Physician Use of an NICU Laboratory Reporting System*

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ABSTRACT

Clinical workstation developers may gain useful insights from studies of physician acceptance and use of computer systems that have been incorporated into daily practice. We used a physician survey, intrinsic monitors built into the system and an observational study to assess physician acceptance and use of a touchscreen workstation that was put in place in an NICU in 1985. Each of the 87 physicians assigned to the 30 bed NICU during the two academic years beginning July, 1987 was sent a questionnaire that assessed experience and attitudes about the system. The 70 responding physicians (80 percent) were unanimous in agreeing or strongly agreeing that the system was "easy to learn" (57 reported it taking less than five minutes), "easy to use", and "integrates smoothly into patient care activities". Over 94 percent of the physicians agreed or strongly agreed that the system was "fast", "saves time", and was "reliable and dependable." Sixty-three of the responding physicians (90%) reported using the system two or more times a day with 53 using it more than five times daily. The most frequently requested new feature was that of time-trend graphs (51 occurrences). The intrinsic monitors were useful in validating design decisions and survey results but also provided new insights relevant to security issues. Similarly, the observation study reinforced some of the survey results but also highlighted an additional issue not brought out by the other two assessment methods. The overall assessment indicated that the system has been both well-accepted and well-used by its intended clinical clientele.

INTRODUCTION

Interest has burgeoned in developing workstations for clinicians to use directly in order to improve clinical productivity, enhance quality of care and control costs. Yet widespread incorporation of computers into the daily work of physicians remains an elusive goal. While physician attitudes about the utility and impact of computers in the clinical setting are ambivalent, generally their potential benefit and their inevitability are acknowledged [1,4,9,10,11]. Clinical workstation developers may gain useful insights from studies of physician acceptance and use of computer systems that have been incorporated into daily practice. Here we report on the results of a three-stage evaluation of physician acceptance and use of a touchscreen laboratory reporting system in a neonatal intensive care unit (NICU). This system has been successfully operating in the NICU since 1985. Because physician acceptance and use have been excellent throughout the workstation's life, we are drawing heavily on the strengths of the system's user interface in our ongoing development of a new clinicians' workstation. The new workstation will provide ready access to laboratory results, easy order entry for laboratory tests and blood products and immediate feedback about the order's appropriateness based on locally developed clinical guidelines.

BACKGROUND

In an attempt to improve the usability of laboratory results while lessening the clerical activity associated with reporting them in a busy NICU, we implemented a special workstation designed to be used directly by physicians

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[3]. With a single touch of the screen the physician gains access to laboratory results that are presented in a format matched to the patient monitoring task. The reporting system was a joint development effort involving the medical, nursing and clerical staff of the NICU, the programming staff of Laboratory Information Systems, and laboratory technologists in the Pediatric Chemistry Laboratory — all at the University of Minnesota Hospital and Clinic. The 30-bed NICU serves as a regional referral center for critically-ill newborn infants.

The workstation was a product of a design committee of six to eight individuals representing most of the major stakeholders in the system. There were two members from the clinical laboratories, two from the laboratories' information services group, the NICU medical director, and two NICU nurses. In twelve meetings over six months this committee designed the system. Most of the work was done by posing questions to the committee members followed by problem solving discussions. This was essentially a prototyping process, although the model was done entirely on paper using screen mockups. After the design was finalized by the committee, program coding was done by Laboratory Information Systems staff with the developing system frequently submitted to design committee members for their evaluation and comment.

When the workstation detects results on a new patient, it automatically sends a request to the laboratory computer for demographic information. The workstation provides the clinical staff notice at a glance of newly reported laboratory results. Results for a specific patient can be viewed by a single touch of the patient's name displayed on the patient roster screen. This leads to the primary results display which summarizes recent trends of the 20 most commonly used monitoring tests presented in physiologically-relevant groups. These test results included serum electrolytes, glucose, urea nitrogen, creatinine, calcium, blood gases, hemoglobin, hematocrit, white cell and platelet count, coagulation panel and bilirubin. This display of the primary tests is augmented by a display of all other laboratory tests depicted in alphabetical order. Groups of primary test results or secondary test results can be expanded to cover a wider time window by touching the usual test result display area. Newly reported tests are displayed on the screen with an inverse video highlight until the house officer of the day indicates that the results have formally been reviewed. Budgetary considerations allowed for the deployment of two identical workstations in two separate areas of the NICU.

METHODS

The touchscreen workstation has been described in detail previously [3]. The workstation was implemented using Lattice C (Lattice, Inc., Glen Ellyn, IL) integrated with a commercial embeddable database management system, MDBS (Micro Data Base Systems, Inc., Lafayette, IN). The system runs under MSDOS on a Hewlett-Packard personal computer with integral touchscreen (Hewlett-Packard Company, Sunnyvale, CA). All user interaction with the workstation is via the touch panel. In fact, no keyboard is attached to the workstation during normal operation. The workstation receives verified test result information via a direct serial link to the laboratory information system (CLS, Knowledge Data System, Inc., Larkspur, CA) running on a Tandem VLX computer (Tandem Computers, Inc., Cupertino, CA).

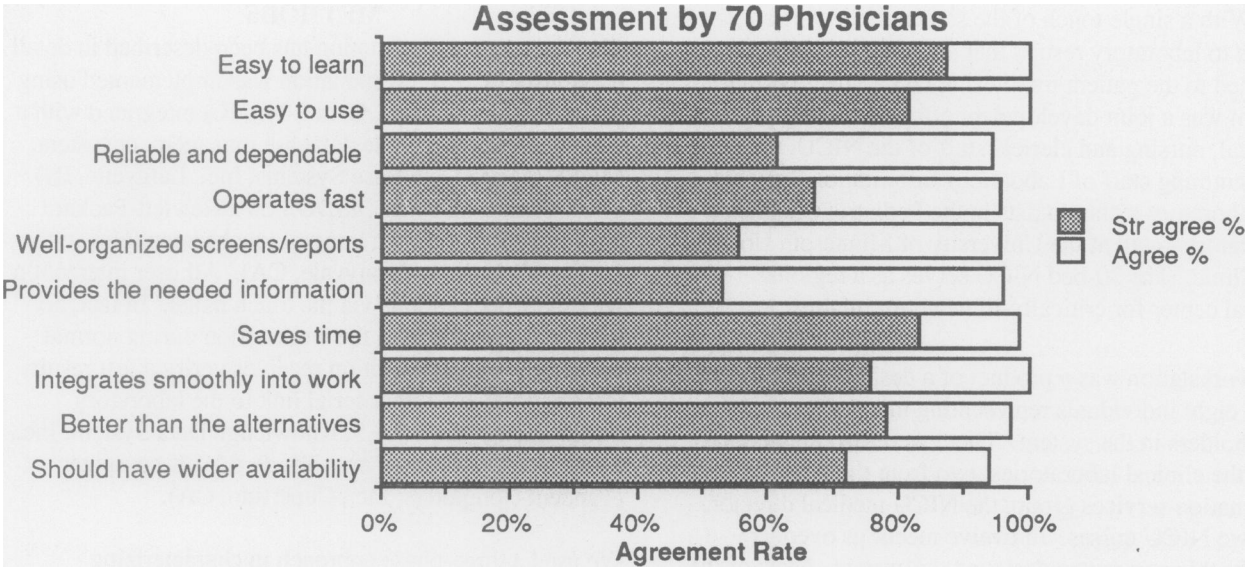
We used a three-phase approach in characterizing physician acceptance of the touchscreen workstation; physician questionnaires, intrinsic monitoring of workstation use, and direct observation and interview of physician users.

Physician Questionnaires

In early June of 1988 and 1989, all physicians assigned to the NICU during the respective academic years were identified from departmental rotation schedules of the Department of Pediatrics. A single page questionnaire, a brief cover letter and a stamped return envelope were mailed to all of these physicians. The survey focused on key characteristics drawn from the literature that were thought important for physician acceptance of clinical computer systems [1,2,4,7,9,10,11,12]. The system's value and usability were assessed through ten questions that used a Likert-like response scale. Five additional multiple choice questions explored usage rate, system learning, and recommended improvements. The 87 physicians eligible for this survey included interns, residents, fellows and faculty. Two faculty physicians eligible for the survey were involved in the original development of the workstation. The other 85 had no such involvement. A numerical code was handwritten on each questionnaire and used to mail reminder questionnaires to those not responding after two weeks. Physicians who responded in 1988 who also worked in the NICU during 1989 were not resurveyed in 1989.

Intrinsic Monitoring of Workstation Use

Counters were embedded in the applications code of the workstation from the beginning so that key events could be tallied. These events reflected usage patterns as well as system load. The counters tallied activity during the period from April 2 to July 30, 1991 accounting for 119 total days.



Interview and Observation

Semi-structured interviews were done with key personnel involved with the development and use of the system. NICU rounds were observed by one of us (GRW) using an unstructured format. The objectives of the observation effort were to learn how information was used in clinical care, where and by whom, to obtain reactions of a few key users to the final system, and to perform an evaluation of the strengths and weaknesses of the project development process. The observer, a board-eligible pediatrician and trainee in medical informatics, was familiar with the clinical content area and with NICU rounds as performed at another hospital. He had not been associated with the original development of the workstation.

RESULTS

Physician Questionnaires

Seventy of 87 physicians returned questionnaires for an 80% response rate. One physician returned two questionnaires with identical responses. One of these was eliminated from the analysis. Of the physicians completing the questionnaire, 30 were interns, 33 other residents, four fellows and three were faculty. The non-responding physicians were about equally divided between interns and other residents.

The length of time it takes to learn how to use a computer system in a clinical setting is an important characteristic. Since house staff may be required to begin caring for patients within minutes of their first arrival on a new service, they don't have time to learn a complicated system. All but one physician reported learning how to use the system in less than 15 minutes with 57 of 69 respondents reporting learning the system in five minutes or less. The training source was predominantly other physicians with only four instances reported in which nursing personnel were the primary source. Sixty-three of the responding physicians (90%) reported using the system two or more times a day with 53 using it more than five times daily.

Physicians were asked to indicate if they strongly agreed, agreed, were neutral, disagreed or strongly disagreed with a series of 10 statements that might describe the system. Their responses are summarized in the figure. The responding physicians unanimously agreed (strongly agreed or agreed) that the system was easy to learn, easy to use and integrated smoothly into the patient care process. All but one of the physicians agreed that the system saved them time. 94% or more of physicians agreed that the system was reliable, fast, presented the data in a well-organized manner, provided the needed information, and was better than alternative methods for laboratory result reporting. Almost all physicians thought the system should be more widely available.

Two questions pertained to changes to the system that physicians would find desirable. The most frequently requested new feature was that of time-trend graphs (51 occurrences). Access to microbiology data and results more than three days old was the feature next most frequently indicated by physicians. The current NICU reporting system does not have access to microbiology results because those reside on an older computer system due to be phased out in the near future. A substantial minority of physicians were interested in ordering laboratory tests or blood products through the system. On the other hand, two respondents specifically indicated

dissatisfaction with the possibility of order entry as it would add additional work to the already overworked house staff. Regarding desired system improvements, almost half (34) reported the system to be satisfactory as is for the role it currently plays. Ten would like to see the system to be faster, six wished it to be more reliable, five suggested availability in other ICUs, and three each asked for easier to read screens or bedside availability.

Intrinsic Monitoring of Workstation Use

During the 119 day monitoring period, slightly more than 13,000 transactions were sent to each of the workstations. Of these, 6676 represented tests for the primary test screen and 5223 were tests displayed on the other results screen. Tests could contain multiple results depending upon laboratory instrumentation. Thus a single hematology test done on a Coulter Counter or a blood gas would be tallied as one test but might lead to the transfer of four or more results depending on the components that were ordered. The difference between the 13,000 transactions and the sum of all tests transactions represented "housekeeping" transactions related to the transfer of demographic information, nightly transfer of patient census data, and minor modifications to table files.

In the main NICU room, the primary screen was accessed over 10,000 times and the secondary screen about 4500 times. At the second workstation located in the step-down care area, primary screen access was done 9615 times and secondary screen access 3592 times. Thus, the primary screen was accessed approximately 165 times a day and, in the majority of cases, the primary screen served the need. The primary screen was printed out 670 times or about three percent of the time. Approximately ten percent of the time, the user chose to expand a set of tests being viewed on the primary screen. This expansion showed tests further back in time and displayed all comments in-line with their respective test data. Although the user could touch a button to close his or her session, almost 40 percent of the time the log out was caused by a parameterized time-out criterion which was set at one minute. This time-out feature led to no complaints — but it is clear that if such a workstation were not in a protected environment, patient data confidentiality would be at risk.

Interview and Observation

An unanticipated benefit of the design effort was improved communication among stakeholder groups. For example, laboratory personnel learned from the NICU nurses that certain phone reports from the laboratory were no longer of interest to the clinicians so the calls were stopped. The only major negative event occurring during the system's development came from a nursing administrator who had not been involved in the design committee. Her view was not supported by the design committee and the comments were seen as having a political rather than clinical basis.

Clinician participants in the design process were very enthusiastic users and proponents of the system. Housestaff were observed using the system as a very natural and convenient tool in their work. They appeared to find it useful and were enthusiastic about it. The NICU system was reported to be remarkably robust and reliable. The only major failure mode is that if the workstation's printer is out of paper, then the workstation will "hang" waiting for the printer.

Although the system appears to be well-accepted and heavily used by physicians, its use has not done away with the "brain board" clipboard maintained by the housestaff for each patient. The clipboard is still useful for reviewing laboratory work reported during the last shift, for the review of trends on an individual patient, for quick reference on staff rounds, and to correlate ventilator settings with blood gas results. In database design terms, the brain board represents another *user view* of the laboratory results. This view was not specifically identified during the design stage, and consequently is not part of an otherwise very functional system.

DISCUSSION

The overall evaluation of the laboratory reporting system by NICU physicians was very positive. Acceptance of clinical computers by physicians is thought to be enhanced by ready accessibility of the computer, ease of use, minimal typing, system responsiveness, and the presence of incentives to use the system [5,6]. Especially notable in terms of physician acceptance in this study are the near unanimity of physicians that the system saves them time and integrates smoothly into patient care. There is no keyboard present and almost all system responses occur in under two seconds. Harried housestaff will not willingly use systems that slow them down.

In our setting, most residents rotate to at least three hospitals and are on any particular service for only five weeks. It would have been untenable to require extensive training on the workstation before new housestaff assumed their clinical duties. Therefore, the system's developers worked to carefully match the system to the clinical task and make its use very intuitive and easy to learn. No formal training program for the constantly changing housestaff has been necessary or requested. Most physicians report that learning to use the system takes less than five minutes. The absence of training costs associated with this system is an important consideration for the hospital. Of course, part of the

reason this system requires no training is its limited functionality. It is focused on making laboratory results accessible in a useful format. While this narrow focus has met an important clinical need, a system with such limited scope will not be sufficient in the future.

The intrinsic measurements that have been collected validate the partitioning of result display into a high priority primary results screen and an "all other results" screen. In the majority of sessions, the primary result screen satisfied the need. However, a larger screen area would have been valuable and would have allowed more test types to be displayed on the primary screen making clinical use even more convenient. Somewhat surprising was the relatively low rate at which the results were printed from the workstation. Physicians appeared to use the workstation to meet ad hoc needs of the moment rather than to ponder over a printout at some later time. The propensity to walk away without "logging off" (which would have required a single touch of the screen) is an area of concern about patient privacy and safety, especially when considering future workstations that allow order entry.

The three approaches to assessment of physician acceptance carried out here were complementary. The intrinsic measures validated some of the survey responses and original design issues but also provided new insights. Similarly, while the observational study was consistent with physician self-reports, it revealed outstanding issues not brought out in the survey or by the intrinsic measures.

The system seems to be remarkably well accepted and regarded even after nearly six years of use. By most accounts, this workstation would qualify as a successful implementation of a narrow set of medical information services. It did face and had to weather some of the common barriers to success [8] including logistical, financial and political ones. There are improvements and enhancements physicians would like to see, but the now-old software technology associated with this workstation limited the extensions that could be made. While we are carrying over the successful aspects of the touchscreen workstation into our new workstation, access to interface building tools, object technology, client-server database systems, and ready network communication will enable much broader functionality and easier adaptability. However, even with the dramatic increase in development potential these technologies provide, the increased complexity and less compelling physician incentives associated with order entry ensure a continuing challenge for those developing systems that physicians will find both useful and usable.

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