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Diffusion of Computer Applications Among Physicians: A Quasi-Experimental Study*

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ABSTRACT

An experimental program involving the use of a hospital information system was implemented and evaluated on four services at Methodist Hospital of Indiana, a 1120-bed, private teaching hospital. Ten other hospital services were assigned to a control group. The program utilized educationally influential physicians to disseminate information concerning the advantages of using predesigned computer-stored personal order sets for the entry of medical orders into a hospital information system. Data from the hospital information system's tapes were collected at three times in order to evaluate the effectiveness of the intervention. A multivariate analysis of variance indicated that the program resulted in a significant increase in personal order set use by physicians, physician assistants, and unit secretaries on the experimental services. The results of the study suggest that the identification and use of educationally influential physicians is an effective means of introducing medical innovations into clinical settings.

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Introduction

Diffusion of Innovations among Professionals

A number of studies indicate serious underutilization of clinical computer applications long after they have been implemented (Freidman & Gustafson, 1977). In some instances, physicians have adopted circumventing strategies to avoid using clinical computer systems (Fischer, et al., 1987). In other cases, hospital staff have interfered with their implementation (Dowling, 1980).

Studies suggest that in collegial organizations or bureaucracies largely made up of professionals, adoption of innovations depends largely on individual decisions (Mintzberg, 1997). Burt (1987) provides a model for this process. He suggests that individuals who are structurally equivalent or who share similar positions in the social structure will largely interact with the same group of individuals and will share similar beliefs, attitudes, and behaviors. Competition among individuals in an organization will motivate them to adopt an innovation soon after they perceive that structurally equivalent individuals have done so.

The findings of a number of studies support these contentions. One survey of innovations in health care organizations concluded that, in addition to a leader, it is important to identify and utilize early adopters who can influence their colleagues to adopt an innovation (USDHEW, 1973). Also, Stross and Harlan (1979) found that two thirds of the family practitioners and internists they surveyed, who were aware of an important study eighteen months after publication of the results, had been informed about the study by another physician. Evidence from the Columbia University drug diffusion study (Coleman, et al., 1966) found that, in general, physicians did not adopt a new drug, tetracycline, unless they had direct contact with a physician who had already done so. A reanalysis of the data from the study by Burt (1987) suggests that the dominant factor driving the diffusion of the drug was physicians' perceptions of the actions of other doctors with comparable standing in the medical community and not just conversations with colleagues. These studies clearly point to the importance of peer influences in understanding the diffusion process. The importance of informal advice and information seeking among physicians is underscored by the results of other studies as well (Maxwell, et al., 1984; Weinberg, et al., 1981; Wenrich, et al., 1971).

Hospitals are a particularly important setting for the diffusion of new technology, since the medical staff constitutes a social system based on shared norms, expectations, and functional interactions (Wenrich, et al., 1971). Acting upon this, researchers at the University of Michigan have identified educationally influential physicians in community hospitals and used them to informally influence the practice of their colleagues (Stross & Bole, 1979, 1980; Stross, et

al., 1983). Substantial improvements in the utilization of diagnostic procedures and patient management were observed in the three community hospitals that utilized influential physicians.

The results of these studies demonstrate the importance of peer networks in communicating information about innovation and persuading physicians to try them out in practice. They also indicate that certain physicians are central to these communication networks and are educationally influential in the dissemination of information concerning medical innovations. Our previous research indicated that physician attitudes toward clinical computer applications significantly affect the extent to which they use a hospital information system (HIS) to communicate medical orders and test results to and from ancillary services (Anderson, et al., 1985). Furthermore, once physicians form their initial attitudes and practice patterns involving the use of the HIS, they are likely to persist over long periods of time (Anderson, et al., 1988). This research also found that prominent physicians who were frequently consulted by other physicians on their hospital service were the first to adopt the HIS in their clinical practice. Moreover, physicians who were structurally equivalent (i.e., had similar consultation patterns with other physicians on the hospital service) adopted the HIS at approximately the same time and evidenced similar patterns of HIS utilization (Anderson, et al., 1986, 1987a, 1987b). This suggests that a strategy that utilizes educationally influential physicians may be an effective means of changing physicians' practice behavior.

Objective

The primary objective of this research was to design, implement, and evaluate a program to change the procedure that physicians use to enter orders into a hospital information system (HIS). The intervention used members of the medical staff identified as being educationally influential in the peer network to influence practice behavior.

Research Methods

Practice Setting

This study was conducted in a 1120-bed, private teaching hospital that implemented the Technicon Medical Information system in 1976. The hospital information system (HIS) is a communication system that links patient units to ancillary services and various departments throughout the hospital. All patient data (i.e., admission information, medical orders, test results, progress notes, etc.) are entered into the computer at terminals throughout the hospital. Most

data entry is menu driven. Hospital personnel make selections from predesigned lists using a light pen (Anderson, 1990).

Physicians generally write medical orders in the chart. These orders in turn are entered into the HIS by unit secretaries or by physician assistants who are frequently registered nurses. Alternatively, physicians may directly enter orders at a terminal instead of writing them. Order entry requires numerous selections from generic menus as shown in Figure 1.

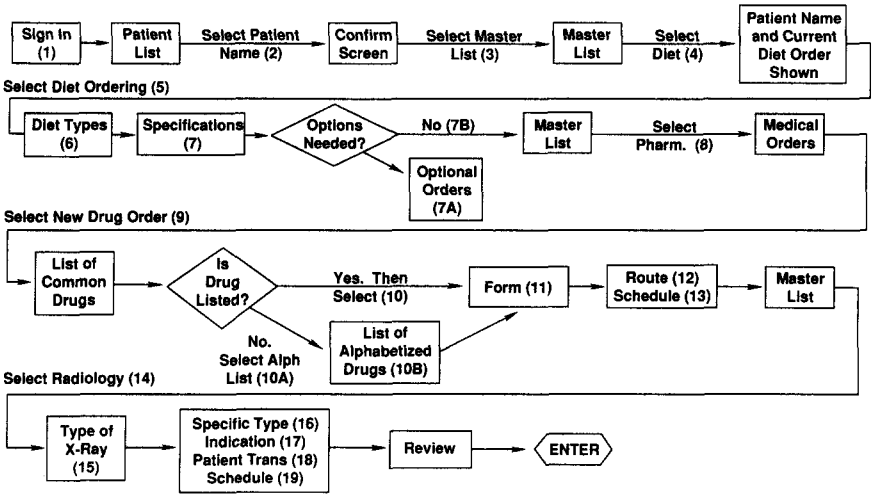

Figure 1. Order Entry — Regular HIS Pathways

As an alternative, physicians can create personal order sets for order entry. These personal order sets are tailored to the specific types of procedures that the physicians frequently order for their patients (see Figure 2). Personal order sets are like preprinted order forms, but appear on the computer monitor. The use of a light pen to make selections from these precomposed lists minimizes the use of the keyboard. The use of personal order sets for medical order entry, especially when used by physicians themselves, has the following advantages: (1) faster order entry, (2) elimination of transcription errors, (3) faster execution and results reporting, and (4) decreased clerical work.

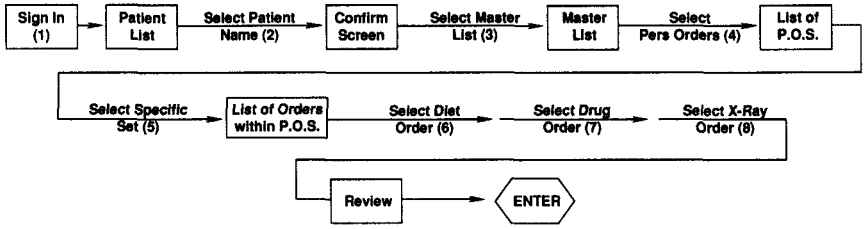

Figure 2. Order Entry — Personal Order Sets

Quasi-Experimental Design

The study used a quasi-experimental design. The following hospital services were selected as the experimental group: cardiovascular disease, general surgery, obstetrics and gynecology, and orthopedic surgery. The four services were selected because of the large number of orders written for patients. Also, these physicians are somewhat specialized so that many of the same medical orders are used for multiple patients with minor modifications. Consequently, the development and use of personal order sets are potentially useful to physicians on these services.

We initiated an experimental program on the four services aimed at physicians identified as educationally influential among their peers. The program was designed to increase the use of personal order sets for the entry of medical orders. Physicians on ten other hospital services were assigned to a control group. Data on order entry were collected from 109 and 231 physicians on the experimental and control services, respectively.

Identification of Influential Physicians

Six weeks of patient data were extracted from the hospital information systems' purge tapes used to store clinical data once the patient is discharged from the hospital. These tapes indicate the attending physician and all consulting physicians for each patient. From these data, binary consultation networks were constructed for each of the experimental services. These matrices indicated the physicians on the service who were consulted by each physician during the six-week period. STRUCTURE, a hierarchical clustering algorithm, was used to analyze the networks (Burt, 1982). Groups of physicians with similar consultation patterns were identified on the four experimental hospital services.

An influential physician was identified in each group using the following criteria: social network measures of each physician's prestige in the consultation network, participation in the hospital's medical education program, and/or participation on medical staff committees. Influential physicians are professionally active, technically proficient, frequently consulted by other physicians, and are generally early adopters of new procedures. Each of these physicians was then contacted and asked to participate in a research project designed to increase use of personal order sets to enter orders into the hospital information system. All of the physicians who were contacted agreed to participate in the study.

Experimental Program

The objective of the experimental program was to demonstrate to the educationally influential physicians the advantages of developing and using personal order sets for medical order entry into the hospital information system. First, however, it was necessary to assess the degree to which each of these physicians used the HIS in practice as well as their knowledge and use of personal order sets. This was accomplished in two steps. First, a questionnaire was used to determine the extent to which physicians used the system to obtain patient lists, laboratory test results, and current medical orders; to print test results; and to enter new medical orders. From this information, a profile of HIS use was created for each influential physician.

Second, prior to meeting with each influential physician, a packet was delivered to the physician's office. This packet contained a short questionnaire as well as listings of any personal order sets they had created and all departmental order sets for their hospital service. The physician was asked to answer questions regarding his/her use of personal and departmental order sets. This material was then picked up and analyzed prior to meeting with each of the influential physicians.

At the meeting, the physician was provided data that indicated his/her overall use of the hospital information system as well as use of personal and departmental order sets for order entry. Individual physician profiles were compared to usage profiles for physicians on their service and to the profile for the hospital medical staff as a whole. During the meeting, the project staff discussed with the physician the advantages of using personal order sets to enter medical orders into the HIS. Following the meetings, physicians continued their normal practice on their hospital services. The project staff did not ask these physicians to engage in any special activities to promote personal order sets.

Six months later, the second phase of the experimental program was implemented. A second meeting was held with the educationally influential physicians.

At this meeting, the influential physicians were provided with information concerning the use of the HIS by the house staff. Second, they were provided with data on order entry times and error rates using the two modes of order entry (i.e., regular HIS pathways and personal order sets). Third, a summary of physicians' perceptions of the advantages and disadvantages of using personal order sets in practice was developed from the first set of meetings with the influential physicians. This summary was used to review the value of the educational program and to reinforce its content.

Evaluation

In order to determine whether increased use of personal order sets occurred on the experimental services as a result of informal consultations with the influential physicians, data were collected three times: prior to the intervention, two months after the first meeting with the influential physicians, and two months after the second meeting with these same physicians. Each time, four weeks of patient data were extracted from the discharge data contained on the HIS tapes. For each physician who had discharged patients during this period, statistics were computed for the number of medical orders entered per patient by the physician using (1) his/her own personal order sets, (2) departmental order sets, and (3) the generic order sets that are a standard part of the hospital information system.

These data were analyzed by means of a multivariate analysis of variance with repeated measures over time. A major advantage of this design is the control that it provides for individual differences between physicians that often are quite large relative to differences due to treatment or intervention effects, which this study is attempting to evaluate.

Results

Identification of Influential Physicians

For each of the experimental services, a matrix was constructed with the rows and columns representing the physicians on the service. A number 1 in a cell indicated that the row physician had consulted with the column physician at least once during the six-week period. STRUCTURE, a hierarchical clustering program, was used to generate groups of structurally equivalent physicians with similar consultation patterns (i.e., they generally consulted the same physicians in the course of caring for patients). This resulted in the identification of five groups of physicians on cardiovascular disease and general surgery and three groups on obstetrics and gynecology and orthopedic surgery.

An influential physician was identified in each cluster of structurally equivalent physicians. Selection was based on the frequency with which the physician was consulted by others on the service as well as by whether or not the physician was an active participant in the hospital's medical education program and/or medical staff affairs.

Evaluation

The evaluation was aimed at determining whether a change in physician behavior took place on the experimental services as a result of providing educationally influential physicians with information documenting the advantages of using personal order sets for order entry into the hospital information system. A multivariate analysis of variance with repeated measures was used to accomplish this. Order entry by physicians, unit secretaries, and physician assistants were simultaneously analyzed. Figure 3 compares the mean number of medical orders entered into the HIS by means of personal order sets on the experimental and control services.

The results of the analysis indicate significant differences between the experimental and control groups ($F1,338 = 15.85$, $p < 0.000$) and between persons entering the orders ($F1,338 = 10.78$, $p < 0.000$). In general, a greater number of orders per patient were entered on the experimental services using personal order sets. Also, the most orders using personal order sets were entered by unit secretaries; the fewest were entered by physicians. Furthermore, the group by time interaction was significant ($F1,338 = 5.80$, $p < 0.003$). The use of personal order sets on the experimental services by physicians, unit secretaries, and physician assistants increased significantly over time. The group who entered the orders by time interaction and the group by who entered the orders by time interaction were not significant.

Discussion

This study was based on the hypothesis that within medical practice settings, such as hospitals, there are physicians who significantly influence the behavior of their colleagues through interaction in the informal consultation network. These individuals have been called educationally influential physicians (see Stross & Bole, 1979, 1980; Stross, et al., 1983). This study was undertaken to determine whether or not educationally influential physicians could be identified and used to introduce innovative procedures into groups of physicians on hospital services.

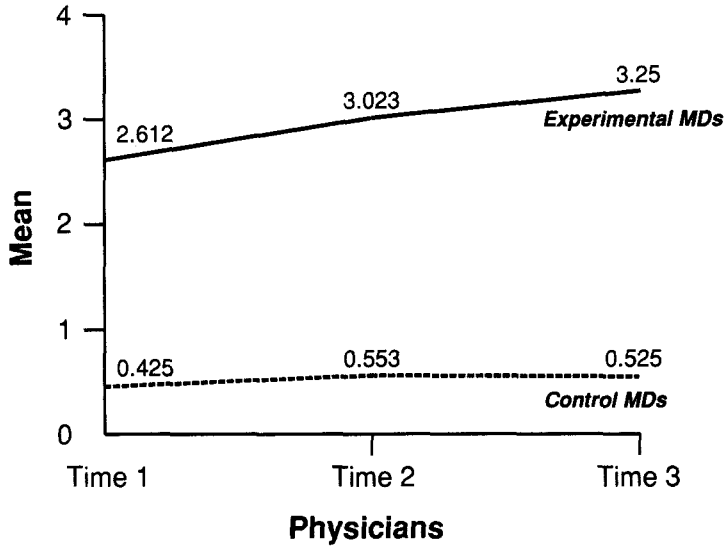

Figure 3a. Physicians

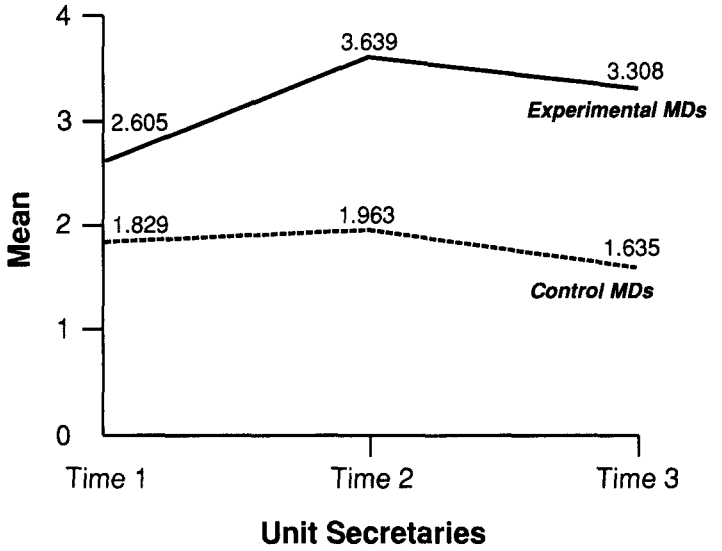

Figure 3b. Unit Secretaries

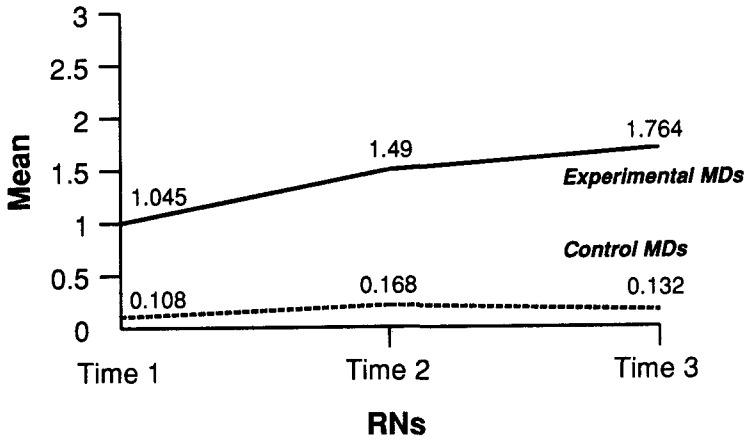

Figure 3c. RNs

The study developed a new methodology that can be used to identify educationally influential physicians using data from hospital information systems. Moreover, these physicians were successfully recruited and participated in the study. This involved two meetings of approximately one hour each with project staff over a twelve-month period. After these meetings, the physicians resumed their normal activities as members of the hospital's medical staff. The hypothesis was tested by analyzing data on medical-order entry obtained from the hospital information system to determine if the educationally influential physicians had influenced the behavior of their colleagues as expected.

Significant changes were observed on the experimental hospital services as a result of the experimental program. The use of personal order sets for order entry into the HIS significantly increased on these units. At the same time, no significant change in patterns of order entry were observed among physicians on the control services.

It appears from the results that the influence of the educationally influential physicians extended beyond the other physicians on the service. Not only did the use of personal order sets increase among physicians on the four services, but their use increased among physician assistants and unit secretaries on these services as well.

The earlier studies that were reviewed have documented that physicians learn about medical innovations from one another. Also, Stross and his colleagues demonstrated that key individuals in informal physician networks play a critical role in the dissemination of information concerning medical innovations. The results of our study indicate that the influence of these educationally influential physicians extends to the entire network of health care providers involved in the care of patients on a hospital unit.

Based on the results of this study, we conclude that the recruitment and deliberate use of educationally influential physicians is an effective means of changing practice behavior. Such an approach to the introduction of new procedures and approaches has great potential given the large number of diverse practice settings. At the same time, many additional questions need to be answered by future research. Are educationally influential physicians equally effective in all specialties and in practice settings other than the hospital? Should the initial sessions with the influential physicians be supplemented with other forms of continuing medical education? Will changes in practice behavior diminish with the passage of time unless reinforced?

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