The Computer-Based Medical Record: Current Status

Steven M. Ornstein, MD; Randall B. Oates, MD; and Gary N. Fox, MD
Charleston, South Carolina; Little Rock, Arkansas; and Reading, Pennsylvania

At the turn of the century, neither hospitals nor physicians routinely kept clinical records. Since then, the medical record has gradually evolved. More recently, as society and medicine have become more complex and sophisticated, inadequacies of the paper medical record have become increasingly apparent. The computer-based medical record addresses many of the deficiencies of the paper record. Meanwhile, barriers to computer-based records have decreased; hardware has become more affordable, powerful, and compact, and software has been refined.

Socially, the major payers for health care are demanding verification of the effectiveness and quality of care, information that involves data-intensive research. The electronic medical record promises to improve quality of care by providing point-of-care reminder and decision support tools as well as a database for substantiating the effectiveness of care. In conjunction with the growing integration of computers into all facets of life, government agencies, computer giants, and medical organizations are currently laying the groundwork for the development of standardized elements and formats for computer-based medical information systems.

As part of the continuing evolution of the medical record, we foresee these forces culminating in the computerization of the clinical record. In this review, we briefly describe the developments that led us to this conclusion and describe computer-based clinical record systems in use in two family practice settings.

Key words. Medical record systems, computerized; software; computers; medical records; information systems. *J Fam Pract 1992; 35:556-565.*

A new patient, a 26-year-old woman, arrives for her appointment. Her complete medical history is instantly available to the physician through her medical card. This information is copied at electronic speed to a computer-based patient record. Viewing her summary screen, the physician confirms her history of well-controlled asthma and notes the medications she is currently taking (theophylline, beta-agonist inhaler). The patient states that during the past 48 hours she has developed a productive cough and fever. After examination, the physician suspects pneumonia. While conversing, the physician momentarily forgets the patient's penicillin sensitivity and types "amo" (the first three letters of amoxicillin) on the prescription line; choices, including default doses, are presented for amoxapine and for amoxicillin. Choosing amoxicillin produces a warning about the patient's penicillin sensitivity. Consecutive choices of erythromycin and a quinolone both produce warnings about interactions with theophylline; an option allows immediate review of information about the interactions. When an antibiotic is chosen, the medication list and the "plan" section of the progress note are automatically updated, a prescription is printed, and the patient's personal medical card is updated. The physician presses the "close encounter" key; a final screen reminds the physician that neither a peak expiratory flow rate nor an oximetry value was entered and that the patient's Pap smear and 10-year diphtheria-tetanus booster are due. When she checks out at the reception desk, a medication information sheet, pneumonia information sheet, and health maintenance reminder sheet (which the physician generated by clicking a couple of keys before closing her file) are presented to the patient for reinforcement of her discussion with the physician.

Unlikely? In this communication, we explore some of the indicators that suggest otherwise. Two users of electronic medical records, one an academic family physician (S.M.O.) and the other a family physician in private practice (R.B.O.), present their experiences with electronic record systems.

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From the Department of Family Medicine, Medical University of South Carolina, Charleston (S.M.O.); the University of Arkansas for Medical Sciences, Little Rock (R.B.O.); and the Department of Family and Community Medicine, Reading Hospital and Medical Center, Pennsylvania (G.N.F.). Requests for reprints should be addressed to Steven M. Ornstein, MD, Department of Family Medicine, Medical University of South Carolina, 171 Ashley Ave, Charleston, SC 29425-5820.

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Evolution of the Medical Record

In the early 1900s, even as medical data were becoming more quantitative, clinical records were primarily stored

in physicians' memories. Recognizing the inadequacy of this method and the importance of accurate patient information, the clinical record was a major focus of the hospital reform program initiated by the American College of Surgeons (ACS) in 1914. The proposal: hospitals should be required to maintain patient records.

In hospitals where records did exist, the standard practice was to maintain a chronological record in which medical notes on all patients were intermixed in a bound volume. The single-patient or "unit" record, introduced in 1907, faced many barriers. "Although the unit record was limited by requirements for additional personnel and expenses, as well as by the inertia of established procedure among staff, in those institutions where it was adopted, the unit record had many beneficial effects . . . . As one clinician observed in 1918, 'Only those who have used the antiquated . . . histories and later studied the unit histories in follow-up work can appreciate the advantages of the system.' "[1]

The objective of the next major change in medical records is not simply to computerize current records, but to develop an integrated *clinical information system* that facilitates management of multiple, complex patient problems for a lengthy interval.

Societal Forces That Increase the Likelihood of Computer-Based Medical Records

The National Academy of Sciences (NAS) was chartered by Congress to advise the government on scientific issues. The Institute of Medicine (IOM) was chartered to assist NAS with medical issues. In 1991, the IOM Committee on Improving the Patient Record published a report, *The Computer-Based Patient Record: An Essential Technology for Health Care*.[2] The committee's report "advocates the prompt development and implementation of computer-based patient records (CPRs). Put simply, [this] committee believes that CPRs and CPR systems have a unique potential to improve the care of both individual patients and populations and, concurrently, to reduce waste through continuous quality improvement."[2(p1)]

The report highlighted a number of specific problems with paper records that were remediable with electronic records. The current medical record is insufficient in content, format, accuracy, and accessibility to allow determination of health care effectiveness and outcomes. Because health expenditures comprise about 13% of the gross national product, lack of appropriate information will soon be unacceptable. Integration and transfer of information between providers and between inpatient and outpatient records is inefficient but increasingly crucial because of the aging (which results in increasing complexity and acuity of illness) and mobility of the population.

Other factors suggest benefits from a clinical information system that uses data from an individual's record as one of its sources of input. The practice of medicine is information-intensive, with 35% to 50% of time and costs being information- and communication-related.[2(p19)] There are increasing types and amounts of information to manage. Clinical knowledge and diagnostic and therapeutic options have increased substantially. At the time of the patient encounter, 70% of the physician's information needs may be unmet.[2(p20)] Through appropriate information linkages, the electronic record serves not only as a passive repository of information, but also as a key that unlocks advice about optimizing evaluation of abnormalities, produces reminders, flags drug-drug, drug-symptom, and disease-drug interactions, and so on.

Such systems will offer physicians timely, accurate, up-to-date, and unbiased information to use in decision making during clinical encounters, as well as providing reminders and alerts. Theoretically, this should increase the effectiveness of medical care and reduce errors of omission and commission. It may also increase the quantity of medical care delivered (increased units of service) by generating reminders for health maintenance, laboratory monitoring of diseases, and adverse drug reactions. Theoretically, the speed, accuracy, and completeness of documentation should be improved, especially as documentation requirements increase. Therefore, computer-based records may improve efficiency by reducing repetitive tasks and by decreasing the time required to locate and record information, and to determine what to do and how to do it. Because of increases in services per patient, increased efficiency may not result in reduced time per encounter.

Obstacles to Implementation of the Computer-Based Medical Record

Obstacles to computerization of the medical record include "the human interface—the place where man and machine meet,"[2(p82)] costs, logistical concerns (such as diffusion of the technology), the element of human resistance to substantial change, legal issues, and lack of consensus on the format, content, and function of computer-based systems.[2(pp94–107),3] These concerns must be addressed during the development and implementation of computer-based systems; but we suggest, as have

others,[4,5] that such concerns will become increasingly insufficient to justify continued use of paper-based records. In fact, computers have become accepted tools. For example, the federal government has established central databases to track physician-specific malpractice and hospital-specific mortality experiences[6]; the Health Care Financing Administration (HCFA) has all but ordered nursing homes to computerize a uniform minimum data set.[7]

Addressing barriers individually, computer hardware costs have declined dramatically. Software costs may now exceed hardware costs, particularly when support, periodic upgrades, and personnel training are included. With more dependable equipment and inclusion of systems to protect against data loss, loss of patient records is probably less likely with computerized records than with paper ones. Rarely are paper records duplicated for "backup" storage at a remote site, whereas this procedure is common with computerized files. Periods when computer-stored data are inaccessible ("downtime") still occur but, like other common electronic equipment (stereos, televisions), downtime is no longer a frequent problem; it may be a less frequent occurrence than unlocatable paper charts.

To address the human-computer interface concern, the computer industry has been actively developing less formidable interfaces, such as pen-based systems that "learn" to understand one's handwriting; voice-interface systems that "learn" users' voices; and touch-screen and pointer-driven ("mouse") systems. Although still evolving, prototypes of all of these systems are currently available commercially. In addition to these hardware-based devices, software developers have also attempted to make programs easier to learn and use.

Even a complete system with acceptable interfaces confronts obstacles to technology diffusion. Characteristics that influence diffusion of new technology include the technology's relative advantages; its complexity; its compatibility with current values, experiences, and needs; its feasibility; and its visibility.[2(p98)] Support by "change agents," such as governmental agencies (eg, HCFA) and medical organizations (eg, the Joint Commission on Accreditation of Healthcare Organizations [JCAHO]),[2(p108)] and the opportunity to experiment with the technology accelerate diffusion.[2(p98)] The rapidity of change and the amount of external pressure brought to bear may also influence resistance.

User Experience

In each of the two following sections, a family physician describes his experience with a medical record software program in actual use for patient care.

Practice Partner Patient Records

Steven M. Ornstein, MD

Since April 1991, the Department of Family Medicine at the Medical University of South Carolina (DFM) has used the *Practice Partner Patient Records* software developed and marketed by Physician Micro Systems, Inc. (PMSI).[8] The reasons for selecting this system, its basic features, and a specific application of the system in the area of preventive services are described below.

Selection of the System

In 1972, the DFM developed one of the first computerized medical record systems in the United States.[9] The DFM maintained this system through April 1991 on several generations of mini-computers with on-site programmers. By the late 1980s, maintenance of a homegrown, single-site system was no longer economically viable. In addition, more sophisticated and less expensive commercial systems were becoming available. In 1990, a search was conducted for a replacement computer system for the department.

The contract was awarded to PMSI because it is a stable software company whose system is microcomputer-based and relatively economical, incorporates all the important features of a fully automated medical record, has easy-to-use data query capabilities, and possesses a sophisticated preventive service's tracking and reminder system (essential for the department's research endeavors). The clinical functions were already available, not planned as in other proposals. Also, PSMI provided additional services, such as offering its system at a reasonable cost to graduating residents for use in their practices, and integrating its system with other systems on campus.

In April 1991, the department entered existing patient data into the PMSI system and went online. Each physician, nurse, and staff member had a 2- to 4-hour introductory group training session. This training was sufficient to begin use of the system. As with all software, as use increased, familiarity and facility with the software increased. After a brief transition period during which both paper and computer records were used, the department adopted a predominantly paperless medical record system.

System Features

The basic system runs on a Novell network, with two IBM-compatible file servers, which have 33 MHz 80386 microprocessors. Data are stored on mirrored 1.2

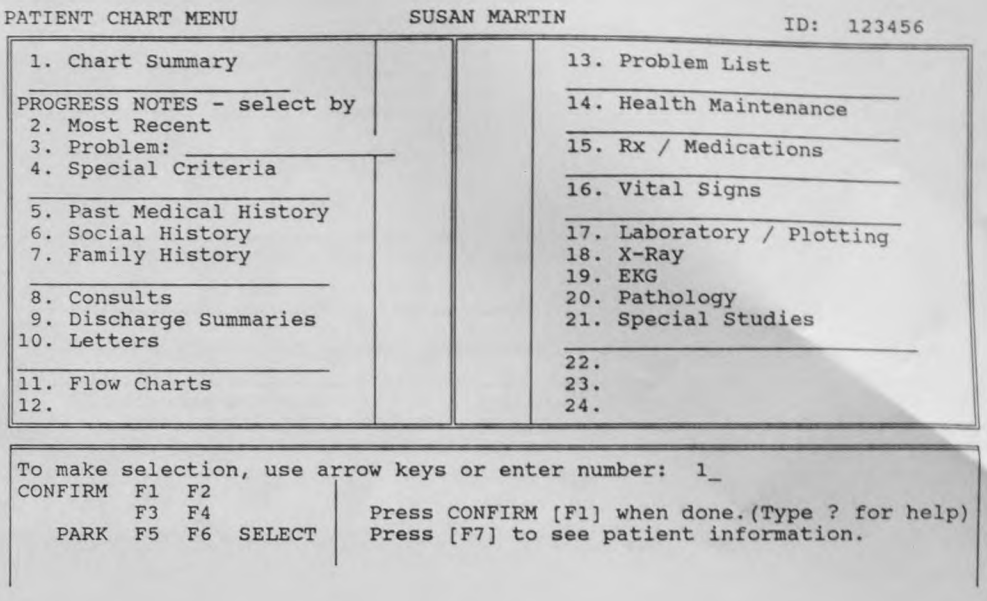

Figure 1. The Patient Chart Menu as it appears on the *Practice Partner Patient Records* software (Physician Micro Systems, Inc).

gigabyte external hard drives with an associated 2.5 gigabyte tape backup system for daily backup and archival storage. Sixty IBM-compatible workstations are connected to the network; most workstations have 80286 microprocessors, although some have 80386SX or 80386 microprocessors. Workstations are located throughout the department with one in each examination room, at nursing stations, in administrative areas, and in many faculty and staff offices. Remote access to the network is available by modem, for vendor support, operator support from home, and access to the clinical database by physicians working in the emergency department or within the hospital, or by physicians on call at home.

In addition to the PMSI *Patient Records* and related *Medical Writer* transcription software described in this paper, the network includes PMSI's *Appointment Scheduler*, which is fully integrated with the *Patient Records* software. PMSI also markets a billing package, which the department did not purchase, as its billing is done by an outside organization. Unrelated software on the network includes word processing, electronic mail, and communications software. Each software option is selected from a menu, which is displayed when a user with a valid identification number logs into the system.

Patient Records can also be used as a stand-alone system, with printed copy provided for a traditional paper chart if desired. Although the hardware and software costs for a network can be considerable, the cost of the basic *Patient Records* software for a single user is less than $2000.

Patient Records

The *Patient Records* software contains five major sections: the patient chart, data entry and loading, system utilities, print options, and patient inquiry and data export. Options and subsequent suboptions are selected from a user-friendly menu system. In this review, emphasis will be placed on the patient chart, which contains the functions most relevant for the clinician.

PATIENT CHART

The Patient Chart (Figure 1) is designed to model a traditional paper chart. It is divided into the following sections:

Chart Summary. This screen (although the term "screen" is used, users who prefer may print a paper copy) displays the patient's most recent visit titles, major problems, allergies, and health maintenance services needed (Figure 2). "Hot keys" allow quick access to vital signs, laboratory data, progress notes, and medications. These sections will be described in more detail below.

Progress Notes. Three sections permit display of progress notes. Notes are displayed in order, beginning with the most recent note. All notes, notes for individual problems, or notes by date range, problem, or text pattern can be displayed. For example, one could search for all notes for the problem "hypertension" or all notes that contain the word "cough."

Problem List. This section provides two tables: Major Problems and Other Problems. Space is provided for a diagnosis, eg, "hypertension"; a note or description of

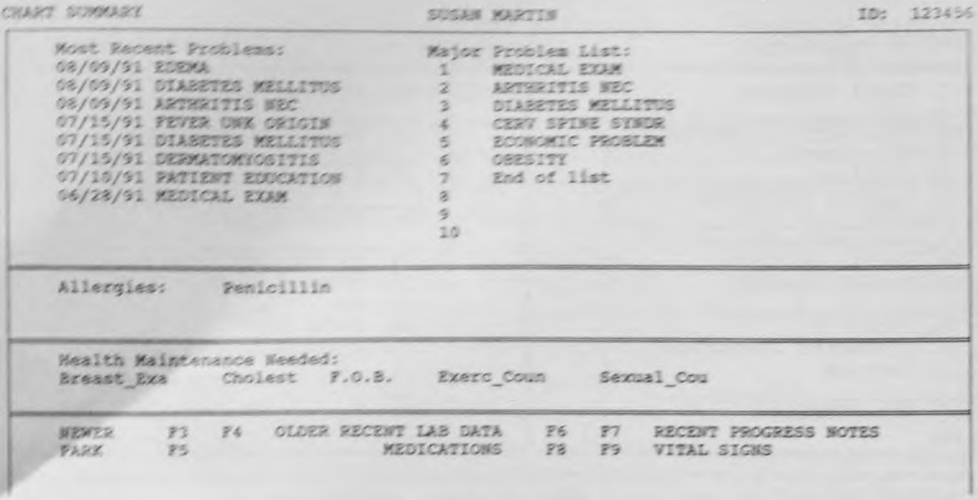

Figure 2. The Chart Summary for the first section accessed on the Patient Chart Menu.

the diagnosis, eg, "labile hypertension"; and two diagnostic codes.

Health Maintenance. The health maintenance section displays a chart of preventive services with the dates on which they have been performed. Services that are past due are highlighted. Initial age and sex-specific health maintenance templates are set up by the user for all patients; however, templates can be easily customized for individual patients. For example, one can delete a recommendation for Papanicolaou smears in a woman who has had a hysterectomy or add one for colonoscopy for a patient who has ulcerative colitis.

Rx/Medications. This section provides lists of medications, both current and historical. It also allows for entry and printing of prescriptions and medication lists for patients. Common prescriptions can be written with a few keystrokes, using templates that are easily created. A future version of the software will permit real-time drug-interaction testing and provide printed drug-information sheets.

Laboratory. This section provides for tabular or graphical display of laboratory data. Abnormal data are highlighted. Additional space is provided for text reports, such as Papanicolaou smears.

Vital Signs. This area provides for the tabular display of vital signs.

Flow Charts. This section permits the design and display of disease-specific flow sheets. For example, a flow chart for diabetes mellitus could be created that would readily display a patient's trends over time in weight, blood pressure, glucose, blood urea nitrogen, creatinine, and urinary protein.

Text Areas. A number of sections are available for the display of text. Although these can be customized by the user, the defaults are for: Past Medical History, Social History, Family History, Consults, Letters, Discharge Summaries, X-Ray, EKG, Pathology, and Special Studies. A future version of the software will permit the graphical display of electrocardiograms and radiographs.

DATA ENTRY AND LOADING

Data entry to *Patient Records* is accomplished in two ways: by direct keypunch and through automated loading. Direct keypunch can be performed in all data areas of the chart. A consistent pattern of keystrokes facilitates learning of data input. Automated loading of data can be done both directly from standard ASCII text files and from PMSI's *Medical Writer*, a medical transcription software package integrated with *Patient Records*.

Medical Writer is a full-featured word processor with an extensive medical dictionary. A nice feature of *Medical Writer* is that it permits the development of standard "fill in the blank" visit note templates for individual diagnoses. These templates can dramatically shorten transcription time and may serve an educational role in teaching settings. Currently, the user must develop these templates; a future version of the software will provide more than 100 prewritten templates. When data are loaded from *Medical Writer* to *Patient Records*, all relevant sections of the chart are updated, such as problem lists, vital signs, and health maintenance data, in addition to progress notes.

ASCII text files can also be loaded into *Patient Records*. This function allows the automated input of data from an outside clinical laboratory. It also permits the entry of text data from outside sources (eg, consultation letters) through an optical scanner.

OTHER FUNCTIONS

System utilities allow the development of templates for prescriptions, social history, past history, laboratory, and

health maintenance, and allow system configuration and file maintenance. Print options allow users to maintain a paper chart, or to send copies of the record to other physicians, attorneys, or insurance companies. The entire chart, a chart summary, or particular chart sections for one or more patients may be printed.

PATIENT INQUIRY AND DATA EXPORT

Patient Records possesses a sophisticated inquiry function that allows searches of the patient database based on numerous demographic and clinical variables. For example, the database can be searched for all patients who are on the medication Captopril and have a visit note with the word "cough." Once the patients who fulfill the search criteria have been identified, the system can print a list of patient names, generate a mail merge file for use in a word processor, or create a text file. Lists or mail merge files are useful for sending patient letters. The text file can be imported by standard database or statistical packages to generate reports or for research projects.

PREVENTIVE SERVICES APPLICATION

An example of how *Patient Records* is used in a combined clinical and research endeavor illustrates the power of a computerized medical record. We use *Patient Records* to track and provide physician and patient reminders for 29 basic screening, immunization, and counseling recommendations of the US Preventive Services Task Force.[10]

Provider reminders for overdue preventive services and a list of relevant patient education materials are provided at the time of each patient visit through the Chart Summary (Figure 2) and Health Maintenance screens. Nurses respond to certain reminders (height, weight, blood pressure) and are encouraged to request physician authorization for other services (immunizations). Physicians respond to the prompts for counseling and screening services. Patient reminder letters are generated by the inquiry function and sent annually, just before each patient's birthday.

Means of data entry used to update preventive services depend on the service. Vital sign and immunization data are updated by nurses at the time of completion. Laboratory data are updated automatically when a laboratory result is loaded into the computer. Screening or counseling provided by physicians may be entered directly by the physician or through dictation.

The research component of this program involves the study of the efficacy of computerized preventive services reminder systems, including patient and physician perspectives on the system.[11]

MEDMOS
Randall B. Oates, MD

System Evolution

It has been said, "Physicians today are faced with 'data overload' and, paradoxically, 'information underload'—the inability to locate pertinent, needed knowledge in a sea of data with which they are inundated."[12] Beginning with residency, the need to manage information efficiently and the potential contribution of computers (eg, computerized *MEDLINE* searching[13,14] and word processing) were evident. The complex user interface of early computers systems, however, often presented a barrier for physicians.

With a busy private practice, I was faced with the spiraling demand for documentation and the inefficiency of repetitious paperwork. I searched—unsuccessfully—for practical computer solutions to improve efficiency. There was a void: few physicians seemed to possess adequate programming skills, and few programmers had insight into the complex environment of primary care.

Then in 1987, *Hypercard* for the Macintosh was introduced. *Hypercard* was designed to facilitate software creation by nonprogrammers. With time, I began using *Hypercard* applications more and word processing less. By 1990, several *Hypercard* modules had evolved within my basic SOAP note, such as modules for prescription writing, generation of patient education materials, and preformatted histories and physical examinations. A database for storage and retrieval of past office visit records was then developed.

As it became apparent that these *Hypercard* modules formed the core of a "user-friendly" computerized medical record system, a more formal approach was initiated. Important design features were specified, including easy and rapid operation without repetitious entry of information. Another focus was linking utilities directly to the medical record, such as linking patient information handouts to diagnoses and prescriptions, and linking differential diagnosis programs to historical and physical findings. As links increased, the program became *MEDMOS*, for the "cosmos" of medical information linking.

Recognizing current practice, and attempting to be evolutionary rather than revolutionary, *MEDMOS* modules have been designed to complement rather than replace paper charts. In general, information is printed and stored in a traditional paper record. Physician training and memorization are minimized by providing on-screen selections for the next action; choices are made by short verbal commands or keystroke commands or mouse clicks.

MEDMOS has continued to evolve. For example,

was released. "Palmtop" computers now exceed the power of the original PC. Advances continue, such as: (1) in data storage, where 3.5-in. optical ("floptical") disks (128 MB) and 5-in. compact disks (600 MB) may provide inexpensive storage of encyclopedic amounts of information[23]; and (2) in user-friendly input options, such as voice recognition[24,25] (including the potential for computer-transcribed dictation, touch screens, and pen-based systems), as well as in systems that allow documents (eg, electrocardiograms) to be "read" into the computer. (Ultimately, these documents would be produced and handled electronically; scanning would assist in transition to electronic records.) Considering the pace of progress, it is likely that the current decade will be one of additional uses and penetration of technologies into additional arenas, such as clinical practice.

The ability to store large quantities of data in a small space may influence medical care substantially, specifically by allowing the option of a lifetime personal medical record. One possibility for this medical record is the "PC-card." These cards, the size of credit cards, theoretically allow 64 MB of fast, electronic, read-write data storage (current releases possess only 12 MB). PC-card slots may soon be common on new PCs.[26] Currently, "the first generation of magnetic-stripe health cards are already being introduced for the entire populations of Portugal, Spain, West Germany. . . . These cards . . . operate rather like medical credit cards."[27] However, trials with "smart cards" containing clinical information are also underway,[27,28] with 40 trials in France alone.[29] In Britain, the "NHS [National Health Service] strategy is to . . . link . . . the Central NHS Register, The Prescription Pricing Authority, . . . family doctors, dentists, pharmacists, and opticians. . . . In 1987, the Department of Health instituted a pilot project to investigate the use of a patient-portable computerized medical record using a Smart Card."[30] Among the elements in this trial, pharmacists fill prescriptions, produce labels, and mark the prescription as filled (the first step in checking compliance) with the electronic card.

We have described two systems currently in use: one thought of by its author as a transitional system with production of paper output (*MEDMOS*), and one that can be used either to produce a paper medical record or as a paperless record (*Practice Partner Patient Records*). We anticipate that the transition to computer-based records will be evolutionary in most medical practices. Initially, we believe that computer-generated records will be used primarily to decrease duplication and to facilitate documentation and transmittal of information. We anticipate that most physicians initially will choose to print notes for a concurrent paper file. Eventually, however, we foresee the paper record sharing the fate of the chronological record of the early 1900s.

During the transition period to computer-based medical records, physicians' initial expectations for themselves and for technology should be realistic. Analogous to other electronic technologies that have become familiar during the 1980s, such as videocassette recorders (VCRs) and microwave ovens, a new user does not need to be familiar with every use or feature initially or, in fact, ever.

We recognize the current difficulty faced by physicians interested in ongoing and reliable information about computer-based medical records systems as these systems evolve. Physicians may obtain some information about medical software from several sources including *MD Computing*'s annual product guide,[31] vendors of medical computer systems, software demonstration diskettes, site visits to practices with installed systems, and exhibits at scientific meetings. We hope that as major developments occur and as experience increases, journals and medical organizations will be of assistance.

Electronic medical records will require an increment in overhead for their initiation and maintenance. This expense must be recognized and must be supported by all who will benefit—payers, government, patients, physicians, and others—to assure successful implementation of patient record–based electronic clinical information systems.[32-34]

During the last decade, several major changes have occurred relatively quickly, such as inpatient diagnosis-related group reimbursement and outpatient relative value scales. Sometime within the current decade, the same may happen with computer-based medical records. We believe that it is important for us (primary care physicians) to urge our organizations to actively represent our interests during the development of computer-based records and to keep us informed about major events. Currently, such an event is the formation of the Computerized Patient Record Institute, whose mission is to promote universal computerized records by the end of the decade. This organization, currently being formed, could be heavily influenced by the federal government (eg, Health Care Financing Administration [HCFA], Agency on Health Care Policy and Research [AHCPR]), computer companies, and medical specialty societies, without representation from family practice.

In summary, we believe that, technologically, current hardware allows affordable and efficient electronic storage, retrieval, manipulation, and transmission of clinical information. Based on current software status, described in this report, we believe that efficient and usable software exists today. Newer versions of current software are scheduled, which will incorporate additional features

and, it is hoped, will incorporate technologic advances and features to further increase ease of learning and use. Additionally, new products may appear as standards are defined and demand increases. Based on the dramatic computer systems advances in the 1980s and considering current technologic feasibility and social pressures, mandated or essentially mandated use of electronic records may occur sooner than many physicians anticipate.

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