii) reviewing patient charts; (iii) reviewing incident reports; (iv) attending medical rounds to listen for clues that an error had occurred; (v) interviewing healthcare personnel to stimulate self-reporting; (vi) analysing doses returned to pharmacy; (vii) testing urine for evidence of omitted drugs and unauthorised drug administration; (viii) examining death certificates; (ix) attending nursing change-of-shift report; (x) comparing medication administration records with physician's orders; (xi) computerised analysis to identify patients receiving targeted drugs that may be used to treat a medication error; and (xii) comparing drugs removed from an automated drug-dispensing device to physician's orders.[4] They found that direct observation detected 300 errors and 73 false-positives for an error rate of 17.9%, chart review detected 17 errors and seven false-positives for an error rate of 0.9%, and incident reports detected only one error for an error rate of 0.04%. In other words, of the 457 confirmed errors, data collectors missed 157 during direct observation, 440 using chart review and 456 using incident reports.[4]

Several studies have examined the type of medications associated with drug errors. Ross et al.[18] found that antibiotics/antivirals, parenteral nutrition/intravenous fluids and anticancer drugs were in the top three categories of drug most frequently involved in intravenous medication error. Edgar et al.[19] found that heparin, lidocaine, and potassium were the agents most commonly involved in critical incidents. Xanthines, cardiovascular agents, antimicrobials and narcotics were most frequently found associated with errors in a tertiary care/teaching hospital.[9]

There may be large discrepancies in the way in which medication errors are defined, how they are reported, and various methods of investigation and procedures to reduce and eliminate errors. However, all efforts at defining, investigating, reporting and reducing medication errors are subjective in nature. None of the various systems are uniform as yet and differences may exist geographically and between hospitals accredited by the Joint Commission on Accreditation of Healthcare Organisation and non-accredited hospitals.[4]

Classification of Medication Errors

The USP National Coordinating Council for Medication Error Reporting and Prevention has developed a standardised categorisation for medication errors, which classifies errors according to the severity of outcome.[20,21] This system was developed to help institutions track medication errors in a consistent and systemic manner. This system may be used in conjunction with medication error tracking software. The classification is as follows:[21]

- Category A (No Error): circumstances or events that have the capacity to cause error.
- Category B (Error, No Harm): an error occurred but the medication did not reach the patient.
- Category C (Error, No Harm): an error occurred that reached the patient but did not cause harm.
- Category D (Error, No Harm): an error occurred that resulted in the need for increased patient monitoring but no patient harm.
- Category E (Error, Harm): an error occurred that resulted in the need for treatment or intervention and caused temporary harm to the patient.
- Category F (Error, Harm): an error occurred that resulted in initial prolonged hospitalisation and caused temporary harm to the patient.
- Category G (Error, Harm): an error occurred that resulted in permanent harm to the patient.
- Category H (Error, Harm): an error occurred that resulted in a near-death event (e.g. anaphylaxis, cardiac arrest).
- Category I (Error, Death): an error occurred that resulted in patient death.

The Central Arkansas Veterans Healthcare System

The Central Arkansas Veterans Healthcare System (CAVHS), Arkansas, USA, a flagship of the Department of Veterans Affairs (VA), is one of the largest and busiest VA medical centres in the US. It is a tertiary care facility with over 550-beds, with healthcare services ranging from disease prevention via primary care, to complex surgical procedures and extended rehabilitative care. The CAVHS

serves as a teaching facility for more than 1300 students and residents enrolled in approximately 70 educational affiliates. The University of Arkansas for Medical Sciences is its primary affiliate.

Pharmacy services at CAVHS include the following: (i) Little Rock Ambulatory Care Clinic; (ii) North Little Rock Ambulatory Care Clinic; (iii) Little Rock Inpatient Pharmacy; (iv) North Little Rock Inpatient Pharmacy; (v) Central Mail Order Pharmacy; (vi) Community Based Outpatient Clinic; (vii) Mountain Home Community Based Outpatient Clinic; and (viii) Prepack Pharmacy. For the fiscal year 2001 all the pharmacy sections combined dispensed approximately 3 965 934 inpatient doses and 1 287 038 outpatient prescriptions.

The purpose of this study was to examine the type and severity of dispensing errors reported by pharmacy services at the Central Arkansas Veteran's Healthcare System from October 1997 through September 2001 and to examine the efforts implemented by the Veteran's Healthcare Administration to reduce overall medication-related errors.

Methods

Dispensing error reports for the CAVHS were obtained for fiscal year 1998 (October 1997) through to fiscal year 2001 (September 2001). Dispensing errors were entered into a database created in the Statistical Package for Social Sciences (SPSS) 9.0.1 (SPSS Inc. Chicago, IL, USA). Errors were recorded according to reporting section: (i) Little Rock Ambulatory Care Clinic; (ii) North Little Rock Ambulatory Care Clinic; (iii) Little Rock Inpatient Pharmacy; (iv) North Little Rock Inpatient Pharmacy; (v) Central Mail Order Pharmacy; (vi) Community Based Outpatient Clinic; (vii) Mountain Home Community Based Outpatient Clinic; and (viii) Prepack Pharmacy. Errors were classified according to the type of error: (i) wrong drug; (ii) wrong dose; (iii) wrong patient; or (iv) other error (e.g. wrong signature, wrong doctor). Errors were also classified according to the severity of error: (i) unrated; (ii) minor; (iii) significant; and (iv) major. Severity was subjectively determined by the pharmacist reporting the error. There may have been poor inter-rater reliability. Dispensing error reports included patient identification, date of report and section involved. It is recognised that this may be a highly subjective system for rating medication errors. However, this system has been in place and used for a number of years therefore ratings should have some consistency from year to year. Information on medication error reduction efforts was obtained from pharmacy administrative services.

For the purposes of this study dispensing errors were analysed as reported by pharmacy services using the category and severity classification in place at CAVHS at the time of this study. Data were analysed using descriptive statistics, case summaries, independent samples t-tests (Bonferroni), χ^2 and Pearson's correlation. Case summaries were used only to determine the frequency of error severity and type of error by pharmacy section. All calculations were performed with SPSS 9.0.1.

Results

A total of 82 dispensing errors were reported from eight different pharmacy services sections for the period October 1997 to September 2001. Pharmacy sections reporting dispensing errors included: Little Rock Ambulatory Care, North Little Rock Ambulatory Care, Little Rock Inpatient Pharmacy, North Little Rock Inpatient Pharmacy, Central Mail Order Pharmacy, Community Based Outpatient Clinic, Mountain Home Community Based Outpatient Clinic and Prepack Pharmacy. Table I provides the number of errors made (including wrong drug, wrong dose and wrong patient and other error) for each pharmacy section. In total, the highest number of errors occurred at the North Little Rock Ambulatory Care Pharmacy (39) and the Little Rock Ambulatory Care Pharmacy (24 errors).

The number of times the wrong drug was selected ranged from 0 to 17 times (mean = 3.9, standard deviation [SD] = 6.1, standard error [SE] = 2.2), but this was not statistically significant across the pharmacy sections (2-tailed t [7] = 1.8, p = 0.115). The wrong dose was selected ranging from 0 to 11 times (mean = 2.6, SD = 4.1, SE = 1.5) and this was not statistically significant across the sections (2-tailed t [7] = 1.8, p = 0.113). The wrong patient selected ranged from 0 to 9 times (mean = 3.0, SD = 3.5, SE = 1.2); there was a statistically significant difference among pharmacy sections (2-tailed t [7] = 2.4, p = 0.044). Errors classified as 'other' occurred from 0 to 3 times (mean = 0.75, SD = 1.2, SE =

Table I. Types of medication dispensing errors reported by pharmacy services at the Central Arkansas Veteran's Healthcare System from October 1997 to September 2001

Pharmacy services	Type of dispensing error				
section	wrong drug	wrong dose	wrong patient	other[a]	total
LRAC	9	7	7	1	24
NLRAC	17	11	9	2	39
LRIP	2	1	1	3	7
NLRIP	2	0	0	0	2
CMOP	0	1	0	0	1
CBOC	0	0	4	0	4
MHCBOC	0	1	3	0	4
PRPACK	1	0	0	0	1
Total	31	21	24	6	82

a Examples of other errors include wrong signature, wrong doctor.

CBOC = Community Based Outpatient Clinic; **CMOP** = Central Mail Order Pharmacy; **LRAC** = Little Rock Ambulatory Care Clinic; **LRIP** = Little Rock Inpatient Pharmacy; **MHCBOC** = Mountain Home Community Based Outpatient Clinic; **NLRAC** = North Little Rock Ambulatory Care Clinic; **NLRIP** = North Little Rock Inpatient Pharmacy; **PRPACK** = Prepack Pharmacy.

0.41), which were not statistically significant across the sections (2-tailed t [7] = 1.8, p = 0.111). Multiple individual comparisons were made using the Bonferroni technique.

There were 31 wrong drug errors, 21 wrong dosage errors, 24 wrong patient errors and six other errors reported in total. χ^2 analysis found significant differences in expected frequency among errors for wrong drug, wrong dosage, wrong patient, and other error (χ^2 [3] = 16.24, p = 0.001). There were 29 unrated errors, 30 minor errors, 21 significant and two major errors (see table II). Significant differences were also found in expected frequency among severity for unrated, minor, significant and major errors (χ^2 [3] = 24.63, p = 0.000 [Fisher's exact test used for n < 5]).

Wrong patient selection, wrong drug, and wrong dose were all significantly correlated with unrated severity, minor severity, and significant severity (table III). Significant correlations were also found between wrong drug, wrong dose and wrong patient selection. There were no significant correlations between wrong patient selection and major severity, or other errors.

Table II. Severity of medication dispensing errors reported by pharmacy services at the Central Arkansas Veteran's Healthcare System from October 1997 to September 2001

Pharmacy services	Severity of dispensing error[a]				
section	minor	significant	major	unrated	total
LRAC	10	6	1	7	24
NLRAC	13	10	0	16	39
LRIP	2	2	1	2	7
NLRIP	2	0	0	0	2
CMOP	1	0	0	0	1
CBOC	2	2	0	0	4
MHCBOC	0	1	0	3	4
PRPACK	0	0	0	1	1
Total	30	21	2	29	82

a Severity was subjectively determined by the pharmacist reporting the error. There may have been poor inter-rater reliability.

CBOC = Community Based Outpatient Clinic; **CMOP** = Central Mail Order Pharmacy; **LRAC** = Little Rock Ambulatory Care Clinic; **LRIP** = Little Rock Inpatient Pharmacy; **MHCBOC** = Mountain Home Community Based Outpatient Clinic; **NLRAC** = North Little Rock Ambulatory Care Clinic; **NLRIP** = North Little Rock Inpatient Pharmacy; **PRPACK** = Prepack Pharmacy.

Table III. Correlations between type of medication dispensing error and severity of the error reported at the Central Arkansas Veteran's Healthcare System from October 1997 to September 2001

	Type of dispensing error				Severity of dispensing error[a]			
	wrong drug	wrong dose	wrong patient	other error	minor	significant	major	unrated
Wrong drug		0.977[b]	0.848[b]	0.519	0.968[b]	0.961[b]	0.165	0.967[b]
Wrong dose	0.977[b]		0.894[b]	0.486	0.971[b]	0.970[b]	0.207	0.969[b]
Wrong patient	0.848[b]	0.894[b]		0.390	0.897[b]	0.944[b]	0.178	0.873[b]
Other error[c]	0.519	0.486	0.354		0.486	0.556	0.662	0.516

a Severity was subjectively determined by the pharmacist reporting the error. There may have been poor inter-rater reliability.

b Statistically significant according to Pearson's correlation at the $p < 0.01$ level, 2-tailed.

c Examples of other errors include wrong signature, wrong doctor.

Discussion

Types of Errors Made

One major error occurred at the Little Rock Ambulatory Care Clinic and involved hyoscyamine 0.125 being entered and filled as levothyroxine 0.125. The other occurred in Little Rock Inpatient Pharmacy when an intravenous fluid label for dextrose 5% in 1/4 normal saline with 20 milliequivalents of potassium chloride was placed on a 250ml bag of heparin 25 000 units. Although classified as major errors, the intravenous fluid label was not administered and it was undetermined whether the patient had taken hyoscyamine instead of levothyroxine.

The adverse drug event prevention study showed that 49% of errors occurred in the drug ordering process, 11% in transcription, 14% in dispensing and 26% in administration.[16] The present study focussed on the 14% of medication errors that occur as dispensing errors. Wrong drug selection was the most common error accounting for 31 (37.8%) of the 82 errors although it was not statistically significantly different among sections. Most of the wrong drug selections involved sound-alike/look-alike names.

Examples of wrong drug selection included the following; hydroxyzine 25mg for hydralazine 25mg, metformin 500mg for metronidazole 500mg, lisinopril for fosinopril, Pravachol®[1] 20mg for Prevacid® 20mg, lovastatin 20mg for simvastatin, dapsone 100mg for dantrolene 100mg, Norvasc® 10mg for nortriptyline 10mg, quinine sulfate 325mg for quinidine gluconate 324mg, lithium 450mg SA for theophylline 450 SA, hydroxyzine 10mg for hydrocortisone 10mg, oxycodone 10mg for Oxycontin® (a controlled-release formulation of oxycodone) 10mg, fluphenazine 10mg for fluoxetine 10mg and hydroxyzine 25mg for HCTZ (hydrochlorothiazide) 25mg.

It is thought that many of these errors originate with short code use in the drug selection field where an entry of HYD25 might pull up hydroxyzine 25mg instead of hydralazine 25mg and MET500 might pull up metformin 500mg instead of metronidazole 500mg. The pharmacist already knows which selection they desire, but the system has so many choices that are very similar, so it is relatively easy to make an error in drug selection.

Wrong patient selection was statistically significantly different among sections and accounted for 24 (29.3%) of the 82 errors. This occurs when the pharmacist selects a patient to fill an order by selecting the initial for the patient's last name and last four of their social security account number but the wrong patient is actually selected. For example H2906 may be Henson 2906, Hanson 2906 or Henderson 2906 and D4902 may be Drake 4902, Davis 4902 or Davidson 4902 and the wrong patient is inadvertently selected from a list of possible alternatives for H2906 or D4902 or other last initial/social security account number alternatives. CAVHS now requires entry of the full social security account number in order to process a prescription order. This requirement was implemented in order to reduce errors from an incorrect patient selection.

1 The use of trade names is for product identification purposes only and does not imply endorsement.

Wrong dosage selection occurred in 21 (25.6%) of the 82 reported dispensing errors. Examples of wrong dosage included: levothyroxine 0.025 filled as levothyroxine 0.05mg, hydrochlorothiazide/triamterene qd (once daily) filled as hydrochlorothiazide/triamterene tid (three times daily), glipizide 5mg filled as glipizide 10mg, valproate semisodium 250mg bid (twice daily) filled as valproate semisodium 500mg bid, clozapine 25mg filled as clozapine 100mg, morphine 100mg filled as morphine 60mg, prednisone 5mg filled as prednisone 50mg, primidone 25mg filled as primidone 250mg, spironolactone 25mg filled as spironolactone 100mg aminosalicylic acid 81mg filled as aminosalicylic acid 325mg, fluorouracil 5% cream filled as fluorouracil 1% cream, liothyronine 5μg filled as liothyronine 50μg, and clonazepam 1mg filled as clonazepam 0.5mg. These errors occur when the pharmacist selects the wrong strength when processing the prescription order or when the technician selects the wrong medication when filling the order and the pharmacist does not catch the error.

Other errors accounted for six (7.3%) of the 82 reported dispensing errors. These errors involved two missed doses, a mislabelling error, a prescription entered by mistake and a prescription not sent at the correct time and one unexplained error where temazepam was apparently given instead of dextropropoxyphene (propoxyphene); however, pharmacy records indicate dextropropoxyphene was dispensed.

Despite the number and severity of these errors only one patient is documented to have taken the wrong drug. A Tylenol® #3 (codeine 30mg + paracetamol 325mg) prescription was filled with Percocet®. Since the patient had already taken the medication with apparently no ill effects the dentist changed the prescription to Percocet®. The remaining 81 reported errors were corrected either before the patient actually received their medication or after contacting the patient at home before they had taken any of the incorrect medication.

Reasons for Under-Reporting of Errors

Assuming only a 2% error rate (derived from pharmacy administration as a target rate) and approximately 5 252 972 total dispensed units for fiscal year 2001 there should have been about 105 059 dispensing errors yet only 82 were reported over the review period. There are several variables, which could account for such a large discrepancy between the number of expected errors and the number of reported errors. The fear of retaliation or use of data against pharmacists for performance evaluations and promotion may be a significant factor in under reporting. Another factor may be that when a pharmacist discovers an error it is simply easier to correct the error than to initiate a chain of paperwork describing the error and circumstances surrounding the error. It would be cost prohibitive to file an incident report for every single error that occurred, no matter how small or potentially insignificant the error.

Institute of Medicine's Recommendations

The IOM report, which is responsible for the patient safety movement, recommended that the Agency for Healthcare Research and Quality should determine which safety practices are effective and disseminate a list of 'best practices' to all clinicians.[2] The publication of Evidence Report 43 in July 2001 included only three (which were unit doses, computerised provider order entry and barcoding) of the 15 best medication practices endorsed by the Massachusetts Hospital Association and the American Hospital Association. None of these recommendations were placed in the top category due to a lack of sufficiently rigourous evidence of efficacy.[22-24]

Important practices such as: (i) the implementation of pharmacy-based intravenous admixture; (ii) the removal of concentrated potassium chloride from nursing units; (iii) educating patients about the safe and accurate use of their medication; and (iv) having a hospital pharmacist available on call 24 hours a day were not included in the IOM report because they have not been assessed in randomised controlled trials. However, clinical pharmacist consultation services were included in the IOM report, based on medium-strength evidence regarding its impact and effectiveness.[2]

The IOM recommendations include the following: (i) adopt a system oriented approach to medication-error reduction; (ii) implement standard processes for medication doses and timing; (iii) implement computerised provider order entry systems;

(iv) standard prescription writing and prescribing rules; (v) use of pharmaceutical software; (vi) implement unit doses; (vii) include pharmacists on patient care rounds; (viii) use machine-readable technology (bar-code); (ix) check patient's arm bands to verify their identity; (x) use special procedures and written protocols for high risk medications; and (xi) do not store concentrated solutions of hazardous material on patient units.[1]

The CAVHS has made a concerted effort to stay at the forefront of improving medication safety for their patients and to adopt all of the IOM recommendations in order to reduce medical errors.

A recent editorial suggests that the medication system itself and institution-specific changes must occur to reduce the incidence of errors. A recent American Society of Health-System Pharmacists survey found that only 79.4% of hospitals and health systems that were surveyed required a pharmacist to approve all medication orders before dispensing, 64.4% were using a computer-generated medication administration record, while 89.3% reported verifying the patient's identity by wrist band before drug administration.[25] These findings, at first glance, indicate that most hospitals and health systems were on the right track in reducing medication errors and improving patient safety. Upon closer examination, this does not appear to be the case. Alarmingly, only 7% of hospitals and health systems that were surveyed used computerised prescriber order entry systems and only 1.5% used bar-code technology at the patient's bedside to verify the patient's identity and that the correct drug was being administered. There appears to be huge gaps between the IOM recommendations and industry-wide efforts at implementing these highly acclaimed best practices.[25,26]

There are several descriptions of the ideal principles and characteristics of a fail-safe medication use system which support a systems approach.[27,28] A recent General Accounting Office Report recognises the increased risk of medication errors for shared patients between the VA and the US Department of Defence (DOD). This report recommends computerised provider order entry for prescription medication, a joint VA/DOD pharmacy and therapeutics committee and a medication systems approach to reduce the risk of medication related errors.[29]

CAVHS embraces the systems approach to reduce potential medication errors. A system has been implemented which co-ordinates standard administration times for medication administration. This decreases miscommunication and confusion from vague administration directions, e.g. TID, QID (four times daily), Q6H (every 6 hours), and Q8H (every 8 hours). All dosage schedules refer to the fixed standardised administration times.

Computerised prescriber order entry is a cornerstone of the IOM's recommendations to reduce medical errors. Research supports the design, implementation and use of computerised prescriber order entry to reduce medication errors.[30-41] The medication use process begins with the placement of a prescription order. CAVHS uses computerised prescriber order entry to ensure access to relevant patient information, appropriate knowledge bases and evidence-based guidelines. Computerised prescriber order entry limits the need for hand-written orders, which can often be misinterpreted leading to the administration of an incorrect medication. Illegibility can be exacerbated by look-alike and sound-alike drug names. All inpatient prescription orders at CAVHS are entered through computerised provider order entry and then electronically verified by pharmacists.

The Scope of Practice Boards develop prescribing guidelines for qualified practitioners who are then granted prescriptive authority based on their education, training and clinical expertise. This process helps ensure a defined level of clinical experience in granting prescriptive authority to clinicians. VA Computerised Patient Record System software enables the provider ease of order entry.[40]

All medications dispensed to VA inpatients are unit-dose. The only exception would be bulk items, which are carried as floor stock. Floor stock items generally comprise three categories: (i) controlled substances; (ii) urgent medications including furosemide, heparin, nitroglycerin and promethazine; and (iii) medication that is not available in unit doses including insulins, lidocaine, psyllium and hydrogen peroxide.

Other original research has clearly shown that pharmacist participation on rounds as a full member of the patient care team was associated with a substantially lower rate of medication errors caused by

prescribing errors.[42] Furthermore, as previously mentioned in this section, clinical pharmacist consultation services received a medium strength of evidence rating for reducing medication errors.[2] CAVHS includes clinical pharmacists on patient care rounds with physician-led, multidisciplinary teams. In addition, many clinics are staffed with clinical pharmacists who are available during clinic hours to act as consultants to providers who have medication-related questions.

In addition to the IOM recommendation to implement bar-coded medication labels, the US FDA is developing a proposal, at the request of the Secretary of Health and Human Services, to mandate bar-coded, product-specific information on the label of all drugs and biologicals for human use.[43] Bar-coding of all medication is strongly supported by the National Co-ordinating Council for Medication Error Reporting and Prevention,[44] the American Society of Health-System Pharmacists[44] and has been shown to reduce medication errors in the VA healthcare system.[45]

Bar-code technology has been used in the grocery industry for years but its application in healthcare represents the leading edge in patient safety today. Bar-code technology helps reduce human error. Bar-Code Medication Administration (BCMA) helps nurses comply with the 'five rights' of medication use – right patient, right medication, right dose, right time and right route. This also provides an online medication administration record, which enhances care team communication.

The VA has greatly reduced the occurrence of errors through the use of the BCMA system.[45] Since implementing the BCMA system, the Topeka VA, Kansas, USA, has reduced the number of wrong medications dispensed by 75%, the number of patient mix-ups by 93%, wrong administration times by 87%, missed doses by 70% and dose errors by 62%.[45] BCMA version 1 was adopted by the CAVHS in 1999. The goal of BCMA was to design and implement software that would electronically validate medication administration accurately at the point of care (patient's bedside). BCMA 2 was adopted by the CAVHS on September 24, 2002. This system includes bar-coding for intravenous admixtures and total parenteral nutrition preparations.[46]

The BCMA system provides clinicians with real-time medication administration data that is readily available to help make important patient-care decisions. Using the BCMA system, nurses use handheld scanners and notebook computers at the patient's bedside to verify the medication, dose, route, time of administration and patient. This system works by wireless connections that transmit the scanned bar-coded information on the patient's wristband to the electronic patient record. The nurse confirms the patient's identity by asking the patient their name. The unit dose medication package is scanned before administering to the patient. A visual alert is sent by the system when it detects the wrong patient, wrong dose, wrong route, wrong drug or wrong administration time. The system also alerts the nurse to potential drug interactions and allergic reactions. These alerts must be addressed before the medication can be given. When scanned, the medication is marked in the electronic medication administration record as having been administered.[46] The VA has installed this system in 163 medical centres throughout the US.[45]

National Center for Patient Safety Programme

In 1997, the Veterans Health Administration recognised that there were problems in the healthcare system and the National Center for Patient Safety (NCPS) programme was started. This programme is designed to improve patient safety with a focus on prevention not punishment. Its mission is to improve patient safety, prevent healthcare errors and develop and nurture a culture of safety.

The NCPS represents the VA's commitment to reducing and preventing adverse medical events while improving the care of patients. This programme has been implemented by all VA facilities.[47]

A unique aspect of the NCPS Programme is its partnership with the National Aeronautics and Space Administration (NASA) in creating the Patient Safety Reporting System (PSRS). The PSRS is a voluntary, confidential, non-punitive programme available to all VA employees for the reporting of events and concerns related to patient safety. NASA has had a similar and very successful programme, the Aviation Safety Reporting System, for more

Table IV. The National Center for Patient Safety's safety assessment code matrix to determine the risk of the medication error, based on the level of severity and probability of the error

Probability of medication error	Severity of medication error			
	catastrophic	major	moderate	minor
Frequent	3	3	2	1
Occasional	3	2	1	1
Uncommon	3	2	1	1
Remote	3	2	1	1

than 25 years. There has never been a violation of a reporter's confidentiality.[47]

The PSRS system does not replace the VA facilities' current incident reporting system. The incident reporting system identifies reasons for errors and provides detailed action plans to decrease the likelihood of recurrence. Instead, the PSRS is designed to identify broad, VA systems-wide problems.

To promote a culture of patient safety, reporting of close calls and near misses is important. A close call or near miss is an event or situation that could have resulted in an accident, injury or illness but did not, either by chance or through timely intervention.

The PSRS describes medical error reporting for CAVHS. A physician completes an initial assessment of the patient to determine the level of injury, which include: no injury, minor injury, major injury or death. If a major injury or death is reported the attending physician and chief of staff must be notified and the patients and/or families are notified also.[47]

After the physician completes their part of the incident report it is forwarded to the appropriate service chiefs for review. Incident reports should reach the patient safety manager within 10 days. The NCPS requires the incident to be reviewed by a patient safety manager and a safety assessment code (SAC) is determined for the actual and potential or most likely 'worse case' scenario that could occur. The patient safety manager uses a SAC matrix to determine the risk of the error, based on the level of severity of the error (catastrophic, major, moderate or minor) and the probability that the error occurs (frequent, occasional, uncommon or remote) [see table IV].[47]

The SAC score determines what action must be taken after an event occurs. Any incident that receives an actual SAC score of 3 (e.g. when a patient falls and breaks their hip) requires an individual root cause analysis to be conducted to review the specifics of the event.[47]

An incident that has a potential SAC score of 3 (e.g. when a patient falls and bruises their elbow) must also have a root cause analysis conducted except for the following types of incidents: medication errors, missing patient, falls and suicide behaviour incidents. An aggregate root cause analysis is done every quarter reviewing all the incidents in these categories that have occurred during the previous 3 months.[47]

Sentinel events are also referred for root cause analysis because they signal the need for immediate investigation. Sentinel events as defined by Joint Commission on Accreditation of Healthcare Organisation include the following: unexpected occurrences involving death or serious permanent physical or psychological injury, or risk thereof; resulting from major blood group incompatibilities or incorrect surgery. Serious injury includes loss of limb or function. A major permanent loss of function means sensory, motor, physiological or intellectual impairment not previously present that requires continued treatment or life style changes.[48]

Conclusion

Selection of the wrong drug was the most common error followed by the selection of the wrong patient. Selecting the wrong drug, wrong patient and wrong dose was significantly correlated with all errors except major severity and other errors. Focusing error reduction efforts on methods to improve selection of the correct drug, correct patient and correct dose should produce the best results in reducing medication errors at the CAVHS. The CAVHS has taken an active role in improving the medication dispensing process. CAVHS now requires entry of the full social security account number in order to process a prescription order and is

looking into methods to eliminate the use of 'short codes' in the drug selection field. These changes should eliminate errors in selecting the wrong patient and wrong drug in the medication dispensing process. One area open to future improvement efforts is that of software screening for correct dosages. These efforts represent a significant commitment to reduce or eliminate errors in the dispensing process.

Recent research suggests that medication errors occur in 5.07–5.22% of patients admitted to general medical-surgical hospitals.[49,50] These hospitals experienced a medication error every 22.04–22.7 hours.[49,50] Factors associated with increased medication errors were: lack of pharmacy teaching affiliation,[49] total cost of care per occupied bed per year,[49] drug-use evaluations,[50] centralised pharmacists,[49] hospital mortality rate,[49] and increased staffing of dispensing pharmacists per occupied bed.[50]

Factors that were associated with decreased medication errors included: presence of a drug information service,[50] pharmacist-provided adverse drug reaction management,[50] pharmacist-provided drug protocol management,[50] pharmacist participation on medical rounds,[50] pharmacist-provided admission histories,[50] increased clinical pharmacist staffing per occupied bed,[50] decentralised pharmacists,[49] and affiliation with a pharmacy teaching programme.[49] CAVHS provides all of the services associated with decreased medication errors except pharmacist-provided adverse drug reaction management.

The VA's goals are to enhance appropriate use of pharmaceuticals in the veteran population and reduce overall healthcare expenditures while providing a consistent quality of care. This objective has been met in part by implementing recommendations from the IOM, which are aimed at reducing medication errors and improving the medication use systems that are responsible for delivering pharmaceutical care.[51]

CAVHS and the VA are on the cutting edge in using new technology and systems theory to improve the appropriate use of medications, reduce medication errors and improve patient safety.

The challenge is for all health systems to embrace proven strategies, which reduce medication errors and improve therapeutic outcomes for their patients. Instead of being designated as 'best practices', these practices should be the standard of care for patients everywhere.

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References

1. Kohn KT, Corrigan JM, Donaldson MS, editors. To err is human: building a safer health system. Washington, DC: Committee on Quality of Health Care in America, Institute of Medicine, National Academy Press, 1999
2. Leape LL, Berwick DM, Bates DW. What practices will most improve safety? Evidence-based medicine meets patient safety. JAMA. 2002 July; 288 (4): 501-507
3. Voelker R. Hospital collaborative creates tools to help reduce medication errors. JAMA 2001 Dec; 286 (24): 3067-9
4. Flynn EA, Barker KN, Pepper GA, et al. Comparison of methods for detecting medication errors in 36 hospitals and skilled-nursing facilities. Am J Health Syst Pharm 2002 Mar; 59 (5): 436-46
5. Young D. More hospitals report medication errors, but USP finds few changes. Am J Health Syst Pharm 2002 July; 59 (13): 1233
6. Bates DW, Leape LL, Cullen DJ, et al. Effect of computerized physician order entry and team intervention on prevention of serious medication errors. JAMA 1998 Oct; 280 (15): 1311-6
7. The United States Pharmacopeial Convention. National Coordinating Council for Medication Error Reporting and Prevention. Definition of medication errors [online]. Available from URL: http://www.usp.org/reporting/review/rev_057.htm [Accessed 1997 Jan]
8. Brennan TA, Leape LL, Laird NM, et al. Incidence of adverse events and negligence in hospitalized patients: results from the Harvard Medical Practice Study I. N Engl J Med 1991; 324: 370-6
9. Lesar TS, Lomaestro BM, Pohl H. Medication prescribing errors in a teaching hospital. a 9-year experience. Arch Intern Med 1997; 157: 1569-76
10. Raju TN, Kecskes S, Thornton JP, et al. Medication errors in neonatal and pediatric intensive care units. Lancet 1989; 12: 374-6
11. Lesar TS, Briceland LL, Delcoure K, et al. Medication prescribing errors in a teaching hospital. JAMA 1990; 263: 2329-34
12. Calliari D. The relationship between a calculation test given in nursing orientation and medication errors. J Contin Educ Nurs 1995; 26: 11-4
13. Rowe C, Koren T, Koren G. Errors by pediatric residents in calculating drug doses. Arch Dis Child 1998; 79: 56-8
14. Leape LL, Bates DW, Cullen DJ, et al. Systems analysis of adverse drug events. JAMA 1995; 274: 35-43

15. Cohen MR, Anderson RW, Attilio RM, et al. Preventing medication errors in cancer chemotherapy. Am J Health Syst Pharm 1996; 53: 737-46
16. Allard J, Carthery J, Cope J, et al. Medication errors: causes, prevention and reduction. Br J Haematol 2002 Feb; 116 (2): 255-65
17. Bates DW, Cullen DJ, Laird N, et al. Incidence of adverse drug events and potential adverse drug events. JAMA 1995; 274: 29-34
18. Ross LM, Wallace J, Paton JY. Medication errors in a pediatric teaching hospital in the UK: five years operational experience. Arch Dis Child 2000; 83: 492-7
19. Edgar TA, Lee DS, Cousins DD. Experience with a national medication error reporting programme. Am J Health Syst Pharm 1994; 51: 1335-8
20. The United States Pharmacopeial Convention. National coordinating council for medication error reporting and prevention. medication error index [online]. Available from URL: http://www.usp.org/reporting/review/rev_ 057g.htm [Accessed 1997 Jan]
21. Hartwig SC, Denger SD, Schneider PJ. Severity-indexed, incident report-based medication error-reporting program. Am J Hosp Pharm 1991; 48: 2611-6
22. Shojania K, Duncan B, McDonald K, et al., editors. Making health care safer: a critical analysis of patient safety practices. Rockville (MD): Agency For Healthcare Research and Quality; 2001. Evidence Report/Technology Assessment No. 43; AHRQ Publication 01-E058
23. Massachusetts Coalition for the Prevention of Medical Errors. MHA best practice recommendations to reduce medication errors. Burlington (MA): Coalition for the Prevention of Medical Errors; 2001 [online]. Available from URL: http: // www.mhalink.org/mcpme/mha_best_practice_recommendation.htm
24. American Hospital Association. AHA initiative: improving medication safety. Chicago (IL): American Hospital Association, 2002
25. Pederson CA, Schneider PJ, Scheckelhoff DJ. ASHP national survey of pharmacy practice in hospital settings: dispensing and administration 2002. Am J Health Syst Pharm 2003 Jan; 60 (1): 52-68
26. Olsen KM. Medication errors: problems identified, but what is the solution? Crit Care Med 2002 Apr; 30 (4): 944-5
27. Lee P. Ideal principles and characteristics of a fail-safe medication-use system. Am J Health Syst Pharm 2002 Feb; 59 (4): 369-71
28. Hronek C, Bleich MR. The less-than-perfect medication system: a systems approach to improvement. J Nurs Care Qual 2002 Jul; 16 (4): 17-22
29. United States General Accounting Office. VA and Defense Health Care. Increased risk of medication errors for shared patients. Report to the Chairman, Subcommittee on Defense, Committee on Appropriations, US Senate. GAO Publication GAO-02-1017. 2002 Sep
30. Computerized provider order entry systems. Health Devices 2001 Sep; 30 (9-10): 323-59
31. Scalise D. CPOE: an executive's guide. Hosp Health Netw 2002 Jun; 76 (6): 41-6
32. Kuperman GJ, Teich JM, Gandhi TK, et al. Patient safety and computerized medication ordering at Brigham and Women's Hospital. Jt Comm J Qual Improv 2001 Oct; 27 (10): 509-21
33. Chan W. Increasing the success of physician order entry through human factors engineering. J Healthc Inf Manag 2002 Winter; 16 (1): 71-79
34. Sittig DF, Stead WW. Computer-based physician order entry: the state of the art. J Am Med Inform Assoc 1994 March; 1 (2): 108-123
35. Teich JM, Merchia PR, Schmiz JL, et al. Effects of computerized physician order entry on prescribing practices. Arch Intern Med 2000 Oct; 160 (18): 2713-4
36. Lee YL, Hsu CY, Hsieh D, et al. Development and deployment of a web-based physician order entry system. Int J Med Inf 2001 Jul; 62 (2-3): 135-42
37. Eskew A, Geisler M, O'Connor L, et al. Enhancing patient safety: clinician order entry with a pharmacy interface. J Healthc Inf Manag 2002 Winter; 16 (1): 52-7
38. Ahmad A, Teater P, Bentley TD, et al. Key attributes of a successful physician order entry system implementation in a multi-hospital environment. J Am Med Inform Assoc 2002 Jan; 9 (1): 16-24
39. Bates DW, Teich JM, Lee J, et al. The impact of computerized physician order entry on medication error prevention. J Am Med Inform Assoc 1999 Jul; 6 (4): 313-21
40. Lovis C, Payne TH. Extending the VA CPRS electronic patient record order entry system using natural language processing techniques. Proc AMIA Symp 2000, 521
41. Chin Hl, Wallace P. Embedding guidelines into direct physician order entry: simple methods, powerful results. Proc AMIA Symp 1999, 225
42. Leape LL, Cullen DJ, Clapp MD, et al. Pharmacist participation on physician rounds and adverse drug events in the intensive care unit. JAMA 1999; 282: 267-70
43. Thompson CA. FDA to develop rules for mandatory bar-code labels: bar codes seen as part of error-reduction strategy. Am J Health Syst Pharm 2002 Jan; 59 (2): 107-12
44. Thompson KK. Bar coding a must for patient safety. Am J Health Syst Pharm 2002 Apr; 59 (7): 667-8
45. Young D. Veterans affairs-bar-code-scanning system reduces medication errors. Am J Health Syst Pharm 2002 Apr; 59 (7): 591-2
46. Rios E, Hix M, Patel M. BCMA: meeting the challenges ahead. Poster Presentation. Arkansas Association of Health-System Pharmacists 2002 Annual Meeting; 2002 Oct, Hot Springs (AR)
47. Central Arkansas Veteran's Healthcare System. Memorandum 00-61 patient safety improvement program. Little Rock (AR): CAVHS, 2001 Dec18
48. JCAHO. Sentinel event policy [online]. Available from URL: http: //www.jcaho.org /accredited+organizations/hospitals/sentinel+events/se_pp.htm [Accessed 2004 Jan]
49. Bond CA, Raehl CL, Franke T. Medication errors in United States hospitals. Pharmacotherapy 2001; 21 (9): 1023-36
50. Bond CA, Raehl CL, Franke T. Clinical pharmacy services, hospital pharmacy staffing, and medication errors in United States hospitals. Pharmacotherapy 2002; 22 (2): 134-47
51. Ogden JE, Muniz A, Patterson AA, et al. Pharmaceutical services in the department of veterans affairs. Am J Health Syst Pharm 1997 Apr; 54 (7): 761-5

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