J.M. Teich

Clinical Systems Research and Development, Partners HealthCare System, and Department of Medicine, Harvard Medical School, Boston, MA, USA

Synopsis

Health and Clinical Management

Introduction

The four papers included in this section represent examples of the use of information technology to augment or replace common functions in the day-to-day management of patients. From rule-based systems which ensure that primary care physicians attend to important health issues, to telecommunications networks that make radiology case conferences possible across telephone lines and networks, to simulators that help predict driver safety, all of these projects have identified a particular problem with information management and found a workable solution.

One lesson that we may learn from these studies is that the most effective uses of information technology are not necessarily grand intellectual leaps or dramatic ways of replacing standard healthcare decision-making. Rather, some of the best uses of information technology are in situations where optimal management rules may already be known, but where their application is problematic because of our inability to keep up with all the relevant data and to apply that data at the right moment. Child immunization is a nearly incontrovertible good, and its concepts are straightforward. The failure to immunize is usually caused by lack of access to vaccine, difficulty in getting the patient to the clinic for immunization, or failure to immunize when the patient is available. Computer programs and other systems can readily help the latter two problems simply by keeping track of immunized and non-immunized patients, and presenting important pieces of information (the following patients in this village are due for immunization; the patient who is in the clinic right now needs a vaccination) at the right time. This ability to convey knowledge "just-in-time" [1] is well within the range of computer skills. In radiology, while advanced systems may seek to automatically provide interpretation of images, this skill is more capably done by expert humans. In Engelmann's system, the computer's ideal role is functional: it brings that expert human and the radiograph directly into the office of a referring physician.

This partnership between human skills and computer skills forms the core of most successful health management systems. In each of the studies presented here, initial analysis showed that there were certain elements of communication, measurement, data recall, and data presentation that were hampering the basic process. These functions were enhanced with technology, while human workers fulfilled decision-making roles which are (as yet) unchallenged by typical computer systems.

We also see, in several of the studies, that optimal information transfer is still a work in progress. In some cases [2-4] there are still significant technological limitations that, once surmounted, will make the outcomes even more successful. Lobach [2] described a change in their computer system which caused erroneous results to be posted for a time. We all still wrestle with this and other issues of clinical software quality – because the computer does so many tasks so quickly, it may be difficult to assess whether it is, in fact, doing the clinical task that was intended. Reasonableness checking, a skill that comes naturally to humans, is still a struggle in the computer world. These researchers acknowledged the problem, and corrected it; they have elegantly tested other aspects of their system to ensure optimal performance.

Complexity and data management are also critical issues: the Iowa study demonstrated many factors that were associated with higher driving risk. Which of these are the true determinants of risk, and which are irrelevant factors that are linked to the key one(s) for other reasons? If we are to use this study to develop a practical screening method, we must isolate the best tests. Otherwise, we may wind up denying operator privileges to safe drivers, and putting higher-risk drivers out on the road. Part of this team's paper described their efforts to isolate independent predictors of driving safety.

Improving Compliance with Practice Guidelines

Lobach and Hammond [2] looked at the thousands of clinical practice guidelines that exist in paper form, and set out to determine whether computerized "just-in-time" presentation of key aspects of these guidelines would improve compliance. Rather than using a single piece of logic to generate a single specific reminder, they looked at the whole collection of health management rules for diabetics and presented those which were relevant, based on the patient's specific health status at the time of the visit.

The Duke team took into account several factors important for user acceptance. They realized that their intervention must be integrated into the regular workflow of each provider, otherwise the providers might overlook it. The intervention display appeared on the printed charge form that providers use in the regular documentation of their care. Because of this, the provider was very likely to see the reminders in the normal course of work. It is also important to note that, while a national guideline was available, the providers at the Duke practice did not fully agree with it; the project team worked with the providers to prepare a modified guideline, with which they could agree. Had they tried to impose the national guideline without sufficient backing from the practice leaders, it is likely that the whole intervention might have been unsuccessful. The intervention was not to teach a new expert treatment method; rather it was simply to help the providers remember their own guidelines at the moment of care.

The Duke team was able to make use of The Medical Record, a clinical information system that has been in place for more than two decades. This record provided the patient-specific information necessary to make highly tailored recommendations. In cases where the practice had additional information on paper or was not using the computerized record, it was more difficult to get accurate patient status, and the correctness of the reminders was reduced as a result. This illustrates the synergistic benefits of a pervasive computerized medical record—it becomes easier to add new features when the computer already contains information that may have been entered for other reasons.

The analysis of the project showed that the computer gave correct recommendations 77% of the time. Most of the incorrect recommendations were caused by a change in the computer system that inadvertently affected the guideline program's ability to collect the proper background data. The clinicians apparently executed a reasonableness check on the recommendations, catching most of these errors. Thus, we see that the clinicians were using the computer reminders to jog their memories, but were not becoming dependent upon them as the "gold standard" of decision-making. Once the error was identified, it could be corrected once and for all (another desirable feature of computer systems) and the system became much more reliable.

A careful analysis of the effects of the guideline intervention showed a significant increase in compliance (the number of individual recommendations for a given visit that were performed by the providers) and in overall guideline adherence (the number of overall status indicators that were up-to-date by the end of the visit). Compliance rose from 15% before the computer assistance to 32% afterward. Remaining process problems included lack of time to perform or document the recommended procedure, or clinical disagreement with specific recommendations on specific patients. The latter problem can probably reduced with further analysis that leads to more fine-tuned rules and guidelines. The problem of lack of clinician time, however, is only partially amenable to computer solution, if at all.

The authors called for capture of ever more data into an automated record, for research into new protocol approaches such as branching logic that interacts directly with the provider, and for testing of their methods in other practice environments.

Teleradiology

Engelmann [3] and associates described the Medicus system, a communication system that allows caregivers at widely separated sites to interactively see and work with the same images. In some environments with high-speed cable connections and high prevalence of image standards this might not be a major problem of health management. However, in most environments these are still luxuries. In order to deal with the real-world technical limitations in their environment, Engelmann and his group devised a clever system that provides the same functionality. Working with ISDN lines at a speed which does not permit real-time image transmission and using whatever protocols are available from the imaging systems, the system transfers image data in batch to a standard workstation at each site that needs the images. This transfer may take hours for a single study, but the providers do not need to be in attendance. Rather, once the data have been transferred, the providers participate in a teleconference to discuss the images. During the conference, the workstations exchange just enough data to open, manipulate, and annotate the images that they already have, always maintaining a synchronized display between the two sites. Security precautions ensure that data cannot be recopied to an uncontrolled site, or printed without appropriate permissions.

The Medicus system has some aspects of an interface engine, transferring data from a variety of formats into a standard format that can be accessed by its own workstation. The complex synchronization software gives the system its elegance, conveying a sense that the conference participants are together in the "reading room"

It is interesting to see the different ways that the system is used. In one site, which does have high-speed in-house communication, the Medicus system is still used as a specialized conferencing workstation, allowing multiple users to work together with a single copy of the image. At another site, the system is used to deliver images and information to referring physicians at satellite hospitals. Still another site performs a more classic telemedicine function: a radiologist at one location performs diagnostic evaluation of images acquired elsewhere. A fourth site uses the system to exchange data for research purposes. Interestingly, there is very little use of the system to obtain expert second opinions. One barrier to this is the absence of reimbursement for such a service.

In their conclusion, the authors called for greater adoption of standards such as DICOM, greater functionality to the workstation, and more widely accessible patient databases as the hallmarks of a next-generation, more functional system. However, even with the current system, they reported that more than 30,000 images had been processed in nine months of operation.

Improving Health Maintenance and Immunization

The paper by Singh [4] and colleagues described the ongoing progress of an international collaboration between Indian and Swedish groups, aimed at improving maternal and child health care and immunization rates in a rural part of India. Here again, the authors had analyzed the existing system process (in this case, prior to 1992) and had found that a lack of information, amenable to technological remedy, was a major factor in low immunization rates. A database, using common microcomputers and an inexpensive printer, was built to record immunizations and births. Now, when health workers visit the community, they record immunization data and health status for that visit; the database also keeps records of every child born in the community. On subsequent visits, the database informs them which children are due for further immunization. This information enables the health workers to target dropouts from the immunization program, to better inform parents of the children's health status, and to give the entire community the sense that the health workers care about them and are keeping track for their benefit.

Through this combination of bookkeeping and motivation, the fully immunized child rate has risen from 28% before the initiation of the computer program, to 82% (for DPT vaccination) in 1996. Oral polio vaccination completion rates have risen from 46% in the first study year to 77%. Other areas have not shown quite as dramatic an increase: tetanus toxoid dropout rates are still around 50%. Antenatal registration has nearly doubled, although the authors pointed out that this is still significantly underreported. Perhaps equally importantly, the authors stated that the community has taken on a greater sense of concern for its own health. The benefit has persisted in the four years since the computer program began, despite harsh climate, poor transportation, and a clinic where the average physician stays only for a few months.

In their conclusion, the authors reiterated that information management was the missing piece of healthcare support in this community, and that computerization can be of great benefit to primary care in remote locations. They called for progressive implementation of information systems, giving the community a chance to build its confidence in the systems through an immunization program, followed by implementation of maternal healthcare and family planning programs.

Determining Driving Risk Factors through Simulation

The final paper in this section [5] used computer technology of a different form – mechanical simulation – to permit an important public safety question to be researched without risk. Rizzo and his co-authors were concerned with the question of whether patients with mild to moderate Alzheimer's disease (AD) could drive safely. In particular, the authors sought to identify specific cognitive or physical impairments that correlated highly with accident risk. The most accurate way to do this was to let the subjects drive under controlled conditions, and observe accidents and near-misses. The Iowa Driving Simulator made it possible for these observations to be made safely, and controlled the experiment by providing identical driving scenarios to each subject. Unfortunately, such a simulator is too expensive to be used for routine driving tests itself; presumably, if that were feasible, then driving skills could be accurately measured for everyone. However, by correlating accident-causing behavior in the simulator to other parameters that are more easily measured, the simulator's accuracy might be transferred to a more practical test.

In the study, 6 of 21 subjects with AD had accidents, compared to 0 of 18 controls ($p=.022$) and 14 of 19 subjects with AD had near-misses, compared to 6 of 17 controls ($p=.042$). All subjects underwent a number of cognitive tests; reduced performance on the Rey-Osterreith Complex Figure Test (CFT) carried an estimated odds ratio of 58:1 for an accident, while no other test added independent risk information. A larger sample size may have improved the discrimination among these tests. The authors concentrated on the useful field of view (UFOV) test, which reflects physical skills that might be important to safe driving. This test also effectively isolated all of the accident subjects on one side of its discriminant line, although the UFOV test was highly correlated with the CFT test. The authors suggest that, with further corroboration, these tests might be used to aid in the decision of which persons with AD can continue to drive.

The usefulness of any simulation is highly dependent on the fidelity of the simulator, how closely it approximates the essential conditions of the actual situation. As Rizzo and colleagues pointed out, humans have, in fact, been adaptable enough to respond capably to even crude, relatively unrealistic early simulators. The Iowa simulator uses parallel computers, image-generating subsystems, a high-acceleration motion base, and numerous sensors to produce multi-sensory feedback and provide a realistic experience for the driver. This potent technology can be used to determine many more risk factors for automobile accidents, and to test new strategies that can make driving safer for all. Further study can help elucidate conditions under which the simulation is more or less useful.

Conclusions

A fundamental goal of medical informatics is to make humans healthier. As in all branches of science, there is room for work on basic theory, intelligent synthesis, and practical application. Each of the projects presented here identified a practical problem and devised specific areas where computer applications, partnered with human skills and analysis, could provide a remedy. From the improved health measures of the Lobach and Singh studies, to the process improvement of the Engelmann work, to the new clinical associations found by Rizzo and colleagues, management of specific health issues has improved.

In all cases, there is still more to do. Technology is still one limiting factor – not only in the development of capable technology but in its distribution and availability. Many hospitals and health practices do not use computerized medical records, and those that do cannot fully capture all data types in a way that provides maximum value. We must strive ever harder to perfect the computer-human partnership, not only by giving appropriate tasks to each, but by continuing to make computer use more acceptable to humans. We must go to the next step in software reliability; while human error tendencies are well accepted, it is more difficult for us to detect errors, vulnerable dependencies, and functional departures in computer programs. Nonetheless, properly applied and validated computer technology does greatly reduce human errors of omission and commission, does help remind caregivers of best practices, and does improve human health by improving of information.

References:

1. Chueh H, Barnett GO. "Just-in-time" clinical information. Acad.Med. 1997;72: 512-17.
2. Lobach DF and Hammond WE. Computerized decision support based on a clinical practice guideline improves compliance with care standards. Am J Med 1997;102:89-98.
3. Engelmann U, Schroter A, Baur U, Werner O, Goransson B, Boralv E, Schwab M, Muller H, Bahner M and Meinzer HP. Experiences with the german teleradiology system MEDICUS. Comput Meth Prog Bio 1997;54:131-9.
4. Singh AK, Kohli M, Trell E, Wigertz O, Kohli S. Bhorugram (India): revisited. A 4 year follow-up of a computer-based information system for distributed MCH services. Int J Med Inf 1997;44:117-25.
5. Rizzo M, Reinach S, McGehee D and Dawson J. Simulated car crashes and crash predictors in drivers with Alzheimer disease. Arch Neurol 1997;54:545-51.

Address of the Author:
J.M. Teich,
Brigham and Women's Hospital,
850 Boylston St., Suite 202,
Chestnut Hill, MA 02167,
USA