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Electronic Medical Records

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The practice of medicine involves management of large amounts of information, making the medical record the cornerstone of communication and documentation. Even today, paper-based systems have persisted despite the computer technology widely available to the practicing clinician. There are many benefits of electronic patient-based records, yet only 20% to 25% of physician-based organizations have adopted electronic medical record systems.[1] This column reviews the historical development of medical records, discusses the advantages and disadvantages of computer-based record systems, and reviews features of electronic record systems.

PURPOSE OF A MEDICAL RECORD

A medical record is an account of the patient's presenting symptoms, with annotations from the physician and other health professionals detailing their observations as well as discussions with the patient. Laboratory tests, imaging studies, and treatment information related to patient care round out the medical record, chronicling a story of the patient care process. The medical record is essential for providing a lineage of symptoms and treatment for the individual provider, but also serves a historical perspective for consultants and health-care insurance carriers as well. In addition, the documentation serves as a foundation as to whether a patient received proper care in the event of litigation or as a source of information for retrospective research.

The focus of the medical record has evolved over time. Hippocrates is credited with the focus on recording observations in a purely chronological order, creating a time-oriented medical record.[2] Physicians at the Mayo Clinic in Rochester, Minnesota initially kept individual records of their patient encounters, which made coordination of care difficult. In 1907, the Mayo Clinic pioneered the concept of one separate file for each patient, creating the patient-centered medical record. Although these systems were improvements, records continued to be somewhat disorganized, a mixture of notes, complaints, test results, and physician opinion on findings. Lawrence Weed, MD, introduced the problem-oriented medical record in the 1960s in order to provide standardization of patient records. The SOAP note,[3] which stands for subjective, objective, assessment, and plan, created a better method to document the line of reasoning for diagnosis and treatment of patient problems.

Despite these improvements in the medical record, paper-based systems have many limitations. In large hospitals, these records may be unavailable because they are stored in the clinic or business office when the patient comes into the emergency room. Access to records is limited to one person at a time, and such access must be on site. Even in a solo practice, paper records may require a large area for storage, and must be organized for ready access. Legibility is a major issue of paper-based records. For example, researchers in a Spanish hospital found 15% of 117 records were illegible.[4] Paper is not a durable media, and is susceptible to both water and fire. Records are often lost or missing, and backup of paper-based records is unwieldy, requiring time and resource-intensive effort. Security of records is limited to locked storage, without the ability to log record access.

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COMPONENTS OF AN ELECTRONIC MEDICAL RECORD

An electronic medical record (EMR) is more than an electronic version of the paper-based record. It is a computer-based system for managing and delivering data required for patient care. The EMR is more than a database because it offers many functions, such as an integrated view of patient data, clinical decision support, clinician order entry, integrated communications support, and access to knowledge resources. The EMR should interface to other systems, such as billing, pharmacy, radiology, scheduling, and practice management.

According to the Medical Records Institute, five levels of an Electronic Healthcare Record can be distinguished (Table).[5] These levels are conceptually helpful in determining what type of EMR is necessary for different practice settings. Solo practitioners may only need a level one record system, but for integration with a local hospital for continuity of information transfer, a more sophisticated system is needed. There are several key issues in making an effective EMR. One of the primary problems is the unique patient identifier or master patient index. It is common in the emergency setting for patients to arrive unconscious, and therefore they may be assigned a medical record number that is later determined to be unnecessary when the patient is able to provide identifying information. Many healthcare systems struggle with integration of several clinical systems such as laboratory, pharmacy, and scheduling in terms of managing patient flow across these platforms.

Data capture is an important issue for EMR systems in striking a balance between needs of users in the clinical setting and having structure for retrieval. Free-form text entry is easiest for most clinicians in that it is how they are trained to think about the patient encounter. Coded-form data, entered usually by dropdown menus or check boxes in certain information fields, provides structure and constraint of data entry to facilitate analysis and storage. An analogous situation is how people can remember text-based URLs such as http://www.primarypsychiatry.com, but the computer prefers to use http://66.216.127.239.[6]

Standards are a vital element of EMR systems in terms of interoperability and communication. Health Level 7 is a standards developing organization accredited by the American National Standards Institute (ANSI).[7] It produces a standard for hospital information systems communication used at most institutions for the exchange, integration, sharing, and retrieval of electronic health information. ANSI X12, or Electronic Data Interchange,[8] is the computer-to-computer exchange of structured information typically used for billing systems. Digital Imaging and Communications in Medicine (DICOM)[9] is a comprehensive set of standards for handling, storing and transmitting information in medical imaging. The Continuity of Care Record[10] is a standard specification being developed jointly by the American Society for Testing and Materials International, the Massachusetts Medical Society, the Health Information Management and Systems Society, the American Academy of Family Physicians, and the American Academy of Pediatrics. It is intended to foster and improve continuity of patient care by creating a minimum standard of health information transportability so that patients going from one provider to another will have sufficient information moving from each provider.

Coded terminologies, such as the *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition (*DSM-IV*)[11] and *International Classification of Diseases*,[12] are also crucial to EMR systems in structuring data for interchange and storage. Similarly, the Current Procedural Terminology[13] codes provide a coding scheme for diagnostic and therapeutic procedures. The Systematized Nomenclature of Medicine[14] is

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TABLE

- Level 1: The automated medical record is a paper-based record with some computer-generated documents.
- Level 2: The computerized medical record makes the documents of level 1 electronically available.
- Level 3: The EMR restructures and optimizes the documents of the previous levels, ensuring inter-operability of all documentation systems.
- Level 4: The electronic patient record (EPR) is a patient-centered record with information from multiple institutions.
- Level 5: The electronic health record adds general health-related information to the EPR that is not necessarily related to a disease.

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another comprehensive coding system originally developed by the College of American Pathologists. Logical Observations, Identifiers, Names, and Codes (LOINC)[15] is a naming system for laboratory tests and observations, such as vital signs and electrocardiogram. These are just a handful of the many coding schemes used in EMR systems.

EARLY ELECTRONIC MEDICAL RECORD SYSTEMS

One of the early EMR systems was COmputer-STored Ambulatory Record,[16] developed by G. Octo Barnett, MD, at Massachusetts General Hospital in Boston in 1968. It is still used as an ambulatory record system and has been implemented at hundreds of locations worldwide where mainframe computer systems with terminals exist. It was written in M (formerly known as Massachusetts General Hospital Utility Multi-Programming System),[17] a programming language geared toward medical databases. This system was one of the first to use computer-based reminders for compliance with clinical guidelines, and computer generated reminders for follow-up of elevated blood pressures.

In 1996, the Chief Information Office of the Veterans Administration introduced Veterans Health Information Systems and Technology Architecture.[18] It is a national EMR system built on a client-server architecture, which ties together work stations and personal computers with graphical user interfaces at Veterans Health Administration facilities. It incorporates software developed by local medical facility staff and allows commercial off-the-shelf software and products to be used with it. It is available for download as open source software and runs on Linux.

The Regenstrief Medical Record System[19] was developed by Clement McDonald, MD, in 1973, and continues to be in use. It was originally written in Basic Plus for ambulatory care, and it now implements many of the coding schemes and communication standards such as LOINC and DICOM, running on a Digital Equipment Corp Alpha. It has inpatient and outpatient order entry systems, which are instruments for visit notes and online questionnaires that replace hardcopy forms. They have been successful with physicians who enter orders, problems, allergies, visit notes, and discharge summaries into the locally developed Gopher order entry system, largely because the system has many convenient output forms, choice lists, defaults, templates, reminders, drug interaction information, charge information, and online articles and textbooks. This system has been developed into a commercial product as well.

ADVANTAGES AND DISADVANTAGES

EMRs or computer-based patient records (CPRs) can overcome all of the issues described above for paper-based records as well as provide new opportunities. Many users can access the same patient record while at different locations. With improving storage capability such as the Blu-ray digital video disk (DVD) capable of 50 Gigabytes of data and increasing Internet speed using digital subscriber line and cable modems, EMRs can be backed-up both on-site and to a remote location. Machine entry text is legible and that data can be reused to quickly generate a new patient encounter. Electronic records can be stored in various formats such as DVD, which is durable and easily duplicated. Data entered in an EMR is often structured for ease of post-entry analysis. Security of electronic records can be accomplished with data encryption as well as hardware security keys and passwords. Access to patient records can be tracked and monitored for inappropriate activity.

A computer-based patient record differs from a computer-based patient-record system (CPRS) in that additional information management tools support clinical decisions. For example, a CPRS could send reminders to follow up on liver function tests and fasting glucose for patients on atypical antipsychotics. Prescription authorizations could be sent as messages to physicians with automatic record documentation once approval was made. The Texas Medication Algorithm Project is an example of a CPRS where the algorithm integrated into the medical record system is used to help lower cost of medication use.[20]

Although there are numerous advantages to using an EMR, it has risks and disadvantages. One of the biggest issues is cost for the initial investment in computer hardware, soft-

"HEALTHCARE CONSUMER ORGANIZATIONS SUCH AS THE LEAPFROG GROUP ENCOURAGE USE OF EMR AND CPOE TO REDUCE ERRORS BY USING THEIR PURCHASING POWER."

ware, and support in terms of training and technical problems. Physicians and staff may need to take time away from patient care in order to learn how to use the system and adjust to the new workflow. Interactions with patients may change with EMR access depending on the physical location of computers in the room and whether physicians make less eye contact. Timing of encounter documentation may shift as well to the end of the day in order to have sufficient time for more thorough documentation. Human and organizational factors are typically the greatest barriers to implementation of a CPR.

A major risk of utilizing an EMR is programming or operator error, which may lead to loss or inappropriate exposure of patient care data. In 2001, for example, Eli Lilly accidentally disclosed the E-mail addresses of 600 patients who had registered for reminders regarding fluoxetine.[21] If a computer system fails, there may be significant down time without data, depending upon the backup system and methodology. In a paper-based system, there will be the loss of one patient record in contrast to the risk of losing many patient records in a computer crash.

One of the major current frustrations with an EMR is the current lack of standards for the data file format, akin to the issue of whether a document written in Microsoft Word on a Windows personal computer can be read on a Macintosh running Mellel or other word processor. Exchange of records, even electronic ones, typically utilize the paper media intermediary via facsimile, mail service, or the patient as courier. For the physician recipient, that data may be re-entered into a different EMR system, or perhaps it will be scanned, which may introduce transcription errors or loss of information due to quality of the scanned image.

Despite the many issues that compromise the advantages of an EMR, there is hope that they will produce benefits, including reduced medication errors, lower cost of health care, increased productivity, and other gains to transform healthcare.[22] Computerized physician order entry (CPOE) systems have been touted as one of the methods to decrease errors, with checks of medication dosage, drug interaction analysis, and decreased transcription errors.[23] Data mining in the EMR—the practice of automatically searching large stores of data for patterns—will help physicians in the evaluation of treatment effectiveness, management of health care, customer relationship management, and the detection of fraud and abuse.[24] Healthcare consumer organizations such as the Leapfrog Group[25] encourage use of EMR and CPOE to reduce errors by using their purchasing power.

CONCLUSION

Using an EMR system has risks and benefits, just as medications do. However, in today's practice of medicine, using only paper no longer makes sense. With imaging studies, digital photos, and perhaps even digital videos to be incorporated into the medical record, use of the electronic record certainly will continue to grow. There are a myriad of commercial and even a few open source vendors who have developed systems for the range of practice settings, from solo to large hospital systems. It is time to download one and join the digital age. (Many vendors will be demonstrating their wares at the Healthcare Information and Management Systems Society meeting in San Diego, February 12-16, 2006.) ***PP***

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