
# Key Capabilities of an Electronic Health Record System: Letter Report

**DETAILS**

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Committee on Data Standards for Patient Safety



# Key Capabilities of an Electronic Health Record System

## Letter Report

Committee on Data Standards for Patient Safety

Board on Health Care Services

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*Willing is not enough; we must do."*
—Goethe

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# KEY CAPABILITIES OF AN ELECTRONIC HEALTH RECORD SYSTEM

## Letter Report

July 31, 2003

Dr. Carolyn Clancy
Director, Agency for Healthcare Research and Quality
John M. Eisenberg Building
540 Gaither Road
Rockville MD, 20850

Dear Dr. Clancy:

In May 2003, the Department of Health and Human Services (DHHS) asked the Institute of Medicine (IOM) to provide guidance on the key care delivery-related capabilities of an electronic health record (EHR) system. An EHR system includes (1) longitudinal collection of electronic health information for and about persons, where health information is defined as information pertaining to the health of an individual or health care provided to an individual; (2) immediate electronic access to person- and population-level information by authorized, and only authorized, users; (3) provision of knowledge and decision-support that enhance the quality, safety, and efficiency of patient care; and (4) support of efficient processes for health care delivery. Critical building blocks of an EHR system are the electronic health records (EHR) maintained by providers (e.g., hospitals, nursing homes, ambulatory settings) and by individuals (also called personal health records).

There is a great deal of interest within both the public and private sectors in encouraging all health care providers to migrate from paper-based health records to a system that stores health information electronically and employs computer-aided decision support systems. In part, this interest is due to a growing recognition that a stronger information technology (IT) infrastructure is integral to addressing such national concerns as the need to improve the safety and quality of health care, rising health care costs, and matters of homeland security related to the health sector. The efforts of all parties—purchasers, regulators, providers, and vendors—to advance the deployment of EHR systems, would benefit from a common set of expectations about EHR capabilities.

The IOM was asked to respond very rapidly to this request from DHHS. Fortunately, a sizable project focused on patient safety data standards was already under way at the IOM, and this new task proved to be an appropriate expansion of that ongoing work. Thus the charge to the IOM Committee on Data Standards for Patient Safety (the IOM Committee) was expanded to address this additional task, and the committee devoted a portion of its previously scheduled meeting of June 9–10, 2003, to the development of this letter report. The IOM Committee's full report on data standards will be issued in fall 2003.

**BACKGROUND**

The development of an IT infrastructure has enormous potential to improve the safety, quality, and efficiency of health care in the United States (Institute of Medicine, 2001). Computer-assisted diagnosis and chronic care management programs can improve clinical decision making and adherence to clinical guidelines, and can provide focus on patients with those diseases (Durieux et al., 2000; Evans et al., 1998). Computer-based reminder systems for patients and clinicians can improve compliance with preventive service protocols (Balas et al., 2000). More immediate access to computer-based clinical information, such as laboratory and radiology results, can reduce redundancy and improve quality. Likewise, the availability of complete patient health information at the point of care delivery, together with clinical decision support systems such as those for medication order entry, can prevent many errors and adverse events (injuries caused by medical management rather than by the underlying disease or condition of the patient) from occurring (Bates et al., 1998, 1999; Evans et al., 1998). Via a secure IT infrastructure, patient health information can be shared amongst all authorized participants in the health care community (National Research Council, 2000).

An IT infrastructure also has great potential to contribute to achieving other important national objectives, such as enhanced homeland security and improved and informed public health services (Institute of Medicine, 2002b; National Committee on Vital and Health Statistics, 2001; Wagner et al., 2001). EHRs, combined with Internet-based communication, may enable early detection of and rapid response to bioterrorism attacks, including the organization and execution of large-scale inoculation campaigns and ongoing monitoring, detection, and treatment of complications arising from exposure to biochemical agents or immunizations (Tang, 2002; Teich et al., 2002). A more advanced health information infrastructure is also crucial for various forms of biomedical and health systems research, as well as educating patients, informal caregivers, and citizens about health (Detmer, 2003; National Committee on Vital and Health Statistics, 2001).

EHR system implementation and its continuing development is a critical element of the establishment of an IT infrastructure for health care. In 1991, the IOM issued a report calling for the elimination of paper-based patient records within 10 years, but progress has been slow, and this goal has not yet been met (Institute of Medicine, 1991; Overhage et al., 2002). It should be noted that the motivation is not to have a paperless record per se, but to make important patient information and data readily available and useable. In addition, computerizing patient data enables the use of various computer-aided decision supports.

There are some noteworthy examples of health care settings in both the private and public sectors in which EHRs have been deployed. A handful of communities and systems have established secure platforms for the exchange of data among providers; suppliers; patients; and other authorized users, such as the Veterans Health Administration, the New England Healthcare Electronic Data Interchange Network, the Indiana Network for Patient Care, the Santa Barbara County Care Data Exchange, the Patient Safety Institute's National Benefit Trust Network, and the Markle Foundation's Healthcare Collaborative Network (CareScience, 2003; Kolodner and Douglas, 1997; Markle Foundation, 2003b; New England Healthcare EDI Network, 2002; Overhage, 2003; Patient Safety Institute, 2002). But these examples are the exception, not the rule. In most of the nation's hospitals, orders for medications, laboratory tests, and other services are still written on paper, and many hospitals lack even the capability to deliver laboratory and other results in an automated fashion. The situation is no different in most small practice settings, where there has been little if any migration to electronic records.

In addition to the technical challenges, there are sizable policy, organizational, financial, and technological challenges that must be addressed to facilitate the adoption of EHR systems (Overhage et al., 2002). Some attempts to introduce order entry systems and other components of an EHR system have been unsuccessful (Auber and Hamel, 2001; Ornstein, 2003). Also, currently available personal health records, which allow patients to enter their own information, have demonstrated limited functionality to date (Kim and Johnson, 2002).

Government health care programs, along with various private-sector stakeholders, are considering options for encouraging the implementation of EHR systems by providers. To achieve widespread implementation, some external funding or incentive programs will be necessary (Institute of Medicine, 2001, 2002a). For example, the Centers for Medicare and Medicaid Services might provide some form of financial reward to providers participating in the Medicare program that have deployed EHR systems. On the private-sector side, various insurers, purchasers, and employer groups are instituting quality incentive programs for specific EHR system functionalities, such as computerized provider order entry for prescription drugs and electronic reporting of performance measures (National Health Care Purchasing Institute, 2003). In addition, a number of employers, health plans, and physicians have recently formed a coalition called Bridges to Excellence, which will provide financial bonuses to providers to encourage improved patient care management systems, including EHR systems (Bridges to Excellence, 2003). Another option is to provide grant funding or access to "low-cost" capital to enable providers, especially those with a safety net role, to invest in acquiring EHR systems (Health Technology Center and Manatt, Phelps and Phillips, LLP, 2003). Certain regulatory strategies might also be pursued, such as requiring providers to have an EHR system as a condition of participation in Medicare (Department of Health and Human Services, 2003).

To implement any of the above strategies, one must first clearly define a functional model of key capabilities for an EHR system. There have been many different views of what constitutes an EHR system. Some EHR systems include virtually all patient data, while others are limited to certain types of data, such as medications and ancillary results. Some EHR systems provide decision support (e.g., preventive service reminders, alerts concerning possible drug interactions, clinical guideline-driven prompts), while others do not. Most current EHR systems are enterprise-specific (e.g., operate within a specific health system or multi-hospital organization), and only a few provide strong support for communication and interconnectivity across the providers in a community. The functionality of EHR systems also varies across multiple settings—from the perspective of both what is available from vendors and what has actually been implemented. Some EHR systems have been developed locally and others by commercial vendors. In summary, EHR systems are actively under development and will remain so for many years.

A "functional model" of an EHR system will assist providers in acquiring and vendors in developing software. For most providers, the migration to an electronic environment will take place over a period of years. The development of a common set of requirements for the functional capabilities of various EHR system software components would allow providers to compare and contrast the systems that are available, and enable vendors to build systems more in line with providers' expectations. To be most useful, a functional model of an EHR system must also reflect a balance between what is desirable and what can feasibly be implemented immediately or within a short time frame. It will be important to update the functional model from time-to-time to reflect advancements in health care technology and care delivery.

## PROJECT OVERVIEW

In response to the request from DHHS in May 2003, the charge to the IOM Committee on Data Standards for Patient Safety was expanded as follows:

> Provide guidance to DHHS on a set of "basic functionalities" that an electronic health record system should possess to promote patient safety. The IOM committee will consider functions, such as the types of data that should be available to providers when making clinical decisions (e.g., diagnoses, allergies, laboratory results); and the types of decision-support capabilities that should be present (e.g., the capability to alert providers to potential drug-drug interactions).

The IOM Committee was asked to focus on *care delivery functions,* and did not address infrastructure functions, such as database management and the use of health care data standards (e.g., terminology, messaging standards, network protocols). Although not within the scope of this project, the IOM Committee would like to emphasize the importance of two infrastructure functions—privacy and security (e.g., access control, encryption). It is absolutely critical that an EHR system be capable of safeguarding privacy and security.

DHHS requested a rapid response because of its desire to implement various programs in 2004 that would benefit from the availability of a functional model for an EHR system. Specifically, the Center for Medicare and Medicaid Services (CMS) is considering offering financial and other incentives to providers to encourage the deployment of EHR systems. The Agency for Healthcare Research and Quality is implementing an applied research program that will provide funding for the implementation and evaluation of innovative IT-related programs. The federal government is also working collaboratively with private sector stakeholders to facilitate the development of a national health information infrastructure (Department of Health and Human Services, 2003).

In addition, the IOM work is the first step of a two-step process. IOM is being asked to identify core care delivery–related functionalities of an EHR system. Health Level Seven (HL7), a leading standards-setting organization working on the development of an EHR functional model, will incorporate these core functionalities into the model, and further specify each functionality along three dimensions: (1) develop a functional statement or definition (what), (2) establish a rationale for the functionality (why included), and (3) establish a compliance metric or test (Dickinson et al., 2003).

Because of the quick turnaround required, the IOM Committee convened a small working group that met at the National Academies' Jonsson Conference Center in Woods Hole, Massachusetts, on June 7–8, 2003. The work of this group served as a starting point for discussions of the full IOM Committee at its June 9–10, 2003, meeting.

## FRAMEWORK FOR IDENTIFYING CORE EHR FUNCTIONALITIES

In recent years, several IOM reports have recommended that the U.S. health care system make a commitment to the development of a health information infrastructure by the year 2010

(Institute of Medicine, 2001, 2002a, 2002c). This IOM Committee concurs with those recommendations.

It is recognized that the EHR system will be built incrementally utilizing clinical information systems and decision support tools as building blocks of the EHR, and the IOM Committee has strived to identify reasonable steps that can be taken by health care providers over the next 7 years to advance the accomplishment of this overall goal. It will be important for the Agency for Healthcare Research and Quality and others to pursue a robust research agenda if the EHR system is to reach full maturity in the years ahead.

Key EHR functionalities have been identified for four settings—hospital, ambulatory care, nursing home, and care in the community (i.e., the personal health record). Additional settings will need to be addressed in the future, such as home health agencies, pharmacies, and dental care.

In considering the core functionalities of EHR systems, it is important to recognize their many potential uses (see Box 1). EHR systems must support the delivery of personal health care services, including care delivery (e.g., care processes), care management, care support processes, and administrative processes (e.g., billing and reimbursement). As individuals engage more actively in management of their own health, they too become important users of electronic health information. There are also important secondary uses, including education, regulation (e.g., credentialing), clinical and health services research, public health and homeland security, and policy support. There are both individual users (e.g., patients, clinicians, managers) and institutional users (e.g., hospitals, public health departments, accreditation organizations, educators, and research entities).

**Box 1. Primary and Secondary Uses of an Electronic Health Record System**

**Primary Uses**

- Patient Care Delivery
- Patient Care Management
- Patient Care Support Processes
- Financial and Other Administrative Processes
- Patient Self-Management

**Secondary Uses**

- Education
- Regulation
- Research
- Public Health and Homeland Security
- Policy Support

SOURCE: Adapted from Institute of Medicine (1997).

To guide the process of identifying core EHR system functionalities, the IOM Committee formulated five criteria, which are listed below. Although each functionality independently may not fulfill all five criteria, when taken together as part of an EHR system, the core functionalities should address all criteria.

- *Improve patient safety*. Safety is the prevention of harm to patients. Each year in the United States, tens of thousands of people die as a result of preventable adverse events due to health care (Institute of Medicine, 2000).
- *Support the delivery of effective patient care*. Effectiveness is providing services based on scientific knowledge to those who could benefit and at the same time refraining from providing services to those not likely to benefit (Institute of Medicine, 2001). Only about

one-half (55 percent) of Americans receive recommended medical care that is consistent with evidence-based practice guidelines (McGlynn et al., 2003).

- *Facilitate management of chronic conditions*. Chronic conditions are now the leading cause of illness, disability, and death in the United States (Hoffman et al., 1996). Persons with chronic conditions account for over 75 percent of all health care spending, and more than half of that spending is on behalf of people with multiple such conditions (Partnership for Solutions, 2002; U.S. Department of Health and Human Services, 2002). More than half of those with chronic conditions have three or more different providers and report that they often receive conflicting information from those providers; moreover, many undergo duplicate tests and procedures, but still do not receive recommended care (Leatherman and McCarthy, 2002; Partnership for Solutions, 2002). Physicians also report difficulty in coordinating care for their patients with chronic conditions, and believe that this lack of coordination produces poor outcomes (Partnership for Solutions, 2002).
- *Improve efficiency*. Efficiency is the avoidance of waste, in particular, waste of equipment, supplies, ideas, and energy (Institute of Medicine, 2001). Methods must be found to enhance the efficiency of health care professionals and reduce the administrative and labor costs associated with health care delivery and financing. Staffing shortages have developed in multiple health care professions, placing added pressure on providers to continually improve care processes with current staffing levels (AHA Commission on Workforce for Hospitals and Health Systems, 2002). The cost of private health insurance is increasing at an annual rate of greater than 12 percent, while individuals are paying more out of pocket and receiving fewer benefits (Edwards et al., 2002; Kaiser Family Foundation and Health Research and Educational Trust, 2002). And rising health care costs will likely contribute to growing numbers of uninsured, who currently total over 41 million, or 1 in 7 Americans (U.S. Census Bureau, 2002). Addressing these issues represents a major challenge.
- *Feasibility of implementation*. The IOM Committee considered this criterion in determining the time frames within which it is reasonable to expect providers' EHR systems will be capable of demonstrating the key functionalities. The timing of this study did not allow for a thorough evaluation of feasibility, so the IOM Committee had to rely on its collective knowledge of the field. In assessing feasibility, the IOM Committee considered whether software is currently available or under development; the time period necessary for vendors to develop, produce, and market new software to achieve certain functionalities; and the willingness of users to purchase and implement such systems. It would be advisable to reassess periodically the feasibility of implementing certain EHR functionalities and modify expectations regarding timing, as appropriate.

## CORE EHR FUNCTIONALITIES

The IOM Committee identified core functionalities falling into eight categories (see Box 2).

**Box 2. Core Functionalities for an Electronic Health Record System**

- Health information and data
- Results management
- Order entry/management
- Decision support
- Electronic communication and connectivity
- Patient support
- Administrative processes
- Reporting & population health management

### Health Information and Data

Although not truly a functionality attribute per se, in order to achieve the objectives set forth for an EHR system, it must contain certain data about patients. Physicians and other care providers require certain information to make sound clinical decisions; however, their information needs are often not met (Bates et al., 2003; Covell et al., 1985; McKnight et al., 2001; Tang et al., 1994). This lack of information can lead to lesser-quality and inefficient care.

As noted, for example, the capability to display previous laboratory test results can significantly reduce the number of redundant tests ordered, not only saving money, but also preventing the patient from undergoing unnecessary tests (Bates et al., 1999; Stair, 1998; Tierney et al., 1987). Also as noted earlier, information on patient allergies and other medications, in combination with alerts and reminders, can decrease the number of medication-related adverse events and improve the prescribing practices of physicians and nurse practitioners (Bates et al., 1999; Kuperman et al., 2001; McDonald, 1976; Teich et al., 2000). In addition, urgent matters, such as abnormal test results, can be addressed on a more timely basis if the physician has the information at the point of care (Bates et al., 2003). EHR systems with a defined dataset that includes such items as, medical and nursing diagnoses, a medication list, allergies, demographics, clinical narratives, and laboratory test results, can therefore ensure improved access to at least some types of information needed by care providers when they need it.

It is also important to note that too much information and data may overwhelm or distract the end user, so EHR systems must have well designed interfaces. The health information and data captured by an EHR system must also evolve over time, as new knowledge becomes available, both clinical knowledge and knowledge regarding the information needs of different users.

### Results Management

Managing results of all types (e.g., laboratory test results, radiology procedure results reports) electronically has several distinct advantages over paper-based reporting in terms of improved quality of care. Computerized results can be accessed more easily by the provider at the time and place they are needed; the reduced lag time increases both efficiency and patient safety by allowing for quicker recognition and treatment of medical problems (Bates et al., 2003). Additionally, the automated display of previous test results makes it possible to reduce redundant and additional testing, thus not only improving efficiency of treatment, but also decreasing costs (Bates et al., 2003; Shea et al., 2002; Tierney et al., 1987). Having electronic results can allow for better interpretation and for easier detection of abnormalities, thereby ensuring appropriate follow-up (Bates et al., 2003; Overhage et al., 2001; Schiff et al., 2003). Finally, access to electronic consults and patient consents can establish critical linkages and improve care coordination among multiple providers, as well as between provider and patient (Bates et al., 2003).

### Order Entry/Order Management

The benefits of computerized provider order entry (CPOE) have been well documented (Bates and Gawande, 2003; Bates et al., 1998, 1999; Butler and Bender, 1999; Kuperman and Gibson, 2003; Kuperman et al., 2001; Mekhjian et al., 2002; Schiff and Rucker, 1998; Sittig and Stead, 1994; Teich et al., 2000; Tierney et al., 1993). Even with little or no decision support capabilities, such systems can improve workflow processes by eliminating lost orders and ambiguities caused by illegible handwriting, generating related orders automatically, monitoring for duplicate orders, and reducing the time to fill orders (Lepage et al., 1992; Mekhjian et al., 2002; Sittig and Stead, 1994). The use of computerized order entry, in conjunction with an electronic health record, is also beginning to demonstrate a positive effect on clinician productivity (Overhage et al., In press).

The strongest evidence of the clinical effectiveness of CPOE is seen in medication order entry. Relatively simple systems have been shown to reduce the number of non-intercepted medication errors by up to 83 percent by using “forcing functions” for medication dose and frequency (Bates and Gawande, 2003), displaying relevant laboratories, and checking for drug–allergy and drug–drug interactions. CPOE is expected to offer similar benefits for laboratory, microbiology, pathology, radiology, nursing, and supply orders, as well as for ancillary services and consults (Butler and Bender, 1999; Sanders and Miller, 2001; Schiff et al., 2003; Schuster et al., 2003; Teich et al., 1992; Wang et al., 2002). Financial benefits—such as reducing the amount of money spent on preprinted forms, assuring that prescribing practices are consistent with a facility’s established formulary, and informing physicians and other providers about cost-saving options and duplicate test orders—have also been demonstrated (Butler and Bender, 1999; Mekhjian et al., 2002; Sittig and Stead, 1994).

### Decision Support

Computerized decision support systems have demonstrated their effectiveness in enhancing clinical performance for many aspects of health care, including prevention, prescribing of drugs, diagnosis and management, and detection of adverse events and disease outbreaks (Bates and Gawande, 2003; Hunt et al., 1998; Johnston et al., 1994; Tang et al., 1999b). In two meta-analyses, computer reminders and prompts were shown to significantly improve preventive practices in such areas as vaccinations, breast cancer screening, colorectal screening, and cardiovascular risk reduction (Balas et al., 2000; Shea et al., 1996). Several studies have also been conducted on the use of computerized decision support to improve drug dosing, drug selection, and screening for drug interactions; these studies have shown overall positive effects on the quality of patient care (Abookire et al., 2000; Evans et al., 1998; Hunt et al., 1998; Schiff and Rucker, 1998). A study comparing clinical decisions made by physicians in the same practice using an EHR system and traditional paper records found that the former group made more appropriate clinical decisions as a result of all the tools available in an EHR system, including decision support (Tang et al., 1999a).

There is also a small but growing evidence base for the effectiveness of such systems in the area of computer-assisted diagnosis and disease treatment and management. In 1992, an expert diagnostic system demonstrated the ability to detect more serious quality problems arising from diagnostic errors than those detected by a state-based peer review organization, suggesting that computerized tools may help prevent such diagnostic misadventures (Lee and Warner, 1992). A 1999 study comparing the performance of clinicians with and without the aid of a diagnostic computerized decision support system found a significant improvement in the generation of correct diagnoses when the system was used (Friedman et al., 1999). Two additional recent studies have revealed that decision support tools could improve clinician compliance with established evidence-based guidelines and protocols (Morris, 2003; Starmer et al., 2000). Other studies on the use of decision support tools have not found improvements, however (Eccles et al., 2002; Rollman et al., 2002).

More sophisticated tools, such as artificial neural networks, have also demonstrated their effectiveness in detecting acute myocardial infarction, breast cancer, and cervical cancer (Bates and Gawande, 2003; Heden et al., 1997; Kok and Boon, 1996; Petrick et al., 2002). In addition, computerized tools can be used to identify and track the frequency of adverse events (Bates et al., 2001; Classen et al., 1991; Honigman et al., 2001) and hospital-acquired infections (Evans et al., 1986), as well as disease outbreaks and bioterrorism events (Pavlin, 2003; Tsui et al., 2003).

**Electronic Communication and Connectivity**

Effective communication—among health care team members and other care partners (e.g., laboratory, radiology, pharmacy) and with patients—is critical to the provision of quality health care. Its lack can contribute to the occurrence of adverse events (Bates and Gawande, 2003; Petersen et al., 1994; Schmidt and Svarstad, 2002; Wanlass et al., 1992). Improved communication among care partners, such as laboratory, pharmacy, and radiology, can enhance patient safety and quality of care (Schiff et al., 2003), and improve public health surveillance (Schiff and Rucker, 1998; Wagner et al., 2001). Electronic connectivity is essential in creating and populating EHR systems, especially for those patients with chronic conditions, who characteristically have multiple providers in multiple settings that must coordinate care plans (Wagner, 2000; Wagner et al., 1996). While communication interfaces are becoming well established for administrative data exchange, there are very few such interfaces for the exchange of clinical data.

Electronic communication tools, such as e-mail and web messaging, have been shown to be effective in facilitating communication both among providers and with patients, thus allowing for greater continuity of care (Balas et al., 1997; Liederman and Morefield, 2003; Worth and Patrick, 1997) and more timely interventions (Kuebler and Bruera, 2000). One recent study found that automatic alerts to providers regarding abnormal laboratory results reduced the time until an appropriate treatment was ordered (Kuperman et al., 1999). Another important communication tool is an integrated health record, both within a setting and across settings and institutions. Such a record allows for improved access to patient data at the point where clinical decisions are made (Institute of Medicine, 1997). In addition, telemedicine has demonstrated effectiveness in certain settings, including pulmonary clinics and intensive care units (Pacht et al., 1998; Rosenfeld et al., 2000; Shafazand et al., 2000); home telemonitoring has been shown to be successful as well (Finkelstein et al., 2000; Johnston et al., 2000; Rogers et al., 2001; Shea et al., 2002; Whitlock et al., 2000).

**Patient Support**

Patient education has demonstrated significant effectiveness in improving control of chronic illnesses (Weingarten et al., 2002). Computer-based patient education in particular has been found to be successful in primary care (Balas et al., 1996). In a 1997 study of 22 clinical trials, interactive educational interventions showed positive results for several major clinical applications, the most frequently targeted of these being diabetes (Krishna et al., 1997). Additionally, as noted earlier, several studies have demonstrated the feasibility of home monitoring by patients (Finkelstein et al., 2000; Johnston et al., 2000; Rogers et al., 2001; Whitlock et al., 2000). In a recent study, for instance, spirometry self-testing by asthma patients during home telemonitoring was found to provide valid results comparable to those of tests collected under the supervision of a clinician (Finkelstein et al., 2000). A multidimensional telehealth system has also demonstrated the ability to decrease stress for some caregivers of patients with Alzheimer's disease (Bass et al., 1998).

**Administrative Processes**

Electronic scheduling systems for hospital admissions, inpatient and outpatient procedures, and visits not only increase the efficiency of heath care organizations, but also provide better, more timely service to patients (Everett, 2002; Hancock and Walter, 1986; Woods, 2001). Use of communication and content standards is equally important in the billing and claims management area—close coupling of authorization and prior approvals can, in some cases, eliminate delays and confusion. Additionally, immediate validation of insurance eligibility should add value for both providers and patients through improved access to services, more timely payments and less paperwork.

Moreover, computerized decision support tools are being used in a variety of settings to identify eligible or potentially eligible patients for clinical trials (Breitfeld et al., 1999; Carlson et al., 1995; Ohno-Machado et al., 1999; Papaconstantinou et al., 1998). Other effective electronic administrative tools include reporting tools that support drug recalls (Schiff and Rucker, 1998) and artificial neural networks that can assist in identifying candidates for chronic disease management programs (Heden et al., 1997; Kok and Boon, 1996; Petrick et al., 2002).

**Reporting and Population Health Management**

Institutions currently have multiple public and private sector reporting requirements at the federal, state, and local levels for patient safety and quality, as well as for public health. In addition, the internal quality improvement efforts of many health care organizations include routine reporting of key quality indicators (sometimes referred to as clinical dashboards) to clinicians. Most of the data for these reports must be abstracted from claims data, paper records, and surveys, a process that is labor-intensive and time-consuming, and usually occurs retrospectively. Thus such reporting is often limited to entities that have sufficient administrative infrastructure to develop the necessary data (Institute of Medicine, 2002c). Additionally, chart abstraction has been shown to involve a number of significant errors (Green and Wintfeld, 1993). Having clinical data represented with a standardized terminology and in a machine-readable format would reduce the significant data collection burden at the provider level, as well as the associated costs, and would likely increase the accuracy of the data reported.

## CORE FUNCTIONAL REQUIREMENTS

When identifying the core functional requirements for an EHR system, the IOM Committee was asked to consider both the *care setting* of each function and the *time frame* for its introduction. Table 1 at the end of this report lists the eight key EHR system capabilities described above, broken down at a more detailed level, according to these two dimensions. The committee was asked to provide guidance pertaining to four care settings: (1) hospitals; (2) ambulatory care settings, including small practice settings, community health centers, and group practices; (3) nursing homes; and (4) care in the community.

In addressing the fourth setting, care in the community, the IOM Committee focused on functional requirements for the personal health record (PHR), defined to include (1) a subset of data from the individual's EHR, and (2) information recorded by the individual, including health maintenance and monitoring data. A PHR may be used in a number of ways by the patient to support their care, disease management, and clinical communication. (Markle Foundation, 2003a). As computer-based PHRs become part of the EHR system, being able to access patients' own narratives of their illnesses will become a valuable source of information for improving care through comparisons with the clinicians' records.

Assuming that the migration from paper records to a comprehensive EHR system will take 7 or more years for most providers, the IOM Committee strived to identify functional requirements for three time periods:

- In the immediate future (2004–2005), it is assumed that providers (i.e., ambulatory care settings, hospitals, and nursing homes) will focus on (1) the capture of essential patient data already found frequently in electronic form, such as laboratory and radiology results; (2) the acquisition of limited decision support capabilities for which software is readily available in the marketplace (e.g., order entry, electronic prescribing); and (3) the generation of reports required by external organizations for quality and safety oversight and public health reporting.
- In the near term (2006–2007), providers' EHR systems should (1) allow for the capture of defined sets of health information, (2) incorporate a core set of decision support functions (e.g., clinical guideline support, care plan implementation), and (3) support the exchange of basic patient care data and communication (e.g., laboratory results, medication data, discharge summaries) among the care settings (e.g. pharmacies, hospitals, nursing homes, home health agencies, etc.) within a community.
- In the longer term (2008–2010), the committee believes that fully functional, comprehensive EHR systems will be available and implemented by some health systems and regions. It may take considerably longer, however, for all providers to be using a comprehensive EHR system that provides for the longitudinal collection of complete

health information for an individual; immediate access to patient information by all authorized users within a secure environment; extensive use of knowledge support and decision support systems; and extensive support for applications that fall outside immediate patient care (e.g., homeland security, public health, clinical research).

In identifying core functionalities for specific provider settings, the IOM Committee also considered the current level of information technology capabilities within a sector. Specifically, the IOM Committee assumed that the migration pathway for hospitals would be more rapid than that for nursing homes, recognizing that many hospitals have some EHR system capabilities already in place while most nursing homes do not, and that hospitals generally have greater access to technical expertise. The migration can also be expected to take longer for physicians' offices than for hospitals, given the differences between the two in financial resources available for IT investments. The IOM Committee set these targets within the context of the current momentum it is observing in the public and private sectors. A loss of momentum would adversely affect these estimates. It is recognized that not every provider will meet the functional requirements by the times indicated. The functional requirements are intended to be challenging but achievable for a sizable proportion of the health care sector.

## CONCLUSION

The IOM Committee is pleased to have had the opportunity to provide guidance on this important issue. The committee hopes its work will be useful to HL7 in its efforts to develop functional statements for an EHR system; to government programs and private purchasers in their efforts to encourage and assist health care providers in deploying EHR systems; to providers and vendors as they strive to acquire and build software products that form part of the foundation for a comprehensive health information infrastructure; and to patients as they seek to participate more fully in decisions regarding their own care.

Paul C. Tang, *Chair*
Committee on Data Standards for Patient Safety

Cc: Ann Marie Lynch, Acting Assistant Secretary for Planning and Evaluation (ASPE), Department of Health and Human Services

Thomas A. Scully, Administrator, Centers for Medicare and Medicaid Services, Department of Health and Human Services

Gary Christopherson, Senior Advisor for the Undersecretary for Health, Department of Veterans Affairs

**Table 1 EHR System Capabilities by Time Frame and Site of Care**

| Core Functionality | Hospitals | | | Ambulatory Care | | | Nursing Homes | | | Care in the Community (Personal Health Record) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004–5 | 2006–7 | 2008–10 | 2004–5 | 2006–7 | 2008–10 | 2004–5 | 2006–7 | 2008–10 | 2004–5 | 2006–7 | 2008–10 |
| **1. Health Information and Data** | | | | | | | | | | | | |
| Key data (using standardized code sets where available) | | | | | | | | | | | | |
| – Problem list | X | | | X | | | | | | X | | |
| – Procedures | X | | | X | | | | | | X | | |
| – Diagnoses | X | | | X | | | See Minimum Dataset Below | | | X | | |
| – Medication list | X | | | X | | | | | | X | | |
| – Allergies | X | | | X | | | | | | X | | |
| – Demographics | X | | | X | | | | | | X | | |
| – Diagnostic test results | X | | | X | | | | | | X | | |
| – Radiology results | X | | | X | | | | | | X | | |
| – Health maintenance | X | | | X | | | | | | X | | |
| – Advance directives | X | | | X | | | | | | X | | |
| – Disposition | X | | | X | | | | | | X | | |
| – Level of service | | X | | X | | | | | | | X | |
| Minimum dataset (MDS) for nursing homes | | | | | | | | | | | | |
| – Defined MDS for nursing homes | NA | | | NA | | | X | | | NA | | |
| – Expanded/refined MDS | NA | | | NA | | | | X | | NA | | |

Note: NA=not applicable

*Table 1 continued*

| Functionality | Hospitals | | | Ambulatory Care | | | Nursing Homes | | | Care in the Community (Personal Health Record) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2004–5** | **2006–7** | **2008–10** | **2004–5** | **2006–7** | **2008–10** | **2004–5** | **2006–7** | **2008–10** | **2004–5** | **2006–7** | **2008–10** |
| **1. Health Information and Data** ***continued*** | | | | | | | | | | | | |
| Narrative (clinical and patient narrative) | | | | | | | | | | | | |
| – Free text | X | | | X | | | | X | | X | | |
| – Template-based | | X | | | X | | | | X | X | | |
| – Deriving structure from unstructured text | | | | | | | | | | | | |
| - Natural Language Processing | | | X | | | X | | | X | NA | | |
| – Structured and coded | | | | | | | | | | | | |
| - Signs and Symptoms | | | X | | | X | | | X | | | X |
| - Diagnoses | X | | | X | | | X | | | X | | |
| - Procedures | X | | | X | | | X | | | X | | |
| - Level of service | X | | | X | | | NA | | | NA | | |
| – Treatment plan | | | | | | | | | | | | |
| - Single discipline | X | | | | X | | | | X | | | X |
| - Interdisciplinary | | | X | | | X | | | X | | | X |
| Patient acuity/severity of illness/risk adjustment | | | | | | | | | | | | |
| – Nursing workload | X | | | NA | | | | X | | NA | | |
| – Severity adjustment | | X | | | | X | | | X | NA | | |
| Capture of identifiers | | | | | | | | | | | | |
| – People and roles | X | | | X | | | | X | | | X | |
| – Products/devices | X | | | X | | | | X | | | X | |
| – Places (including directions) | X | | | X | | | | X | | | X | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **2. Results Management** | | | | | | | | | | | | |
| Results Reporting | | | | | | | | | | | | |
| – Laboratory | X | | | X | | | X | | | X | | |
| – Microbiology | X | | | X | | | | X | | X | | |
| – Pathology | X | | | X | | | | X | | X | | |
| – Radiology Reports | X | | | X | | | | X | | X | | |
| – Consults | | X | | | X | | | X | | | | X |
| Results Notification | X | | | X | | | | X | | X | | |
| Multiple views of data / Presentation | X | | | X | | | | X | | | X | |
| Multimedia support | | | | | | | | | | | | |
| – Images | | | X | | | X | | | X | | | X |
| – Waveforms | | | X | | | X | | | X | | | X |
| – Scanned documents | | | | | | | | | | | | |
| - Patient consents | | X | | | X | | | | X | | | X |
| – Pictures | | | X | | | X | | | X | | | X |
| – Sounds | | | X | | | X | | | X | | | X |
| **3. Order Entry/Management** | | | | | | | | | | | | |
| Computerized provider order entry | | | | | | | | | | | | |
| – Electronic prescribing | X | | | X | | | X | | | NA | | |
| – Laboratory | X | | | X | | | | X | | NA | | |
| – Microbiology | X | | | X | | | | | X | NA | | |
| – Pathology | X | | | X | | | | | X | NA | | |
| – XR | X | | | X | | | | | X | NA | | |
| – Ancillary | X | | | | X | | | | X | NA | | |
| – Nursing | X | | | | X | | | | X | NA | | |
| – Supplies | X | | | | X | | | | X | NA | | |
| – Consults | X | | | | X | | | X | | NA | | |

*Table 1 continued*

| Core Functionality | Hospitals | | | Ambulatory Care | | | Nursing Homes | | | Care in the Community (Personal Health Record) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004–5 | 2006–7 | 2008–10 | 2004–5 | 2006–7 | 2008–10 | 2004–5 | 2006–7 | 2008–10 | 2004–5 | 2006–7 | 2008–10 |
| **4. Decision Support** | | | | | | | | | | | | |
| Access to knowledge sources | | | | | | | | | | | | |
| – Domain knowledge | X | | | X | | | | X | | X | | |
| – Patient education | X | | | X | | | | | X | X | | |
| Drug alerts | | | | | | | | | | | | |
| – Drug dose defaults | X | | | X | | | X | | | NA | | |
| – Drug dose checking | | X | | | X | | | X | | NA | | |
| – Allergy checking | X | | | X | | | X | | | NA | | |
| – Drug interaction checking | X | | | X | | | X | | | NA | | |
| – Drug–lab checking | | X | | | X | | | | X | NA | | |
| – Drug–condition checking | | X | | | X | | | | X | NA | | |
| – Drug–diet checking | | X | | | X | | | | X | NA | | |
| Other rule-based alerts (e.g., significant lab trends, lab test because of drug) | | X | | | X | | | X | | NA | | |
| Reminders | | | | | | | | | | | | |
| – Preventive services | X | | | X | | | | X | | X | | |
| Clinical guidelines and pathways | | | | | | | | | | | | |
| – Passive | X | | | X | | | | X | | X | | |
| – Context-sensitive passive | | X | | | X | | | | X | | X | |
| – Integrated | | X | | | X | | | | X | NA | | |
| Chronic disease management | NA | | | | X | | | | X | | X | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Clinician work list | X | | | X | | | | X | | NA | | |
| Incorporation of patient and/or family preferences | | X | | | X | | | | X | | X | |
| Diagnostic decision support | | | X | | | X | | | X | NA | | |
| Use of epidemiologic data | | | X | | | X | | | X | NA | | |
| Automated real-time surveillance | | | | | | | | | | | | |
| – Detect adverse events and near misses | | X | | | X | | | X | | NA | | |
| – Detect disease outbreaks | | X | | | X | | | X | | NA | | |
| – Detect bioterrorism | | X | | | X | | NA | | | NA | | |
| **5. Electronic Communication & Connectivity** | | | | | | | | | | | | |
| Provider–provider | X | | | X | | | X | | | NA | | |
| Team coordination | | X | | | | X | | | X | NA | | |
| Patient–provider | | | | | | | | | | | | |
| – E-mail | X | | | X | | | NA | | | X | | |
| – Secure web messaging | X | | | X | | | NA | | | X | | |
| Medical devices | | X | | | | X | | X | | | | X |
| Trading partners (external) | | | | | | | | | | | | |
| – Outside pharmacy | | X | | | X | | | X | | X | | |
| – Insurer | X | | | X | | | | X | | X | | |
| – Laboratory | X | | | X | | | | X | | NA | | |
| – Radiology | | X | | | X | | | | X | NA | | |

*Table 1 continued*

| Core Functionality | Hospitals | | | Ambulatory Care | | | Nursing Homes | | | Care in the Community (Personal Health Record) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004–5 | 2006–7 | 2008–10 | 2004–5 | 2006–7 | 2008–10 | 2004–5 | 2006–7 | 2008–10 | 2004–5 | 2006–7 | 2008–10 |
| **5. Electronic Communication & Connectivity *continued*** | | | | | | | | | | | | |
| Integrated medical record [1] | | | | | | | | | | | | |
| – Within setting | X | | | X | | | | X | | NA | | |
| – Cross-setting | | | | | | | | | | | | |
| - Inpatient–outpatient | X | | | X | | | | | X | | X | |
| - Other cross-setting | | X | | | X | | | | X | | X | |
| – Cross-organizational | | | X | | | X | | | X | | | X |
| **6. Patient Support** | | | | | | | | | | | | |
| Patient education | | | | | | | | | | | | |
| – Access to patient education materials | X | | | X | | | | X | | X | | |
| – Custom patient education | | X | | | X | | | X | | | X | |
| – Tracking | | X | | | X | | | | X | | X | |
| Family and informal caregiver education | | X | | | X | | | X | | | X | |
| Data entered by patient, family, and/or informal caregiver | | | | | | | | | | | | |
| – Home monitoring | | NA | | | X | | | NA | | | X | |
| – Questionnaires | | X | | | X | | | NA | | X | | |
| **7. Administrative Processes** | | | | | | | | | | | | |
| Scheduling management | | | | | | | | | | | | |
| – Appointments | X | | | X | | | | | X | X | | |
| – Admissions | X | | | NA | | | | | X | NA | | |
| – Surgery/procedure schedule | X | | | X | | | NA | | | NA | | |

[1] Defined as the extent to which a single record integrates data from different settings, providers, and organizations (e.g., Primary Care Physician, specialist, hospital).

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Eligibility determination | | | | | | | | | | | | |
| – Insurance eligibility | X | | | X | | | X | | | X | | |
| – Clinical trial recruitment | X | | | X | | | NA | | | | X | |
| – Drug recall | X | | | X | | | NA | | | NA | | |
| – Chronic disease management | X | | | X | | | | X | | NA | | |
| **8. Reporting and Population Health Management** | | | | | | | | | | | | |
| Patient safety and quality reporting | | | | | | | | | | | | |
| – Clinical dashboards | X | | | X | | | X | | | NA | | |
| – External accountability reporting | X | | | X | | | X | | | NA | | |
| – Ad hoc reporting | X | | | X | | | X | | | NA | | |
| Public health reporting | | | | | | | | | | | | |
| – Reportable diseases | X | | | X | | | X | | | NA | | |
| – Immunization | X | | | X | | | | X | | NA | | |
| Deidentifying data | | X | | | X | | | X | | NA | | |
| Disease registries | X | | | X | | | X | | | | X | |

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# Appendix A
# Committee and Staff

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# Appendix B
# Reviewers

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

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Although the reviewers listed above have provided many constructive comments and suggestions, they did not see the final draft of the report before its release. The review of this report was overseen by **Don E. Detmer,** Dennis Gillings Professor of Health Management, The Judge Institute of Management Studies, University of Cambridge, and Professor Emeritus, Professor of Medical Education, University of Virginia, appointed by the National Research Council and Institute of Medicine, he was responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.