8. Popkin MK, Mackenzie TB, Hall RC, Garrard J. Physicians' concordance with consultants' recommendations for psychotropic medications. Arch Gen Psychiatry 1979; 36:386-9.
9. MacKenzie TB, Popkin MK, Callies AL, Jorgensen CR, Cohn JN. The effectiveness of cardiology consultation. Concordance with diagnostic and drug recommendations. Chest 1981; 79:16-22.

Computer-Based Medical Records: Time For An Upgrade

Twenty-three years ago, as a family practice resident, I was introduced to computer-based medical records. Larry Weed had spearheaded the development of the PROMIS system at the Medical Center Hospital, University of Vermont. I used it on the gynecology floor, where computer terminals and printouts replaced the hospital chart. Most residents avoided it, preferring to keep the physicians' notes, laboratory results, and needed orders on 3 × 5-inch cards stuffed into shirt pockets. The system was later installed, temporarily, in a few physician offices. It never proved feasible for practice because of high development and hardware costs, the ongoing need for technical support, and despite touch screen technology, time-consuming data entry.

Twenty years later this first generation of computerized medical records used in ambulatory care has four long-term survivors: (1) STOR (Summary Time-Oriented Record)[1] developed and used at the Ambulatory Care Center of the University of California, San Francisco; (2) RMRS (Regenstrief Medical Record System)[2] developed at the University of Indiana, where workstations are currently used both in inpatient and outpatient settings; (3) COSTAR (Computer Stored Ambulatory Record)[3] developed at the Massachusetts General Hospital and used by the ever-expanding Harvard Community Health Plan; and (4) TMR (the Medical Record)[4] developed at Duke University and in use there since 1977. In its current form TMR is installed at Duke's busy family practice center and is well described in this issue of the *Journal*.[5]

By examining the evolution of this technology and seeing what functions have proved viable in practice, we can become wiser about the future of computerized medical records. Yarnall, Michener, and Hammond[5] reassure those considering medical record systems about two often-voiced concerns. First, the reliability of their hardware and software is high, and downtime has been very limited. One doesn't need to fear computer crashes that will destroy data or that there will be periods during which there is no computer system available. I suspect that in part this reliability is because the system's developers and programmers are nearby and highly invested in the system. Second, the authors note that there has been no unauthorized access to patient records. Although they do not describe their security system, systems need to have a balance between insuring patient record privacy and easy access to patient data for providers. TMR seems to have found it.

TMR shares many attributes with the other successful computer-based record systems — both the four noted above and those of more recent design that have been reported in the literature. Such attributes include:

1. Record summaries (patient at a glance) for providers that have demographic data, past visit summaries, problem lists, medication lists, and recent laboratory and radiographic results. Computer-generated flow sheets can help present data over time. The advantages of these record summaries are well described.[3,6-8]
2. Prompts or reminders about needed screening and preventive care. Many reports document that these reminders can greatly improve physician performance.[9-13] TMR, in addition, sends birthday "reminder" letters to patients.
3. Linkage with other computer systems, such as billing, scheduling, hospital, laboratory, and radiology. The TMR either has modules that do these functions or has the ability to interface these systems, which helps keep data-entry costs down.

Submitted 7 April 1994.
From the Department of Family and Community Medicine, University of California, San Francisco. Address reprint requests to Jonathan E. Rodnick, MD, Department of Family and Community Medicine, University of California, San Francisco, Box 0900, San Francisco, CA 94143-0900.

TMR also has a few other bells and whistles that have not been widely copied but deserve mention. These include childhood immunization flow sheets and reminders, automatic letters to patients with needed education and follow-up depending on their laboratory results, preprinted prescription forms with the pharmacist updating the patient's medication list, and a complete obstetric record and flow sheet that is immediately available in the labor and delivery area.

Besides the advantages of these specific functions, computerized records improve communication between providers. The medical record summary is available at all times and at multiple sites, and the record is always legible! It means that accurate management information can be collected quickly, that the quality of monitoring and assurance is improved, and that clinical research in office practice is easier to do.

If TMR and other computerized record systems are so great, why have they not been more widely adopted during the past 20 years? I do not think it is from lack of good medical software or from a lack of practices wanting to try them out. For example, three recent reports, two from academic practices[14,15] and one from a large HMO,[16] describe unsuccessful experiences with computerized records. In each instance after an expenditure of great amounts of money and thousands of physician hours, the computer record system was removed.

Schoenbaum and Barnett[3] cite three key reasons why computer-based record systems have been so slowly adopted. First, there is a great diversity of medical environments and system requirements. Most offices or clinics already have billing, laboratory, or scheduling systems that must then be tossed out, or expensive software interfaces must be written. As there are few standards for medical vocabulary and data structure, it is no simple feat to get computers to talk to each other. Second, data entry is the Achilles' heel of computerized records. Typing data into computers is time consuming, error prone, costly, and rarely done on-line by physicians. All things considered, the total time needed by physician and staff for computer entry of an encounter is usually greater than the time needed for a handwritten or dictated note. Third, the transition to computer-based records is traumatic and disruptive. During this time, especially, there is need for expensive personnel, such as expert software programmers.

The $64,000 question is whether computer record systems save money. The answer, of course, depends on one's perspective. Yarnell, Michener, and Hammond describe two ways of looking at computer costs. One way is to look at only the costs of maintaining the system by adding up the yearly cost of personnel, space, and computer upkeep. Calculated this way, the TMR at Duke costs $1.78 per patient encounter. The authors do not say whether this figure includes time for filing, pulling charts, or materials. The cost estimate also does not include software development, which for TMR probably added up to between 10,000 and 100,000 person hours. Nevertheless, the yearly add-on cost for data-entry personnel and hardware maintenance, once the system is designed and running, seems reasonable for what one gets.

The second way takes into account what one gets (i.e., benefits) from computerization. The authors, unfortunately, do not do this by quantifying new savings. Only one study has shown overall savings, using computers for laboratory ordering and displaying the charge for tests, which got physicians to order fewer tests.[17] Instead they have calculated what it would hypothetically cost to provide manually the same functions as the computer system. This approach is the "deautomation" method of accounting. Yarnell, Michener, and Hammond estimate by this method that it would cost $8.84 per patient encounter to collect and organize manually the data that TMR can do for $1.78. They might have overestimated the value placed on these benefits, but I suspect the bottom line is that computer record systems can, once they are up and running, save money primarily through improved communications.

Computerized record systems have been described as an orphan technology[3]; i.e., although there are important benefits, if their development and implementation are left entirely to the private sector, there is little hope of receiving enough financial return to justify the needed investment. I doubt this situation will continue for three reasons. First, the Institute of Medicine[18] and other professional groups have issued reports that will help define a standard vocabulary and record structure. A standard that allows hardware and software products of different manufacturers to function together is essential to wider adoption of computer record systems. Second, the software

has been developed and the hardware is now inexpensive. Future users do not have to pay for the high development costs. In addition to TMR there are at least another five to ten well-tested medical record systems available for purchase. Most, if not all, will work on today's microcomputers. Many have paid a lot of attention to easy data entry, but none yet offers voice recognition technology. Direct entry by physician remains a difficult challenge. Third, medical practice is changing, and these changes are leading to larger groups, to structured decision making, and to increasing competition based on cost and quality. Those with an information-intensive infrastructure are much more likely to succeed. Will TMR give Duke Family Medicine Center a competitive advantage in the managed care marketplace? I hope so. And if so, will managed competition finally spur the widespread adoption of computerized record systems? If this occurs, it will be another proof of Fink's law that four times out of five, the right things happen for the wrong reason (personal communication Donald L. Fink, MD, June 1989).

Jonathan E. Rodnick, MD
San Francisco, CA

References

1. Whiting-O'Keefe QE, Whiting A, Henke J. The STOR clinical information system. MD Comput 1988; 5:8-21.
2. 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.
3. Schoenbaum SC, Barnett GO. Automated ambulatory medical record systems. An orphan technology. Int J Technol Assess Health Care 1992; 8:598-609.
4. Stead WW, Hammond WE. Computer-based medical records: the centerpiece of TMR. MD Comput 1988; 5:48-62.
5. Yarnall KS, Michener JL, Hammond WE. TMR: a comprehensive computer system for the family physician. J Am Board Fam Pract 1994; 7:324-34.
6. Rodnick JE. Should the complete medical record be computerized in family practice? An opposing view. J Fam Pract 1990; 30:460-4.
7. Carey TS, Thomas D, Woolsey A, Proctor R, Philbeck M, Bowen G, et al. Half a loaf is better than waiting for the bakery truck. A computerized mini-record for outpatient care. Arch Intern Med 1992; 152:1845-9.
8. Benson DS, Reimlinger G. Electronic medical records in the ambulatory setting: the quality edge. J Ambulatory Care Manage 1991; 14:78-87.
9. McPhee SJ, Bird JA, Fordham D, Rodnick JE, Osborn EH. Promoting cancer prevention activities by primary care physicians. JAMA 1991; 266:538-44.
10. Tape TG, Campbell JR. Computerized medical records and preventive health care: success depends on many factors. Am J Med 1993; 94:619-25.
11. Garr DR, Ornstein SM, Jenkins RG, Zemp LD. The effect of routine use of computer-generated preventive reminders in a clinical practice. Am J Prev Med 1993; 9:55-61.
12. Ornstein SM, Garr DR, Jenkins RG. A comprehensive microcomputer-based medical record system with sophisticated preventive features for the family physician. J Am Board Fam Pract 1993; 6:55-60.
13. Frame PS. Can computerized reminder systems have an impact on preventive services in practice? J Gen Intern Med 1990; 5(Suppl):S112-5.
14. Chessare JB, Torok KW. Implementation of COSTAR in an academic group practice of general pediatrics. MD Comput 1993; 10:23-7.
15. Dambro WR, Weiss BD, McClure CL, Vuturo AF. An unsuccessful experience with computerized medical records in an academic medical center. J Med Educ 1988; 63:617-23.
16. Payne TH, Murphy G, Wagner EH. The ambulatory medical record project at Group Health Cooperative. What did a decade of experience teach us? J Ambulatory Care Manage 1992; 15(3):44-54.
17. Tierney WM, Miller NE, McDonald CJ. The effect on test ordering of informing physicians of the charges for outpatient diagnostic tests. N Engl J Med 1990; 322:1499-504.
18. Dick RS, Steen EB, editors. The computer-based patient record: an essential technology for health care. Committee on Improving the Patient Record, Division of Health Care Services, Institute of Medicine. Washington, DC: National Academy Press, 1991.

Rates, Panels, And Health System Reform

Family physicians have always been experts in collecting information about the kinds of patients and types of diseases seen in practice, but without knowing the underlying size and composition of the practice (a "denominator"), useful applications of these data have been limited. Assum-

Submitted, revised, 9 May 1994.

From Group Health Cooperative of Puget Sound and the Department of Family Medicine, University of Washington, Seattle. Address reprint requests to Stephen L. Tarnoff, MD, Group Health Cooperative of Puget Sound, 200 15th Avenue E, Seattle, WA 98112.