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SIMULATION OF HOSPITAL MEDICATION ERRORS

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ABSTRACT

The purpose of this study was (1) to investigate the frequency, type and severity of medication errors in a large midwestern private teaching hospital; (2) to assess the impact of the use of pharmacists to detect and correct medication errors; (3) and to construct a computer simulation model to study the problem of medication errors in a hospital. Physicians' medication orders on two medical-surgical units were reviewed by hospital pharmacists for a period of 12 weeks. A total of 6,966 drug orders were reviewed. Errors were recorded and classified by type and severity. Pharmacists also contacted physicians, unit secretaries, and central pharmacy staff and attempted to correct errors before prescriptions were dispensed and administered to the patient. A computer simulation model was constructed to model the medication order process using INSIGHT, a general purpose discrete event simulation language.

INTRODUCTION

Medication errors in hospitals are a serious problem resulting in morbidity, mortality, and liability actions against health care providers and institutions (Dubois and Brook, 1988; Fink, 1983; Steel et al., 1981). One study in a large teaching hospital found that doctors made mistakes in three out of every 1,000 drug prescriptions they wrote (Lesar et al., 1990). In 57.6 percent of the cases, the errors could have caused significant problems for patients ranging from life-threatening reactions to side effects. A two year study of three neonatal intensive care units found 13.4 medication errors and incidents per 1,000 patient days (Vincen et al., 1989). Twenty percent of orders written by physicians that were in error resulted in serious incidents.

The purpose of this study was (1) to investigate the frequency, type and severity of medication errors on two medical-surgical units in a large midwestern private teaching hospital; (2) to assess the impact of the use of pharmacists to detect and correct medication errors before they affected the patient; (3) and to construct a computer simulation model to study the problem of medication errors in a hospital.
METHODS

Hospital Setting

The study was performed in a 1160 bed, private community hospital. Nursing units contain 3-7 computer terminals linked to the hospital information system (HIS). Physicians, nurses, and other authorized hospital personnel can enter and retrieve medical orders and patient data using a keyboard or a light pen. Orders can be entered into the computer system directly by physicians or nurses and unit secretaries may enter orders for the physicians. When entering orders, the physician or his/her agent can select screens that display either general orders or personal order sets that are similar to preprinted order sheets (Anderson, 1987, 1990, 1991).

Data Collection

The quality assurance records in the central pharmacy were used to obtain baseline data on the number of medication errors that were detected prior to this study. All problem reports on file from the two hospital units during the previous 12 months were examined and medication errors were classified by type and severity.

In order to collect data on medication order errors, hospital pharmacists verified every drug order written by physicians on two medical-surgical units during the day and evening shift for a 12 week period. A total of 6,966 drug orders were reviewed for this study. This was accomplished by reviewing a copy of the written order and comparing it to the order that was entered by unit secretaries into the hospital information system. The hospital information system transmitted the orders to the central pharmacy where the drugs were dispensed and delivered to the unit for administration.

When an error was detected, the pharmacist completed a form that identified the prescribing physician, unit secretary and/or nurse involved with the order, the nature of the incident, and the action taken to correct the error. Hospital pharmacists were also available for consultation on the units during the day and evening shifts. They recorded information about all consultations.

Analysis

A classification scheme was developed to classify the types of medication errors and their severity. These were based on studies by Betz and Levy (1985), Blum (1988), Davis and Cohen (1981), Folli and others (1987), Lesar and others (1990); and Vincer (1989).

These data were used to construct a computer simulation model to study medication errors in the hospital. INSIGHT, a general purpose discrete event simulation language was used (Roberts, 1983).

RESULTS

Figure 1 indicates the medication error detection rates on the two hospital units during the two time periods. During the 12 month baseline period, pharmacists detected only 48
prescription errors or 1 error per 1,000 drug orders. During the 12 week baseline period when all drug orders on the hospital units were reviewed, pharmacists detected 227 errors. This represented a rate of 32 errors per 1,000 orders.

Figure 1

Number of Errors Detected per 1000 Orders

![Bar Chart]

Figures 2 and 3 show the types of medication errors detected by pharmacists. In general, 83 percent of the errors were made in transcribing the physicians' orders and entering them into the medical information system. Physicians made errors in writing prescriptions in 14 percent of the cases. The other three percent of the errors were in dispensing and administering medications.

Medication errors were classified by their potential severity in Figures 4 and 5. On both hospital units, over 70
or the wrong information concerning dosage, route, or frequency. If not detected and corrected, these prescriptions could have resulted in adverse effects on the patient. About 6 percent of the medication errors were potentially serious. These errors might have resulted in serious toxic reactions or inadequate therapy for a serious illness. The last category of medication errors were potentially lethal and may have resulted in the death of the patient. Two percent of the errors were classified into this category.

While on the units, hospital pharmacists were available for consultation. Figures 6 and 7 indicate that a total of 164 consultations took place during the study period. Of these, 44 percent were initiated by nurses, 28 percent by physicians, 27 percent by unit secretaries responsible for entering orders into the medical information system, and one percent by other hospital personnel. The frequency of consultations varied among the 19 pharmacists from a high of 5 per day to less than two consultations per month.

THE COMPUTER SIMULATION MODEL

A computer simulation model was constructed to model medication errors in a hospital. INSIGHT, a general purpose discrete event simulation language, was used to model the process (Roberts, 1983). A preliminary model is graphically represented in Figure 8.

Node 1 is a source node that creates order sets that consist
of 0 to 4 medication orders. The model assumes that physicians make 4.6 errors per 1,000 orders when writing prescriptions. Once an error is made the model assigns attributes at nodes 2 and 3 namely, a type of error and a severity.

At node 5, orders are entered into the hospital information system by a unit secretary. This requires resources in the form of personnel and a computer terminal. If either is unavailable, there may be a delay as orders wait in a queue at node 4.

The model assumes that units secretaries make 27 transcription errors in every 1,000 orders they enter into the HIS. Attributes (i.e., type and severity are assigned to these errors at nodes 6 and 7.

At nodes 8 and 9, hospital pharmacists review the written medical orders. Orders that do not include medications go into a sink at node 11. Medication orders are verified at nodes 10 and 12 by comparing the written order to the order that was entered into the HIS.

Errors are corrected by pharmacists at nodes 13 and 14. This may involve consultation with the physician who wrote the order and/or other hospital personnel.

Once the orders have been verified by the pharmacists, the medications are dispensed in the central pharmacy. The model assumes that dispensing errors are made at the rate of 4.3
errors per 1000 orders. Attributes are assigned to these errors at nodes 15 and 16. Once the medications are delivered to the unit, they are administered by an RN. The model assumes errors are made at the rate of 5.7 per 1,000 orders. Attributes are assigned at nodes 17 and 18. The process is complete at node 19, a sink.

DISCUSSION

This study has investigated the problem of medication errors in a hospital. Over a 12 week period, 227 medication errors were detected on two hospital units. This amounts to about 33 errors per 1,000 orders. Eighty-three percent were transcription errors; 14 percent were prescription errors; while the remainder of the errors were made in dispensing and administering medications. In general 30 percent of the errors were serious enough that they might have had adverse effects upon the patient. Two percent were potentially fatal. A total of 164 consultations with pharmacists took place during the study period.

Based on these data, a preliminary computer simulation model was constructed using INSIGHT. At this time, the model lacks information about activity times and resource availability. Once these are added to the model, it can be used to simulate the drug ordering process in a hospital and the errors made
during this process. This will permit the investigators to study how changes in the process may affect resource requirements and medication errors.

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BIOGRAPHY

James G. Anderson is Professor of Sociology at Purdue University. He holds the following degrees from The Johns Hopkins University: B.E.S., M.S.E., M.A.T. and Ph.D.

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