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IMPACT OF A CLINICAL INFORMATION SYSTEM ON HOSPITAL COSTS

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Concern over the rising costs of medical care has been expressed frequently by patients, legislators, and members of the health care community. The public expects "perfection" when it comes to medical care delivery. When an individual patient is considered, the expectation is that "maximum" care will be given. To help prove that these expectations are being met there is a growing demand for documentation of the clinical care process as well as proof of procedures being done. A major part of the cost of the care provided in hospitals is for personnel (57 percent at LDS Hospital affiliated with the University of Utah) and major portions of these expenses are for personnel who provide direct patient care (nursing 37 percent, surgery 7 percent, laboratory 5 percent, respiratory care 4 percent, and X-ray 4 percent). Anything that will make the care process more efficient will be welcomed.

At the same time that there is a need for improved efficiency in health care delivery, medical knowledge, new drugs, and new medical procedures abound. The decreasing cost of computers with their increasing capability present an attractive solution to many of the hospital problems of being efficient yet at the same time delivering "state of the art" care. It has been observed that many errors in medicine appear to be due to errors associated with simple clinical events that the computer might help avoid. Also there is evidence that clinically relevant medical knowledge is frequently not applied either because of ignorance and/or the inability to process all the patient data. Therefore, with the cost of computers dropping and the need to perform simple repetitive tasks, which the computer is capable of doing, we find ourselves in an ideal position to have the computer help us with the "clinical" tasks of medicine and at the same time help us with the task of efficient documentation.

Evaluation of the cost effectiveness of any process in the health care field is complex. As a consequence, studies in this field, especially as they relate to the use of computers, are limited and open to challenge. Only recently have computers been used to enhance the "clinical" practice of medicine. We present four example studies where benefits have been shown using the HELP computer system at LDS Hospital in Salt Lake City, Utah (Pryor et al. 1983).

PHARMACY ALTERING

As prescribed drugs are entered into the HELP system by clinical pharmacists on nursing divisions, a "knowledge base" of drug-drug interactions, drug-laboratory contraindications, and allergies screens patient data for potential complications (Hulse et al. 1976). If the drug is contraindicated for any reason the clinical pharmacist is notified before the drug is dispensed. Compliance of physicians with these alerts occurs more than 90 percent of the time. After observing the high compliance rate and the positive attitude of our physician staff we began to explore methods of evaluating the benefit-to-cost ratio of our system. Cost data were readily available because each clinical module is implemented only after initiation of a charge for service. Statistics were logged on the number of prescriptions and number of alerts that were generated by the computer system. However, evaluation of the benefit of the pharmacy alerts was more difficult. The value of each drug alert was highly variable depending on whether or not the drug reaction would actually occur and what the degree of severity would be. To make the benefit assessment quantitative, expert opinions on the value of each pharmacy alert were obtained independently from five clinical practicing pharmacists.

During a two-year period more than 53,000 patients were monitored for more than 246,000 patient days. Less than 4 percent of the patients had pharmacy alerts and less than 0.7 percent of the drugs ordered resulted in alerts. The current charge made to patients for the pharmacy alert service is 35 cents per patient day, just over $86,000 for the two-year period. The estimated benefit from the experts was more than $339,000. Therefore, the benefit-to-cost ratio was a highly favorable 3.94 to 1.

LABORATORY ALERTS

A second alerting system was established after experience with the pharmacy alerting system produced such encouraging results. As laboratory data were sent to the HELP system from the clinical laboratory, a data-driven knowledge base was automatically applied. If the patient data indicated a life-threatening condition an alert was generated. A randomized design was set up to help evaluate the effectiveness of these alerts. When an alert occurred on a study patient, a nurse clinician promptly gave the information to the patient's physician. Control patients' physicians were left to obtain the information on their own through computer or by reviewing the patient chart, and were given no computer prompts about the alert condition. All patients were followed up by nurse clinicians using structured protocols based on action-oriented criteria.

There were several categories of alerts where physicians' treatment patterns were changed. The incidence of life-threatening alerts based only on laboratory data was small. Only about 4 percent of the patients, outside the intensive care unit, generated alerts and approximately half of these were treated correctly and promptly. Even though the number of alerts was small there was still a positive effect on physician behavior. Physicians liked the "real-time" alerts because they were made available to them at a time when it was most effective for them to modify their treatment decisions.

MICROBIOLOGY MONITORING

The costs of inappropriate antibiotic therapy, hospital-acquired infections, and continuous surveillance by infectious disease personnel contribute to the expenses incurred by patients. At present, antibiotics as a group are one of the most frequently prescribed drugs and represent more than 35 percent of drug costs (Hendeles 1976). Between 30 and 40 percent of all hospitalized patients receive one or more antibiotics during their hospital stay; however, up to 67 percent of these patients may have no evidence of infection (Maki and Schuna 1978).

Antibiotic therapy is usually started before the culture results are available and physicians must choose a broad-spectrum antibiotic. Broad-spectrum antibiotics cover a wider range of possible pathogens but are often more expensive. The final susceptibility results may demonstrate that a less-expensive antibiotic can be used or the culture may be negative, indicating that no drug is required. In choosing therapy, the most effective and most cost effective antibiotics may be passed over. In addition, with new agents being introduced at an unprecedented rate, it is increasingly difficult for physicians to keep abreast of important pharmacological developments and costs (Avorn and Soumerai 1983)

Antibiotic prophylaxis is used in surgery patients who are without infection, with the objective of reducing subsequent postoperative infections. Studies show antibiotic prophylaxis should be limited only to high-risk patients, or to those for whom the development of an infection might have a catastrophic result (Veterans Administration 1977). Prophylactic drugs should usually be stopped within 48 hours, since continuing prophylaxis increases the risk of drug toxicity and bacterial superinfection and does not reduce the incidence of subsequent infection (Medical letter 1979).

During February and March 1979, the Utah Professional Standards Review Organization conducted a study of prophylactic antibiotic use in 21 Utah hospitals (Britt et al. 1981). The study included 2,782 patients, of which 1,163 (46 percent) received antibiotic prophylaxis. Prophylactic antibiotics were used a total of 4,753 days and according to this study 3,831 days (81 percent) were inappropriate. At the rate of $50.00 a day (1979 prices) this practice added approximately $190,000 to the patients' bills during a two-month period. The identification of patients receiving inappropriate prophylactic antibiotics required additional time, manpower, and cost.

Emori et al (1980) found that infection control practitioners (ICPs) in large hospitals (> 300 beds) spent an average of 36 hours each week on nosocomial (hospital acquired) infection surveillance. Nosocomial infections represent an important endemic problem affecting 3 to 8 percent of hospitalized patients—this represents more than 2 million infections annually in the United States. Studies have shown that the typical nosocomial infection prolongs hospitalization 4 to 10 days and increases hospitalization charges $600 to $700 (1979 prices), thereby increasing the patient's bill by about 15 percent (Haley et al. 1981).

Patient microbiology data were added to the HELP system by interfacing the clinical laboratory computer system. With the aid of experts in infectious disease, a knowledge base was developed that identified: (1) nosocomial infections, (2) patients not receiving antibiotics to which potential pathogens are sensitive, (3) patients who could be receiving less expensive antibiotics, and (4) patients on prophylactic antibiotics longer than necessary (Evans et al. 1985, 1986).

A two-month study was conducted where the nosocomial infections identified by the computer were compared with the nosocomial infections found by the ICPs. Patients identified by either method had their medical charts reviewed by infectious disease physicians to verify the infections. During the same two-month period the patients identified by the computer who could have received a less expensive antibiotic had their medical charts reviewed by the physicians. The physicians decided whether the patient needed an antibiotic for a specific culture and also if the less-expensive antibiotic recommended by the computer was appropriate.

The computer identified significantly more patients with nosocomial infections ($p < 0.002$) and total nosocomial infections ($p < 0.03$) than the ICPs. During the two-month study the ICPs spent a total of 138 hours doing nosocomial infection surveillance and analysis. Their time was spent examining microbiology laboratory summary results, checking nursing notes and "Kardexes," checking admit and discharge dates, and surgeries, following up on patients in isolation, and selecting charts for retrospective review. The ICPs spent 8.0 hours during the two-month study analyzing the data and making a summary chart. It took 8.6 hours to take the pertinent data from the computer alert and make a summary chart for the two methods. However, the computer could have saved 130 person-hours in surveillance while at the same time identifying more infections.

Of the 155 patients found to have infections, 54 (35 percent) had a nosocomial infection marked on the facesheet of their chart and 101 (65 percent) did not. Reevaluation of these 101 charts showed that several would have received a higher level in a diagnostic related grouping if the medical records department had known about the infection and the hospital would have received an additional $18,000 for the year.

There were 39 computer alerts stating that although the patient was receiving an appropriate antibiotic, he or she could have been receiving a less-expensive antibiotic. The physicians decided that 31 (80 percent) of these alerts were correct and the patient could have received the computer-recommended antibiotic.

For 23 days during a six-week period all patients who were initially given a cephalosporin for the first time had their charts checked by a clinical pharmacist to see if the drug was for therapy or prophylaxis. The patients receiving prophylactic cephalosporins were then followed to see if the drug was discontinued within 48 hours. The patients who received the cephalosporins longer than necessary were compared with the patients who were identified by the computer as being on prophylactic cephalosporins more than 48 hours.

Of the 506 patients receiving cephalosporins for the first time, 440 (87 percent) were receiving the cephalosporins for prophylaxis. Of the 440, 89 (20 percent) were discharged before 48 hours, 166 (38 percent) had their cephalosporins stopped before 48 hours, while 185 (42 percent) did not. Of the 185 patients receiving the chephalosporins longer than 48 hours, 156 (35 percent of the 440) did not have any evidence of infection or a microbiology test ordered or waiting results. The computer sensitivity for locating these patients was 100 percent, and specificity was also 100 percent, i.e., no patient was falsely identified.

The ICPs spent 138 hours during the study (17 hours a week) on infection surveillance and analysis. This time would likely have been a great deal more at other hospitals since few hospitals have the computer review capabilities present at the LDS Hospital. Emori et al. (1980) found that ICPs in large hospitals (> 300 beds) spent an average of 36 hours each week on surveillance. Checking the patients' surgery data, X-ray data, previous admission dates and other culture reports was done by the ICPs at LDS Hospital utilizing existing computer programs on a terminal. The data for all suspected infection patients could be performed at one location, thus making it unnecessary to check these patients' charts. The computer notifies the infectious disease staff of patients with possible nosocomial infections within 24 hours of positive culture data. Thus, using the computer alerts the ICPs can check the patient's chart while the patient is still in the hospital, have proper treatment started, and document the infection on the chart. The prompt identification can also benefit the patient, prevent or more promptly identify hospital epidemics, protect hospital personnel from potentially contagious diseases, and help administrative services such as medical records and patient billing in recognizing nosocomial infections.

Penicillins comprised 77 percent of the correct recommendations by the computer; 75 percent of the time when a penicillin was recommended as a less expensive antibiotic the patient was on a cephalosporin. The average cost of the penicillins given IV (intravenously) is $10.00 per gram whereas the average cost of the four most commonly used cephalosporins given IV is $17.00 per gram. If the drug is given three times a day for seven days that would be a difference of $147.00 per infection. Based on the 24 cases found during the two-month surveillance period you would expect to find 144 during a year resulting in a savings of over $21,000 per year.

During a 23-day period, 156 patients received prophylactic cephalosporins longer than necessary. The additional cost of these antibiotics given IV in the hospital is over $50.00 a day. Thus if these patients received a cephalosporin for only one day longer than the 48 hours, an extra $6,650 was spent on unnecessary antibiotics. For the entire year that would be an extra $115,000 just for antibiotics. However, Shapiro et al. (1979) found that the duration of prophylactic antibiotic use was correlated with duration of hospital stay.

Computer surveillance is now the basis for infection surveillance at LDS Hospital. The study showed that the computer can identify: (1) patients with nosocomial infections more quickly, more efficiently, and at less cost than the manual methods; (2) patients who could be on less-expensive antibiotics; and (3) patients who are receiving prophylactic antibiotics longer than necessary. The key to reducing the cost of these antibiotics, however, is in making sure that the computer-alerted patients are followed up responsibly.

RESPIRATORY CARE

Use of the computer for documenting respiratory care (RC) procedures is an example of how clinical information can be used for cost benefit. Instead of writing results of RC procedures in the patient's chart, therapists enter the clinical information into a computer terminal at the

Table 7.1
Therapists' Evaluation of Computer Charting Compared to Manual Charting (percent of responses of 48 therapists)

	Better	Same	Worse
Time spent	59	33	8
Ease of entry	65	25	10
Ease of review	52	17	31
Accuracy	54	27	19
Productivity	77	19	4

nursing station. The clinical information can then be used not only for reporting but also for billing, management, and monitoring patient care (Andrews et al. 1985).

Results of surveys taken before and after implementing computer charting showed that therapists preferred using the computer over manual charting. Before computer charting, 17 of 37 (46 percent) felt that computer charting would make their job easier, compared to 29 of 38 (76 percent) after using computer charting. Table 7.1 shows therapists felt the computer was an improvement.

Charting RC procedures on the computer streamlined the processing of information. Writing RC procedures results in the patient's chart being eliminated; instead the information is entered into the computer. The results can be reviewed from any nursing division computer terminal and printouts can be easily obtained if desired. When a patient is discharged, a permanent record of all RC documentation is printed and placed in the partient's chart.

Manual charting required therapists to document billing charges on separate forms. These forms were processed by the department secretary and taken, a day or two later, to the billing department where a clerk would enter these charges into the computer. Computer charting eliminated these steps. A therapist simply charts the clinical information into the computer; the billing process is automatic and transparent.

Since billing is automatically extracted from the clinical documentation, there is complete assurance that documented procedures are billed. This assurance is important when third-party reimbursement is dependent on the documentation of the care performed. The accuracy of the clinical charting determines the accuracy of the patient's bill.

Computer charting also gives the therapist another incentive for accurate documentation. A daily management report provides verification of all procedures that have been documented by each therapist. Supervisors can quickly ascertain that all procedures assigned have been documented. The productivity of each therapist can be accounted for and used as an objective part of the therapist's performance appraisal. The management report also provides RC department statistics of performed procedures and lists documentation of missed treatments. This information is helpful in justifying staffing requirements.

Inconsistencies and duplication of charting are easily identified using the computer. While most mistakes or uncharted procedures can be found using the management report, other, less-obvious, mistakes can be searched for using the computer. Inconsistencies such as overcharges on hourly care can be checked so that a patient is not charged for more than 24 hours of therapy in a single day.

Computerized charting is also used to check that proper care is being given. Patients who are on long-term oxygen therapy without having a blood gas test performed are reported so that a therapist may assess the need for oxygen and notify the physician. Medical necessities for oxygen utilization can therefore be automatically monitored.

The productivity of the respiratory care department is a calculation of work units done and employee hours worked. The first three months of 1984 (before computer charting) showed a productivity of 87.8 percent (the average productivity of 1983 was 89 percent); after implementing the computer (March thru December 1984) the productivity has averaged 106.4 percent The increase in productivity of 18.6 percent represents a savings of $220,375 per year.

CONCLUSIONS

The examples discussed in this chapter show how the computer can improve the quality as well as the efficiency of hospital care. From the observations made with the alerting programs we have found that:

1. The number of alerts (potential errors) is less than projected. (Medicine is practiced better than the studies suggest, although still not perfect.)
2. Error rates are often small enough that human reviewers are not accurate at detecting them nor are humans cost effective at performing such tasks.
3. Many potential errors can be detected and prevented.
4. Physicians are responsive to the alerts and make changes in their treatment. Physicians also appreciate receiving the "alert" at a time when they can modify and optimize therapy.

It is only a matter of time before most data-logging procedures done in hospitals will be more cost effective using computer methods. With the expected increase in efficiency will also come better records and better data to be used by medical decision-making algorithms.

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