The Electronic Medical Record: Promises and Problems

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Despite the growth of computer technology in medicine, most medical encounters are still documented on paper medical records. The electronic medical record has numerous documented benefits, yet its use is still sparse. This article describes the state of electronic medical records, their advantage over existing paper records, the problems impeding their implementation, and concerns over their security and confidentiality.

As noted in the introduction to this issue, the provision of medical care is an information-intensive activity. Yet in an era when most commercial transactions are automated for reasons of efficiency and accuracy, it is somewhat ironic that most recording of medical events is still done on paper. Despite a wealth of evidence that the electronic medical record (EMR) can save time and cost as well as lead to improved clinical outcomes and data security, most patient-related information is still recorded manually. This article describes efforts to computerize the medical record.

Purpose of the Medical Record

The major goal of the medical record is to serve as a repository of the clinician's observations and analysis of the patient. Any clinician's recorded interactions with a patient usually begin with the history and physical examination. The history typically contains the patient's chief complaint (i.e., chest pain, skin rash), history of the present illness (other pertinent symptoms related to the chief complaint), past medical history, social history, family history, and review of systems (other symptoms unrelated to the present illness). The physical examination contains an inventory of physical findings, such as abdominal tenderness or an enlarged lymph node. The history and physical are usually followed by an assessment which usually adheres to the problem-oriented approach advocated by Weed (1969), with each problem analyzed and given a plan for diagnosis and/or treatment. Subsequent records by the clinician are usually in the form of progress notes, which are written for each encounter with the patient, whether done daily in the hospital setting or intermittently as an outpatient. Interspersed among the records of one clinician are those of other clinicians, such as consultants and covering colleagues, as well as test results (i.e., laboratory or x-ray reports) and administrative data.

These various components of the records are often maintained in different locations. For example, each physician's private office is likely to contain its own records of notes and test results ordered from that office. Likewise, all of a patient's hospital records are likely to be kept in a chart at the hospital(s) where care is rendered. Only at large health centers, where both hospital and ambulatory care is provided (i.e., public or university hospitals), will the complete medical record for a patient exist in one location—and perhaps not even there.

The medical record serves a number of other purposes. For example, it is used to provide documentation that a patient was seen or a test was performed in order that the clinician can obtain reimbursement by an insurance company or government agency. It is also used as a medium of communication among different clinicians as well as ancillary professionals (i.e., nurses, physical therapists, and respiratory therapists) who see the patient. In addition, the medical record serves as a legal record in the event of claims due to malpractice or occupational injury. Finally, it also is used to abstract data for medical research.

In recent years, the medical record has taken on new purposes. With the growing concern over the cost and quality of medical care, it serves as the basis for quality assurance by health care organizations, insurance companies and other payors, and the federal government. This activity has taken on increasing importance with the growth of managed care, which requires that clinical decisions be scientifically justified as well as cost-effective. Another more recent area of use has been in decision support, where clinicians are reminded about the efficacy of or need for tests, or are warned about potential drug interactions. All of these newer purposes are greatly enhanced by the EMR.

The Paper-Based Medical Record

Despite the documented benefits of the EMR, most clinical encounters are still recorded by hand in a paper record. This is not without reason. Dick and Steen (1991) note that the traditional paper record is still used due to its familiarity to users, portability, ease of recording "soft" or "subjective" findings, and its browsability for non-complex patients. There is also a sense of ownership of paper records, due to their being only one copy, which increases the sense of their security (although it will be noted below that this may be a false sense of security).

Nonetheless, there are many problems with paper-based medical records. The first is that the record can only be used in one place at one time. This is a problem for patients with complex medical problems, who interact with numerous specialists, nurses, physical therapists, etc. Another problem is that paper records can be very disorganized. Not only can they be fragmented across different physician offices and hospitals, as noted above, but the record at each location itself can often be disorganized, with little overall summary. In most paper records, pages are added to the record as they are generated chronologically, making the viewing of summarized data over time quite difficult.

Another problem with the paper record is incompleteness. In an analysis of U.S. Army outpatient clinics, Tufo and Speidel (1971) found as many as 20% of charts had missing information, such as laboratory data and radiology reports, a finding consistent with more recent observations (Korpman & Lincoln, 1988; Romm & Putnam, 1981).

A final problem with the paper-based record is security and confidentiality. Although usually ascribed as a problem of the EMR, there are attributes of the paper record that increase its vulnerability to access by non-privileged outsiders. Its difficulty in duplication leads to a great deal of photocopying and faxing among providers and institutions. Furthermore, abstractions of the paper record are stored in large databases, such as those of the Medical Information Bureau, which are maintained by health insurance companies to prevent fraud but contain medical information of more than 12 million Americans (Rothfeder, 1992).

Additional Challenges for the New Health Care Era

The problems of the paper-based record listed above are magnified in this new era of health care fueled by managed care. Managed care systems, typified by health maintenance organizations (HMO's), act as both health care insurer and provider. The traditional indemnity insurer operates in a fee-for-service environment where the providers are reimbursed based on charges billed. The managed care organization, on the other hand, is provided a fixed fee per patient, which gives it the incentive to keep patients healthy and provide care cost-effectively. The benefits and drawbacks of managed care are beyond the scope of this article, but suffice it to say that managed care will play an increasingly larger role in the provision of American health care, and successful managed care organizations require cost efficiency, which in turn requires effective management of information.

There are many areas where improved information management can aid managed care organizations. For example, because many of these organizations provide comprehensive health care for their subscribers, they need effective communication between different providers, ancillary staff, and/or hospitals. Likewise, they need to determine whether those groups are providing cost-effective care and not ordering excessive laboratory tests, x-rays, etc. Finally, these organizations often try to control the use of expensive medications and substitute their use with cheaper but equally effective ones.

Even outside the context of managed care, the efficiencies in communication and cost will be desired by society in general as the cost of health care continues to consume larger proportions of the gross domestic product. All payors, even traditional fee-for-service insurance companies, are beginning to require it.

Implementations of the Electronic Medical Record

Although the complete EMR does not currently exist, portions of the medical record have been computerized for many years. The most heavily computerized aspects are the administrative and financial portions. On the clinical side, the most common computerized function has been the reporting of laboratory results, usually made easier with the installation of automated equipment for laboratory specimen testing. As more information recording functions become computerized (i.e., clinician dictations transcribed into word processing systems), increasing proportions of the record are computerized as well.

Dick and Steen note that all comprehensive EMR's share several common traits (Dick & Steen, 1991). First, they all contain large data dictionaries that define their contents. Second, all data are stamped with time and date so that the record becomes a permanent chronological history of the patient's care. Third, the systems have the capability to display data in flexible ways, such as flowsheets and graphical views. Finally, they have a query tool for research and other purposes.

A number of successful EMR implementations have been in place for decades. One of the earliest ambulatory care record systems was COSTAR (Computer-Stored Ambulatory Record), developed at Massachusetts General Hospital in Boston (Barnett et al., 1979). It allows patient registration and scheduling, storage and retrieval of clinical data, and financial capabilities such as billing. The core COSTAR system is in the public domain so that other vendors and institutions can modify and enhance it. Another well-known ambulatory system is the Regenstrief Medical Record System at Indiana University (McDonald, Blevins, Tierney, & Martin, 1988), which implements similar functions but is also well-known for its capacity for physician decision support (see below).

There have also been a number of long-standing EMR systems for hospitals. The HELP (Health Evaluation through Logical Processing) system was developed at the University of Utah and Latter-Day Saints (LDS) Hospital in Salt Lake City (Warner, Olmsted, & Rutherford, 1972). Similar to the Regenstrief system, it attempts to actively assist physician decision-making by providing alerts of potentially problematic situations and reminders for routine care.

Most of the above systems, as well as newer ones, have evolved with computer and network technology itself. Most systems initially consisted of dumb terminals connected to mainframes or minicomputers, but have since evolved into microcomputer-based networks embracing client-server architectures. Future technologies, such as voice recognition or pen-based input, will likely cause further evolution of these systems.

Benefits of the Electronic Medical Record

There are many potential benefits of the EMR. Unlike the paper record, it can potentially be used by anyone who needs it at any time. It can also be accessed easily from remote sites, such as a clinic across town or even across the country. It is unlikely that data will be lost or misplaced. With an appropriate back-up mechanism, it should serve as a permanent record of an individual's interaction with the health care system. Furthermore, with the availability of all the patient's data, new views and other summaries can be generated instantaneously. Finally, with the potential for the incorporation of reminders and decision support, the likelihood of mistakes and omissions should decrease.

In addition to benefiting the individual patient, the EMR is also likely to benefit the larger population. Clinical research will likely be enhanced, as researchers have easier access to information about patients that will increase understanding of disease and its treatment. Screening and other preventive measures will become easier to implement as patients of various attributes (i.e., gender, age, presence of other risk factors) can be identified and contacted.

A number of studies have documented some of the benefits of the EMR. The most comprehensive work in this area has come from Indiana University, where the Regenstrief computerized medical record system has been developed over the last two decades. An initial clinical focus of the system was on reminders for clinicians to perform various actions (such as ordering a test or prescribing as therapy) based on rules they had themselves generated. Examples included the recommendation to order a routine mammogram or check the serum potassium level of a patient on diuretic medication. A randomized controlled trial showed that physicians who were given these reminders were more likely to comply with these measures that had been deemed important by physicians themselves (McDonald, Hui, & Smith, 1984).

Most of the documented benefits of the EMR have emerged from settings where clinicians use the system highly interactively as opposed to a passive replacement for the paper record. This requires that clinicians use the system for order entry, where orders for tests and medications are entered directly by the clinician. In another study at Indiana University, Tierney, Miller, Overhage, & McDonald (1993) performed a randomized controlled trial of a complete order entry system that included innovations such as displaying the cost of the test or medication, showing a list of pending tests, and directly linking with an online drug reference manual. Those randomized to use the system were found to generate 12.7% less charges without compromise in patient care. Their patients also spent nearly one day less in the hospital. The authors estimated that implementing this system hospital-wide could save as much as $300,000.

Another site of studies documenting the benefits of the EMR has been Brigham and Women's Hospital (BWH) in Boston. Cost savings in several areas have been documented due to display of less expensive but equally efficacious alternatives. For example, the medication accounting for the largest cost of any single medication in this hospital is the drug odansetron, used to control nausea in cancer chemotherapy patients. By programming the order entry system to use as a default an equally effective but less costly dose, the hospital was able to save $100,000 over a one-year period (Bates, Kuperman, & Teich, 1994). The hospital is currently modifying its order entry system to remind physicians of tests ordered too frequently, such as a serum theophylline level ordered within 24 hours of a previous one (David W. Bates, personal communication).

An additional measure to save costs has been the use of algorithms to assist decision-making. While comprehensive expert systems such as QMR (Miller, Masarie, & Myers, 1986) are too time-consuming and complex for everyday use, focused decision support has been shown to be effective. At Brigham and Women's Hospital, an algorithm to determine the probability of chest pain being due to myocardial infarction (and hence assist with the decision to admit a patient to the hospital) has been shown to perform more accurately than physicians (Lee et al., 1991). This allows patients most likely to have myocardial infarction to be admitted to the intensive care unit, with those less likely being admitted to the regular hospital ward or being sent home.

A problem with studies of EMR systems, however, is that they tend to be site-specific (Dick & Steen, 1991). A successful EMR not only requires the proper technology, but also commitment from both health care institutions and providers. Therefore, the same computer system that is very successful in one institution may fail miserably in another. As a result, studies of EMR systems can be difficult to generalize from one institution to the next. Even within an institution, the EMR may be constantly changing as technology and the software itself evolve, making the results of a study of last year's system less meaningful.

Another problem in the assessment of the EMR is just what constitutes "benefit." Being a highly quantitative field, medicine is likely to require showing some numerical benefit, such as reduced cost or increased quantity or quality of life. It is difficult, however, to measure user satisfaction for something as complex as the medical record. Furthermore, given the complexity of factors that impact a patient's outcome from an interaction with the health care system, it is difficult to isolate variables, such as those related to the EMR, as the cause of beneficial or adverse outcomes (Rind, Davis, & Safran, 1995).

Problems for the Electronic Medical Record

A number of problems have been identified with the EMR, including increased provider time, computer down time, lack of standards, and threats to confidentiality. Studies at the institutions described above (Bates, Kuperman, & Teich, 1994; Tierney et al., 1993) have shown that electronic order entry increases the amount of time physicians spend entering orders. In the study at BWH (Bates, Boyle, & Teich, 1994), residents required 44 more minutes per day using computerized order entry, although internal medicine residents using the order entry gained half of that time back in cost savings elsewhere. Furthermore, the overall rate of user satisfaction of the system was very high. Developing means to streamline order entry are now a priority.

Another concern with EMR systems is computer down time. Although the threat of not having access to the right piece of information at the right time is real, the increasing reliability of computer systems makes this less of a problem. At Oregon Health Sciences University, for example, the daily scheduled down time has been reduced over the last several years from 1 hour to 10 minutes (Jim Elert, personal communication). Most hospital computer systems and the databases that run on them are being designed for non-stop usage.

A more significant problem with EMR systems is the lack of standards to interchange information. While a number of standards exist to transmit pure data, such as diagnosis codes, test results, and billing information, there is still no consensus in areas such as patient signs and symptoms, radiology and other test interpretation, and procedure codes. Although some associate the National Library of Medicine's Unified Medical Language System (UMLS) with a comprehensive clinical vocabulary, its goal is much more modest, to serve just as a meta-thesaurus linking terms across different terminology systems (Lindberg, Humphreys, & McCray, 1993).

A related problem to standards is that a large proportion of clinical information is "locked" in the form of narrative text (Hripcsak et al., 1995). Although a number of systems have been successful in limited domains (Sager, Friedman, & Lyman, 1987), the technology for natural language processing (NLP) is still unable to interpret narrative text with the accuracy required for research and patient care applications. While NLP is difficult for well-written published medical documents, it is even harder for medical charts that contain poorly structured, highly elliptical language, with frequent misspellings to boot. Even if such language could be parsed, the lack of an underlying framework make its semantic interpretation more difficult (Evans, Cimino, Hersh, Huff, & Bell, 1994). Some have proposed to solve this problem with menu-driven data collection systems, but these have generally been successful only in limited areas, such as obstetric ultrasound (Bell & Greenes, 1994; Greenes, Barnett, Klein, Robbins, & Prior, 1970).

A final concern about the EMR is the problem of security and patient confidentiality. This problem, of course, exists independent of the EMR, as a great deal of medical information, abstracted from paper records, already exists in electronic repositories. Well-known privacy experts have documented the threats that misuse of this information has on personal privacy (Rothfeder, 1992). As noted above, the paper record is no barrier to duplication, as medical records are routinely copied and faxed among health care providers and insurance companies already. While some fear the EMR will exacerbate this problem, others note that computer-based records, with appropriate security, are potentially more secure and at a minimum leave a trail of documentation of those who access them.

Most medical centers already have security. Employees given access are usually required to sign a confidentiality statement indicating their understanding of the privacy of patient data. At most centers a password is required to enter the system, although some institutions also use a physical device, such as a key card. Virtually all systems also keep an audit trail of who accessed which patient and their data, providing a retrospective mechanism for discipline should breaches of security occur.

While there currently exists an array of technologies, including encryption and authentication, that could erect barriers between medical information and its unauthorized use, it must also be noted that there is a tradeoff, as every computer user knows, between security and ease-of-use. Since the pace of medical care in emergency settings as well as busy clinical areas can be hectic, providers may become frustrated with layers of security. As with the information field in general, policies and legislation will need to be implemented that make the EMR usable but protect the individual's privacy.

The Future of the Electronic Medical Record

With the increased incentive to document and scrutinize the delivery of medical care, the use of the EMR should continue to increase. While this article has identified many of its benefits, it has also listed some of the drawbacks and impediments which need to be addressed for the EMR to achieve its full potential.

What are the challenges to developing the effective EMR? First, the system must be beneficial to the user, the individual clinician who will be entering the data and using the results for patient care decisions. Thus, data entry must not be excessively time-consuming or otherwise difficult, while obtaining information out must be similarly fast and easy. Clinician involvement is crucial for successful implementation of EMR's (Bria & Rydell, 1992). On the other hand, the system must not compromise patient confidentiality. Reasonable mechanisms must be implemented to insure patient information is not viewed by inappropriate viewers and those who breach security are appropriately punished. However, the security must not be so restrictive as to impede use of the system by clinicians.

It is likely that the clinician of the future will interact heavily with computers. Not only will various processes of health care delivery become increasingly automated, but larger amounts of non-patient information, such as the medical literature, will also be accessed electronically. This future clinician will likely use a computer to enter findings and diagnoses, take advantage of links that connect these with decision support modules and the medical literature, and communicate with colleagues and others taking care of the patient.

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