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MEDICATION ERRORS IN A GENERAL HOSPITAL

This report evaluates the safety of drug administration in a 356-bed general hospital with a unit-dose distribution system. The distribution system is fully computerized and incorporates order entry by physicians, monitoring by pharmacists and maintenance of medication administration records by nurses. Starting in November 1994, 839 opportunities for error were observed in 12 hospital units. Fifty-seven (6.8%; 95% confidence interval [CI], 5.1% to 8.5%) errors in medication were noted, according to ASHP guidelines; three of these (0.3%) warranted patient monitoring. Corrective measures were implemented. In a re-evaluation in June 1995 (855 opportunities for error observed), 30 errors were detected (3.5%; 95% CI 2.4% to 5%); none warranted patient monitoring. The principal types of error detected were in monitoring, time, patient compliance, dose and prescribing. Severity level definition was useful to evaluate the errors. This study was useful for increasing staff members' awareness of the problem and obtaining an annual medication error rate for use as a clinical quality indicator for purposes of continuing evaluation and improvement.

KEY WORDS: Errors, medication, quality assurance, hospital

INTRODUCTION

There have been few studies of medication errors in Spain and Europe. In Spain, 38.8% of hospitals have more than 90% of beds using unit-dose drug distribution systems and 54.1% have more than 50% of beds using this system (results of a survey of 210 hospitals) [1]. In Europe, this percentage is lower (6.5%), since the most frequently used medication distribution system is the ward-based pharmacy system, which can vary greatly among countries (results of a survey of 1,344 hospitals from 18 countries) [2]. The purposes of the study reported here were to evaluate the medication error rate in Hospital de Barcelona, Catalonia, Spain; to propose corrective measures; to re-evaluate the situation to verify the efficacy of these measures; and to implement a system to obtain periodic measurements of the medication error rate as a clinical quality indicator.

BACKGROUND

Accidents with medications are undesired events in the process of medicine use. Accidents include medication errors, the subject of this study, and adverse drug reactions [3], not discussed here.

Medication errors are defined as discrepancies between the medication order and the medication that the patient receives or does not receive [4]. Ever since the first studies were performed [5], researchers in this field have had as their goal the reduction and prevention of medication errors. This error rate is an important clinical quality indicator in hospitals [6].

Self reporting methods underestimate the number of errors made. The best method for obtaining this error rate is the disguised-observation technique of Barker and McConnell [5]. Medication administration records (MARs) cannot be assumed to be correct for purposes of studying medication errors [7]. Only a few reports cite severity levels of medication errors [8].

In 1993, the American Society of Hospital Pharmacists (ASHP) published guidelines for the prevention of medication errors in hospitals [9]. In an ASHP survey reported in 1995, 47.6% of 393 hospitals surveyed in the United States had quality improvement programmes for reducing medication errors [10].

METHODS

Study site

This study was done at Hospital de Barcelona, a general hospital for acute patient care with the following activity indicators for 1995: average number of occupied beds, 305; average stay, 5.07 days; 18,846 patients; 12,876 operations; and 2,297 deliveries. The hospital has 1,000 attending physicians and covers 33 specialties. In 1995, the pharmacy department processed 159,944 prescriptions and dispensed 1,639,071 units of medicine, of which 908,050 were dispensed by the unit-dose system and 695,666 by stock replacement with each unit identified by bar-code. In 1995 it was necessary to repackage 169,535 units of medicine in the hospital pharmacy (the pharmaceutical industry in Spain does not yet supply all drugs in unit doses). The hospital's computer system is an IBM 9121-190 with 146 terminals (six in Pharmacy Services), 21 personnel computers and 60 printers (seven in Pharmacy Services) that is used by 1,500 persons (physicians, nurses and administrative and other personnel).



Drug distribution system

Hospital de Barcelona has a computerized unit-dose drug distribution system with daily distribution to all hospital units. It includes computerized prescription entry (32% of all medication orders, entered by 82 physicians who are responsible for 40% of the activity) done by staff physicians and by those consulting physicians who have become accustomed to using the system. Medication orders entered in the computer in the various hospital units are printed on a pharmacy printer and are validated by a pharmacist. Hand-written prescriptions (68% of the total number of prescriptions) are sent from the hospital units to pharmacy services by internal fax and are entered in the computer by pharmacists. Pharmacy services provides 24-hour service with shift pharmacists who validate 100% of the prescriptions online. MARs (Figure 1)

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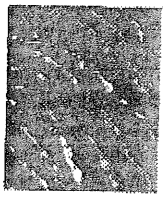
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003 METRONIDASOL I.V. 500 MG/100 ML Ini: 17/05 Do 24h Fin: 24/05 Do 24h Tiempo Infusion: 30M I: NO ADMINISTRAR IM. IV. ADMINISTRAR 500 MG(100 ML) EN 30 MINUTOS (80-100 GTS/MIN APROXIMADAMENTE)	IV	8H	1 UN	1 UN	...24	...8...16..
004 GENTAMICINA VIAL 80 MG/2 ML Ini: 17/05 Do 24h Fin: 24/05 Do 24h I: ADMINISTRAR VIA IM. PARA ADMINISTRACION IV USAR EL VIAL DE 80MG/80ML O BIEN DILUIR EN 50 ML DE NACL 0,9 % Y ADMINISTRAR EN 30 MIN.	IM	8H	1 UN	1 UN	...24	...8...16..
007 ENALAPRIL COMP 5 MG Ini: 18/05 Lu 08h Fin: 06/06 Sa 08h	PO	24H	2 UN	2 UN	...8	
009 1L/24H RINGER LACT + RANITIDINA RINGER LACTATO BOLSA 1000 ML RANITIDINA AMP 50 MG/5 ML Ini: 18/05 Lu 16h Fin: 02/06 Ma 08h Tiempo Infusion 8H	IV	8H	1000 ML 50 MG	1 UN 1 UN	...24	...8...16..
010 PETIDINA AMP 100 MG/2 ML Ini: 18/05 Lu 16h Fin: 07/06 Do 12h I: SC, IM O IV LENTA PREFERIBLEMENTE DILUIDA CONTRAINDICADO DURANTE TRATAMIENTO CON ANTIDEPRES. IMAO. SI PRN MAXIMO 1-1.5 MG/KG C/4 HORAS	SC	4H	75 MG	1/4 UN	20	24 4 8 12 16..

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Figure 1. Computerized medication administration record



for use by nursing staff are computer generated and printed at the ward-based printers. MARs include standard instructions for each drug and, as applicable, specific notes for a given patient and medicine, as indicated by the physician. MARs are computer generated with each change of prescription, and all are generated every 24 hours, coinciding with the floor changes in unit-dose containers that take place from 1715 to 1745 each day. When there are changes in medication orders that require drug dispensing, drugs are sent by pneumatic tube to the floor. The drugs have labels prepared on a pharmacy services printer, and they include patient data, drug data and the next administration time.

Although Pharmacy Services does not have a unit for intravenous additives, the computer program facilitates the preparation of these drugs by nurses by including administration instructions in MARs for intravenous drugs; moreover, since all medication orders are validated by a pharmacist, this is a minor problem. For each dispensing of intravenous medication, a label is supplied for the intravenous solution where the medicine will be diluted, including patient data, drug, dose, solution, administration time, perfusion time, and volume and rate of administration in drops per minute.

Study design

To design and plan this study, a team was formed consisting of the directors of pharmacy services and nursing, two physicians (one quality control specialist and one staff paediatrician), three pharmacists, four nursing supervisors and one statistical consultant. A data collection form was designed based on the 12 types of error as defined by the ASHP [9].

A pilot study was undertaken during 1 week in four hospital units with the goal of defining the sample size and evaluating the approximate error rate that was expected to be found, which was estimated to be about 10%. For a hospital with 35,000 drug administrations per month, the sample size needed for observation was defined as 840 administrations, and these were distributed as 70 administrations in each of 12 floors. Specialties were distributed as follows: surgery (two floors of 30 beds), internal medicine (one floor of 30 beds), paediatrics (one floor of 15 beds), traumatology (two floors of 30 beds), cardiology and cardiac surgery (one floor of 30 beds), oncology (one floor of 30 beds), gynaecology (one floor of 30 beds), obstetrics (one floor of 26 beds) and surgery requiring minimum hospitalization (one floor of 30 beds and one floor of 22 beds). The adult and paediatric intensive care units, emergency room and operating rooms were not included in the study. The evaluation was done in November 1994 and the re-evaluation in June 1995.

Data collection

Observations of drug administration were recorded by 14 nursing supervisors (12 staff and 2 night duty). Each supervisor observed drug administrations on her floor at 0800, 1200, 1400, 1600, 1800 and 2000, the night-duty supervisors observed administrations at 2200, 2400 and 0600 on all floors. The study included administration of intravenous medications and controlled substances. The study methodology was explained to the nursing supervisors in a general session in which they were given the data collection forms. It was explained to them that results from different floors could not be used for comparative purposes since the number of observations on each floor would be too low to have statistical validity. Nursing personnel were informed that the value for a hospital quality indicator was being obtained, without specifying the exact nature of the study in order to avoid changes in behaviour. Supervisors observed nurses administering a drug to a given patient and later verified against the original medication order. When the observer was able to correct an error, this was done so discreetly, but the administration was nevertheless recorded as an error. Completed forms were sent to pharmacy services and four pharmacists (each reviewing the forms from three floors) reviewed the pharmacy validation of the medication orders, both those entered in the computer by physicians and those received by fax and entered by a pharmacist, verifying the entered medication order against the original. Data from the collection forms were entered in a dBase III database in both phases of the study.

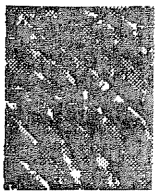
Analysis of the errors and their level of severity was undertaken by an expert panel consisting of a pharmacist, two nursing supervisors and a physician.
The error rate was calculated by dividing the total number of errors (doses incorrect for one or more reasons) by the number of opportunities for error (doses administered plus doses omitted) and this figure was multiplied by 100 to give the value as a percentage [4]. The 95% confidence interval of this percentage was calculated by the binomial test [11].

Data analysis was by the SPSS/PC statistical program. Comparison of error rates was by the χ^2 test; that of the percentages of errors with severity level greater than 1, by the Fisher test [11]. In all cases the level of statistical significance was $p < 0.05$ [11].

Results of the evaluation phase were analysed in work groups comprising the personnel involved in each hospital unit along with members of the team that designed the study. These groups developed corrective measures for physicians, pharmacists, nurses, the computer system and the work circuit (January to March 1995). These measures were included in a summary document that was made known all involved in the study (to all the nurses on all floors at specific meetings and to all staff physicians) and were implemented (April and May 1995). One measure that required a great deal of effort by the pharmacists but was found to be very useful was the training of all hospital nurses on the computer's pharmacy program in a series of 15 training sessions. The re-evaluation was done during the month of June 1995. Hospital management supported the study and the implementation of corrective measures. The results of both phases of the study were presented by a pharmacist, a physician and a nursing supervisor in a general clinical session for hospital medical and nursing personnel (September 1995).

RESULTS

In the evaluation phase, 839 opportunities for error were observed (32.7% of which were from prescriptions from



	Evaluation	Re-evaluation
N	57	30
%	6.8	3.5
95% CI	5.1–8.5	2.4–5.0
	(χ^2 = 8.54 p = 0.003)	

Table 1. Medication errors during evaluation and re-evaluation

computerized medication orders); in the re-evaluation phase, 855 opportunities were observed (32% from computerized medication orders). The medication error rate decreased significantly (Table 1), from 6.8% in the evaluation phase to 3.5% after the implementation of corrective measures (Table 2).

Physicians
- Avoid giving imprecise orders
- Prescription entry by computer
- Avoid verbal orders

Pharmacists
- Avoid accumulating verification orders for urgent dispensing
- Improve communication with weekend pharmacists
- Note clarifications
- Take into account next dose when dosage frequency is changed in order to avoid overlapping
- Establish protocols for intravenous administration of drugs with narrow therapeutic indexes through flow-control devices

Nurses
- Systematic verification of all medication orders (patient, drug, dose, route, time)
- Promote computerized prescription order entry among physicians

Computer system
- Adapt the program to paediatric and cardiology patient needs
- Simplify the medication profile for physicians
- Provide access to drug data on pharmacist's verification screen

Table 2. Corrective measures proposed

Medication errors were divided into six mutually exclusive categories (Table 3). A possible cause of each error was proposed by the members of the work group who analysed the errors (Table 4). Seven severity levels were used [8] to classify the errors detected. Severity level errors also decreased in the second phase of the study (Table 5).

The three errors with a severity level of greater than 1 that were detected in the first (evaluation) phase were the following: tolbutamide tablet (Rastinon/L) instead of paroxetine tablet (Motivan/L), severity level 3 (unauthorized drug), required a determination of the patient's glycemia level and increased patient monitoring. The cause of this error was a poorly written prescription that both the pharmacist and the nurse misunderstood from the physician's hand written order. The second error was an

	No. Errors (% of Total)	
Type of Error	Evaluation	Re-evaluation
Time	16 (28)	5 (17)
Patient compliance	14 (24.5)	10 (33.3)
Incorrect dose	13 (23)	7 (23.4)
Drug preparation technique	6 (10.5)	1 (3.3)
Incorrect drug	4 (7)	3 (10)
Omission	2 (3.5)	0 (0)
Other	2 (3.6)	4 (13

Time = administration more than 1 hour before or after scheduled by the computer. Patient compliance = the patient refuses to take the medication. Incorrect dose = the correct drug given in an incorrect amount. Drug preparation technique = not the recommended drug preparation technique. Incorrect drug = the drug given is not the one ordered. Omission = any ordered dose that was not given. Other = registry by the nurse in the MAR before medication was given, not informing the patient about the medication.

Table 3. Types of error detected in the two phases of the study

	No. Errors (% of Total)	
Proposed Causes of Error	Evaluation	Re-evaluation
Unclear or incorrect prescription	11 (19)	12 (40)
Incorrect medication administration record	14 (25)	6 (20)
Incorrect selection or preparation by nurse	11 (19)	7 (23)
Delay or advance of more than 1 hour by nurse	16 (28)	5 (17)
Drug chart unavailable	3 (5)	0 (0)
Incorrect drug supplied by pharmacy	2 (4)	0 (0)

Table 4. Proposed causes of error observed

	Evaluation		Re-evaluation	
Severity Level	n	%	N	%
1	54	6.5	30	3.5
2	2	0.2	0	0
3	1	0.1	0	0
	(χ^2 = 11.2 p < 0.01)			

Severity level of errors [8]: 0 = no error occurred, 1 = no harm for the patient, 2 = increased monitoring, 3 = change in vital signs or additional laboratory monitoring but no harm, 4 = need for drug treatment or increased length of stay, 5 = permanent harm, 6 = contribution to death.

Table 5. Administrations with some error: analysis by severity level



indomethacin tablet dispensed with a 90-minute delay (severity level 2, incorrect time). The patient complained of pain, since immediate dispensing had been ordered, and a delay ensued despite the order's being sent in writing to the pharmacy and claimed by telephone. The third error was the administration of a 30 mg morphine tablet rather than the 40 mg tablet prescribed (severity level 2, incorrect dose). The cancer patient affected required more analgesia and the physician increased the morphine dose to 40 mg in a hand-written prescription that was correctly entered in the pharmacy computer (the MAR printed on the floor was correct), but the nurse administered a 30 mg tablet. There were no errors of a severity level greater than 1 in the second (re-evaluation) phase.

The frequency of errors observed with the computerized medication orders was compared with that for hand-written orders (Table 6). In the evaluation phase, this rate was significantly less in the computerized prescription orders. In the second phase, fewer errors were observed for computerized prescriptions, but the difference was not significant, probably due to the small number of errors found during this phase.

	Evaluation		Re-evaluation	
Medication Orders	n	% error	N	% error
Computerized	274	3.6	273	2.2
Hand-written	565	6.3	582	4.1
	(χ^2 = 5.71 p = 0.02)		(χ^2 = 1.67 p = 0.17)	

Table 6. Comparison of error rates observed in computerized and hand-written medication orders

DISCUSSION

The medication error rate decreased significantly after implementing corrective measures; the severity level of the errors also decreased. The error rates obtained in this study are within the range of reported rates [4].The performance of this study at Hospital de Barcelona has helped to create awareness among all personnel involved in the chain of drug prescription, dispensing and administration of the problem of medication errors, which is one of the risks to which a hospitalized patient is most frequently exposed. This has led to a statistically significant decrease in the hospital's error rate that probably would not have occurred had the nursing supervisors for each hospital unit not been involved, at least in these first two studies.

The types of error most frequently found in the two phases of the study were wrong time, patient noncompliance and incorrect dose. The most frequent causes of the errors were incorrect or illegible prescriptions, incorrect validation in the pharmacy, incorrect verification by the nurse against the original medication order, incorrect drug preparation by the nurse and a delay or advance of more than one hour in the time of administration. Errors of omission occurred less frequently in this study in comparison with those reported by other authors [4], which we attribute to the fact that the unit-dose drug distribution chain is computerized. Errors in time (in our study, administering medication more than 1 hour before or after the time scheduled in the MAR) may be too strict to evaluate the administration of some drugs such as sedatives, which should be adapted to the patient's habits. With regard to the greater frequency of patient noncompliance, this occurred principally in scheduled analgesic doses that the patient did not want to take once postoperative pain diminished (hospital with a high level of surgical activity), of which the physician was advised by the nurse so that the prescription could be revised.

Fewer errors were found in the prescriptions that were entered by computer than in those hand-written, and this difference was statistically significant in the evaluation phase of the study. This was also true in the re-evaluation phase, although the difference was not statistically significant, probably because fewer errors were detected in this phase of the study. As Dean et al state [7], direct order entry in the computer by physicians can reduce errors that are caused by poor handwriting, since it avoids transcription in the pharmacy and verification against the original by the nurse. We work continuously in our hospital to encourage physicians to enter medication orders directly; we have been successful with staff physicians, regular consultants and on-call physicians, but we need to persuade many more outside physicians (open hospital) to use this system in the near future.

One outcome of the study is the formation of a medication errors committee to obtain annual error rates for the hospital. The committee members also analyse the communication process for the most serious errors that occur in the hospital which, although not a valid system for obtaining error rates, does assist in correcting critical points in the drug prescription, dispensing and administration chain. The study has been useful for increasing awareness of the personnel involved of the need to report the most serious errors, which, due to infrequent occurrence, are difficult to detect by observation in small samples. Once made aware of the importance of this problem, in 1995 nurses and physicians advised the medication errors committee of eight errors with a severity level of greater than 1. Three of these errors involved implementing rather important corrective measures in the system to avoid future occurrences.

CONCLUSION

The medication error rate at Hospital de Barcelona decreased significantly in the second phase of the study, dropping from 6.8% to 3.5% after the implementation of corrective measures. During the first (evaluation) phase, the errors detected had a greater level of clinical significance. This study has led to the establishment of a system to obtain an annual medication error rate for use as a clinical quality indicator at our hospital for purposes of continuing evaluation and improvement.

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