Original Investigations

Research Paper ■

Evaluation of User Acceptance of a Clinical Expert System

REED M. GARDNER, PhD, HENRY P. LUNDSGAARDE, PhD

Abstract   **Objective:** To measure the attitudes of physicians and nurses who use the Health Evaluation through Logical Processing (HELP) clinical information system.

Design: Questionnaire survey of 360 attending physicians and 960 staff nurses practicing at the LDS Hospital. The physicians' responses were signed, permitting follow-up for nonresponse and use of demographic data from staff files. The nurses' responses were anonymous and their demographic data were obtained from the questionnaires.

Measurements: Fixed-choice questions with a Likert-type scale, supplemented by free-text comments. Question categories included: computer experience; general attitudes about impact of the system on practice; ranking of available functions; and desired future capabilities.

Results: The response rate was 68% for the physicians and 39% for the nurses. Age, specialty, and general computer experience did not correlate with attitudes. Access to patient data and clinical alerts were rated highly. Respondents did not feel that expert computer systems would lead to external monitoring, or that these systems might compromise patient privacy. The physicians and nurses did not feel that computerized decision support decreased their decision-making power.

Conclusion: The responses to the questionnaire and "free-text comments" provided encouragement for future development and deployment of medical expert systems at LDS Hospital and sister hospitals. Although there has been some fear on the part of medical expert system developers that physicians would not adapt to or appreciate recommendations given by these systems, the results presented here are promising and may be of help to other system developers and evaluators.

■ **J Am Med Informatics Assoc.** 1994;1:428–438.

The Institute of Medicine (IOM) of the National Academy of Sciences recently recommended that computerization of the medical record be an essential technology.[1] However, moving from the manual chart to a computerized record has been more difficult than anyone expected. Schoenbaum and Barnett in Boston,[2] McDonald et al. at the Regenstrief Institute in Indianapolis,[3,4] and others[5-12] have found the task complex and demanding.

In a recent review article about computer records as an "orphan technology," Schoenbaum and Barnett listed six factors that impeded acceptance of a computerized medical record.[2] Two of these factors involve changes that affect health care professionals: 1) "the need for physicians [and also nurses, in our case] to change their habits of medical record keeping," and 2) the need to address " . . . interface issues involving direct use of the system by professionals." Through similar assessments McDonald et al. found that "the difficult side of computer-stored medical records systems [was] getting the data in."[3] In response to this problem, McDonald and the Re-

Affiliations of the authors: Department of Medical Informatics, University of Utah School of Medicine and LDS Hospital, Salt Lake City, UT (RMG); and Department of Anthropology, University of Kansas, Lawrence, KS (HPL).

Correspondence and reprints: Reed M. Gardner, PhD, LDS Hospital, 325 8th Avenue, Salt Lake City, UT 84143.

genstrief group have developed a strategy for collecting data and building their electronic medical record in stages.[3,4] Anderson et al. have identified many technical and organizational factors associated with implementation and adaptation of medical information systems that " . . . result in unforeseen costs, unfulfilled promises and disillusionment."[13] In addition, the limited diffusion and underutilization of these systems relate to a wide variety of psychological, social, organizational, and management factors that characterize the contemporary health care setting.[14,15]

Studies have documented how inattention, on the part of developers, to the specific clinical needs of end users may result in system underutilization and, in some well-documented cases, even sabotage.[16-21] Bailey[21] has identified many of the complex beliefs, attitudes, and behaviors that influence computer use among professionals: "The way in which computer users react to various aspects of the systems they employ is a critical success criterion for information systems. If satisfaction levels are high, the user will adapt his/her activities to take advantage of the computer. Should satisfaction levels get too low, the user may cease to cooperate and may even become antagonistic toward the system. *Therefore, measuring and managing users' attitudes toward various aspects of their information systems was an important part of making those systems successful*" [emphasis added].[21] Stead et al., among others, have suggested using questionnaires as a tool to assess user attitudes.[22]

The Health Evaluation through Logical Processing (HELP) clinical computer system was developed in an evolutionary fashion at LDS Hospital over a period of 20 years.[23-27] In January 1987, Intermountain Health Care (IHC), the parent corporation that owns LDS Hospital and 23 other hospitals in the Intermountain Region of the United States (Utah, Idaho, and Wyoming), decided that implementation of the HELP system at other IHC hospitals was crucial to its goal of improving the quality and efficiency of health care delivery. Corporate officials were persuaded that ongoing evaluation research should be a part of the ambitious program to transplace the HELP system. IHC management wanted to understand more about the factors contributing to the successful implementation of the HELP system at LDS Hospital to facilitate implementation at sister hospitals.

Prior studies of the HELP system had identified professional collaboration as a key factor in system utilization.[26,27] An initial evaluation study of the attitudes of physicians and nurses at one of the sister hospitals has been published.[27] This article reports a study of the attitudes of physicians and nurses at LDS Hospital about the impact of the clinical system on practice and the relative priorities of different functions.

Background

LDS Hospital

The LDS Hospital is a 520-bed comprehensive tertiary care facility. The hospital has educational and research health care missions. At the time of the study, the facility handled 23,612 admissions per year (including obstetrics patients and newborns), with an average length of stay of 5.19 days. There were 14,549 inpatient operative procedures performed and 9,518 outpatient visits per year. There were 360 private practice attending staff with 20 geographic full-time faculty and 33 full-time housestaff at LDS Hospital plus 35 housestaff rotating through LDS Hospital from the University of Utah.

HELP System

The HELP system is a comprehensive clinical information system.[23-25] Data are integrated into a centralized database from the intensive care unit, the clinical laboratory, medical records, nurse charting, order entry, and a variety of other functions and locations. The system is used to gather patient data and it also presents integrated data for physician and nurse review. In addition, the system provides expert advice. Today, for example, computerized clinical and laboratory data are continuously and automatically reviewed by the HELP system's "inference engine" (i.e., decision programs). The system warns physicians about dangers of drug contraindications, based on other medications patients are taking, as well as provides relevant laboratory data, demographic variables, and information about patients' drug allergies. Nurses use the HELP system to review patient data as well as to "chart" their patient care activities.[28-30]

Attending staff physicians and housestaff use the system primarily for online data retrieval and review. Although the HELP system database is used by clinical investigators across patient populations (usually a batch process) for research purposes, the primary use of the clinical computer system is for online data access for patient care. The retrieval capabilities include a variety of summary reports of "coded" patient data, such as laboratory and medication data, with computer-generated interpretations and reminders. In addition, free-text dictated reports of things such as the history and physical examination and x-ray interpretations are available for easy review. Phy-

sicians, both attending and housestaff, use the system to enter blood, total parenteral nutrition, and a small group of other selected computer orders.

Methods

Separate questionnaires were used to explore the attitudes of physicians and nurses about the clinical computing system. These two groups represent the major voluntary HELP computer system users. Questions for the two categories of respondents were designed to solicit information about user views and attitudes. Several categories of questions were adopted from psychological studies,[31,32] a previous Battelle study of user attitudes toward the HELP system,[33] our own previous work with medical information systems,[23-27] and, in particular, the personal experiences of one of the authors (RMG), who was one of the developers of the HELP system at LDS Hospital.[23 25]

Questionnaires were pretested and critiqued by physicians and nurses.[27] It was quickly learned that the medical and nursing staff wanted succinct and relevant questions that would not test their expressed low tolerance for more paperwork. Fixed-choice questions, using a standard and familiar Likert-type scale, were used as the primary data source. In addition, a "Free-Text Opinion Space" was provided to allow physicians and nurses to express other views about different aspects of the hospital's computer system. Participants were promised access to the generalized findings from the study after its completion.

Questionnaires for both physicians and nurses were divided into the seven sections noted in the appendix. Those questions with an MD identifier noted beside them were asked only of physicians, while those with an RN identifier were asked only of nurses. Approval to distribute questionnaires to the professional staff was obtained from administrators, department leaders, and our institutional review board (IRB).

On March 1, 1989, the questionnaires were mailed to 360 active attending staff physicians affiliated with LDS Hospital. Each questionnaire had a physician name label attached so we could sort the responses by physician demographics (such as specialty and age) and remind physicians who were slow in returning their questionnaires. A cover letter, including an endorsement by the president of the LDS Hospital medical staff, explained the plan to correlate responses with user demographics. By July 17, 1989, after several follow-up reminders, 246 (68%) of the physicians had returned completed questionnaires.

The Nursing Service insisted that all of the nursing questionnaires be anonymous. Anonymity required that each nurse respondent supply demographic data to explore possible relationships between "user" attitude and factors such as age, length of service, and assignment. Questionnaires were mailed to the entire LDS Hospital nursing staff (960 people) on February 28, 1990. By March 20, 1990, 374 completed questionnaires (39%) had been received. We determined, after making general announcements at nursing staff meetings, that further response would be unlikely. Because of the anonymity requested by the Nursing Service, nurse-specific reminders could not be sent to increase the response rate.

Descriptive statistics suitable for the analysis of nominal data were used to determine whether a relationship existed between user demographic attributes and user responses to specific fixed-choice questions. Variables such as age, number of hospital admissions, computer knowledge, patient length of stay (LOS), and provider specialty were explored as possible factors that might predict physicians' responses to different questionnaire items. Correlation coefficients between each of these variables and individual questionnaire responses were computed using the interactive SPSS program (SPSS Inc., Chicago, IL) running on an Apple Macintosh computer (Apple Computer, Sunnyvale, CA). A two-tailed Student t-test with a standard significance level of 0.05 was used to test the relative strength of the relationship between physicians' demographic variables and their responses to each question. The same procedure, using nurse-specific demographic variables, was followed for the analysis of nurses' responses to each question.

Results

Physician Demographics

Physician demographics were obtained directly from medical staff office records. The ages of the 246 respondents ranged from 27 to 82 years. The mean physician age was 45.5 years (SD = 11.5 years). Of the 246 respondents, 183 (74%) were from internal medicine or related specialties and 63 (26%) were from surgery and related specialties. The mix of staff at the time of questionnaire completion was 240 medicine (66.6%) and 120 surgery (33.4%). The return rate from medicine was 76% and from surgery it was 53%, which by chi-square analysis was statistically significant at the $p = 0.01$ level. Of the 246 physicians who completed the questionnaire, 160 had admitted patients during calendar year 1988. The remaining physicians were from specialties such as radiology and pathology and did not normally admit patients.
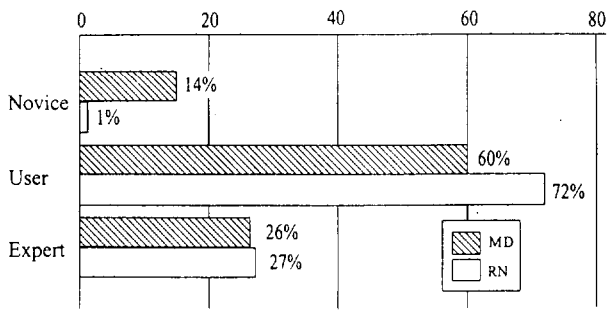
Figure 1 Computer experience, expressed in percentages, of physicians (MD) and nurses (RN) at LDS Hospital who responded to a questionnaire about the Health Evaluation through Logical Processing (HELP) clinical information system. Thirty-four physicians (14%) and only four nurses (1%) considered themselves novices. There were 148 physicians (60%) and 269 nurses (72%) who identified themselves as users. There were 64 physicians (26%) and 101 nurses (27%) who classified themselves as experts.

Each physician was matched with his or her cumulative annual patient LOS to learn whether any significant differences in attitudes were related to experience with the HELP system. Patients' LOSs in cumulative days, for the 1988 calendar year for individual respondents ranged from 1 to 3,528 (mean = 426.8; SD = 537.5). For our physician respondents, age, specialty, patient LOS, number of hospital admissions, and relative computer expertise did *not* singly, or in combination, predict user satisfaction with the HELP system.

Nurse Demographics

Three hundred seventy-four of 960 nurses (39%) completed the questionnaire. The ages of the nursing staff respondents ranged from 20 to 67 years (mean = 33.57 years; SD = 8.52). The nurses had an average of 9.52 years of professional experience; as a group, an average of 6.96 of those years had been spent at LDS Hospital. For these respondents, age was not associated with any statistically significant difference in computer literacy, satisfaction with computer training and support, or opinions about the desirable HELP system features. Small but statistically significant differences between age groups were evident from responses to only four of the 40 questions asked.

Effect of Frequency of Use

Whereas a statistically significant correlation was not identified between intensity of computer experience and user satisfaction, a correlation was found between duration of experience and user satisfaction, i.e., those professionals who used the HELP system on a routine basis (e.g., intensive care unit physicians

and nurses) expressed greater satisfaction with the system than did those who worked in areas of the hospital where daily computer use was occasional, clerical, or not required of all health care providers (e.g., physical therapists).

General Computer Experience

Figure 1 details the computer experience of both the physicians and the nurses. A large population of physicians (34 or 14%) considered themselves to be
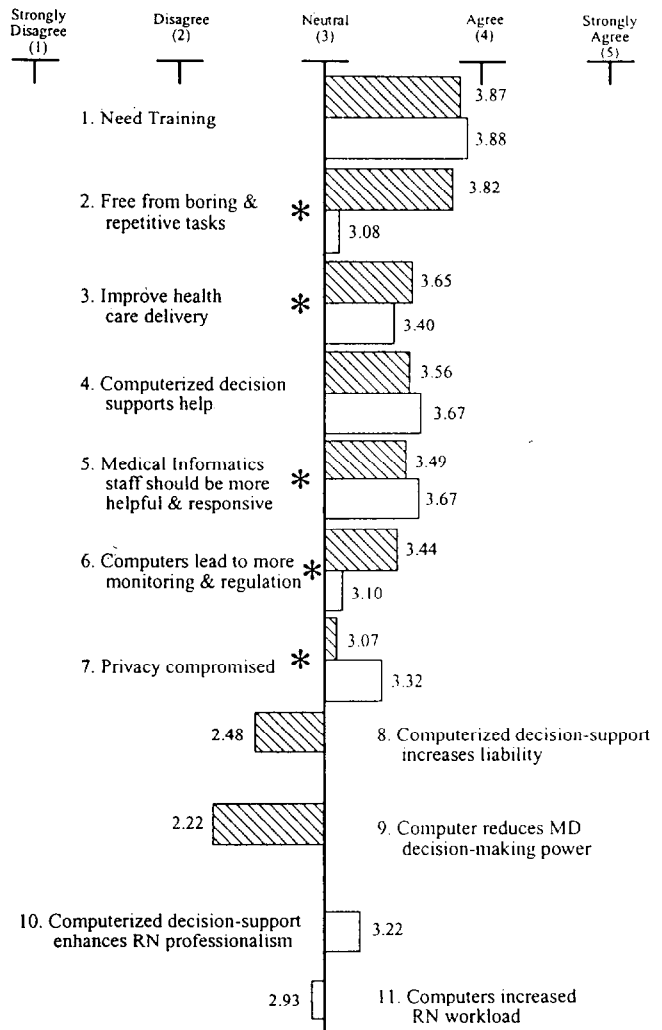

Figure 2 General opinions of physicians (MD) and nurses (RN) at LDS Hospital regarding their computer training and experience with computers in the hospital, as determined by questionnaire. Note that the "neutral" score of 3 is highlighted with a vertical line. There were differences between physicians' and nurses' opinions, those with statistical significance at the $p < 0.05$ level are marked with an asterisk (*). Of special interest are three "opinions" that showed statistically significant and important differences between the two groups of respondents: "Free from boring & repetitive tasks" (#2), "Improve health care delivery" (#3), and "Computers lead to more monitoring & regulation" (#6). ▨ = MD, □ = RN.
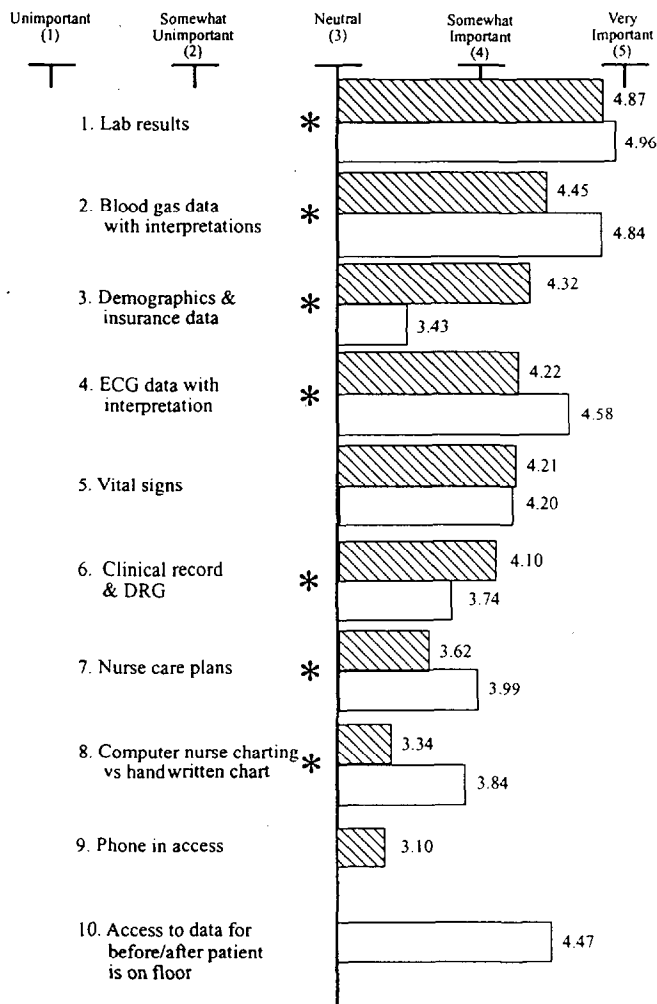
Figure 3 Importance of having computer access to a variety of patient information as ranked by physicians (MD) and nurses (RN) at LDS Hospital through a questionnaire. Note that the "neutral" score of 3 is highlighted with a vertical line. There were differences between physicians' and nurses' opinions; those with statistical significance at the $p < 0.05$ level are marked with an asterisk (*). Of special interest are six "opinions" that showed statistically significant and important differences between the two groups of respondents: "Blood gas data with interpretation" (#2), "Demographic & insurance data" (#3), "ECG data with interpretation" (#4), "Clinical record & DRG" (#6), "Nurse care plans" (#7), "Computerized nurse charting versus handwritten charts (#8). ▧ = MD, ▢ = RN.

NOVICE computer users, while only four (1%) of the nurses classified themselves as being in this category. More than a fourth of the physicians and nurses considered themselves EXPERT computer users by having had some programming experience.

General Opinions

Figure 2 outlines the responses of the physicians and nurses to their computer training and experience with computers in the hospital. Both the physicians and the nurses had positive feelings about computers helping to improve health care delivery and about computerized decision support systems being useful in clinical practice. Differences between the physicians' and nurses' opinions that reached statistical significance ($p < 0.05$) are marked with an asterisk (*) in Figure 2. Of special interest are three "opinions" that showed statistically significant and important differences between the two groups of respondents. For "Free from boring and repetitive tasks" (#2), the physicians "agreed" while the nurses felt almost "neutral." For "Improve health care delivery" (#3), the physicians were more positive than were the nurses. For "Computers lead to more monitoring & regulation" (#6), the physicians were much more concerned than were the nurses about the role that computerized patient records might play in the regulation of practice behavior. The physicians did not express concern about the possibility that decision support systems potentially could increase their liability or could reduce their own decision-making power.

Value of Computer Access to Various Patient Data

The responses of the physicians and nurses about access to a variety of data are shown in Figure 3. Many responses were close to the score of 5 (VERY IMPORTANT) and many were above a score of 4 (IMPORTANT). Laboratory results and blood-gas data review capabilities were judged to be the most important. Also shown in Figure 3 are the differences between the physicians' and the nurses' opinions. Those with statistical significance ($p < 0.05$) are marked with an asterisk (*). Of special interest are six "opinions" that were not only statistically significantly different, but that showed wide distinctions between the two groups. The nurses were more interested in "Blood gas data with interpretation" (#2) than were the physicians. The physicians were more concerned about "Demographics & insurance data" (#3), presumably for billing reasons, than were the nurses. The nurses had higher interest than the physicians in "ECG data with interpretation (#4). Perhaps the interpretations of both blood gas (#2) and ECG (#4) were of more interest to the nurses. "Clinical record & DRG" (#6) was of more interest to the physicians than to the nurses, probably for billing reasons. "Nurse care plans" (#7) were of much more interest to the nurses than to the physicians, probably because they form the care work outline for the nurses. "Computer nurse charting versus handwritten chart" (#8) was preferred by the nurses over the physicians, probably because nurses refer to the charting much more than do physicians.
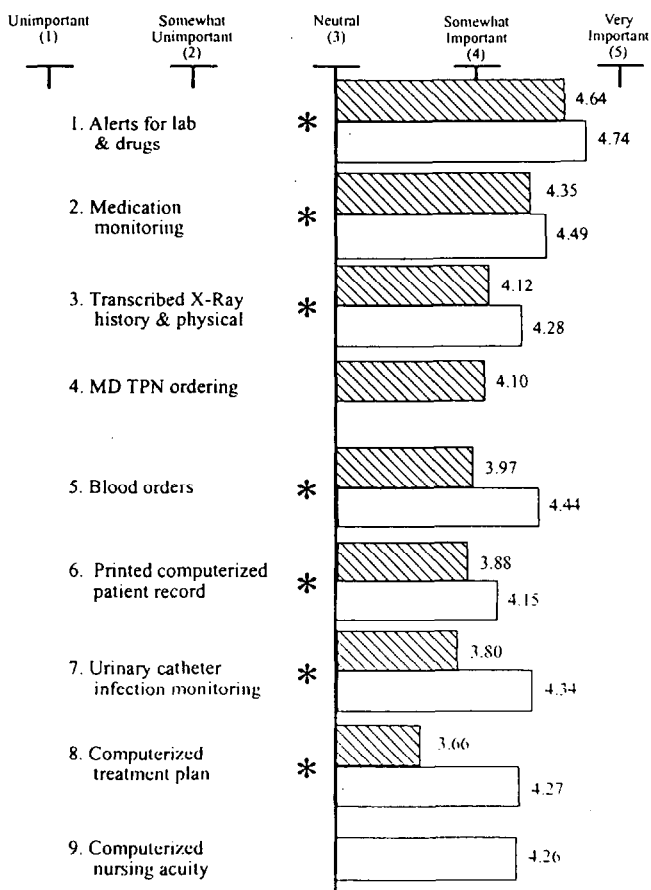
Figure 4 Desirability of computer features as ranked by physicians (MD) and nurses (RN) at LDS Hospital through a questionnaire. Note that the "neutral" score of 3 is highlighted with a vertical line. There were differences between physicians' and nurses' opinions; those with statistical significance at the $p < 0.05$ level are marked with an asterisk (*). Of special interest are four "opinions" that showed statistically significant and important differences between the two groups of respondents: "Blood orders" (#5), "Printed computerized reports" (#6), "Urinary catheter infection monitoring" (#7), and "Computerized treatment plan" (#8). ▧ = MD, □ = RN.

Computer Features Assessment

Figure 4 shows very positive responses to computer features, many of which (numbers 1, 2, 4, 5, 7, and 8 in the list) represent "expert" capabilities of the HELP system. In every case where comparison was possible, the nurses ranked these computer features higher than did the physicians. Responses to four computer features showed statistically significant differences between the two groups. The nurses were more enthusiastic about "Blood orders" (#5) than were the physicians. "Printed computerized reports" (#6) were more important to the nurses than to the physicians. "Urinary catheter infection monitoring" (#7) was more important to the nurses than to the physicians. "Computerized treatment plan" (#8) was

also more important to the nurses than to the physicians.

Future Features Desired

Figure 5 summarizes the ranking of future computer features by the physicians and nurses. Since the respondent groups have different needs, only two questions (numbers 1 and 3) concerning future features were compared. Of special note are two future features that were not only statistically significantly different, but which showed differences between the physicians' and nurses' "opinions." The nurses felt that "Develop & evaluate lab alerts" (#1) was more important than did the physicians, perhaps because the nurses are involved in the operational part of this process. "Easier lab ordering" (#3) and computeri-
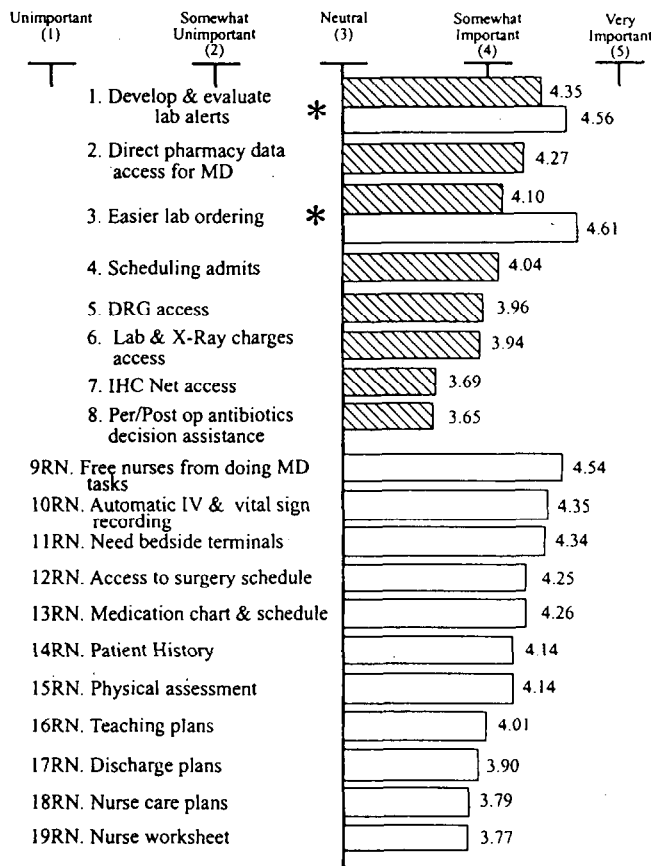

Figure 5 Desirability of future computer features as ranked by physicians (MD) and nurses (RN) at LDS Hospital through a questionnaire. Note that the "neutral" score of 3 is highlighted with a vertical line. There were differences between physicians' and nurses' opinions; those with statistical significance at the $p < 0.05$ level are marked with an asterisk (*). Of special note are two "opinions" that showed statistically significant and important differences between the two groups of respondents: "Develop & evaluate lab alerts" (#1) and "Easier lab ordering" (#3). ▧ = MD, □ = RN.

Table 1 ■

Ranking of Features in Computer Data Review by Physicians (MD) at the LDS Hospital

Feature	MD Ranking						
	1st	2nd	3rd	4th	5th	Score*	%
1 Lab review	132†	27	10	9	13	153.7	32.6
2 Pharmacy alerts	20	40	19	13	30	55.6	11.8
3 Vital signs	11	36	35	27	26	52.6	11.2
4 Patient location	15	33	24	12	21	46.7	9.9
5 Blood gas interpretation	3	32	30	34	27	42.9	9.1
6 Drug review	9	11	19	24	21	31.0	6.6
7 Intake/output reviews	4	4	29	26	19	26.0	5.5
8 Blood ordering	9	9	11	9	14	22.2	4.7
9 Antibiotic/infection alert	2	6	13	29	21	20.8	4.4
10 Phone-in data review	6	8	14	15	5	19.4	4.1
TOTAL	211	206	204	198	197	470.9	100.0

*"Score" was calculated by taking the first preference and multiplying it by 1, taking the second preference and multiplying it by 1/2, taking the third preference and multiplying it by 1/3, and so on.
†Number of physicians.

zation of this task was of most interest to the nurses because they do most of the lab ordering.

Ranking of Features

Tables 1 and 2 summarize the physicians' and nurses' rankings of various data reviews. The rankings were obtained by counting each time a respondent ranked one of the features according to a specific category. For example, 132 physicians ranked lab review as "most important" while 27 ranked it as second most important, and so on. Laboratory data received the highest rankings for the two groups, and by a wide margin. The next highest rankings (vital signs, patient location, and so on) were about one-third as popular and are given in Tables 1 and 2. Pharmacy alerting was ranked relatively high by both groups. Nurses and physicians ranked data review capabilities differently. The nurses ranked computerized nurse charting and blood-gas review with computerized interpretation high, yet the physicians did not.

Free-Text Opinion Space

Physicians' free-text responses

In addition to the above-mentioned informative rankings, 99 of 246 (40%) of the physicians who completed the questionnaires also contributed narrative responses, ranging in length from one sentence to one page, about different problems or features of the HELP system. Most voluntarily signed their statements. Knowing the identity of each physician respondent made it possible for medical informatics staff to ex-

plore and discuss user design features directly with individual physicians.

The free-text opinions were categorized and are summarized below in order of frequency of response:

Limited use—16 physicians felt that their use of computers was too limited for them to provide educated answers to question.

Need for computer instruction—15 physicians asked for more instruction in computer use.

Complimentary statement—Seven physicians made complimentary statements about the HELP system.

Home or office phone access—Seven physicians wanted to be able to access data from their homes or office computers.

Need for more features—Five physicians suggested that additional computer features be added to the system.

System response time—Five physicians complained about the computer system being too slow.

Better laboratory data access—Five physicians asked for expanded laboratory data access.

Confidentiality—Four physicians expressed additional concerns about confidentiality; one psychiatrist was especially concerned.

Other comments included suggestions for supporting other computer platforms as terminals (the HELP system currently supports IBM PC type or compatible computers but not Apple Macintosh computers), im-

Table 2 ■

Ranking of Features in Computer Data Review by Nurses (RN) at the LDS Hospital

Feature	RN Ranking						
	1st	2nd	3rd	4th	5th	Score*	%
1 Lab review	177†	70	39	30	24	237.3	29.8
2 Nurse charting	70	24	31	22	25	102.8	12.9
3 Blood gas interpretation	22	76	59	48	31	97.9	12.3
4 Pharmacy alert	24	31	45	33	45	71.8	9.0
5 Vital sign review	13	31	41	38	46	60.9	7.7
6 Patient location	16	28	40	30	23	55.4	7.0
7 Shift reports	22	30	13	25	31	53.8	6.8
8 Blood ordering	8	31	37	31	28	49.2	6.2
9 Intake/output review	1	15	27	39	35	34.3	4.3
10 Drug review	1	14	22	39	36	32.3	4.1
TOTAL	354	350	354	335	324	795.6	100.0

*"Score" was calculated by taking the first preference and multiplying it by 1, taking the second preference and multiplying it by 1/2, taking the third preference and multiplying it by 1/3, and so on.
†Number of nurses.

proving nurse charting, and having either computer charting or hand charting (not both). Further individual comments related to special interests of specific physicians.

Nurses' free-text responses

Of the 374 nurses who completed the questionnaire, 372 (99%) also made remarks in the margins or on the page left blank for free-text opinions. Because of the large number of components, these responses are summarized in two categories:

Positive responses

Laboratory data review—Several nurses felt that having laboratory data available on computer terminals was very valuable to them.

Legibility—The nurses commented that their computer-printed charts were readable and understandable.

Structured charting—Many of the nurses found that the structure required by computers was helpful.

MIB—The Medical Information Bus (MIB) is a communication technology used in intensive care units (ICUs) to acquire data from intravenous (IV) pumps and bedside monitors. A large number of the ICU nurses appreciated having data automatically and routinely collected from these devices.[34]

Ergonomics—Data gathered in the ICU showed that the nurses preferred to sit while charting. Recently, stools with wheels have been installed at bedsides, allowing nurses to sit while charting at bedside terminals. LDS Hospital nursing and medical informatics staff continually monitor situations and modify them as needed.

Negative responses

Slow response time—This was a consistent complaint. To put this negative comment into perspective, average response time to retrieve a laboratory result was less than four seconds.

System downtime—System downtime, even though the measured availability was 99.6%, was a consistent complaint.

Incomplete computer record—Several nurses felt that the computer system did not give them the ability to complete parts of the medical record. This may be related to the mix of "coded" charting *and* free-text comments required by the computer.

Editing difficulties—The nurses found that the computer record was more difficult to edit than a tradi-

tional handwritten hard copy.

Confidentiality—Several nurses were concerned with this issue. Late in 1992, in response to this concern, a hospital-wide security system was installed to diminish breaches of confidentiality.

Lack of staff education—The current staff education program includes three nurses who work full-time on computer problems affecting nursing services. This addition has made a major difference in the computer competence of the nurses and their attitudes toward computers.

Redundant charting—There were several comments about the need to perform some redundant charting tasks (in the computer and also in the handwritten patient chart or on specialized forms).

Not enough terminals and need bedside terminals—These scarcities have not been almost completely eliminated. There are now over 1,200 terminals in the LDS Hospital, one at each bedside and several at central nursing stations and other vital locations.

Uncooperative physicians—Physicians are supposed to order blood products on the computer but some *do not*. Nurses are frustrated by this lack of cooperation from physicians.[35,36]

Discussion

Implications

For both the physicians and the nurses, age, specialty, and general computer experience did not predict satisfaction with the clinical computer system or their ranking of system features. Clayton et al. have recently found similar age-related results.[37] Satisfaction was correlated with duration of use and frequency of use of the system. The latter confirmed findings of the Battelle researchers in their 1977 study at LDS Hospital.[33] This finding has implications for system implementation efforts because it suggests that experience with a system is the best way to break down attitudinal barriers to use of that system. The challenge is to get the inexperienced user who has a negative attitude to use the system enough that his or her attitude can begin to change. Because of the differences between nurse and physician data and reporting needs, we are convinced that multiple users and data use factors must be considered as the electronic medical record is further developed.

The survey results indicate positive attitudes on the parts of both the physicians and the nurses regarding the impact of the HELP clinical information system on practice. Specifically, staff concerns that comput-

erized expert systems would be a risk or would interfere with clinical practice were *not* found.

The rankings of various system functions should be of interest to health care organizations that are planning to implement clinical information management systems. A survey of such an organization's inexperienced users will identify areas where users have the most trouble with the manual system and where they hope a computer will help. The rankings in this article represent the judgment of users who have access to one of the most complete, mature, and stable clinical information systems. They show where the users think the computer has actually helped.

Limitations

Since the sample taken was nonprobabilistic, the statistical inferences that may be drawn from the findings are limited. Nonetheless, the responses to fixed-choice as well as to open-ended questions are thought to be representative of the general opinions and views held by the members of the hospital's clinical staff.

The assignment of subjects to computer experience categories was based upon a single question. A separate instrument designed to measure this item might produce additional information.

Interpretation of the data with regard to differences between the physicians and the nurses must be qualified by the difference in response rates. The higher response rate for the physicians was achieved because their questionnaires were not anonymous and we could pursue nonresponders on an individual basis. In the future, we would recommend use of an outside agency to administer the questionnaires to the nurses so that identity could be concealed from the hospital but revealed to the agency for the purpose of follow-up.

The original data were collected in 1989 and 1990. Interpretation should consider subsequent changes in information technology and the health care system. Such changes would be likely to be in the direction of a more positive attitude toward the information system.

Conclusion

The responses to the questionnaire and free-text comments provided encouragement for future development and deployment of medical expert systems at LDS Hospital and sister hospitals. Although there has been some fear on the part of medical expert system developers that physicians would not adapt to or appreciate recommendations given by these sys-

tems, the results presented here are promising and may be of help to other system developers and evaluators. Based on these findings and on our daily working relationships with physicians, implementation of more expert system applications is under way at LDS Hospital and other IHC hospitals.

References ■

1. Dick RS, Steen EB, eds. The Computer-based Patient Record: An Essential Technology for Health Care. Washington, DC: Institute of Medicine, National Academy Press, 1991.
2. Schoenbaum SC, Barnett GO. Automated ambulatory medical records systems: an orphan technology. Int J Technol Assess Health Care. 1992;8:598–609.
3. McDonald CJ, Tierney WM, Overhage JM, Martin DK, Wilson GA. The Regenstrief medical record system: 20 years of experience in hospitals, clinics, and neighborhood health centers. MD Comput. 1992;9:206–17.
4. Tierney WM, Miller MM, Overhage JM, McDonald CJ. Physician inpatient order writing on microcomputer workstations: effects on resource utilization. JAMA. 1993;269:379–83.
5. Aydin CE. Occupational adaptations to computerized medical information systems. J Health Soc Behav. 1989;30:163–79.
6. Aydin CE, Rice RE. Bringing social worlds together: computers as catalysts for new interactions in health care organizations. J Health Soc Behav. 1992;30:168–85.
7. Lundsgaarde HP, Fisher PJ, Steele DJ. Human Problems in Computerized Medicine. University of Kansas Publications in Anthropology, no. 13. Lawrence, KS: University of Kansas, 1981.
8. Bria WF II, Rydell RL. System benefits and evaluation. In: The Physician-Computer Connection: A Practical Guide to Physician Involvement in Hospital Information Systems. Chicago: American Hospital Association, 1992.
9. Goldman L. Changing physician's behavior: the pot and the kettle (editorial). N Engl J Med. 1990;332:1524–5.
10. Weed LL. Medical Records, Medical Education and Patient Care: The Problem Oriented Medical Record as a Basic Tool. Chicago: Year Book Medical Publishers, 1969.
11. Fischer PJ, Stratmann WC, Lundsgaarde HP, Steele DJ. Use and impact of computers in clinical medicine. Symposium on Computer Applications in Medical Care. 1980;4:1722–30.
12. Blum BI. Hospital information systems. In: Clinical Information Systems. New York: Springer-Verlag, 1986.
13. Anderson JG, Aydin CE, Jay SJ, eds. Computers in Health Care: Research and Evaluation. Newbury Park, CA: Sage Publications, 1994.
14. Anderson JG, Jay SJ, eds. Use and Impact of Computers in Clinical Medicine. New York: Springer-Verlag, 1987.
15. Fishbein M. A behavior theory approach to the relations between beliefs about an object and the attitude toward the

Journal of the American Medical Informatics Association   Volume 1   Number 6   Nov / Dec 1994

437

object. In: Fishbein M, ed. Readings in Attitude Theory and Measurement. New York: John Wiley & Sons, 1967:389–400.

16. Dowling AF Jr. Do hospital staff interfere with computer implementation? Health Care Manage Rev. 1980;5:23–32.

17. Counte MA, Kjerulff KH, Salloway JC, Campbell BC. Implementing computerization in hospitals: a case study of the behavioral and attitudinal impacts of a medical information system. J Organiz Behav Manage. 1984;6:109–22.

18. Williams LS. Microchips versus stethoscopes: Calgary hospital, MDs face off over controversial computer system. Can Med Assoc J. 1992;147:1534–47.

19. Massaro TA. Introducing physician order entry at a major academic medical center: I. Impact on organizational culture and behavior. Acad Med. 1993;68:20–5.

20. Massaro TA. Introducing physician order entry at a major academic medical center: II. Impact on medical education. Acad Med. 1993;68:25–30.

21. Bailey JE. Development of an instrument for the management of computer user attitudes in hospitals. Methods Inf Med. 1990;20:51–6.

22. Stead WW, Haynes BR, Fuller S, et al. Designing medical informatics research and library resource projects to increase what is learned. J Am Med Informatics Assoc. 1994;1:28–33.

23. Pryor TA, Gardner RM, Clayton PD, Warner HR. The HELP system. J Med Syst. 1983;7:87–102.

24. Kuperman GJ, Gardner RM, Pryor TA. HELP: A Dynamic Hospital Information System. New York: Springer-Verlag, 1991.

25. Gardner RM. The HELP clinical decision-support system. J Med Pract Manage. 1994;9:177–81.

26. Gardner RM. Observations and opinions: collaborations in clinical computing at LDS Hospital. MD Comput. 1994;11(1):10–3, 63.

27. Lundsgaarde HP, Gardner RM, Menlove RL. Using attitudinal questionnaires to achieve benefits optimization. Symposium on Computer Applications in Medical Care. 1989;13:703–8.

28. Pryor TA. Computerized nurse charting. Int J Clin Monit Comput. 1989;6:173–9.

29. Halford G, Burkes M, Pryor TA. Measuring the impact of bedside terminals. Nurs Manage. 1989;20(7):41–5.

30. Bradshaw E, Sittig DF, Gardner RM, Pryor TA, Buff M. Computer-based data entry for nurses in the ICU. MD Comput. 1989;6:274–80.

31. Farrell AD, Cuseo-Ott L, Fenerty M. Development and evaluation of a scale for measuring practitioners' attitudes toward computer applications. Comput Hum Behav. 1988;4:207–20.

32. Greenbaum J, Kyng M. Design at Work: Cooperative Design of Computer Systems. Hillsdale, NJ: Lawrence Erlbaum Associates, 1991.

33. Barrett JP, Pesut RN. Final Report on Evaluation of the Acceptance of HELP by the Medical Staff of LDS Hospital and Determination of Physician Attitudes toward the System and Their Expectations of the System. Columbus, OH: Battelle Columbus Laboratories, 1977.

34. Gardner RM, Hawley WH, East TD, Oniki T, Young HFW. Real time data acquisition: recommendations for the Medical Information Bus (MIB). Int J Clin Monit Comput. 1992;8:251–8.

35. Gardner RM, Laub RM, Golubjatnikov OK, Evans RS, Jacobson JT. Computer critiqued blood ordering using the HELP system. Comp Biomed Res. 1990;23:514–28.

36. Lepage EF, Gardner RM, Laub RM Golubjatnikov OK. Improving blood transfusion practice: role of a computerized hospital information system. Transfusion. 1992;32:253–9.

37. Clayton PD, Pulver GE, Hill CL. Physician use of computers: is age or value the predominant factor? Symposium on Computer Applications in Medical Care. 1993;17:301–5.

APPENDIX

Questionnaire Sent to Physicians and Nurses

Note: **Comments in italics have been inserted to aid in reader understanding. The order of questions has been rearranged for easier understanding. Those questions with an MD beside them were asked only of physicians, while those with an RN beside them were asked only of nurses.**

General Computer Experience

1. I have used computers and have some programming experience (Expert)
2. I have used the LDS Hospital computer system to enter data but have no programming experience (User)
3. I have no experience with computers (Novice)

General Opinions

5 = strongly agree   4 = agree   3 = neutral   2 = disagree
1 = strongly disagree   0 = not applicable

1. The LDS Hospital Education staff should develop more systematic training programs to teach physicians (nurses) how to use and understand the computer system's many features and their benefits
2. Computers can free physicians (nurses) from boring, repetitive tasks
3. Computer applications should play an increasing role in professional practice because they generally improve the delivery of health care services
4. Computerized decision support is useful
5. The Medical Informatics staff should be more helpful and responsive in assisting both new and experienced computer users
6. Health care providers will be monitored more closely by administrators, government agencies, and third parties if computers are commonly used
7. Use of computers in practice may compromise the confidentiality of patient information
8. MD Relying on computer results increases professional liability
9. MD Widespread use of computer applications will reduce the decision-making power of individual physicians
10. RN Relying on computerized decision support enhances nurses' professionalism
11. RN Computers have significantly increased the daily workloads of nurses

Value of Computer Access to Various Patient Data

To assess the values of a variety of patient data types, the following questions were asked.

5 = very important   4 = somewhat important   3 = neutral
2 = somewhat unimportant   1 = unimportant   0 = no opinion

1. Laboratory test results are
2. Blood gas data with interpretations are
3. Patient demographics and insurance information are
4. ECG data with interpretations are
5. General patient vital sign data (such as BP, HR, and temperatures) are
6. Hospital clinical records and diagnostic related grouping (DRG) data are
7. Nursing care plans are

8. Nurse charting versus handwritten charting is
9. MD Accessing the LDS Hospital computer from a personal computer in my office or home is
10. RN Patient data, before and after arrival on the floor, is

Computer Features Assessment

To make an assessment of the importance of various HELP system features, the respondents were asked.

5 = very important   4 = somewhat important   3 = neutral
2 = somewhat unimportant   1 = unimportant   0 = no opinion

1. Alerts that warn of potentially dangerous situations such as life-threatening laboratory abnormalities or drug interactions are
2. Medical monitoring and generation of pharmacy alerts at the actual time an order is placed is
3. Availability of timely transcribed x-ray and history and physical examination medical records on the computer is
4. MD Physician ordering for total parenteral nutritional needs is
5. Blood ordering, which will assist in complying with "Joint Commission" (JCAHO) guidelines and adhering to LDS Hospital quality assurance standards, is
6. Printed computer-generated patient records that are more accurate, legible, and complete are
7. Monitoring and reporting on urinary culture specimens from patients with Foley catheters or suprapubic collection devices is
8. Treatment protocols that can be used by physicians, nurses, or ancillary staff are
9. RN Computerized nursing acuity is

Future Features Desired

To help plan for the future, the respondents were asked to help set priorities by ranking the following future potential projects.

5 = very important   4 = somewhat important   3 = neutral
2 = somewhat unimportant   1 = unimportant   0 = no opinion

1. Continued development, expansion, and evaluation of the LDS Hospital laboratory alerting system will be
2. MD Direct physician access to the pharmacy knowledge base for prescription advice will be
3. Easier computer method for ordering of lab tests and procedures by physicians, nurses, clerks, and office staff will be
4. MD Scheduling admissions and recording demographic, insurance, and clinical information as part of preadmitting and admitting procedures will be
5. MD Hospital clinical records and diagnostic related grouping (DRG) data will be
6. MD Ability to review charges for laboratory tests and x-ray procedures will be
7. MD Computer access to clinical information at other IHC hospitals for patients you may transfer to LDS Hospital will be
8. MD Decision support for pre- and postoperative use of antibiotics will be
9. RN Freeing nurses from order-entry tasks that an MD can/should do will be
10. RN Automatic, computerized recording of IV infusions and vital signs will be
11. RN Bedside computer terminals in most patient rooms will be
12. RN Access to an accurate and continually updated surgery schedule will be
13. RN Computerized medication scheduling/charting will be
14. RN Computerized patient history will be
15. RN Computerized documentation of the physical assessment will be
16. RN Computerized teaching plans will be
17. RN Computerized discharge planning will be
18. RN Computerized nurse care plans will be
19. RN Computerized nurse worksheet (to replace the written Kardex) will be

Ranking of Features

To give a feel for the features of the HELP system that the users preferred, the following statement was asked of physicians and nurses.

Please rank the following ten specific features of the LDS Hospital computer system based on how you feel they contribute to your professional practice.

MOST IMPORTANT	MD		RN
1. _____	A	Pharmacy Alerts	
2. _____	B	Lab Review	
3. _____	C	I/O Review	
4. _____	D	Blood Ordering	
5. _____	E	Patient Location	
6. _____	F	Drug Review	
7. _____	G	Phone-in Data Review	Nurse Charting
8. _____	H	Vital Signs Review	
9. _____	I	Blood Gas Interpretation	
10. _____	J	Antibiotic/Infection Alerts	Shift Reports
LEAST IMPORTANT			

Free-Text Opinion Space

To solicit "free-text" responses from the participants, the following statement was placed on the top of a blank sheet of paper.

Please use this space to discuss any aspects of the LDS Hospital computer system