CHAPTER 3

Health Information Technology

CHAPTER OVERVIEW

This chapter outlines major historical developments in the evolution of health information technology and discusses government initiatives to support its implementation. It highlights both benefits and challenges of using this technology and the progress of its implementation to date.

Historical Overview

The concept of using modern health information technology (HIT) to improve the quality and reduce the costs of health care is not new. In fact, the U.S. federal government has a half-century history of many HIT initiatives. One of the earliest is traceable back to the Kennedy Administration in the early 1960s. A report from the President's Science Advisory Committee, "Some New Technologies and their Promise for the Life Sciences," was optimistic about the benefits HIT would bring to biomedical research and the healthcare system.[1] Ironically, the report written more than a half century ago is still relevant to the HIT of today:

> The application of computer technology to the recording, storage, and analysis of data collected in the course of observing and treating large numbers of ill people promises to advance our understanding of the cause, course, and control of disease. The need for a general-purpose health information technology stems in large part from increasingly rapid changes in the pattern of illness in the United States and from equally significant changes in the way medicine is practiced. The acute infectious diseases from which the patient either recovered or died have largely given place to chronic disorders which run an extremely variable course dependent on many factors both in the environment and within the patient himself. . . . Within any sizable community there are numerous administrative

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organizations charged with providing health services. It is not uncommon for a single patient to be cared for by a large number of agencies in a single city, and workers in any one agency usually cannot find out about the activities of others; sometimes they even fail to learn that other agencies are active at all. . . . Modern data-processing techniques make it possible to assemble all the necessary information about all the patients in a given geographical or administrative area in one place with rapid access for all authorized health and welfare agencies. Such a system would produce an immediate and highly significant improvement in medical care with a simultaneous reduction in direct dollar costs of manual record processing and an even greater economy in professional time now wasted in duplicating tests and procedures.[1]

The federal government took the most significant step in the history of HIT on April 27, 2004, when President Bush created the Office of the National Coordinator for Health Information Technology (ONCHIT or "the ONC") by Executive Order.[2] It was then legislatively mandated in the American Recovery and Reinvestment Act (ARRA) when signed by President Obama on February 17, 2009.[3] Part of the ARRA is the Health Information Technology for Economic and Clinical Health Act (HITECH) that designated $36.5 billion to promote the development of a nationwide network of electronic health records (EHRs). EHRs are computerized patient records that are essentially replacing paper charts.

Surprisingly, despite this sizable investment and more than a half century of government incentives and technological advancements, the best scientific evidence today indicates that the benefits of HIT on the quality and cost of health care are, at best, mixed.[4] This chapter will explore the history of how HIT has evolved and the imprint HIT has made on the current healthcare system, and speculate on how HIT will likely influence the future healthcare system and health care in general.

Historical Challenges in Implementing Health Information Technology

Using computers to improve health care in many ways parallels the development of the information technology industry. The late 1960s and early 1970s saw several pioneering efforts at a small number of universities to apply HIT to various aspects of the healthcare delivery process. Early systems were not the ubiquitous, web-based, interactive systems of today but were usually a hybrid of computer and paper integrated into a clinical work process.

One early example from the 1970s at Indiana University is where a small army of data entry clerks manually entered data into a computer on key parts of patients' medical records. The night before a patient's clinic appointment, a one-page, paper encounter form was printed for the next day's appointment listing the patients' name, record number, medical problem list (i.e., the known diagnoses and medical problems), medication list, medication allergies, and suggestions based on an analysis of the data in the computer system. "Suggestions" were calculated based on what patient information the computer had at the point in time the encounter form was printed the night before the patient's visit (e.g., laboratory results, prescription data, diagnoses, vital signs). The software detected any of 290 agreed-upon patient-care protocols or conditions defined by the biomedical literature and best medical practice. When a physician saw the patient in the clinic, they would handwrite notes on the paper encounter form and manually annotate the computer-printed problem list, medication list, and other items. Later, a team of data entry clerks would review the annotated encounter forms and update the computer system to reflect the physician's orders and updates to the patient's condition. The encounter form would then be filed to the patient's paper chart. The Indiana group conducted a study demonstrating a 29 percent improvement in adherence to agreed-upon treatment protocols in the group of physicians who received the computer "suggestions" for recommended treatments on the encounter forms versus those who did not.[5] Similar systems were designed and built during the same time period at a number of other U.S. universities, including The University of Pittsburgh,[6] The University of Utah,[7,8] Vanderbilt University,[9,10] Duke University,[11] and Harvard University/Massachusetts General Hospital.[12] These pioneering systems were custom designed, built, and maintained by in-house teams of computer programmers and systems engineers. Because of the custom designs, their great expense, and the fact they did not comprehensively implement the entire patient record, they were not practical for widespread use. Despite these limitations, the pioneering work done with these early systems laid the foundation for modern EHR design.

It was not until the 1990s that commercially produced EHR systems were mass marketed and sold to healthcare institutions in high volume. These commercially produced systems allowed hospitals to implement comprehensive EHRs without the prohibitive costs of designing and building custom systems. Instead, hospitals could buy an "off-the-shelf" system that although not completely customized to institutional work flows, could be configured to meet most of their perceived institutional needs. The "off the shelf," commercially produced EHRs of today still require extensive configuration to accommodate a hospital's unique and varying work processes. Also, commercial systems were not capable of easily exchanging patients' health information between systems and institutions. In fact, the configuration differences between institutions are often so significant that even institutions with the same commercial EHR systems cannot electronically exchange patients' records without customized software.

As the installed base of commercial systems expanded, many researchers at universities that pioneered early, customized systems began to study issues with implementation of new HIT in the healthcare setting.[13,14] Researchers learned there is a great deal more than just selecting the "right system" to insure a successful HIT implementation. **FIGURE 3-1** illustrates the three essential components required for successful HIT implementation.

The first essential component is the technology. However, organizations often focus solely on this first component with the mistaken belief that merely selecting the "right" technology or the "right EHR" is the most important aspect of HIT implementation.

The second component of successful implementation, work policies and procedures, makes implementing HIT systems in the clinical environment extremely challenging due to wide variations

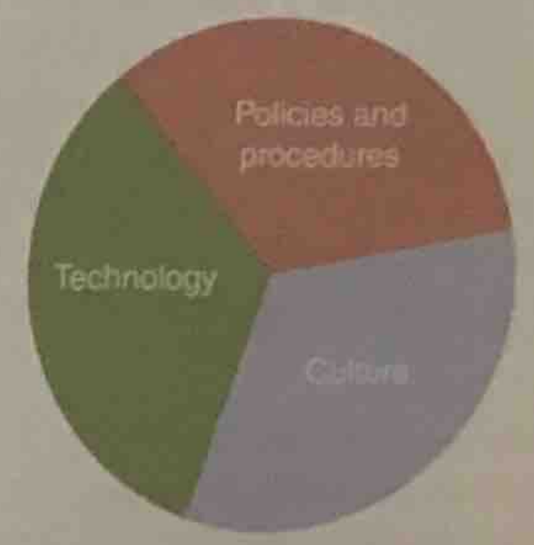

FIGURE 3-1 The Three Essential Components of a Successful HIT Implementation

in work policies and procedures among different organizations and institutions. An organization's policies and procedures describe and define the processes through which work is carried out. The process component is complex, because it requires HIT system implementers to understand fully all existing work processes. Many such processes are not written or formalized, having evolved over the years to accommodate the unique characteristics of a particular organization. Further, actual work processes may significantly differ from those officially documented or assumed to be in place, while many critical work processes are not documented at all. When a HIT system is implemented, it is common for many of the undocumented processes to become apparent for the first time.[15] Undocumented or unknown work processes have been the root cause for many HIT implementation failures.[16]

The third component is the most significant—the institutional and organizational culture—what people are willing to do.[14] This is the most critical, least studied, and least understood of the HIT implementation components.[17] Ash and Bates summarized the importance of organizational culture with regard to EHR adoption:[13]

> The organizational culture must be ready to support adoption by the individuals within it. There has been a period when clinicians have not experienced a sense of collaboration and trust between them and hospital administration. Consequently, if clinicians believe the administration wants to force them to use Computerized Physician Order Entry (CPOE), for example, they may dig in their heels. They may be more resistant to arguments based on safety and patient care benefit if the level of trust is not there. On the other hand, if the impetus comes from the clinical staff, other clinicians may be more apt to adopt sooner, and readiness will be at a higher level. One gauge of readiness is the extent to which certain categories of people hold positions within the organization. In particular, administrators at the highest level must offer both moral and financial support and demonstrate that they really believe in the patient care benefits of the systems. There must be clinical leaders, including a chief medical information officer if at all possible, who understand the fine points of implementation strategies, and opinion leaders among the clinical staff members. In addition, there need to be sufficiently skilled implementation, training, and support coordinators who understand both clinical and technical issues.*

There is a significant publication bias in the biomedical literature against revealing HIT implementation failures. Because of the human tendency to avoid publicizing an individual's mistakes, the body of literature is strongly skewed toward successful implementations and studies. This has made it more difficult to study and understand causes of HIT implementation failures. A significant advance for the HIT industry as a whole would be a shift in its culture toward not only reporting HIT failures, but also viewing them as valuable learning opportunities to be highlighted rather than embarrassing events to be downplayed and forgotten.

One major example of a HIT implementation failure occurred at the prestigious Cedars-Sinai Hospital in Los Angeles, California, in 2002. Three months after implementing a new $34 million HIT system, several hundred physicians refused to use it. Cedars-Sinai attempted to implement a new electronic medical record that changed the way physicians ordered patient treatments and

*Reproduced from Ash JS, Bates DW. Factors and forces affecting EHR system adoption: report of a 2004 ACMI discussion. *J Am Med Inform Assoc.* 2005;12:8-12. © 2005, with permission from BMJ Publishing Group Ltd.

tests in the hospital. Prior to implementing the new system, physicians wrote their orders on paper forms in the patients' paper charts. After new patient orders were written, physicians gave the chart to nurses or ward clerks to read and implement the orders. The new system required physicians to type orders directly into a computer workstation, where the software provided the physician with immediate feedback if they attempted to enter an order that the computer either did not understand or interpreted as a mistake. An article in the *Washington Post* reported:[18]

> A veteran physician at the prestigious Cedars-Sinai Medical Center here had been mixing up a certain drug dosage for decades. Every time he wrote the prescription for 10 times the proper amount, a nurse simply corrected it, recalled Paul Hackmeyer. The computers arrived—and when the doctor typed in his medication order, the machine barked at him and he barked back. . . . "What we discovered was that for 20 years he was writing the wrong dose."

This failure illustrates the three principal HIT implementation components described above:

- *Technology:* With physicians required to enter orders directly to the computer system, time required to enter orders became dependent on the computer's ordering input format and system response time.
- *Process:* Many undocumented processes in the old system were not carried to the new system. In this example, the nurse's automatic correction of an obvious dosage error was a critical, undocumented, process—a nursing check on the orders' accuracy. Although the new system caught the error, the physician user in this case could no longer rely on the nurse's checking and correcting his orders.
- *Culture:* The new system required physicians to interact with a computer, which took more time than writing orders on paper forms. The new system required physicians to change the way they practiced medicine in the hospital and as is common, people dislike change. This was a significant change in physicians' work culture in which nurses had routinely checked and corrected physician orders without communicating the corrections. Physicians also had to deal with a barrage of system alerts when they were imprecise or inaccurate in entering their orders. While potentially enhancing patient safety, responding to the system alerts increased the time (and physician irritation) required for physicians to place orders.

Another historical barrier to broad implementation of HIT is the gap between those who bear the costs of the technology and those who receive its benefits. The purchase and operation of an EHR system represents a major investment for large healthcare organizations and especially for small private physician groups. Not only must physician groups bear the costs of the hardware and software, but they also must support ongoing IT maintenance, staff training, and software upgrade costs. Because small practice groups often have no experience or expertise with IT issues, they also experience anxiety about making decisions necessary to convert from paper to electronic charting. While economies of scale make the marginal costs of adopting EHR technology somewhat lower for large healthcare organizations, these organizations often do not realize the costs savings from their investment. A good example of this is a healthcare system participating in a health information exchange (HIE). HIE systems share patient information across institutions and multiple EHR platforms. This allows patients and physicians access to a patient's comprehensive health record from multiple institutions, regardless of where the patient was seen. HIEs often reduce the number of duplicate laboratory and imaging tests, saving the patient and the payer significant expense.

However, the healthcare system may lose money by not receiving revenue for the duplicate tests not performed and for the expense they bear supporting the HIE. As with large healthcare systems, small practices that invest in EHR technology may not directly benefit from the technology. Patients may receive more age-appropriate screening[19,20] and preventive care[21], along with reduced duplicate testing, because physicians have access to HIEs and patient records from outside the practice group or health system.[22] However, from a practice's financial perspective, these factors actually may produce a significant disincentive for adopting EHRs.

The Federal Government's Response to Health Information Technology Implementation Challenges

As mentioned previously, the U.S. government has sought ways to incentivize adoption of HIT for more than half a century. The largest incentive program to date has been the $36 billion in the HITECH Act that created the Medicare and Medicaid Electronic Health Record Incentive Program.[23] The Center for Medicare & Medicaid Services (CMS) used these funds to incentivize Eligible Professionals (individual physicians in solo or multi-physician practice groups) and Eligible Hospitals as they adopt, implement, upgrade, or demonstrate meaningful use of certified EHR technology to improve patient care. There were three progressive stages to the "Meaningful Use Program" with deadlines; the highest financial incentives were awarded to Eligible Professional or Eligible Hospitals for the earliest compliance with standards in each stage.[24] This program was in part an effort to address a portion of the gap between those that bear the costs of HIT implementation (physicians and hospitals) and those who receive most of its benefits (patients, public health agencies, and payers).

Eligible Professionals could receive up to $44,000 through the Medicare EHR Incentive Program and up to $63,750 through the Medicaid EHR Incentive Program. Eligible Professionals could participate in either the Medicare or Medicaid EHR Incentive Programs but not both. Eligible Hospitals could participate in both the Medicare and Medicaid incentive programs.[25] Each hospital incentive included a base payment of $2 million plus an additional amount determined by a formula based on the number of discharges per year.[26–28] **TABLE 3-1** compares the Medicare and Medicaid adoption incentive programs for Eligible Professionals and Eligible Hospitals.[23–25,29–35]

In 2009, the ONC was designated "the principal federal entity charged with coordination of nationwide efforts to implement and use the most advanced health information technology and the electronic exchange of health information."[36] In short, CMS provided the financial incentives for the meaningful use program and the ONC set the requirements. The ONC's mission, noted in its 2016 budget justification to Congress, is to "improve health, health care, and reduce costs through the use of information and technology."[37] **FIGURE 3-2** depicts the ONC's current organizational structure. The ONC had a budget of $60 million in fiscal year 2015.[38] The HITECH Act also created a HIT Policy Committee and the HIT Standards Committee under the auspices of the Federal Advisory Committee Act.[39] Both committees have multiple workgroups with representatives from payers, academia, and the healthcare industry. They address a variety of HIT-related issues including certification/adoption, governance, HIE, meaningful use, privacy and security, quality measures, implementation, and a HIT vocabulary standards committee.[39]

The Health IT Policy Committee makes recommendations to the National Coordinator for Health IT on a policy framework for the development and adoption of a nationwide health information infrastructure, including standards for the exchange of patient medical

TABLE 3-1 Comparison of Medicare and Medicaid Adoption Incentive Programs for Eligible Professionals (Individual Physicians in Solo and Group Practices) and Eligible Hospitals (Including Critical Access Hospitals)

	Medicare Program	Medicaid Program
Eligible Professionals	■ Administered by CMS ■ $44,000 Maximum per physician (over 5-year period) ■ 90% or more of practice must be outpatient based ■ Cannot participate in Medicaid Program if enrolled in Medicare Program ■ Must apply for Stage 1 Meaningful Use by 2012 to obtain the maximum incentive ■ Medicare imposes payment penalty on those failing to demonstrate meaningful use beginning 2015	■ Administered by State Medicaid Agency ■ $63,750 Maximum per physician Participate (over 5 years) ■ Must have ≤ 30% Medicaid patient volume or ≤ 20% Medicaid patient volume and be a pediatrician or practice predominantly in a Federally Qualified Health Center or Rural Health Clinic and have ≤ 30% patient volume attributable to needy individuals ■ ≤ 90% of practice must be outpatient based ■ Cannot participate in Medicare Program if enrolled in Medicaid Program ■ Can begin to certify for Meaningful Use by 2016 and still receive full incentive ■ Non-participants exempt from Medicaid payment reductions
Hospitals (Including Critical Access Hospitals)	■ Administered by CMS ■ Can begin receiving incentive FY 2011 to FY 2015, but payments will decrease for hospitals that start receiving payments in FY 2014 and later ■ Medicare and Medicaid Program eligible ■ Must apply for Stage 1 Meaningful Use by FY 2013 to receive maximum incentive ■ Hospitals that do not successfully demonstrate meaningful use will be subject to Medicare payment penalties beginning in FY 2015 ■ Incentive payments are based on several factors, beginning with a $2 million base payment	■ Administered by State Medicaid Agency ■ Acute care hospitals (including critical access and cancer hospitals) with at least 10% Medicaid patient volume are eligible ■ Children's hospitals are eligible regardless of their Medicaid volume ■ Can apply for both Medicare and Medicaid Programs ■ Incentive payments are based on a number of factors, beginning with a $2 million base payment.

Data from the Centers for Medicare & Medicaid Services and the Office of the National Coordinator for Health Information Technology.

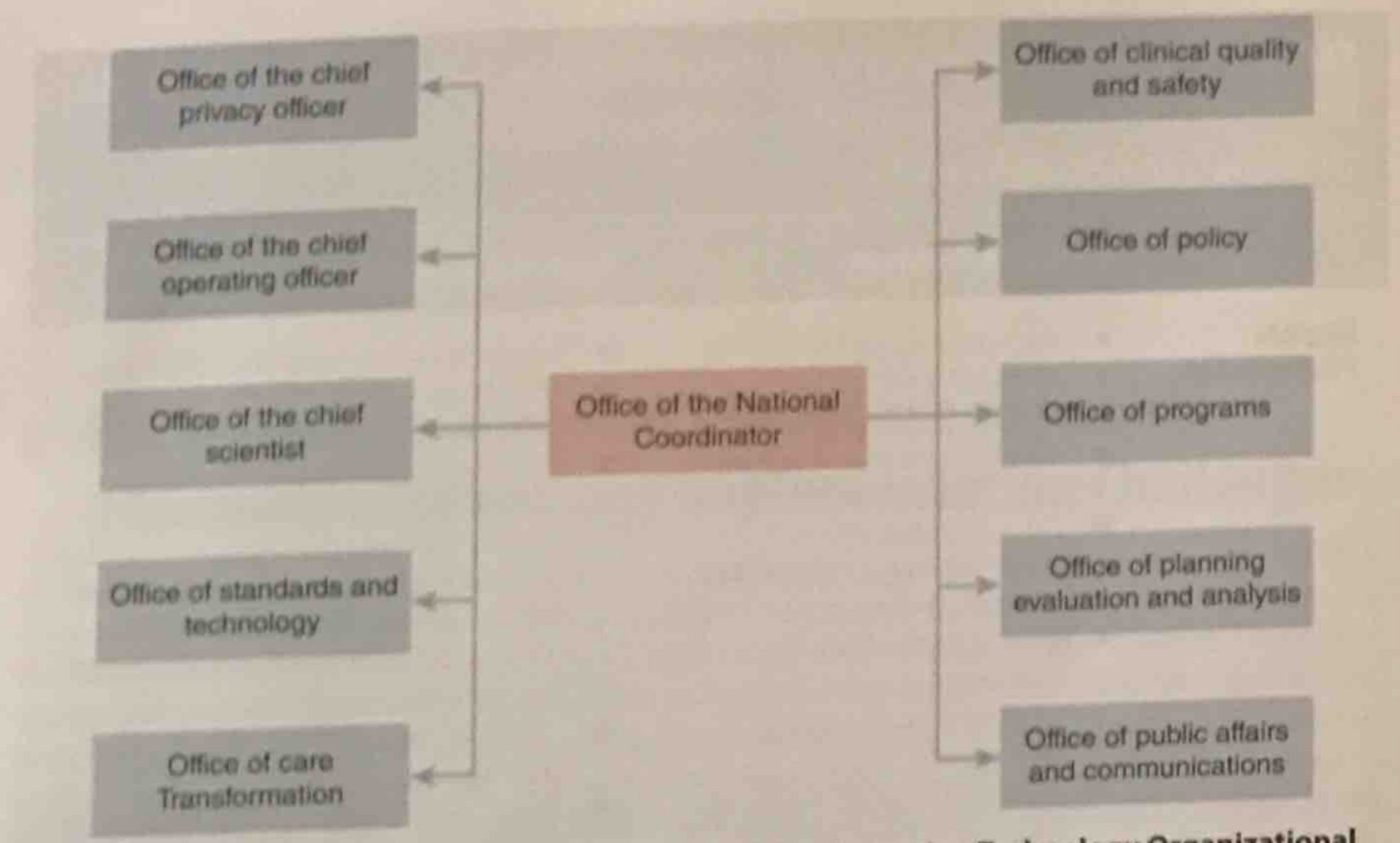

FIGURE 3-2 Office of the National Coordinator for Health Information Technology Organizational Structure

Modified from the Office of the National Coordinator of Health Information Technology' https://www.healthit.gov/newsroom/about-onc

information. The American Recovery and Reinvestment Act of 2009 (ARRA) provides that the Health IT Policy Committee shall at least make recommendations on the areas in which standards, implementation specifications, and certification criteria are needed in eight specific areas.

The Health IT Standards Committee is charged with making recommendations to the National Coordinator for Health IT on standards, implementation specifications, and certification criteria for the electronic exchange and use of health information.

The meaningful use requirements were developed by these committees and the ONC. The evidence for the majority of meaningful use objectives was only at the expert opinion level. The science of HIT awaits rigorous research studies to validate the choices and designs of the meaningful use criteria.

To receive the maximum incentive payment under the meaningful use program, Eligible Professionals who chose to participate in the Medicare Program had to achieve stage 1 of Meaningful Use by 2012 or by 2014 for a reduced amount.[32] Eligible Professionals who chose to participate in the Medicaid Program had to achieve stage 1 by 2016 to receive the maximum payment.[40] Those eligible professionals who begin to certify under the Medicare Program in 2015 or later or under the Medicaid Program after 2016 will receive no incentive payments.

By the end of November 2014, only 25.2 percent of Eligible Professionals and 43.1 percent of Eligible Hospitals had met stage 2 requirements.[41,42] Many physicians and hospitals complained about the difficulty and complexity of the reporting requirements as well as the lack of HIT tools readiness to support these requirements from HIT vendors. On October 6, 2015, CMS published a fact sheet titled "EHR Incentive Programs in 2015 and Beyond" to communicate

a simplification of the meaningful use requirements.[43] The criteria for Eligible Professional "modified stage 2" were simplified to 10 objectives, including one consolidated public health reporting objective. Previously, stage 2 required Eligible Professionals to meet 17 core objectives plus 3 of 6 menu objectives and to report electronically 9 out of 64 approved Clinical Quality Measures (CQM).[44] (These are standardized measures for healthcare providers and institutions to report on various aspects of the quality of care they provide.) For Eligible Hospitals, modified stage 2 objectives were reduced to 9, including one consolidated public health reporting objective. Previously, stage 2 required Eligible Hospitals to report on 16 core objectives plus 3 out of 6 menu objectives and to electronically report 16 out of 29 CQMs.[45] Under the same announcement, CMS finalized the requirements for stage 3 for 2017 and subsequent years. These included 8 objectives for Eligible Professionals and Eligible Hospitals, more requirements for interoperability, and improved quality reporting alignment with CMS quality reporting programs.[43]

Detailed information on the meaningful use requirements for modified stage 2 is available for Eligible Professionals[46] and Eligible Hospitals.[47] Some examples of meaningful use requirements for modified stage 2 for Eligible Professionals include:

- Performing a security risk analysis one time per year
- Using clinical decision support to improve performance on high-priority health conditions.
- Using Computerized Physician Order Entry (CPOE)
- Using an e-prescribing system for at least 50 percent of prescriptions
- Providing a summary care record when transferring patients from facility to facility
- Providing patient education with HIT
- Performing medication reconciliation at appropriate times
- Providing the capability for patients to view their electronic health information securely online or by downloading or transmitting it directly to a third party
- Using secure electronic messaging (email) to communicate with patients
- Transmitting required public health information electronically to the appropriate agencies

As noted previously, the ONC also has funded several programs to facilitate the adoption of EHRs. Examples include training programs to increase the number of professionals with IT skills required in the healthcare domain. Other programs fund the development of HIE standards across multiple EHR vendor platforms. The ONC also funds annual surveys to track HIT adoption and more recently HIT "developer contests" that incentivize innovation in ONC-targeted areas with monetary prizes.

HIT Opportunities: Improving Healthcare Delivery Quality, Effectiveness, and Efficiency

With mediocre evidence to date for HIT goals to improve healthcare quality and reduce costs, the question looms: What is the driving force behind the United States' quest to implement HIT? The answer resides in understanding the limitations of the human brain and limited attention span. A healthy human's performance begins to measurably decrease in about 40 minutes while monitoring a continuous process.[48] These limitations explain regulations for work-time breaks for air traffic controllers and anesthesiologists, work-hour limitations for airplane pilots and commercial truck drivers, and more recently work-hour limitations for medical students and residents.[49] These regulations recognize that human performance is limited by innate biology and physiology

and that fatigue degrades performance; no amount of training or willpower can overcome these biological and physiological limitations. These acknowledgements apply to healthcare delivery where a physician in a busy outpatient clinic or inpatient ward is much like an air traffic controller monitoring a continuous process. Patients are tightly scheduled with additional patients often "doubled-booked" at the last minute because of acute illness. Every patient must be seen and volumes of data accessed, processed, and synthesized to formulate a diagnosis and a plan of care. At the same time, the physician must document the encounter in detail, complete all required forms and insurance paperwork, respond to electronic pages and phone calls, speak with consultants, manage correspondence, and in many cases, also supervise midlevel providers, nurses, and office staff. Stead and Hammond have shown that the amount of data accessed and used by clinicians per medical decision is increasing exponentially despite the fact that physicians' ability to cope with the higher information load remains constant.[50] The driving concept behind EHRs' potential to improve the quality and reduce the cost of health care is represented in **FIGURE 3-3**.[51]

The ultimate goal is to combine the intuitive strengths of humans with the limitless data retention and recall speed of computers to create a hybrid system that is intuitive with a tireless data-processing capability. The physician's medical experience and communication and intuition abilities combine with the computer's ability to never tire or forget information. In other words, the computer provides the physician with a computerized decision support system (CDSS). The computer does not supplant the physician's role but enhances it by providing and managing the deluge of patient information to optimize the physician's performance beyond the brain's biological capability. However for CDSS to work, "the [computerized] interventions must deliver the right information, to the right person, in the right format, through the right channel, at the right point in workflow."[52] If any of these five requirements are missing, the system will tend to fail. With EHRs, the right place and the right point in the workflow often are when the physician is entering patient orders at a computer workstation, a process termed CPOE. At this place and time, the physician's mind is focused on the patient just seen or the patient they are currently thinking about. This also is the place and time at which it is easiest for the physician to take action, such as writing new orders that result in timely follow through for a patient's care.

For example, when a physician has completed a patient interview and examination and is using an EHR to enter e-prescriptions that will be sent securely over the Internet to the patient's pharmacy, the computer can present the physician with a pop-up "reminder" that the patient is allergic to the medication being prescribed. It can also indicate that the prescribed medication requires at least annual kidney function monitoring and that the last record of kidney function laboratory work is more than a year old. In this event, the system can present the physician with an option to order the appropriate laboratory work or to ignore the warning with a keystroke or mouse click. Most decision support is designed with these "soft stops" or interventions that allow the physician to heed or ignore the warning as he or she believes to be most appropriate. CDSS

FIGURE 3-3 Why EHRs Have Potential to Improve Quality and Reduce Costs

Adapted from Friedman CP. What informatics is and isn't. J Am Med Inform Assoc. 2013;0:1-3. Computer: © iStockphoto/Thinkstock. Head: © Lightspring/Shutterstock, Inc.

"hard stops" do not allow physician options to ignore a warning. An example of a "hard stop" could be the use of a very expensive, broad spectrum antibiotic that by hospital policy can only be ordered by an infectious disease specialist. In this case, the CDSS would not allow the physician to order the medication but would inform them that an infectious disease consult is required to order the drug and would make ordering that consult a mouse click away. A nonmedical example of a "hard stop" is the automobile design preventing the shift of an automatic transmission out of park and into drive unless the brake petal is depressed. This was implemented after reports of multiple accidental injuries and deaths attributed to unanticipated automobile movements. In this, like the medical example, the decision support system prevents the operator from making an error with high probability of significant adverse consequences. Because the computer never fatigues, the reminders compensate for physicians' biological limitations and the human–computer hybrid system outperforms what either could accomplish on its own.

There are hundreds of studies and randomized controlled trials published in the peer-reviewed, biomedical literature that have demonstrated how CDSS holds the potential to improve physician performance in myriad different healthcare venues. CDSS similarly designed to produce pop-up warnings and recommendations to physicians have been shown to improve ordering of age-appropriate screening tests,[19,20] appropriate antibiotic prescribing for inpatients,[53] appropriate advance directive discussions with patients,[54] use of preventative care for hospitalized patients,[19] appropriate weaning of patients from mechanical ventilators, appropriate reductions of inpatient resource utilization,[55] reduction in prevalence of Methicillin-Resistant Staph Aureus (MRSA) in a community,[56] isolation rates of patients admitted to the hospital with drug-resistant infections,[57] screening for sexually transmitted diseases in hospital emergency departments,[58] accurate capture and recording of patient temperatures by nurses in the inpatient setting,[59] and many other situations. Until recently, most of these studies were performed at major university healthcare centers that had custom-designed EHR software systems maintained by local IT departments with relatively large IT support budgets (compared with the smaller budgets of community hospitals).[17] In 2006, Chaudhry et al. published a systematic review of 257 CDSS studies published up to 2005 that concluded 25 percent of the studies were from four major academic institutions that all had custom designed systems and ". . . only 9 studies evaluated multifunctional, commercially developed systems."[17] Therefore, while there are hundreds of studies demonstrating the *potential* for CDSS to improve the quality of care and/or reduce its costs, the appropriate application of this research to typical healthcare settings in other than large academic institutions is largely unknown.

The Agency for Healthcare Research and Quality commissioned the most systematic, rigorous, and comprehensive review of CDSS studies to date and published the results in 2012.[60] The systematic review analyzed 311 studies in the peer-reviewed, biomedical literature and found moderately strong evidence confirming three previously reported factors associated with successful CDSS implementation:

1. Automatic provision of decision support as part of clinician workflow
2. Provision of decision support at time and location of decision making
3. Provision of a recommendation, not just an assessment

The study also identified six additional factors that were correlated with the successful implementation of CDSS:

1. Integration with charting or order entry system to support workflow integration
2. No need for additional clinician data entry
3. Promotion of action rather than inaction

4. Justification of decision support via provision of research evidence
5. Local user involvement in the CDSS development process
6. Provision of decision support results to patients as well as providers

The study found a high strength of evidence for CDSS to improve the ordering and completing of preventive care and ordering and prescribing recommended treatments "across academic, VA, and community inpatient and ambulatory settings that had both locally and commercially developed CDSS systems."[60]

There was a moderate strength of evidence that CDSS improves appropriate ordering of clinical studies, reduces patient morbidity and cost of care, and increases healthcare provider satisfaction.

Studies demonstrated a low strength of evidence for CDSS impact on efficiency of the user, length of hospital stay, mortality, health-related quality of life, and "adverse events" or medical errors.

The study also pointed out some significant voids in the current biomedical literature. None of the studies addressed the impact of CDSS on healthcare delivery organization changes, on the number of patients seen per unit of time, on user knowledge, on system cost-effectiveness, or on physician workload.

In summary, the current cumulative evidence for the benefits of EHRs with CPOE and CDSS is mixed. Even in areas where there is a high strength of evidence such as improvement in the ordering and completing of preventive care, the effective magnitude of the improvement is small, even though statistically significant.[60]

Health Information Exchanges

Virtually none of the commercially available EHR systems available in today's market or the custom-designed systems at large academic institutions can easily exchange patients' health information with care providers outside of their institutions. Despite more than 50 years of efforts, patients' health information remains "siloed" and "it is not uncommon for a single patient to be cared for by a large number of agencies in a single city, and workers in any one agency usually cannot find out about the activities of others; sometimes they even fail to learn that other agencies are active at all."[1] Barriers to interoperability of EHRs or the sharing of patient information across multiple institutions, providers, and EHR systems often become immediately apparent when a patient with a significant illness sees a number of different specialty physicians and attempts to coordinate the flow of information among them. Unlike other industries such as air transportation, that has cooperated to create a standardized ticketing system, the healthcare system has been marginally successful in designing a common platform or standard to allow a patient's records to be compatible with multiple vendor systems. In addition, health domain data are orders of magnitude larger and more complex than data for ticketing in the airline industry. In addition, the Health Insurance Portability and Accountability Act (HIPAA) regulations have had a chilling effect on healthcare institutions' willingness to share data with other institutions because they are responsible for patient privacy and the security of patient data.

Another reason patients' health information is not easily transmitted between various institutions with different EHR systems is that some EHR vendors actively block information transfer. Allegations of information blocking reached a sufficient level that on April 10, 2015, the ONC delivered a "Report to Congress on Health Information Blocking."[61] According to the report,

"The full extent of the information blocking problem is difficult to assess, primarily because health IT developers impose contractual restrictions that prohibit customers from reporting or even discussing costs, restrictions, and other relevant details. Still, from the evidence available, it is readily apparent that some providers and developers are engaging in information blocking."[62] The ONC has taken several actions to address this problem, including proposing new certification requirements for EHR systems.

These and other factors led to development of HIEs with their corresponding administering organizations, regional health information organizations (RHIOs). RHIOs attempt to create systems, agreements, processes, and technology to manage these factors in order to facilitate the appropriate exchange of healthcare information between institutions and across different vendor platforms. While most states and regions of the United States have RHIOs, the actual state of implementation and real data exchange varies widely. For example, some states have active RHIOs that are in the planning stages of establishing relationships with all key stakeholders, creating administration agreements, creating governance structures, securing funding, attempting to develop business models for sustained funding of the organization, etc. Other RHIOs have functioning HIEs where medical data are being exchanged between institutions and across disparate software EHR platforms. The ONC has funded many RHIOS to develop and test their national standards for HIE with the ultimate goal of creating the "Nationwide Health Information Network" that would be a network of regional networks across the whole country. Despite the testing and demonstration projects to date, actively functioning HIEs exist only at regional levels.

Each vendor's building toward one common standard would significantly reduce the technical complexity of data exchange. Unfortunately, vendors' products are still not being built toward one national standard to facilitate electronic HIE. Despite these limitations, there have been significant accomplishments in implementing the data and IT standards necessary to facilitate the exchange of health information among multiple EHR platforms. Today, most institutions participating in HIEs must build or configure "interface engines" that convert an institution's data format to the form used by the HIE. This is a major challenge as no single standard provides sufficient specification of data formats and communication protocols. Rather, a number of standards address various domains of data management. In addition, the voluminous scope of modern health care and continuous advancements in knowledge and technology make managing data in the healthcare domain extremely dynamic and complex.

As an example of this complexity, the Logical Observations Indexes Names and Codes (LOINC) standard was developed in the 1990s to solve a problem with an older health information communication protocol that specified how clinical data should be identified for transmission between computer systems. LOINC uniquely defines codes for information, such as blood chemistry laboratory tests, and clinical observations, such as patient blood pressure that can be recorded in many different formats. There are currently more than 70,000 LOINC-defined codes for uniquely reporting laboratory tests and clinical observations.[63] For example, there are 419 different codes for reporting blood pressure. With its unique codes for laboratory tests and clinical observations, LOINC enables computer systems receiving the data to generate exact interpretations. This is called semantic interoperability. Semantic interoperability is essential for patient record transmission from one EHR system to another so that the meaning of the critical data contained within the records is not at risk of erroneous interpretation.

Because new laboratory tests are constantly being developed and existing assays are being improved, LOINC creates and disseminates new codes so that semantic interoperability can be maintained. Old codes are not deleted from the system, ensuring that researchers using prior

clinical databases can retrieve prior results comparable with new codes. LOINC is supported by the National Library of Medicine (NLM), one of the National Institutes of Health. The LOINC Committee publishes quarterly updates and holds twice-annual, national meetings to discuss proposed new clinical observations and laboratory tests for the assignment of new LOINC codes.

For an HIE to transfer information accurately, each EHR system must map its own internal code for each datum to a standard code to ensure that information passed from one EHR to another in the exchange is interpreted exactly the same by the receiver as by the sender's system. LOINC is one of the many HIT-related standards. The Systematic Nomenclature of Medicine (SNOMED) was originally developed by the College of American Pathologists (CAP) to specify tissue pathologic diagnoses. The same group also developed a standard for clinical observations called SNOMED Clinical Terms (SNOMED-CT). LOINC and SNOMED-CT domain standards somewhat overlap, but their design characteristics are valuable in different situations; for example, exchanging laboratory results (where LOINC works better) versus coding patient problem lists within EHRs (where SNOMED-CT works better). Similar to LOINC, CAP also provides periodic updates to SNOMED-CT codes.

To keep track of the many coding standards and the terms within, the NLM built and maintains the Unified Medical Language System (UMLS), which houses a massive "metathesaurus" and a variety of tools for mapping between and discovery of more than 200 biomedically related terminology standards.[64] Because LOINC, SNOMED-CT, and the 200 or so other standards are periodically updated, the UMLS also is updated regularly to keep the interstandard terminology mapping current and accurate.

Using HIEs, designated member groups of healthcare institutions exchange data in a standardized format using a combination of the previously described standards. This cooperation enables the access to a comprehensive clinical data set on individual patients across multiple institutions and multiple EHR vendor platforms.

There are two kinds of HIE architectures: "monolithic" and "federated." With the monolithic architecture design, all member institutions periodically send copies of their clinical data to one central repository where all the data reside together in one format. The advantage of this approach is that a patient's comprehensive data can be maintained in one place and in one format. However, this approach has several disadvantages. First, the frequency with which members contribute and update copies of institutional data can vary, making the comprehensive HIE medical record potentially out of date. Second, aggregating data from multiple institutions creates administrative complexity with regard to HIPAA regulations. HIPAA requires each healthcare institution to maintain security of its patients' data. If an institution's data are "mixed" in the HIE database with data from other institutions, the responsibility of ensuring patient privacy and data security reverts to all HIE member institutions. HIPAA requirements make fulfilling healthcare organization obligations to insure patient privacy more difficult and complex. Third, when data are aggregated by a third party or HIE, the ability of the source institution to assert control over data contributed to the collective HIE is limited. If, for example, an institution desires to stop participating in an HIE because of concern for patient privacy and data security, it may be technically difficult and time consuming to selectively delete all data from one institution from the HIE database. The monolithic model of health-information exchange is depicted in **FIGURE 3-4**.

The federated model of health information exchange is the most widely used, allowing contributing institutions to maintain control over data for which they are responsible under HIPAA. In this model, institutional data resides within each institution's system. The HIE database is small, containing only a master patient index (MPI) housing the identifiers for each patient in the form of each institution's unique patient record numbers along with patient

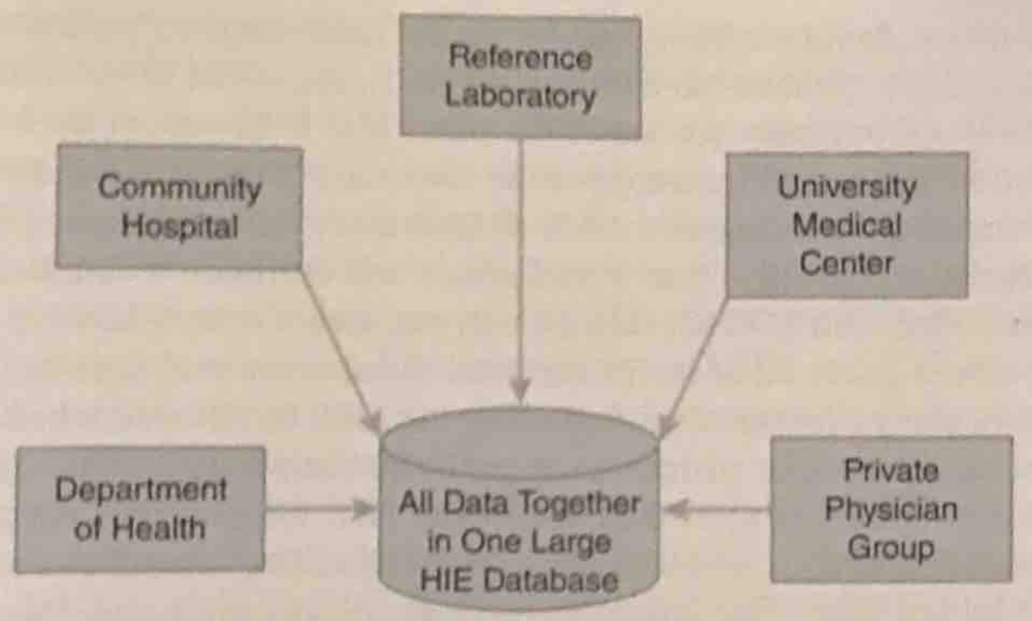

FIGURE 3-4 HIE Monolithic Model
Institutions periodically send copies of their clinical data to one central repository. Individual trans-institutional patient records are maintained in the central database where they can be accessed by authorized users.

demographic data sufficient to facilitate accurate identification of individual patients with the same or similar names. This information is mapped to all of the institutional-specific patient identifiers in the exchange. **FIGURE 3-5** depicts the federated model.

With the federated model, a patient who has medical records at more than one institution in the HIE would have all medical record numbers from the various institutions that store their clinical data linked together in the common MPI, along with basic demographics such as address, date of birth, and social security number. This allows for fast and accurate identification of patients named "John Smith" because the MPI maintains sufficient identifying information to ensure selection of the correct patient among all institutions in the exchange.

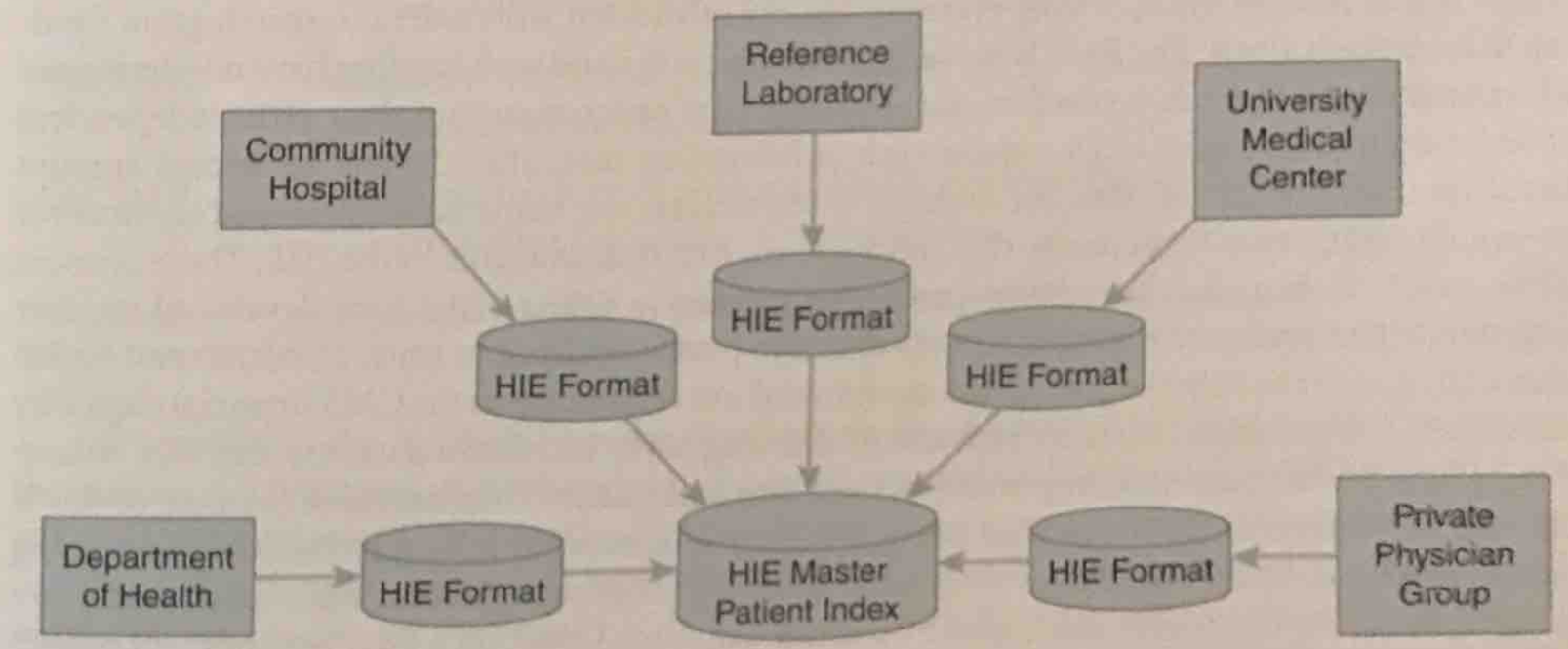

FIGURE 3-5 HIE Federated Model
Institutions maintain copies of their own data at their site in the format used by the HIE. Individual trans-institutional patient records are assembled in real time by searching all institutions' databases only when needed/requested by authorized users. Individual institutions can "opt-out" of the HIE at any time by disabling access to their database.

"John Smith" would be identified from others with the same name by parameters such as date of birth or social security number. No clinical data are stored in the MPI. Clinical data usually are maintained in the proprietary format of the particular EHR system used by each institution. Each institution also maintains a copy of the same data in the HIE standardized form. For example, all HIE members could agree to code all laboratory test results using the LOINC standard described earlier. Each institution would create and maintain a database of all patients' laboratory results coded with LOINC. When a user requests a comprehensive record from the HIE, the system would query all of its institutional members in real time to send all the data available on a particular patient as identified using the MPI. In this way, when an HIE receives a records request on a particular patient, each institution sends data on the requested patient from the database where all clinical data are in the HIE format. This process ensures that the data are collected securely, assembled into a comprehensive record, and made available to authorized users in real time. This comprehensive record is only accessible on a patient-by-patient basis for immediate patient care purposes; it is not copied to any institution's system. When the user logs out of the HIE, the comprehensive record assembled for that episode of patient care is deleted.

The federated model has several advantages over the monolithic model. With the federated model, each institution maintains complete control over its data, simplifying compliance with HIPAA regulations. If, for example, a data breach occurs in the database of an HIE that uses the monolithic model, responsibility for the data breach is not always clear. Data breaches in a federated system usually are attributable to a particular institution and not the HIE (unless there is a data breach of the MPI). Another benefit of the federated system is that trans-institutional data can be up-to-the-minute accurate because each time a user requests access, the clinical data from all institutions are assembled in real time. Institutional HIT administrators typically favor the federated model because they have the option of withdrawing from the HIE at any time in order to maintain control of patient privacy and data security under HIPAA guidelines.

While communities with HIEs generally appreciate the benefits of interoperability, the current reality is that most of the operating HIEs are heavily subsidized with federal research grant funding to keep them afloat. The RHIOs that administer the HIEs and seek funding have not developed a business model that can be used in all communities in order to sustain their HIEs independent of federal funding. Some HIEs require each participating institution to pay an annual amount based on their institution's size, the number of physicians, etc. Some have developed services for payers, charging them for access to the comprehensive records available in the HIE. These services allow payers to increase their claims-processing efficiency. Other HIEs have developed services to generate comprehensive quality reports to sell to payers desiring to track physician and health plan outcomes or to help them meet the meaningful use requirements for CMS financial eligibility incentives. Some communities are resistant to allowing payer access to a data resource they believe should be solely dedicated to improving patient care and quality.[65] An excellent example of this is the State of Vermont's 2006 law that prevented data miners from selling physicians' prescribing data to pharmaceutical companies who wanted the information to inform their marketing practices. In 2011, the law was struck down by the U.S. Supreme Court on a First Amendment basis.[66] Physicians may feel uncomfortable participating in an exchange they know government, payers, or pharmaceutical companies may use for monitoring individual practice outcomes and patterns. While the benefits of HIEs are documented and desirable, solving the cultural and business-model issues will be essential to obtaining the national goal of a network of regional exchanges that will span the entire country.

Another challenge to developing interoperability is the fact that many institutions' HIT resources are dedicated to keeping up with current quality reporting requirements, meaningful use adoption, and other mandated HIT issues. One recent example is the CMS-mandated conversion from using the International Classification of Disease Version 9 billing codes (ICD-9) to ICD-10. Originally designed to identify diagnoses for billing purposes only, ICD-9 codes have become valuable in performing automated chart reviews for quality control and research purposes. However, because of several deficiencies with ICD-9, the new ICD-10 standards have been mandated. A full discussion of the key differences between ICD-9 and ICD-10 is well beyond the scope of this book. A focus on just one issue illustrates the magnitude of the change—the impact on the complexity of physician documentation.

There are approximately 13,000 ICD-9 codes and more than 65,000 ICD-10 codes. The greater number of ICD-10 codes is due to the higher specificity of ICD-10. For example, ICD-9 codes did not include laterality (i.e., right and left side of body). ICD-9 has a grand total of two possible codes for a thumb fracture:

815.01	Closed Fracture of the Base of the Thumb (First) Metacarpal
815.11	Open Fracture of Base of Thumb (First) Metacarpal

Some of the codes for the same injury in ICD-10 include:

S62.511B	Displaced fracture of proximal phalanx of right thumb, initial encounter for open fracture
S62.511D	Displaced fracture of proximal phalanx of right thumb, subsequent encounter for fracture with routine healing
S62.511G	Displaced fracture of proximal phalanx of right thumb, subsequent encounter for fracture with delayed healing
S62.511K	Displaced fracture of proximal phalanx of right thumb, subsequent encounter for fracture with nonunion
S62.511P	Displaced fracture of proximal phalanx of right thumb, subsequent encounter for fracture with malunion
S62.511S	Displaced fracture of proximal phalanx of right thumb, sequela

In addition to the six ICD-10 codes listed above, there are 99 additional choices to account for various combinations of displaced/nondisplaced, open/closed, proximal/distal location, right/left, union/nonunion/mal-union of fracture, routine/delayed healing, initial/subsequent encounter, and so on. For decades, physicians have been writing their narratives in patient records supporting the billing process for the simpler ICD-9 code set. With ICD-10, the narrative in this example requires sufficient documentation to support the selection of the exact ICD-10 billing code; in other words, the narrative must include mention of displaced/nondisplaced, open/closed, proximal/distal phalanx location, right/left, etc. Failure to do so could result in not being reimbursed or even being fined if a CMS chart audit was performed. This requirement for added specificity has been the most significant change to the way in which physicians' document diagnoses in decades.

The Veterans Administration Health Information System

No discussion of HIT, EHRs, and HIEs would be complete without noting the HIT system used by the Veterans Administration (VA). The VA is a model representing a single-payer healthcare system in the United States. Unlike other components of the healthcare delivery system, the VA HIT system supports only one payer, one pharmaceutical formulary, one provider group, and one supplier of laboratory testing. All VA physicians are employees of the same organization, so new policies and practices can be communicated, implemented, and monitored much more easily and efficiently than in the U.S. multi-payer, multi-formulary, siloed systems. Also, the VA has one universal EHR system with CPOE and CDSS. The VA EHR is able to code all data in one format that allows veterans who move from state to state to have their entire VA medical record seamlessly follow them. All these factors have allowed the VA to offer high-quality care at a relatively reasonable cost. Until the United States creates a single-payer system and uses the same EHR universally, the larger system will suffer from the enormous complexity and costs of developing and maintaining multiple data standards to support the exchange of health information among institutions and across vendor platforms.

Electronic Health Record Adoption Progress in the United States

The National Center for Health Statistics (NCHS) has tracked the use of EHRs in the outpatient setting since 2006. The NCHS specifically defines two levels of adoption as "any" and "basic." This distinction is important because many other surveys report EHR adoption rates but do not define in any detail what "EHR adoption" actually means. This survey uses an exacting definition of "any" and "basic" EHR adoption that produces results that are much more valid than surveys where "adoption" is not well defined. **FIGURE 3-6**, "Percentage of office-based physicians with EHR systems: United States, 2001–2013,"[67] illustrates the adoption trends for the outpatient setting. This report indicated:

> In 2013, the National Ambulatory Medical Care EHR Survey showed that about 78 percent of office-based physicians used any EHR system. Since 2006 (first year for which data are available), the percentage of physicians who reported having an EHR system that met the criteria for a basic system increased 336 percent—from 11 percent in 2006 to 48 percent in 2013. Adoption of a basic EHR system varied greatly by state. Adoption ranged from 21 percent in New Jersey to 83 percent in North Dakota.

The ONC has been tracking hospitals' adoption of EHRs since 2008 using standard definitions of "Certified" and "Basic" EHR systems. **FIGURE 3-7**, "Percent of non-federal acute care hospitals with adoption of at least a Basic EHR with notes system and possession of a certified EHR: 2008–2014" illustrates the hospital EHR adoption rates.[68] This report states:

> In 2008, hospital adoption of at least a Basic EHR system was above 20% in only 2 states (Connecticut and New Mexico). Three years later, hospital adoption of at least a Basic EHR system was above 20% in 32 states and above 40% in 7 states. In 2014, hospital adoption of at least a Basic EHR system was above 60% in all but 2 states (Hawaii and West Virginia), and above 80% in 17 states.[68]

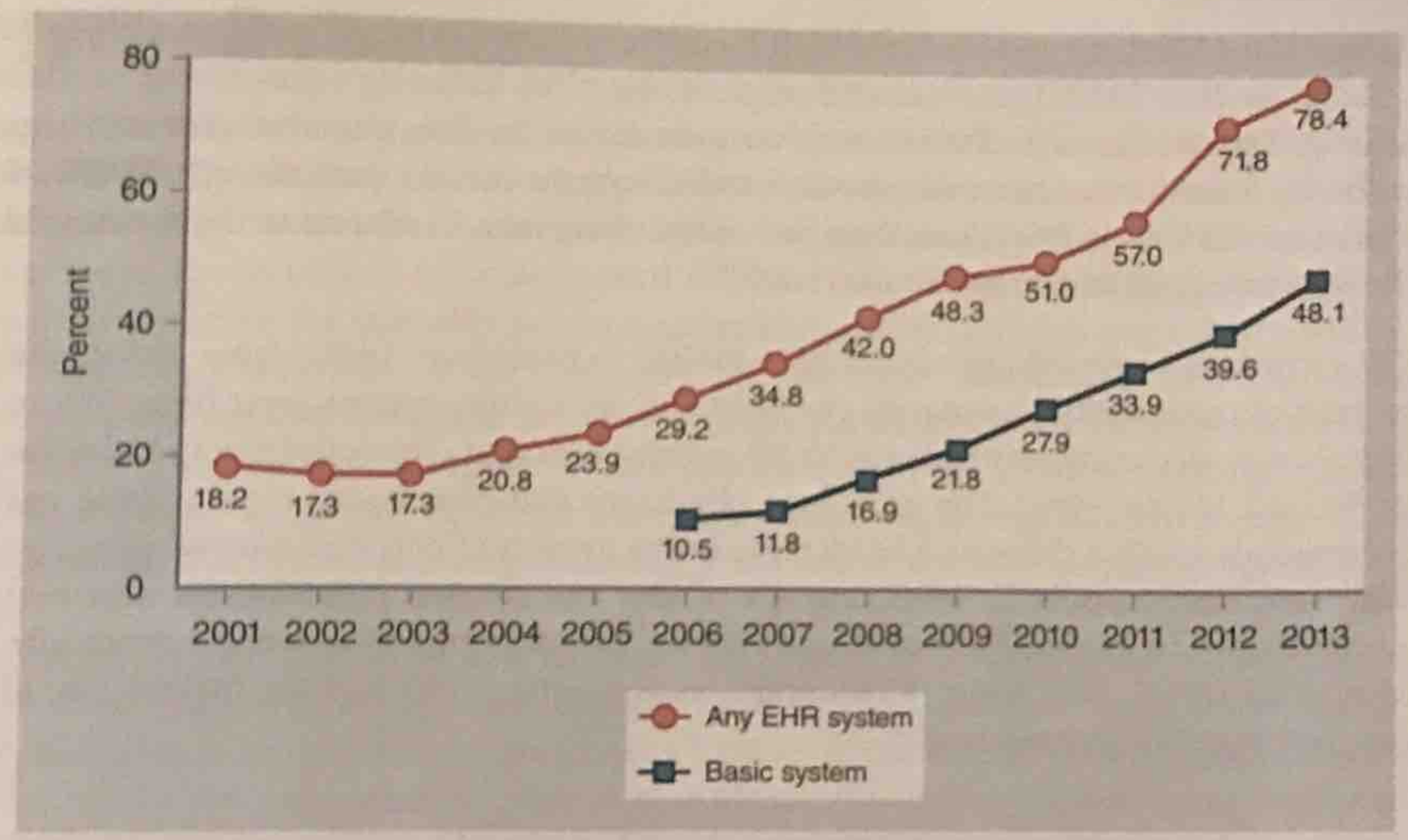

FIGURE 3-6 EHR Adoption Among U.S. Office-Based Physicians, 2001–2013

Reproduced from CDC/NCHS, National Ambulatory Medical Care Survey and National Ambulatory Medical Care Survey, Electronic Health Records Survey NCHS Data Brief No 143, http://www.cdc.gov/nchs/data/databriefs/db143.htm.

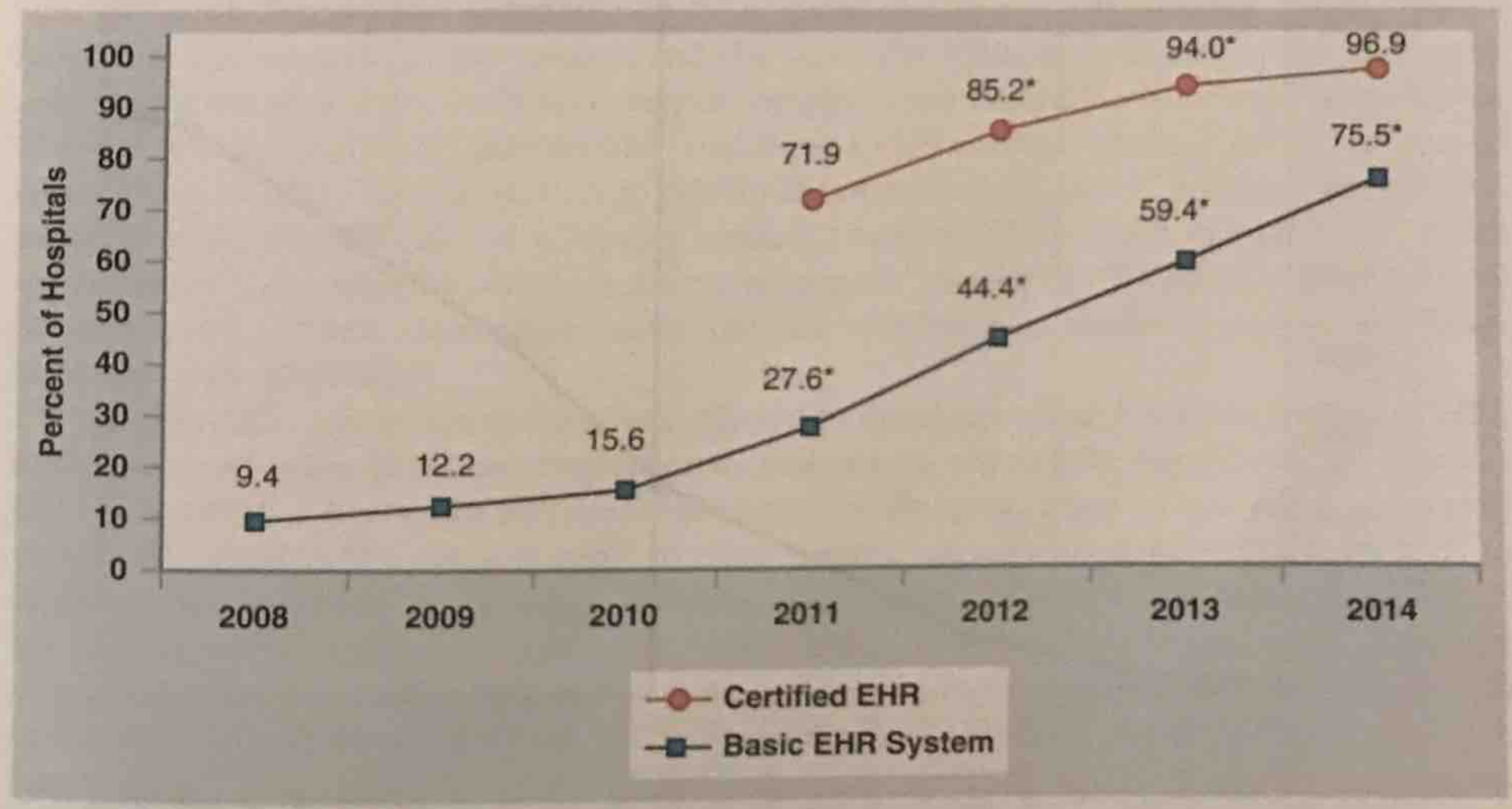

FIGURE 3-7 Percent of Non-federal Acute Care Hospitals with Adoption of at Least a Basic EHR with Notes System and Possession of a Certified EHR: 2008–2014

Reproduced from ONC/American Hospital Association (AHA), AHA Annual Survey Information Technology Supplement.

Note that EHR adoption rates are typically published every two to three years by the NCHS and the ONC. At the time of this printing, the most recent surveys published by NCHS and ONC were through 2013 and 2014, respectively.

As part of the Medicare and Medicaid EHR Incentive or "meaningful use" programs, Eligible Providers had to use their EHRs to meet several program objectives, including e-prescribing. In addition, the Medicare Improvements for Patients and Providers Act, or the "eRx incentive" program, began in 2008, offering financial incentives for providers to facilitate the use of e-prescribing.[69] **FIGURE 3-8** is a graph from an ONC Data Brief illustrating the e-prescribing rates in relation to the meaningful use and eRx incentive programs. From the data brief:[69]

> The growth in e-prescribing has not been limited to physicians. In the same period, the percent of community pharmacies enabled to accept e-prescriptions grew from 76% to 96%. Nearly all community pharmacies are enabled to accept e-prescriptions in Delaware (99%) and Maine (99%). The growth of physicians and pharmacies e-prescribing has corresponded with a thirteen-fold increase in the growth of new and renewal prescriptions sent electronically. In 2008, only 4% of new and renewal prescriptions were sent electronically. In 2013, 57% of new and renewal prescriptions were sent electronically. Minnesota (89%), Wisconsin (83%), and Massachusetts (77%) had the highest rate of new and renewals sent electronically.

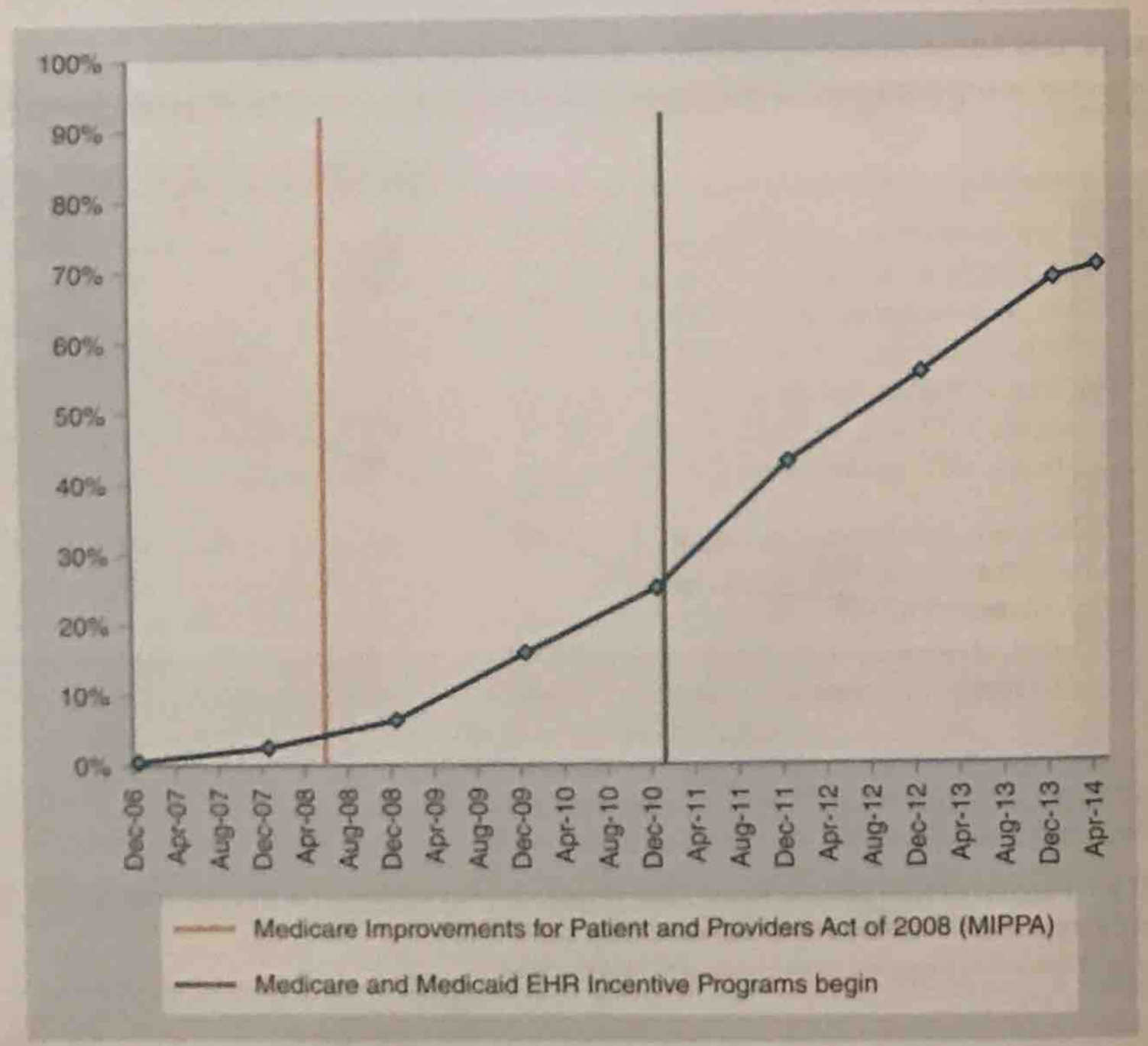

FIGURE 3-8 Percent of Physicians e-Prescribing Using an EHR from December 2006 and April 2014

Reproduced from ONC analysis of physician prescriber data from Surescripts. Denominator from SK&A 2011 Office Based Providers Database. https://www.healthit.gov/sites/default/files/briefs/physician-ehr-prescribing-increases2014.pdf

Future Challenges

Although there is mounting evidence supporting the value of EHRs with CPOE and CDSS in several well-defined areas such as improving preventive care delivery, extensive meta-analyses report combined average results. There have been several inconclusive and negative studies, and some have actually shown patient harm associated with the installation of CPOE. In one of the most extensively reported, the mortality rate in a neonatal intensive care unit more than doubled after a CPOE system was installed at the University of Pittsburgh.[70] Much has been written about the reasons for this negative result and despite the finger pointing, there is virtually universal agreement that HIT can be very disruptive to work processes and work cultures resulting in significant harm to patients.[71] Some have called for more HIT standards and regulation to prevent these negative consequences in the same way as the U.S. Food and Drug Administration regulates medical devices.[72,73]

Due to the administrative and technical difficulties of achieving the Nationwide Health Information Network, proprietary entities have offered alternate approaches to develop personal health records (PHRs) through which patients create their own records in a standardized format. In these approaches, patients may physically carry records or make them available to caregivers via the Internet. Microsoft, Google, and many other corporate entities have built such systems but with little marketing success. Google Health announced its shutdown on June 24, 2011, after only three years of operation. Google joins other lesser-known firms that have decided to close down PHR services.[74] Design of existing PHRs requires patients to have a high level of health literacy and computer savvy. A major reason analysts believed Google Health failed was the newness of the concept and the facts that PHRs are difficult to use and many people find the data-entry work necessary to complete their record too laborious.[75] One survey of patients found that only 7 percent had tried using a PHR and only about 3 percent continued to use them in 2011.[75] Other barriers to patient adoption include lack of personal health management tools, the difficulty in achieving semantic interoperability such that personal health management tools could be useful, problems vetting the identity of PHR users, patient privacy concerns, and perhaps, most importantly, the lack of a business model to support the long-term operation of PHRs.[74]

In addition to physicians and patients affected by development and implementation of HIT, there are many other healthcare professionals and venues affected by significant complexities and characteristics that make HIT implementation challenging. Many of the same issues previously discussed in this chapter apply to these venues, such as standardized data formats to facilitate data portability, work culture barriers, system costs, training issues, and other matters. For example, some emergency medical services (EMS) providers have begun to use a variety of portable EHRs to collect data at the scenes of patient incidents with systems designed to transmit data to receiving hospitals. The same issues that complicate the ease of universal HIE between healthcare institutions apply to the data exchange between EMS and hospital systems and will not be resolved easily.

To achieve the HIT goals of improving healthcare quality and reducing costs, extensive and rigorous work remains in the research and implementation arenas. After 50 years of efforts, most notably in the past five years, government, industry, and academia are only now recognizing the critically important and interdependent roles that standardization, administrative processes, and work cultures play in the achievement of HIT-desired outcomes.

KEY TERMS FOR REVIEW

Computerized Decision Support System (CDSS)
Computerized Physician Order Entry (CPOE)
Electronic Health Record (EHR)
Federated Model of Health Information Exchange
Health Information Exchange (HIE)
Health Information Technology for Economic and Clinical Health Act (HITECH Act)
Information Blocking
Meaningful Use
Monolithic Model of Health-Information Exchange
Office of the National Coordinator for Health Information Technology (ONCHIT or "the ONC")
Personal Health Record (PHR)
Regional Health Information Organization (RHIO)

CHAPTER ACRONYMS

ARRA American Recovery and Reinvestment Act
CAP College of American Pathologists
CDSS Computerized Decision Support System
CMS Centers for Medicare & Medicaid Services
CPOE Computerized Physician Order Entry
CQM Clinical Quality Measures
EHR Electronic health record
EMS Emergency medical services
HIE Health information exchange
HIPAA Health Insurance Portability and Accountability Act
HIT Health information technology
HITECH Health Information Technology for Economic and Clinical Health Act
LOINC Logical Observations Indexes Names and Codes
MPI Master patient index
NCHS National Center for Health Statistics
NLM National Library of Medicine
ONC Office of the National Coordinator (short for ONCHIT)
ONCHIT Office of the National Coordinator for Health Information Technology
PHR Personal health record
RHIO Regional Health Information Organizations
SNOMED Systematic Nomenclature of Medicine
SNOMED-CT Systematic Nomenclature of Medicine – Clinical Terms
UMLS Unified Medical Language System

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