Health IT and EHRs

Principles and Practice

Sixth Edition

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About the Author

Margret K. Amatayakul, MBA, RHIA, CHPS, CPHIT, CPEHR, CPHIE, FHIMSS has more than 40 years of experience in national and international healthcare information management. She is a leading authority on electronic health record (EHR) strategies and has extensive experience in EHR selection, project management, and optimization for their use in a meaningful way. After having served as director of medical record services at the Illinois Eye and Ear Infirmary, associate professor at the University of Illinois at the Medical Center, associate executive director of the American Health Information Management Association, and executive director of the Computer-based Patient Record Institute, Ms. Amatayakul formed the consulting firm, Margret\A Consulting, LLC, in 1999 to assist providers, health plans, and vendors with EHR and associated regulatory practices, including HIPAA transactions and code sets, privacy, and security; meaningful use incentive programs, and health reform initiatives. She also served as adjunct professor at the College of St. Scholastica and is on the advisory council of the University of Illinois at Chicago College of Applied Health Sciences. She provides health information systems technology consulting services, freelance writing, and educational programming to the healthcare industry.

Preface

The amount of change from one edition of this book to the next continues to be monumental. Since the 2013 update to the fifth edition was published, EHRs have been adopted by the vast majority of hospitals, many physician practices, and an increasing number of other types or provider settings. In fact, the federal government's meaningful use (MU) incentive program that was the key topic of the fifth edition is being supplanted in the federal government by a focus on the broader scope of health information technology (health IT) in general. Though not without some measure of complaints and controversy, the industry:

- Has seen unprecedented amounts of federal funding put toward incentivizing adoption of EHR, providing associated workforce training, and supporting research in best health IT practices. These incentives are now transitioning into components of reimbursement under health reform initiatives; much as quality measures—such as avoidance of certain types of readmissions and reducing emergency department visits—have influenced Medicare payments.
- Is focusing EHR efforts on optimizing their use, replacing "starter" EHRs with more robust systems, and acquiring complementary health IT to ensure that every aspect of information use within a given setting is automated. While there remains considerable concern over the usability of EHR systems and their potential for unintended consequences, provider settings are focusing on workflow and process improvement to improve use and reduce risk. Vendors are also looking into ways to make it easier for users to use these systems.
- Is expanding the scope of health IT beyond EHR within a given entity to finding ways to better share health information across the continuum of care and with patients. Interoperability, or the ability for disparate systems to exchange data, continues to be a challenge. But new ways to share information are being found. A variety of health information exchange services support provider-to-provider sharing of health information. Patient consent structures and data/information governance processes have also enabled enhanced use of clinical information—for personalized medicine, quality improvement, and clinical research. Is integrating clinical information with administrative and financial information in an effort to achieve greater value for healthcare spending. Health reform initiatives focused on finding best practices that reduce cost and improve the quality of care and patient experience

of care depend on accurate and standardized data. Value-based payment, as the mechanism for paying providers under health reform, is focused on paying for positive outcomes, not just what services are provided. This is a significant shift in how healthcare is reimbursed and will require significant focus on the quality of data in the EHR and data from improved revenue cycle management, It is also being recognized that health depends not only on the medical care which a person receives, but on a person's life style. Information about health and social determinants of health are being brought together as population health.

Objectives of this Practical Guide

This sixth edition is being renamed *Health IT and EHRs* as a result of the expanded scope of the technology needed for all health information collection and use. The sixth edition is also focused more on serving as a textbook in addition to serving as a reference work for readers who work in any health setting, whether a healthcare provider organization, vendor, health plan, or policy-maker. The book introduces the full scope of health IT in chronological fashion, covering the information systems development life cycle, strategic planning, goal setting workflow and process mapping, change management, vendor selection, project management, and implementation, training, and ongoing maintenance of EHR and other health IT systems. It also addresses the essential elements of data infrastructure, information technology, privacy and security, and interoperability for all forms of health IT. Finally, there is considerable expansion in chapters covering techniques to achieve value with health IT in various acute care, ambulatory care, and specialty care settings as well as for consumer health IT, enterprise content and record management as an EHR bridge technology, revenue cycle management, and population health. Those familiar with the fifth edition of *Electronic Health Records: A Practical Guide for Professionals and Organizations* will find that some of the chapters have been moved around, consolidated, or expanded in the sixth edition. Two chapters have been added, on revenue cycle management and population health, given expanded interest in integrating information on clinical, administrative or financial, and social determinants of health.

Chapter 1 defines health IT and the EHR, summarizes the key elements of the federal government's programs for incentivizing use of EHRs, and explains the origins of EHR and its future directions and envisioned benefits. It also provides a framework and conceptual model of the components comprising EHR in a provider setting and the components comprising health IT. These frameworks serve as references throughout the remaining chapters in the book. Chapter 2 provides grounding in general systems theory and the systems development life cycle to reinforce that an EHR is not a single application but, rather, a system of health IT components that must work together and with other health IT components. Chapter 3 addresses the purpose, scope, and governance of strategic planning for health IT, including how to construct and document a migration path that addresses not only hardware and software but the people, policy, and process issues needed to achieve success with health IT.

Chapter 4 introduces the concept of healthcare value and the US focus on the Triple Aim goals for EHR and health IT. It encourages the application of a process to set both SMART and STRETCH goals and to monitor achievement. Types of benefits of health IT are described and ways to measure benefits, including how to compile a total cost of ownership and return on investment analysis for EHR and other health IT. Chapter 5 identifies the importance and scope of workflow and process improvement, providing detailed information on how to use workflow and process mapping tools, ensure process improvement through managing team empowerment, group facilitation, and process improvement techniques. Chapter 6 focuses on change management for health IT. It discusses the nature of health IT change and the need for change management, planning for

communications, and creating change leaders. Chapters 7 through 9 cover the various aspects of health IT vendor selection and contract negotiation; project management; and systems implementation, training, and ongoing maintenance. These tasks in various degrees are performed with every acquisition of health IT – whether a new system or a replacement. Chapter 7 provides information on conducting a vendor selection, including critical tasks of due diligence, contract negotiation, and contract management throughout the duration of systems implementation. Chapter 8 focuses on project management, another task that is conducted for every new, modified, or replaced information system. The scope and characteristics of an EHR or other health IT project are described, especially with respect to human resource requirements, organizational structures, team-building characteristics, and skills sets for being or hiring a successful project manager. Chapter 9 covers health IT implementation planning and management, including risk management. The importance of infrastructure preparedness, configuration management, testing, data and chart conversions, and ongoing strategies for successful adoption and optimization of health IT are described.

Chapters 10 through 13 cover more of the technical aspects of health IT and EHRs. Chapter 10 describes the data, information, and file structures necessary for an EHR and other health IT, It defines the role of data infrastructure in the creation of the data-information-knowledge-wisdom continuum; describes types of data, their formats, and process requirements; discusses vocabulary standards; distinguishes between types of data architectures; defines data management and data modeling; describes the importance of a data dictionary and metadata; and discusses the importance of governance, data quality, and data integrity. Chapter 11 provides a primer on computer concepts, communications technologies, internet services, data storage and retrieval, and emerging technologies. Chapter 12 is devoted completely to privacy and security, explaining federal privacy and security standardization efforts, discussing breach management and notification, reviewing Red Flags and Payment Card Industry Data Security as applicable to certain health-related organizations, and identifying emerging privacy and security threats and suggesting strategies for addressing them. Chapter 13 on interoperability describes the maturity of interoperability, describes technical standards, explains the role of semantic interoperability, introduces standard messaging protocols, and emphasizes the importance of process interoperability for healthcare. Chapter 13 also covers health information exchange, including organizational structures, architectures, and services; and explains how providers may share data over the nationwide health information exchange called eHealth Exchange.

Chapters 14 through 18 focus on specific types of EHR applications, with an emphasis on optimizing their use. Chapter 14 describes optimization strategies for the acute care EHR components of results management, point of care documentation, computerized provider order entry and barcode medication administration, clinical decision support, and reporting. Chapter 15 describes EHR in the ambulatory care environment, with an emphasis on comparing and contrasting acute and ambulatory EHRs, functions of an EHR in the ambulatory setting, and recommending tactics for optimizing use of EHR in an ambulatory setting. Chapter 16 covers EHR in specialty organizations, focusing on the nursing home, home health, and behavioral health facilities, but also addressing the full scope of special facility needs for EHRs. Chapter 17 focuses on PHRs, describing their attributes, functionality, and supporting standards. The current state of PHR utilization, benefits and barriers for adoption, policies and practices that may aid in overcoming barriers to use, describes mobile health devices, and discusses the impact of consumer empowerment on PHRs and their role in value-driven healthcare initiatives. Chapter 18 addresses enterprise content and record management as an EHR bridge technology, also describing how electronic content management technologies fit into the overall strategic health IT migration path.

Finally, chapters 19 and 20 provide content that is new to the sixth edition of this book. Chapter 19 on revenue cycle management is included to emphasize the importance of revenue cycle management in integrating administrative and financial data with clinical data in the current push to value-based payment. The chapter describes revenue cycle management challenges, enhancements

to HIPAA transactions, and opportunities for health IT to better support revenue cycle management for health reform. Chapter 20 defines population health and its scope, including health IT needed for population health management, tools to support quality measurement for improved health outcomes, and discusses the importance and use of big data and healthcare analytics to measure quality of care, cost, and experience of care and provide intelligence for continuous improvement.

As suggested by the ever-accelerating pace of change in health IT and EHR, a textbook should be considered a means to understand basic concepts and promote best practices—including the need to keep current. There are many factors that influence the dynamics of health IT and EHR, including technology advances, continuous product improvement, user acclimation to health IT and EHR, and public policy—especially a new administration at the federal government which can shift emphasis seemingly without warning. Readers are encouraged to continue their pursuit of knowledge about health IT and EHR by continuously scanning the web for new information. That said, it is important to note that any websites listed in this book were current and valid as of the date of publication. However, web page addresses and the information on them may change or disappear at any time and for any number of reasons. The reader is encouraged to perform general web searches to locate information where site addresses listed here are no longer valid.

Note to academic educators: Instructor materials for this book include lesson plans, chapter slides, test banks, EHR simulation modules, and other useful resources. Visit http://www.ahima.org/publications/educators.aspx for further instruction. If you have any questions regarding the instructor materials, please contact AHIMA Customer Relations at (800) 335-5535 or submit a customer support request at https://secure.ahima.org/contact/contact.aspx.

Acknowledgments

The first edition of this book acknowledged the contribution of Rita Finnegan, past president and former executive director of AHIMA. It was Ms. Finnegan who brought me into the field of health information management (HIM) and achieved AHIMA support for the Institute of Medicine's first patient record study that led to my involvement in the formation of the Computer-based Patient Record Institute (CPRI) and extended my network of associates and influence well beyond traditional boundaries.

As noted in subsequent editions of this book, that network has only continued to grow and be enriched by many colleagues, clients, and students who teach me so much. These opportunities help me to achieve my professional goal of seeing EHRs become the basic supporting infrastructure for healthcare, now enhanced with many other forms of health IT. This sixth edition with its dual focus on EHR and health IT occurred largely as result of the unprecedented investment by the federal government in supporting EHR acquisition and implementation and then moving rapidly to health reform initiatives that depend heavily on data derived from EHRs and processed by other forms of health IT in many new ways. Challenges still remain, but significant progress is being seen.

Finally, a book is not a realization of one's passion without expressing appreciation to those who made a direct contribution to the work. The staff and reviewers from AHIMA kept me on my toes. With each edition, there are many unidentified persons who review the book and offer suggestions that are greatly appreciated. It is especially helpful to have input from students' perspective. As with previous editions of the book, two students who conducted their management practicum with me, Amanda Turek and Mika Ishikawa, offered recommendations for content and help with case studies for the instructor's manual. Finally, my husband, Paul, is the ever-present force that keeps me going and makes this work so special to me. My sincere thanks to all.

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AHIMA provides supplementary materials for approved academic educators who use this book in their classes. Materials include curriculum map, test bank questions and answers, and PowerPoint slides. Visit **http://www.ahimapress.org/Amatayakul5290** and click the link to download the files. Please do not enter the scratch-off code from the interior front cover, as this will invalidate your access to the instructor materials. If you have any questions regarding the instructor materials, contact AHIMA Customer Relations at (800) 335-5535 or submit a customer support request at https://secure.ahima.org/contact/contact.aspx.

Chapter 1
Introduction to Health IT

Key Terms

American Recovery and Reinvestment Act of 2009 (ARRA)
Bar code medication administration record (BC-MAR)
Basic EHR
Centers for Medicare and Medicaid Services (CMS)
Certified EHR technology (CEHRT)
Clinical data repository (CDR)
Clinical data warehouse (CDW)
Clinical decision support (CDS) system
Clinical documentation system
Clinical messaging system
Clinician
Computerized provider order entry (CPOE)
Connectivity system
Context sensitive
Core clinical systems
Data mining
Discrete data
Document imaging system (DIMS)
Electronic document/content management (ED/CM) system
Electronic document management system (EDMS)
Electronic health record (EHR)
Electronic medical record (EMR)
Electronic medication administration record (EMAR)

Enterprise-wide MPI (EMPI)
Executive decision support
E-visits
Five rights of medication administration
Health information exchange (HIE)
Health information network
Health information technology (health IT)
Health Information Technology for Economic and Clinical Health Act (HITECH)
HIE organization (HIO)
Home monitoring
Human-computer interfaces (HCI)
Inference engine
Integrated delivery network (IDN)
Interoperability
Intranet
Knowledge sources
Laboratory information system (LIS)
Meaningful use (MU)
Medication management system
National Quality Forum (NQF) Health Outcomes Policy Priorities
Natural language processing
Office of the National Coordinator for Health Information Technology (ONC)
Personal health record (PHR)
Pharmacy information system (PIS)
Picture archiving and communication systems (PACS)
Platform
Point-of-care (POC) charting
Portal
Predictive modeling
Print file
Radio frequency identification (RFID)
Radiology information system (RIS)
Registries
Reporting
Report writers
Results management system
Rules engine (also called inference engine)
Smart peripherals
Source system
Storage area network (SAN)

Storage system
Structured data
Supporting infrastructure
System
Telehealth
Unstructured data
Wireless on wheels
Workflow technology

Learning Objectives

- Define health IT and the EHR.
- Summarize the key elements of the federal government's programs for incentivizing use of EHRs.
- Explain the origins of the EHR and its future directions.
- Describe how the envisioned benefits of health IT have been achieved to date.
- Describe a framework and conceptual model of the components comprising the EHR in a provider setting.
- Describe a framework and conceptual model of the components comprising health IT.

Health information technology (health IT) is defined as "the application of information processing involving both computer hardware and software that deals with the storage, retrieval, sharing, and use of healthcare information, data, and knowledge for communication and decision making" (HRSA n.d.). Health IT is not new; however, because health IT can include highly sophisticated systems that require transformative change, adoption has been a slow process. In 2004, the federal government recognized the slow pace of adoption in general, and electronic health records (EHRs) in particular. A national goal for EHR adoption by 2014 was set, but the pace of change did not immediately increase. In 2006, Healthcare Information Management and Systems Society (HIMSS) Analytics found that only 3.6 percent of US hospitals had two of the core components of an EHR: computerized provider order entry (CPOE) and bar code medication administration record (BC-MAR) systems to support improved medication management. By 2008, the number of hospitals with such applications had increased to just 5.8 percent (HIMSS 2006–2015). Then, in 2009, the **American Recovery and Reinvestment Act (ARRA)** and the **Health Information Technology for Economic and Clinical Health Act (HITECH)** introduced financial incentives for hospitals and physicians to make meaningful use of federally **certified EHR technology (CEHRT)**. (In federal parlance, CEHRT moves beyond a **basic EHR**, which includes computerized documentation but offers minimal or no clinical decision support that alerts clinicians of potential issues with their patients.) This federal incentive program, which is often referred to simply as **meaningful use (MU)**, has resulted in significantly improved use of EHRs and other forms of health IT. By the end of 2015, HIMSS Analytics reported that 62 percent of hospitals had CPOE and BCMAR, with another 31 percent having additional health IT beyond what is required for MU. Furthermore, approximately 36 percent of physician offices had adopted EHRs by this point in time (HIMSS 2006–2015).

When considering these statistics, it should be noted that HIMSS uses an analytical structure that is generally, but not specifically, consistent with MU. Therefore, HIMSS data on rates of health IT adoption are different than those reported by the federal government. The **Office of the National Coordinator for Health Information Technology (ONC)** is the agency within the US Department of Health and Human Services (HHS) designated to serve as the primary resource for the United States on the adoption of health IT and promotion of a nationwide health information exchange. According to ONC's healthIT.gov dashboard, 75 percent of all nonfederal acute care hospitals had adopted a basic EHR as of December 31, 2015, and 97 percent of such hospitals had possession of CEHRT that meets ONC requirements for MU, including the increasingly sophisticated clinical decision support required as MU moves through its staged adoption requirements. HIIMSS statistics about EHR adoption also vary from the government's statistics about MU because the **Centers for Medicare and Medicaid Services (CMS)**, which administers Medicare, Medicaid, Children's Health Insurance Program, and the Health Insurance Exchange Marketplace, provides the measures of usage requirements to earn the MU monetary incentives (or incur reimbursement adjustment penalties), but the extent to which actual use includes workarounds or equates to the degree of desired value from EHR is variable. EHRs represent a huge change for hospitals and physician offices. They require a significant investment in time, money, process change, and human factor reengineering to be successful. EHRs in particular change how **clinicians** (a collective term used to describe physicians, nurses, and all other healthcare professionals who deliver care directly to patients) perform not only their documentation but how they practice medicine. Furthermore, the process of implementing health IT is ongoing, as constantly changing clinical knowledge and increasing expectations require continual maintenance and enhancements.

Scope of Health IT

As defined at the start of this chapter, health IT is an expansive concept, which includes EHRs as well as additional forms of information technology, such as data warehousing and analytics, apps on mobile phones, personal health records, health information exchange, and many others. The definition of health IT also continues to evolve in response to technological changes, regulatory requirements, and political priorities. There is considerable work to be done to enhance EHR products, especially in moving toward new generations of the technology and in optimizing their use to gain full value (Wallace 2014). Additionally, the federal government is pressing forward to encourage the use of health data from EHRs and other sources (such as financial systems, health plans, public health resources, personal health records and monitoring devices, disease registries, and genomic research) to improve the quality, cost, and experience of care in the United States. In 2014, the ONC laid out a vision in *Connecting Health and Care for the Nation: A 10-Year Vision to Achieve an Interoperable Health IT Infrastructure*. In 2015, it provided the *Federal Health IT Strategic Plan: 2015–2020* (ONC 2015a) and delivered the detailed *Connecting Health and Care for the Nation: A Shared Nationwide Interoperability Roadmap* (ONC 2015b). Recognizing that there needs to be ever greater attention on privacy and security in an interoperable environment, ONC works with HHS Office for Civil Rights (OCR) and the National Institute of Standards and Technology (NIST) to ensure that the healthcare community has appropriate privacy and security resources (see chapter 12).

EHR Definition

Defining the EHR has not been simple. Even as progress in implementing EHRs has been made, there continues to be a mix of different terminology, sometimes in an attempt to differentiate among types of products, other times resulting from force of habit and perhaps an unwillingness to change.

For example, in hospitals, the term *electronic medical record* (EMR) may be used to describe systems based on **electronic document management systems (EDMSs)**, which are storage solutions based on digital scanning technology in which source documents are scanned to create digital images of the documents that can be stored electronically. Hospitals may even state that they have both an EMR (that is, the EDMS) and an EHR, referring to systems that meet MU requirements. Alternatively, physicians' offices frequently use EMR to describe EHR systems in their offices, even when those systems are highly sophisticated. Physicians may use the term EMR out of habit, but they may also use it to keep the focus on medical care as opposed to the broader scope of healthcare, which encompasses disease prevention and wellness.

In 2008, the federal government asked the National Alliance for Health Information Technology (NAHIT) to develop definitive definitions to distinguish between EMR and EHR. These definitions are as follows (NAHIT 2008):

- **Electronic medical record:** An electronic record of health-related information on an individual that can be created, gathered, managed, and consulted by authorized clinicians and staff within one healthcare organization.
- **Electronic health record:** An electronic record of health-related information on an individual that conforms to nationally recognized interoperability standards and that can be created, managed, and consulted by authorized clinicians and staff across more than one healthcare organization.

Today, the federal government has adopted the term *EHR* exclusively. An EMR is more limited than an EHR, which is an information system framework rather than a single application. An EHR can be implemented in a variety of ways, providing many different functions, and achieving a multiplicity of purposes.

In sum, the federal government's present definition of EHR encompasses functions identified by the Institute of Medicine (IOM; now known as Health and Medicine Division [HMD] of the National Academies of Science, Engineering, and Medicine) in its early efforts to define the term, which suggested that the functions performed by an EHR serve to collect and integrate data from multiple sources, capture and enable use of data at the point of care, and support clinical decision making (IOM 1991). MU enhances those fundamental elements by adding support for quality measurement and reporting and for the enablement of health information exchange. When these five elements are embodied in components that work in harmony, the result may be considered the EHR as now required under MU and as illustrated in figure 1.1.

MU Incentive Program

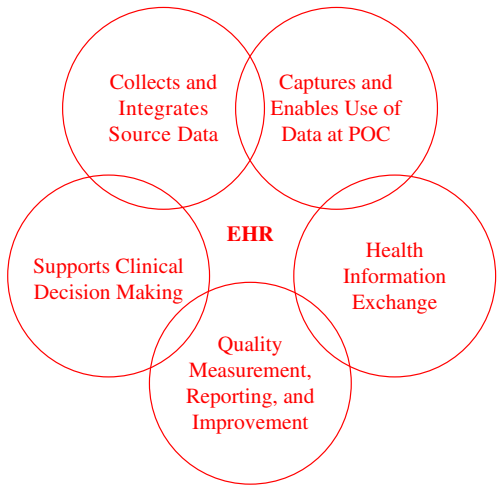
The federal government's MU incentive program has driven the widespread adoption of EHR technology in the United States. While many are calling for significant changes in the program or for the program to be dropped (which a representative of CMS observed early in 2016 could happen by the end of 2016 [Miliard 2016]), the program created a foundation of functionality for all providers (Halamka 2015).

There were three primary components (and associated regulations) to the MU incentives program: a certification program for EHR technology, standards and criteria for CEHRT, and objectives and measures for earning incentives.

ONC HIT Certification Program

ONC oversees the ONC HIT Certification Program to ensure EHR technology is tested and certified as meeting standards and criteria (ONC 2015c). This program establishes the requirements

Figure 1.1. Fundamental functions of EHR

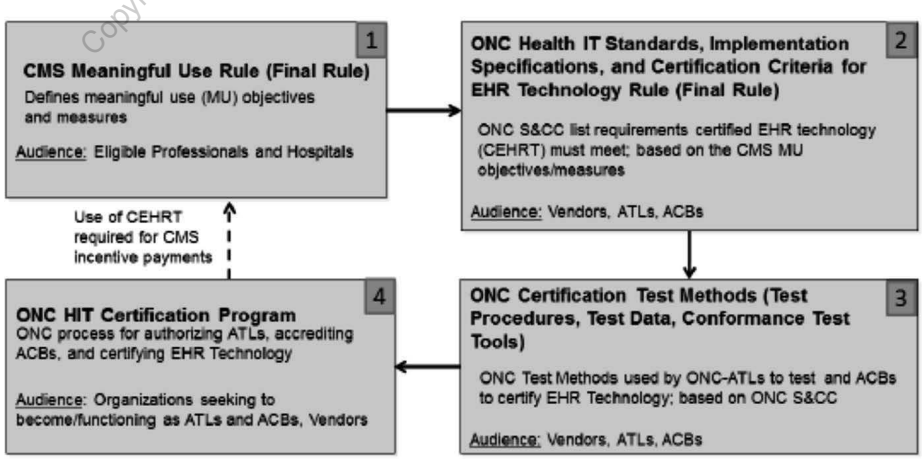


for accredited testing laboratories (ATLs) and authorized certification bodies (ACBs) and uses the American National Standards Institute (ANSI) National Voluntary Laboratory Accreditation Program (NVLAP) to accredit testing laboratories. NIST develops test procedures and conformance test tools based on the ONC's EHR certification criteria (Snelick and Taylor 2013). The process of testing and certification is illustrated in figure 1.2.

ONC Standards and Criteria for CEHRT

Regulations from ONC define the standards and criteria that CEHRT must meet (45 CFR 170(b)). Criteria describe the specific functionality that an EHR must have if it is to be used to earn MU incentives. There are general criteria as well as criteria specific to inpatient settings and ambulatory settings. Adopted standards address specifications for exchanging health information content, vocabularies for representing health information, and the protection of health information created, maintained, and exchanged by EHR technology.

Figure 1.2. CEHRT testing and certification process



Source: National Institute of Standards and Testing (NIST).

Objectives and Measures for Earning MU Incentives

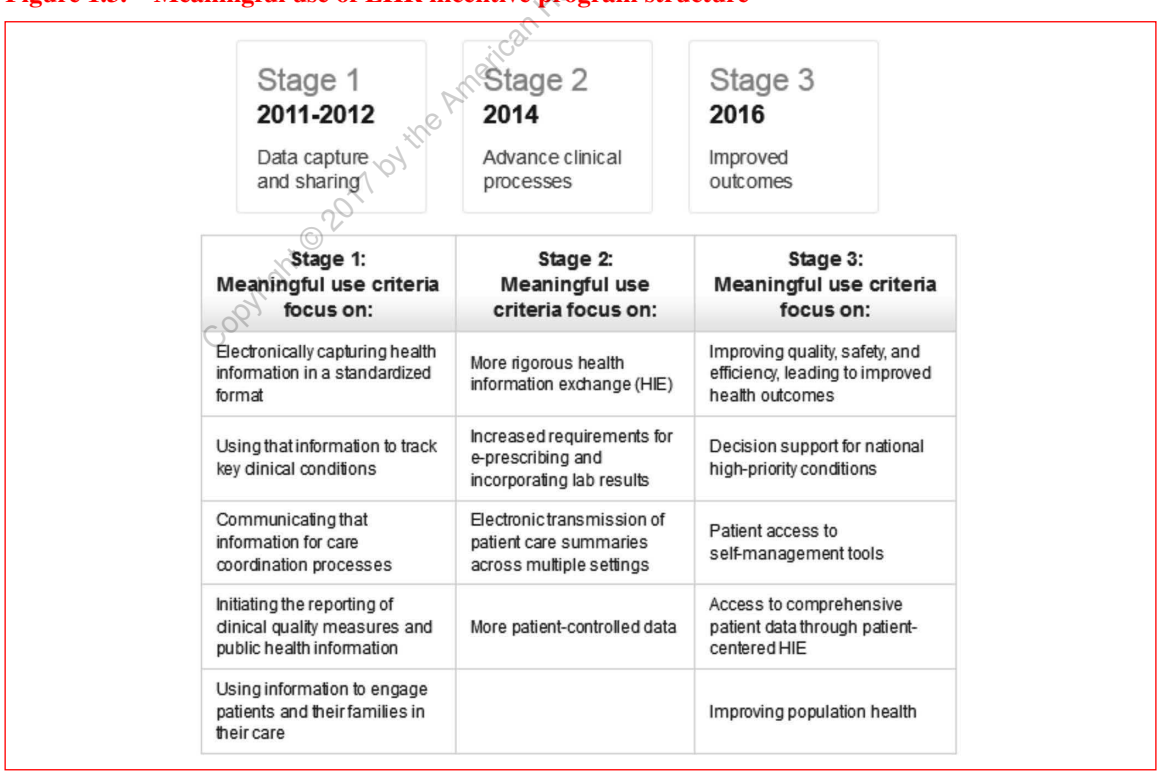
Objectives and measures for earning MU incentives are defined in CMS regulations (42 CFR 412, 413, 422, and so on). Consistent with the ONC-established standards and criteria, the objectives and measures include those that eligible hospitals (EHs) must meet, those that eligible professionals (EPs)—who are primarily physicians in ambulatory settings—must meet, and those that both EHs and EPs must meet.

Recognizing that it would take time to achieve the objectives of the MU incentive program, the federal government structured the program in three stages, as illustrated in figure 1.3. David Blumenthal, the national coordinator of ONC between 2009 and 2011, likened the stages to an escalator "that moves the health system upward toward improved quality and effectiveness in health care" (Blumenthal and Tavenner 2010). The HealthIT.gov Policy Committee describes the stages of the MU incentives as bending the curve towards transformed health (see figure 6.1 in chapter 6).

The incentives initially provided a maximum of $44,000 for Medicare EPs over the course of the five-year period 2011 through 2015 and a maximum of $63,750 for Medicaid EPs through 2021. For EHs, the incentives are based on a formula that includes a base of $2 million plus $200 per certain number of Medicare (or Medicaid) discharges during the same five-year period. In 2012, stage 2 measures were finalized and one additional year was added for providers to implement EHRs before a downward adjustment in Medicare reimbursement would be applied to those who did not adopt an EHR. There was no downward adjustment for Medicaid incentives.

As providers started implementing MU stage 2, a number of challenges were identified and the industry started calling for a delay of stage 3. On December 6, 2013, CMS announced a delay for stage 3 until 2017; however, work continued on drafting stage 3 requirements to give vendors time to develop products. On October 16, 2015, the federal government issued a final rule with a special

Figure 1.3. Meaningful use of EHR incentive program structure



Stage 1: Meaningful use criteria focus on:	Stage 2: Meaningful use criteria focus on:	Stage 3: Meaningful use criteria focus on:
Electronically capturing health information in a standardized format	More rigorous health information exchange (HIE)	Improving quality, safety, and efficiency, leading to improved health outcomes
Using that information to track key clinical conditions	Increased requirements for e-prescribing and incorporating lab results	Decision support for national high-priority conditions
Communicating that information for care coordination processes	Electronic transmission of patient care summaries across multiple settings	Patient access to self-management tools
Initiating the reporting of clinical quality measures and public health information	More patient-controlled data	Access to comprehensive patient data through patient-centered HIE
Using information to engage patients and their families in their care		Improving population health

Source: https://www.healthit.gov/providers-professionals/how-attain-meaningful-use

comment period for stage 3 measures. The rule gave providers until January 1, 2018, to comply; incorporated greater flexibility; afforded greater alignment between the clinical quality measures required under MU and those required for the Medicare program; and supported use of newer technologies (McCann 2015).

Despite these changes in the MU incentives program, physicians continued to call for further delays and changes. The Medicare Access and CHIP Reauthorization Act of 2015 (MACRA) afforded an opportunity for such changes. In April 2016, a proposed rule was issued that would establish parameters for a new quality payment program (QPP) for physicians. The QPP includes a merit-based incentive payment system (MIPS) and alternative payment models (APMs). Twenty-five percent of the performance requirements to earn an incentive under MIPS include "advancing care information," which is described as the former MU incentives program. Only time will tell how successful MIPS will be in incentivizing future EHR use among physicians (CMS 2016).

Origins and Future Directions of the EHR

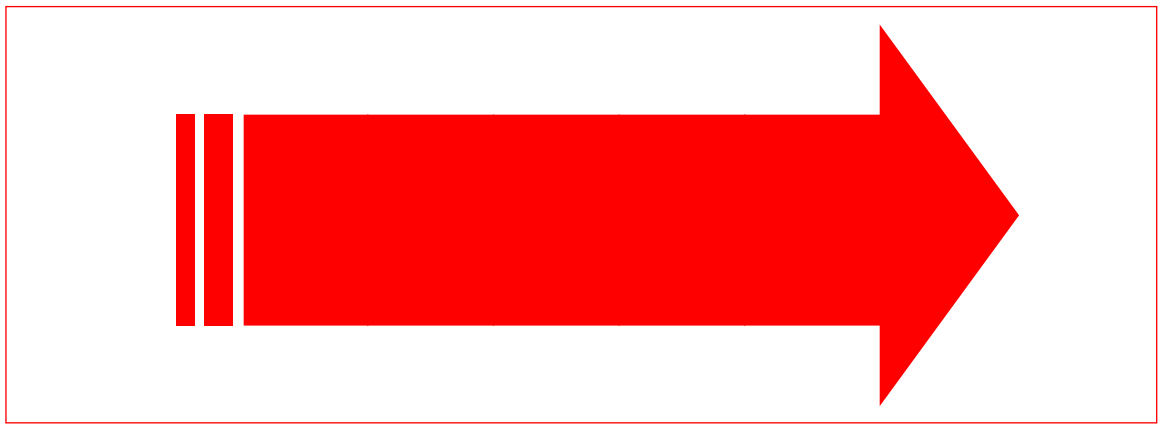
The concept of the EHR has existed since the early use of computers in healthcare in the late 1960s and early 1970s. Figure 1.4 illustrates the major milestones in the history of EHR implementation.

The IOM/HMD Vision for EHRs

Since issuing its first study of applying technology to patient records in 1991, the HMD (formerly IOM), an independent, nongovernmental organization that advises policy makers and the public, has been a strong proponent for vision and benefits of an EHR. Development of the MU requirements were structured around the **National Quality Forum (NQF) Health Outcomes Policy Priorities** (HIT Policy Committee 2009, 2011) that grew out of *To Err Is Human* (1999), a landmark IOM publication that propelled the United States into true action. This study, which was the first in what became a series of IOM reports describing the US "healthcare quality chasm," called upon the nation to do the following:

- Improve quality, safety, efficiency, and reduce health disparities.
  - Provide access to comprehensive patient health data for patient's healthcare team.
  - Use evidence-based order sets and computerized provider order entry
  - Apply clinical decision support at the point of care

Figure 1.4. History of EHR implementation



  - Generate lists of patients who need care and use list to reach out to patients
  - Report information for quality improvement and public reporting
- Engage patients and their families in their healthcare
  - Provide patients and families with timely access to data, knowledge, and tools to make informed decisions and manage their health
- Improve care coordination
  - Exchange meaningful clinical information among professional healthcare team
- Improve population and public health
  - Communicate with public health agencies
- Ensure adequate privacy and security protections for personal health information
  - Ensure privacy and security protection for confidential information through operating policies and procedures and technologies and compliance with applicable law
  - Provide transparency of data sharing to patient

The contributions of the IOM/HMD to the vision of the EHR are significant. They address a specific need for standards development and certification support and define the scope of the transition to the EHR and the need for interoperability early on. The following key quotes from the original IOM report still remain visionary:

- "Merely automating the form, content, and procedures of current patient records will perpetuate their deficiencies and will be insufficient to meet emerging user needs" (IOM 1991, 2).
- The EHR "encompasses a broader view of the patient record than is current today, moving from the notion of a location or device for keeping track of patient care events to a resource with much enhanced utility in patient care (including the ability to provide an accurate longitudinal account of care), in management of the healthcare system, and in extension of knowledge" (IOM 1991, 3).
- The EHR is "the core of healthcare information systems. Such systems must be able to transmit data to other types of clinical and administrative information systems within healthcare institutions; they must also be able to transmit data to and accept data from other healthcare institutions or secondary databases" (IOM 1991, 51).

The early IOM reports and subsequent works of the Computer-Based Patient Record Institute (CPRI), which grew out of the first patient record study, describe specific outcomes for an EHR that remain valid today. An EHR should do the following (CPRI 1997):

- *Improve quality* of healthcare through data availability and links to knowledge sources.
- *Enhance patient safety* with context-sensitive reminders and alerts, clinical decision support, and automated surveillance, chronic disease management, and drug/device recall capability.
- *Support health maintenance,* preventive care, and wellness through patient reminders, health summaries, tailored instructions, educational materials, and home monitoring/tracking capability.
- *Increase productivity* through data capture and reporting formats tailored to the user, streamlined workflow support, and patient-specific care plans, guidelines, and protocols.

- *Reduce hassle factors* and improve satisfaction for clinicians, consumers, and caregivers by managing scheduling, registration, referrals, medication refills, work queues, and by automatically generating administrative data.
- *Support revenue enhancement* through accurate and timely eligibility and benefit information, cost-efficacy analysis, clinical trial recruitment, rules-driven coding assistance, external accountability reporting/outcomes measures, and contract management.
- *Support predictive modeling* and contribute to development of evidence-based healthcare guidance.
- *Maintain patient confidentiality* and exchange data securely among all key stakeholders.

To solidify these outcomes and add more specificity to the EHR definition, HHS sought further guidance from the IOM on key care delivery–related capabilities of an EHR system. The IOM's *Key Capabilities of an Electronic Health System* (2003) describes the EHR as including the following:

- 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 healthcare provided to an individual
- Immediate electronic access to person- and population-level information by authorized, and only authorized, users
- Provision of knowledge and decision-support that enhance the quality, safety, and efficiency of patient care
- Support of efficient processes for healthcare delivery

In 2009, the IOM published *Computational Technology for Effective Health Care* in conjunction with the National Research Council. Whereas the IOM's series of reports on medical errors describe the need to cross the healthcare quality chasm, this report describes the need to cross the healthcare IT chasm. The study included site visits to eight US medical centers that were acknowledged leaders in applying IT to healthcare. Despite finding a number of successes and considerable money spent on IT, the report observes that "today's health care fails to deliver the most effective care and suffers substantially as a result of medical errors. In addition, many medical interventions undertaken today are in fact not necessary" (Stead and Lin 2009, 3). However, the report notes that "these persistent problems do not reflect incompetence on the part of health care professionals—rather, they are a consequence of the inherent intellectual complexity of health care taken as a whole and a medical care environment that is not adequately structured to help clinicians avoid mistakes or to systematically improve their decision making and practice" (Stead and Lin 2009, 3). The report classifies relevant factors into the following three areas (Stead and Lin 2009):

- *Tasks and workflow of healthcare.* "Health care decisions often require reasoning under high degrees of uncertainty about the patient's medical state and the effectiveness of past and future treatments for the particular patient." "Workflows are often complex and characterized by many interruptions, inadequately defined roles and responsibilities, poorly kept and managed schedules, and little documentation of steps, expectations, and outcomes."
- *Institution and economics of healthcare.* The diversity of payer coverage plans complicates administration. "Incentives for payment are often distorted or perverse, leading (for example) to more generous compensation for medical procedures than for communication with patients or for diagnosis or preventive care."

- *Current implementations of healthcare IT.* Many healthcare institutions spend considerable money on IT, but "IT applications appear designed largely to automate tasks or business processes." "They are often designed in ways that simply mimic existing paper-based forms and provide little support for cognitive tasks of clinicians or the workflow of the people who must actually use the system." Many of the applications do not address "human-computer interaction principles," leading to "poor designs that can increase the chance of error, add to rather than reduce work, and compound the frustrations of executing required tasks." The result is often "new forms of error that are difficult to detect."

In conclusion, the report urges the industry to adopt principles for both evolutionary and revolutionary change and identifies research challenges that the government, computer science community, and healthcare institutions should address.

The Evolution of EHR Technology

Despite their 50-year history and significant refinement over time, EHRs are still described as being "very early in the EHR maturity lifecycle" (Halamka 2012). EHRs were originally built on a **platform** (underlying technology that supports various applications) that used mainframe computers. Today, EHRs predominantly use client/server technology, a second-generation platform that relies heavily on personal computers tapping into first-generation platform mainframe databases (Hanover 2015). These types of EHRs can capture and organize patient information within a hospital or physician office environment, but they are not designed to share and/or organize data across many different systems. Even when EHR software vendors offer software as a service (SaaS) in a cloud-computing arrangement, the software is not built on a third-generation platform architecture (Web Services Architecture [WSA]), so it does not operate as a flexible application program interface (API), which can interact with other applications and share data (Boone 2011). In addition, vendors can charge substantial fees to build interfaces (special software written to help exchange data between two or more second-platform systems) as well as steep per-transaction fees for data sharing. Such vendor practices, known as *information blocking,* may contribute to the inability to share data (Lichtenwald 2015; DeSalvo and Daniel 2015).

There is much room for innovation in EHR design. Many physicians and other clinicians seek improvements to address frustrating productivity issues and inflexibility in EHRs, and federal health reform initiatives require the integration of clinical and financial data for new reimbursement structures and for sharing data across the continuum of care and beyond. The prospect of future EHRs that are enhanced with new technology and support for sharing health data in a much broader environment is very exciting. Ideally, the EHRs of tomorrow will contribute great value by fulfilling the vision of the EHR pioneers and addressing many new demands.

Check Your Understanding 1.1

Choose the best answer:

1. The construct that reflects a record about an individual with the ability to share information is:

   a. Electronic health record

   b. Electronic medical record

   c. Health IT

   d. Personal health record

2. According to HIMSS Analytics, what percentage of hospitals have more health IT than what is required for MU?
   a. Less than 1 percent
   b. 10 percent
   c. 30 percent
   d. 50 percent or more

3. According to ONC, what percentage of nonfederal acute care hospitals have implemented an EHR of some kind?
   a. Less than 25 percent
   b. About 50 percent
   c. About 75 percent
   d. Nearly 100 percent

4. EHRs were first conceived in:
   a. 1960s
   b. 1980s
   c. 1991
   d. 2010

5. In the MU incentive program, which body establishes standards for what is required in an EHR?
   a. Centers for Medicare and Medicaid Services (CMS)
   b. Institute of Medicine (IOM)
   c. National Institute of Standards and Technology (NIST)
   d. Office of the National Coordinator for Health Information Technology (ONC)

6. In the MU incentive program, what describes EHR functionality?
   a. Criteria
   b. Measures
   c. Objectives
   d. Standards

7. Which of the following EHR functions supports the goal to improve patient safety?
   a. Context-sensitive reminders and alerts
   b. Predictive modeling
   c. Secure data exchange
   d. Tailored instructions

8. According to an IOM study conducted in 2009, new forms of medical errors are arising from:
   a. Incompetent use of EHR
   b. Not addressing human-computer interactions
   c. Programming errors
   d. Resistance to use by clinicians

EHR and Health IT Framework and Conceptual Model

EHRs and other forms of health IT are systems. In general systems theory, a **system** is a set of interrelated elements that work together to achieve a goal. A fundamental challenge in health IT remains to achieve **interoperability** among disparate systems—that is, to ensure that applications can work together, it must be possible to share data from one application with another application in a meaningful way.

Components of EHR Systems

As healthcare organizations undertake the evolutionary and revolutionary changes in adopting EHRs and other types of health IT, it is important to remember that elements in these systems include not only hardware and software but also people, policy, and process components, as illustrated in figure 1.5.

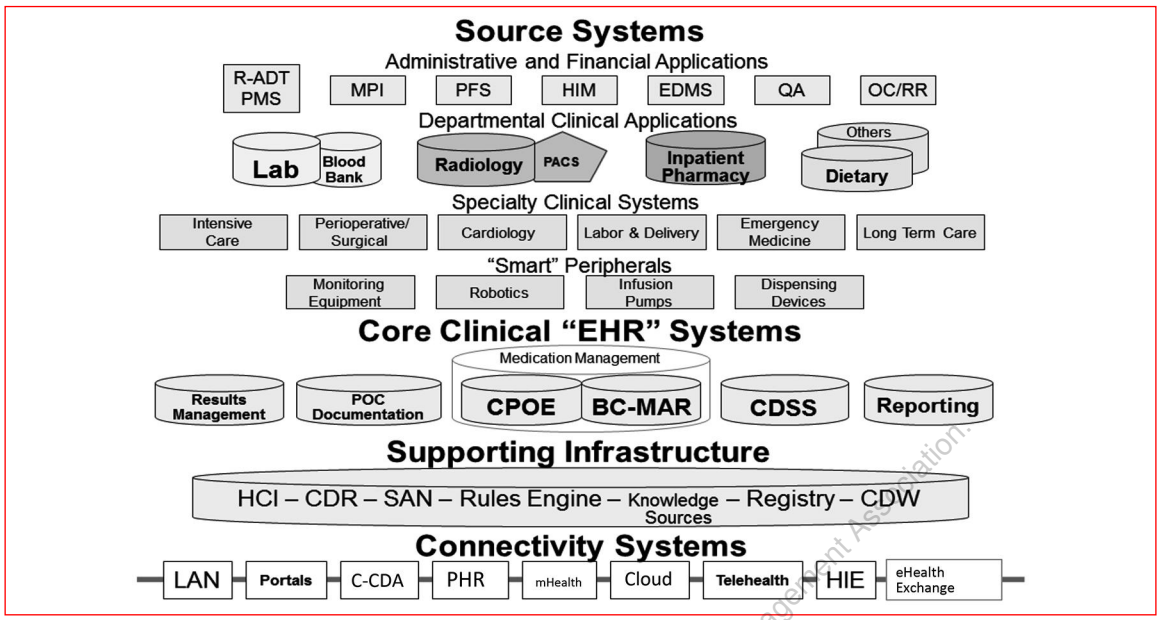
Of course, an EHR system must provide technical components that people can use, consistent with policy, for the various processes they perform. Figure 1.6 displays a conceptual model that depicts the technical components of EHR. In contrast to the MU standards, criteria, and measures, which describe the functionality that must be present in an EHR in order for eligible professionals and hospitals to become meaningful EHR users and earn incentives, figure 1.6 illustrates how the functionality is deployed in various applications, supporting infrastructure, and connectivity systems.

Categories of Information Systems in the EHR

As figure 1.6 suggests, there are four main categories of information systems that contribute to and comprise an EHR: source systems, supporting infrastructure, core clinical systems, and connectivity systems. Further information about the privacy and security elements that completely wrap around the EHR components is provided in chapter 12. Further information about interoperability in general is provided in chapter 13.

Figure 1.5. EHR system components

Figure 1.6. Conceptual model of EHR



Source Systems

Source systems collect data, including administrative, financial, and clinical data, that contribute to the health record. Examples of basic source systems include laboratory information systems (LISs), pharmacy information systems (PISs), radiology information systems (RISs), nutrition and food service information systems, physical therapy information systems, emergency department information systems, and many other ancillary, or departmental systems. Some source systems distinguish specialized source systems by clinical specialty, such as cardiology or labor and delivery, or by type of services, such as intensive care unit or emergency department. Source systems may also include smart peripherals, such as smart infusion pumps or robotics.

Core Clinical Systems

Core clinical systems enable use of data at the point of care. These applications support specific clinical functionality and are often considered the applications that comprise an EHR and define whether a care delivery organization has an EHR. They include the following:

- **Results management systems** where data from laboratory tests and other diagnostic studies can be trended, potentially with other data such as medication administration, vital signs, and so on
- Point-of-care (POC) charting systems for recording nurse assessment, history and physical examination, progress notes, and so on
- **Medication management systems**, including CPOE and electronic medication administration record (EMAR) or BC-MAR systems
- **Clinical decision support (CDS) systems** for integrating data with clinical decision support rules for supplying reminders, alerts, context-sensitive order sets and templates, and other clinical guidance
- **Reporting systems** to generate visit summaries, referral letters, quality reporting, patient follow-up lists, and other patient care–related reports

Supporting Infrastructure

Supporting infrastructure integrates data from applications internal to a given care-delivery organization. In a hospital, each of the clinical information systems just described may be standalone systems. In an ambulatory care setting, they tend to be less separate. However, for the clinical information systems to be most effective, data should be integrated across the systems and with data from all source systems. Supporting infrastructure, then, may include the following:

- A clinical data repository (CDR) that captures and organizes data in one location
- A **rules engine** (also called **inference engine**) to supply the CDR with programming logic for CDSS
- **Knowledge sources** that supply information from external sources to the rules engine
- **Report writers** or wizards that enable compilation of data into various reports
- **Storage systems,** such as **storage area networks (SANs)**, to back up and archive data
- Presentation layer software and **human-computer interfaces (HCI)**, which are various forms of input devices to help capture data at the point of care
- A **clinical data warehouse (CDW)** where sophisticated analysis can be performed on the data

Further information about supporting infrastructure technology is provided in chapter 11.

Connectivity Systems

Connectivity systems support the integration of data across different organizations and with patients or their caregivers. As noted previously in this chapter, it is becoming increasingly important to share data across the continuum of care for a variety of purposes, such as better-coordinated care, quality measurement and reporting, population health, precision/personalized medicine, new reimbursement models, and so on. Examples of connectivity systems include the following:

- *Local area networks (LANs)* support exchange of information within a given organization.
- ***Portals*** support remote access to the EHR for providers and patients. A patient portal allows patients access to information from their EHR (or to view, but not to alter, their EHR). The Consolidated-Clinical Document architecture (C-CDA) is a standard means with which to exchange documents.
- *Personal health records (PHRs)* enable patients to build their own health records with information obtained from their EHR and information they supply themselves, such as a diabetes management diary or information from another provider.
- *Mobile health (mHealth)* is the use of mobile HCIs as well as physiological monitoring systems (such as activity trackers). Some of these support uploading of data to a PHR and, in some cases, transmission of data to a provider.
- *Cloud computing* refers to using a network of remote servers hosted on the Internet to store, manage, and process data.
- *Telehealth* is the delivery of health-related services and information via telecommunications technologies. Telehealth may support local care to those who are homebound or in difficult-to-access places (such as prisons) as well as remote care around the world. Telehealth technology comes in many forms, from simple telephone connectivity to sophisticated robots.
- *Health information exchange (HIE)* is a term that implies a formal, agreed-upon process of information sharing, typically through a health information organization (HIO) that serves as an intermediary. The eHealth Exchange is a national effort to provide HIE.

As illustrated by this list of examples, connectivity systems refer not only to the hardware to make connections but also to the software that is used with and beyond EHR—making the discussion of connectivity really about EHR *and* health IT. Figure 1.7 superimposes a conceptual model of health IT over the conceptual model of the EHR.

Sequence of EHR and Health IT Systems Implementation

Provider organizations have typically taken an incremental approach to compile the components of an EHR and adopt other types of health IT. Each organization needs to create its own migration path. This path must recognize the existing infrastructure in the organization, its culture and resources, and the goals the organization expects to achieve from an EHR. Migration paths vary depending on whether the organization is a hospital, a clinic, a physician office, an **integrated delivery system (IDS;** a network of hospitals and clinics managed by a parent company), or other type of provider facility as well as the extent to which a suitable HIE is available. The following brief discussion of source systems and core clinical EHR systems is provided in the sequence typically implemented. Further discussion of EHRs in various types of provider settings is found in chapters 14, 15, and 16.

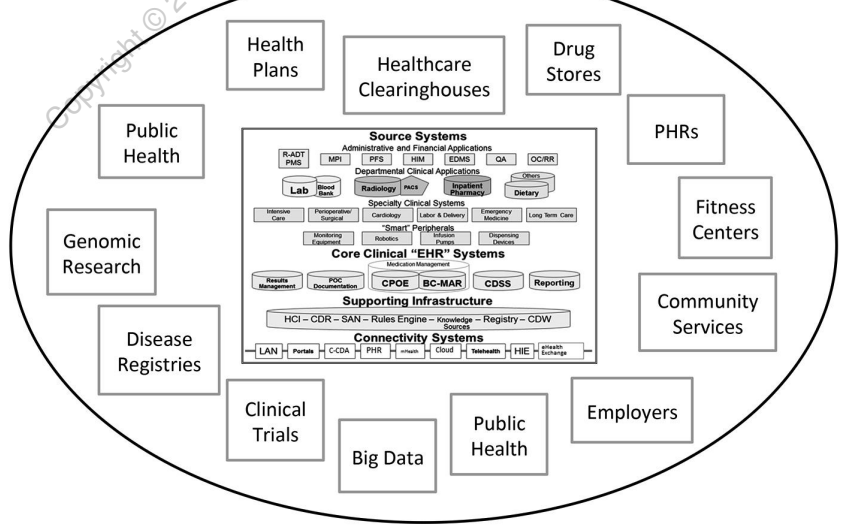
Registration-Admission, Discharge, Transfer and Practice Management Systems

In inpatient settings (hospitals and nursing facilities), the registration-admission, discharge, transfer (R-ADT) system is the most fundamental system needed to register patients, record their demographic and insurance information, and track admission, discharge, and transfer (among different levels of care within the setting) status. In an ambulatory setting (clinic or physician office), the practice management system (PMS) performs these functions as applicable. These systems also include a master person index (MPI), which may serve multiple entities within an integrated delivery system and is then referred to as an **enterprise-wide MPI (EMPI)**.

Patient Financial Services and Billing Systems

Another foundational system is one that receives charges and generates claims. These systems, which are known as patient financial services (PFS) in the hospital setting and as billing systems

Figure 1.7. Conceptual model of health IT



in ambulatory settings, may also support eligibility checking to validate insurance coverage, determine co-payment requirements, and potentially identify deductible amounts. Such systems can also check claims status with an insurance company, receive electronic remittance advice, manage any required prior authorizations, and—in experimental stages now, but expected in the future—process electronic claims attachments. In the ambulatory environment, the PMS often integrates patient registration, scheduling, MPI, and billing.

Administrative Systems

Other systems closely related to financially oriented systems include a number of applications within the health information management (HIM) department, such as chart tracking, incomplete record control, dictation and transcription systems, speech dictation systems, encoders and computer-assisted coding systems, chargemasters, registries, and others. Some of these administration system applications are in transition as EHRs are adopted. For instance, when paper charts become obsolete, organizations will eventually no longer need chart tracking systems (although many organizations continue to maintain older paper charts until the statute of limitations runs out and they can be destroyed). Traditional dictation systems have all but vanished, replaced at least with digital dictation systems and, more recently, with speech dictation. Other applications will likely continue to be used well into adoption of EHRs, including speech commands and discrete reportable transcription (DRT) using speech recognition technology coupled with natural language processing; tools to assign International Classification of Diseases (ICD) codes; and other applications related to revenue cycle management—including those that may be a shared responsibility with the PFS department.

The HIM department may or may not be responsible for other administrative systems, such as physician credentialing systems, which are often managed by the medical staff office; compliance systems managed by a corporate compliance officer; and contract management systems used by procurement officers. In some organizations, HIM departments share responsibility for clinical documentation improvement and clinical quality assurance (QA) with the nursing department, which is responsible for case management and uses various software applications for such services.

Electronic Document Management Systems

A variety of departments may use an EDMS. Most commonly, the HIM department is responsible for the EDMS for the overall health record. However, independent EDMSs (of various types) may commonly be found in the emergency department, radiology, PFS, human resources, and other areas.

There are different types of EDMSs—from simple to sophisticated. **Document imaging systems (DIMS)** merely capture images of forms to be stored in a computer system for later retrieval. Other systems enable electronic feed (formerly referred to as COLD [computer output to laser disk] feed) to store in an automated archive various types of digital documents (for example, typed documents from a transcription system, voice files from a dictation system, electronically generated documents from a speech dictation system, print files such as from a laboratory system, or wave-form files from a monitoring system, e-fax, and e-mail). Most EDMS used in healthcare organizations for managing the health record enable indexing of forms. Some of these systems, known as **electronic document/content management (ED/CM) systems**, also support management of some data content on forms to aid retrieval of information. Content management systems may also refer to systems designed primarily to support intranets or web pages on the Internet.

An EDMS can be integrated with **workflow technology**, which helps direct work on documents. For example, workflow technology can determine when a record is ready for coding and put it into the appropriate coder's work queue. Simultaneously, the PFS department may access documents in the EDMS for reference or to generate a claims attachment.

An EDMS may have sophisticated functionality to select blocks of text to view or easily distribute work for processing; however, the EDMS primarily affords access to what was originally paper-record content from multiple locations. It is often used as an interim technology or bridge

strategy along a migration path to the EHR or as a supplemental technology to achieve a totally paperless environment (Rhodes and Dougherty 2003).

Order Communication/Results Retrieval Systems

Order communication/results retrieval (OC/RR) systems are another type of administrative system. They are not the same as CPOE or results management systems that are part of the core clinical EHR system. OC/RR systems can be used to transmit orders to various ancillary departments and view results of laboratory and other diagnostic studies or the status of orders. OC/RR systems help integrate various source systems for operational purposes. However, they are essentially paper-based because they rely on handwritten orders transcribed into a computer by clerical or nursing staff and diagnostic study results typically generated in a paper or **print file** format.

Staff can use OC/RR systems to automatically transmit orders instead of phoning, using a courier, faxing, or sending orders via pneumatic tube, and these systems provide access to results from multiple locations. OC/RR systems are often among the first information systems acquired in a hospital after the R-ADT and PFS, and their existence is essential for an EHR. If these systems are from different vendors, as they may well be, separate interface programs must be written to permit the systems-wide sharing of patient demographic data.

Ancillary/Clinical Department Applications

OC/RR systems are designed to communicate with systems that receive and process orders and generate results. The three major ancillary or clinical department systems in a hospital include the **laboratory information system (LIS)**, (inpatient/clinical) **pharmacy information system (PIS)**, and **radiology information system (RIS)**. Other systems may include blood bank and imaging (to capture radiology and other clinical images), which are called ***picture archiving and communication systems (PACS)***. Other clinical departments may also acquire applications to help them manage their services and workflow. These include dietary/nutrition and food services, central supply, physical therapy, respiratory therapy, speech therapy, occupational therapy, rehabilitation services, and others.

Ancillary systems serve two primary functions. The first is to manage the department. For example, the LIS receives an order for a laboratory test and then provides considerable support for generating specimen collection lists, labels for specimen vials, connectivity with autoanalyzers, calibration of devices, quality checks, and even staff scheduling. A clinical PIS can do similar and equivalent functions, including maintaining the inventory of drugs, tracking drug expiration dates, and so on. The second function of these ancillary applications is to generate the clinical results they have processed (and associated charges). Hence, although the ultimate purpose of an LIS is to generate laboratory test results, it does so with support for many other functions to get to the point that it can generate the results. Similarly, many functions support the dispensing of medication via a clinical PIS or the delivery of a tray of nutritionally appropriate food to a patient on a soft diet via a foodservice ordering system.

Specialty Clinical Applications

Although there may be a fine line between what might be considered a departmental clinical application and a specialty clinical application, the distinction often reflects a matter of priority. Whereas departmental clinical applications serve any patient, specialty clinical applications serve patients with specific disease states or particular levels of required nursing care. Applications for intensive care, perioperative/surgical, and emergency medicine units address the special staffing needs and services of patients who require those types of services. Vendors have also created niche products for cardiology, oncology, labor and delivery, psychiatry, and other highly focused specialties.

There are also applications specific to the various forms of long-term care (LTC): nursing homes, home health, and hospice services. Hospitals and ambulatory settings that support LTC services may acquire these applications as separate products from different vendors or as components within a suite of products from a single vendor (depending on vendor offerings) over a considerable

period of time, depending on their patient populations. Dentists, chiropractors, public health professionals, and other specialized healthcare providers may have their own clinical applications.

Smart Peripherals

Smart peripherals are medical devices that can be directly connected to an information system to enable capture of their information into the EHR. For example, monitoring equipment may supply patient-specific information, such as fetal monitoring records, blood pressure data, or blood sugar levels, and may be used in a hospital, other care delivery facility, or the home setting. Robots in laboratories and pharmacies, in particular, can automate, and thus reduce errors, in handling of specimen and drug dispensing. Robots can be programmed to find nursing units or patient rooms and then used as couriers. Again, these systems may be acquired at different times in a migration path, depending on the organization's mission and goals.

Clinical Messaging Systems/Provider-Patient Portals

Clinical messaging systems add to OC/RR and EDMS systems the dimension of real-time access to information through web-based technology. The web-based technology may be applied within the **intranet** (the organization's own internal network) or may entail the exchange of information through a secure web portal from the Internet.

Clinical messaging systems are often used to provide connectivity between a hospital and the offices of its medical staff members, and there is growing interest in using clinical messaging for communications with patients. For example, a patient portal can be used for secure e-mail exchange as well as for other patient applications, such as e-visits. An **e-visit** is a reimbursable evaluation and management service provided by a physician or other qualified health professional to an established patient using an electronic-based communication network. It must be noted that a portal is not the same as a personal health record.

Registries

Registries are systems to which care delivery organizations may contribute specific information for subsequent analysis and comparison. Frequently, registries are disease-, condition-, or procedure-specific, such as cancer registries, diabetes registries, and immunization registries. These registries are often maintained by a medical specialty society or public health department. They support individual patient follow-up as well as aggregation of data for trending and statistical analysis.

An increasing number of EHR vendors, medical specialty societies, and other vendors are developing registries for capturing and reporting quality measurement data. These registries enable hospitals to use a centralized data collection service to contribute quality measurement data to organizations that require such information, including the Joint Commission, Medicare, and MU programs, among others. In addition, providers who contribute to such registry services can receive analyses of their data as well as information about how their data compare to those from other providers.

Results Management Systems

Although OC/RR systems enable viewing and printing of results from laboratory tests and other studies, more sophisticated processing of these results is feasible when they are produced as structured data. For example, if laboratory test results are generated as structured data, they may be graphed or structured into a table. If medication administration and vital signs data are saved as structured data (from BCMAR and POC charting systems), they can be combined with laboratory test results in a structured form to evaluate the impact of the medication on the patient's condition. Because such systems are more sophisticated than results-reporting systems, they are considered an important component of an EHR.

Point-of-Care Charting Systems

Point-of-care (POC) charting systems, also called **clinical documentation systems**, are systems in which clinicians enter data as they care for patients. These data include history and physical

exam records, findings from assessments, progress notes, vital signs, and so on. POC charting systems in hospitals initially focused primarily on nursing staff documentation, but these systems increasingly support other clinicians and physicians to a more limited extent. In the ambulatory environment, EHRs are used by all clinicians, especially physicians and nurses. Data entered into POC charting systems may be structured or unstructured.

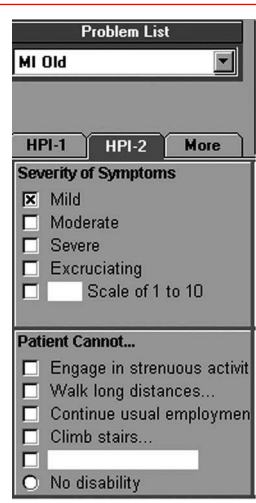
Structured data, also called **discrete data**, refer to data that have been predefined as a set of limited, standardized options. Structured data enable standardized values to be supplied for specific variables, so the data can be used in clinical decision support systems and provide standardized meaning for reporting purposes. A user selects the data values desired for each variable (such as patient condition or history of present illness) from a drop-down menu or checklist by using a mouse, arrow keys, touch screen, voice command, or other type of human-computer interface. In some cases, the user may be asked to enter a number or numeric score. For example, to record the severity of symptoms, a nurse or physical therapist may select a numeric score from a standard pain scale, as shown in the top portion of figure 1.8. It is important to note that the purpose of structured data entry is to help ensure standardization. Therefore, when setting up structured data entry, it is important to ensure that the appropriate scale, scoring system, or code set is specified in some way. Interestingly, there are several pain scales used in healthcare. Nurses often use a scale scoring pain from 1 to 10 whereas physical therapists typically score pain from 1 to 4.

Unstructured data refers to narrative data or images of information, as is illustrated by the empty box in the section under "Patient Cannot . . ." in figure 1.8. Here, an area is reserved for authorized clinicians to type or dictate anything they want to record. Such unstructured data are more difficult to use in searches or for reporting purposes and generally are not converted into tabular or graphical form; however, they can be essential to ensure complete documentation.

Early in their introduction, POC charting systems required significant changes in workflow. They were often time-consuming and difficult to use. Attempts were made to use computers stationed at the bedside because returning to a small number of computers at a nursing station was inadequate for efficient documentation. Today, POC charting systems are much more sophisticated. Data entry may be performed using handheld devices, such as smartphones, laptop computers, or tablets. Many of these devices are wireless, and some are secured to carts (commonly referred to as **wireless on wheels**, or workstations on wheels, or WOWs).

Structured data may be captured via any of these data-entry devices in a variety of ways. Drop-down menus, check boxes, or radio buttons are commonly used to select data points from templates.

Figure 1.8. Structured data entry in an EHR



Smart text (or what would be called *macros* in word processing) is a code that, when invoked, represents an entire phrase, sentence, or paragraph. Voice commands, touch screens, a stylus, or the standard keyboard can be used to activate any of these methods. Type-ahead is a function where typing the first few letters in a desired word presents a list of words from which to choose, as illustrated in figure 1.9. Many EHRs may keep track of data frequently entered by a user and automatically build a list of favorites to reduce the time needed to select options from a long, generic list.

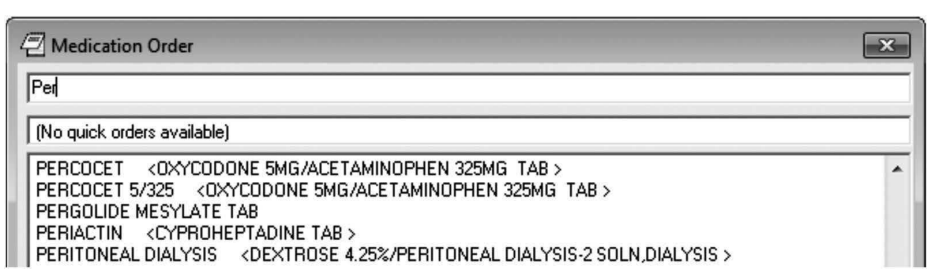
To capture unstructured data, users can employ the typical dictation processes (including speech dictation) or simply keyboarding, often using word processing functions such as copy and paste and drag and drop. Unstructured data entry aids can be helpful, but they can lead to errors (for example, copying information into the wrong chart) and compliance issues (for example, notes are not unique to specific patients). The most sophisticated systems will apply **natural language processing** to unstructured data, which permits the narrative text to be converted to structured data for processing by the computer. This last form of data entry is still in the developmental stage.

Computerized Provider Order Entry and E-Prescribing Systems

Computerized provider order entry (CPOE) systems are intended for use by physicians and other authorized providers (for example, physician assistants, nurse practitioners, and nurse midwives, according to their licensure) to enter orders directly into the computer and be given prompts, reminders, or alerts about the order. Because these systems enhance legibility, they reduce the risk of data entry errors, and their decision support capability enhances patient safety and healthcare efficiencies. Decision support might include calculating the appropriate dose of a medication (especially for pediatrics) or alerting the provider that a medication is contraindicated under certain circumstances, such as when the patient has a known allergy to it, is taking another medication that may counteract the effects of the drug being considered, is being prepped for a certain diagnostic study, or has liver or kidney disease. The CPOE system might identify that a specific drug is not covered by the patient's insurance and possibly offer equivalents that are covered or less expensive. CPOE has been heavily promoted for patient safety purposes to avoid medication errors, but it can also be helpful in identifying duplicate orders for services, providing cost comparisons of diagnostic studies, and alerting providers about needed preventive care services. Orders from a CPOE system should be distributed to their respective departmental clinical systems, including tasking nurses to perform specific functions for the patient.

In a clinic or other ambulatory care setting, CPOE systems include the ability to initiate diagnostic studies, order referrals, schedule appointments, and task nursing staff for other functions, such as procedure assistance or identifying when a patient is ready to leave and be given instructions on wound care, medication administration, and so on. In an ambulatory environment, including not only the physician office or clinic but also on discharge from a hospital or emergency department, e-prescribing (e-Rx) systems give the prescriber the ability to write a prescription and

Figure 1.9. Illustration of the "type-ahead" function



Source: Computerized Patient Record System via US Veterans Health Information Systems and Technology Architecture.

have it transmitted directly to a retail pharmacy system. E-Rx systems may be standalone or a special function of the CPOE system in an ambulatory care EHR system.

Electronic/Bar Code Medication Administration Record

Electronic medication administration record (EMAR) is the automation of many of the processes associated with medication administration in a hospital. In its most basic form, EMAR is a printout generated by the pharmacy system that nurses can use to identify what medications should be administered to a patient and then document the administration. More sophisticated forms of EMAR display the medication administration record on the computer so nurses can perform direct data entry. An EMAR system can have **bar code medication administration records (BC-MARs)**. When an EMAR systems includes bar code or **radio frequency identification (RFID)** technology to add the dimension of positive identification of the patient, the medication being administered, and the nurse administering the drug, the system is referred to as a bar code medication administration record (BC-MAR) system. In addition to identification and documentation, BC-MAR systems provide alerts for medication timing and information about the medication that a nurse can review to better understand potential patient reactions. It also aids workflow by scheduling medication administration. These systems are important for improving patient safety through the **five rights of medication administration**, first promoted through the Institute for Safe Medication Practices (ISMP). These rights are ensuring the right patient, right drug, right time, right dose, and right route (ISMP 1999). Together, CPOE systems and EMAR/BC-MAR systems provide for more accurate medication management.

Reporting

Reporting with respect to EHR may have a variety of meanings. In some cases, reports may be visit summaries, referral letters, or even an electronic copy of the EHR for the patient. Content for these may be standardized using the HL7 Clinical Document Architecture (CDA) standard.

Reporting from an EHR is also the process of querying existing data to search and retrieve data specific to a patient, produce lists (often used for patient follow-up), aggregate data from multiple patients, or perform sophisticated analysis that generates new information. Lists may be in the basic form of a tabulation, but data may also be reported in the form of labels to affix to mailings or even connected to autodial systems to call patients for follow-up or recall purposes. Some EHRs have special report wizards to aggregate data into statistical reports (for example, the number of surgeries each physician performs in a month), whereas others require special report-writing software. To generate new information, special analytical tools may be needed in addition to or in place of report-writing software.

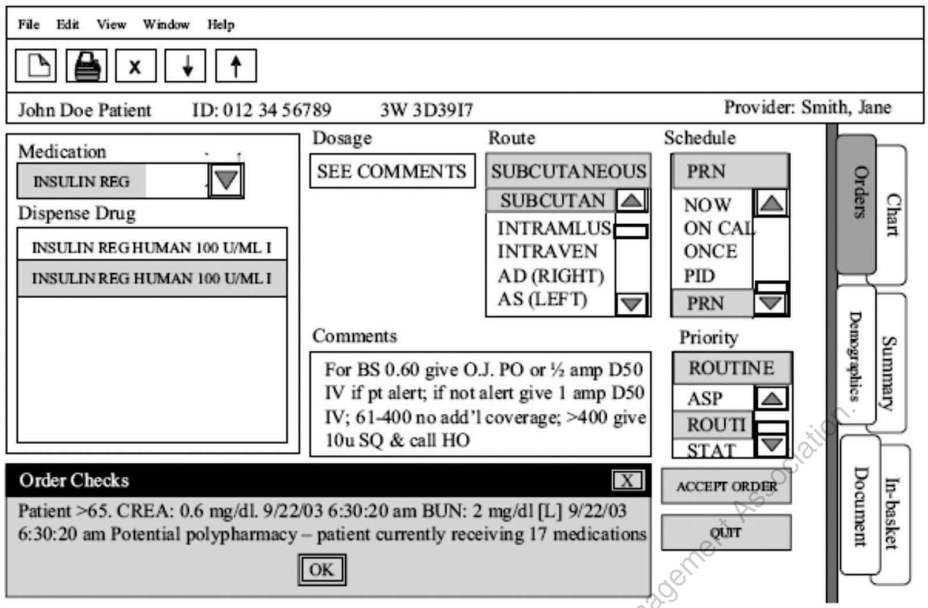
As noted above, an issue with current EHR applications is that they are almost exclusively focused on direct care–delivery functionality because their underlying database structure has been optimized to perform online transaction processing. Consequently, the ability of these applications to develop reports for quality studies or other functions, or even produce a hard copy of the legal health record, is limited. For example, if a provider wants to generate an ad hoc report to compare treatment modalities for a specific disease, most EHRs would require use of special report-writing software that takes a fair amount of programming skill to use effectively. More sophisticated analytics generally require a clinical data warehouse in addition to the sophisticated analytical software.

Clinical Decision Support

Clinical decision support (CDS) refers to software that processes information to help users make a clinical decision. Some CDS capability is embedded within core clinical applications that comprise the EHR, such as within CPOE, BC-MAR, and POC charting. In other cases, CDS may be acquired as separate applications of a variety of types.

Some types of CDS provide active decision support, such as alerts or reminders to which the user must respond. Figure 1.10 is an example of a CDS alert that is called "Order Checks." Other

Figure 1.10. Example of active CDS



CDS types are considered passive because the user chooses whether to use the support. CDS is generated by preprogrammed logic or rules. For example, if a patient comes to an emergency department with chest pain, a CDS system may remind the physician to check all applicable body systems for the cause of the patient's pain (for example, cardiovascular, gastrointestinal, and pulmonary). Alerts about allergies, contraindications, or a drug being off-formulary are common forms of CDS found in CPOE and e-Rx systems. Other types of CDS support coding in a physician office EHR system, where the complexity of the patient encounter must be reflected in the evaluation and management (E/M) codes from the Current Procedural Terminology (CPT). These codes ultimately contribute to the level of reimbursement for the visit. However, as "Avoiding Fraud Risks Associated with EHRs" by Helton (2010) suggests, "an electronic health record can reduce a healthcare provider's exposure to risk posed by the fraudulent use of healthcare data, but only to the extent that the provider has established proper controls within the system" (2010).

A CDS system also may integrate clinical practice guidelines, protocols, or care pathways into a template used for data entry. The CDS system not only offers the ability to chart against these guidelines or pathways but also makes them **context sensitive**, so that only the parts of the guidelines that are applicable to the given patient are offered for charting. For example, guidelines regarding female anatomy would not be presented as part of CDS for a male patient's physical examination. Moreover, the CDS system may tap external knowledge sources to provide more comprehensive information. For example, if a physician is unfamiliar with a new drug offered as an alternative suggestion, he or she might click a link to access a reference that provides more complete information. A physician faced with an unusual set of symptoms and signs could potentially use the CDS to look for reference material on the Internet to develop a differential diagnosis, or there may be a special form of CDS that provides specific support for differential diagnosis. A pharmacist may need to make suggestions for alternative medications when a patient has an allergy or research the efficacy of various drugs when there is an unusual diagnosis. The CDS system may produce tailored instructions for the patient.

CDS should be contrasted with **executive decision support**, which is typically a standalone system that analyzes a large volume of aggregated data and provides trending information. Executive decision support is typically retrospective, providing quality improvement, productivity, staffing, and marketing information for executives. CDS is concurrent (provided at the time data are entered) or even prospective (when presenting best practices in anticipation of care). Clinical data, however, also may be aggregated for quality improvement studies, predictive modeling, or clinical research.

Clinical Data Repository

A **clinical data repository (CDR)** is a relational database that has been optimized for processing many transactions. Such transactions may be as simple as viewing laboratory test results or as complicated as analyzing data in an HPI against knowledge sources and generating a differential diagnosis. The key is that a CDR is intended to support direct care–delivery functions. In most ambulatory EHRs, because all data are collected into a relational database optimized for processing transactions, the system is by definition using a CDR. However, a CDR is often not acquired in an ambulatory environment that has multiple source systems and separate core clinical components to its EHR or in an inpatient environment with the many different source systems, each with its own database, until such time as many of the core clinical applications are in place. At that time, the need for integrating data from all the different source systems becomes crucial—both for ease of access as well as to support more sophisticated clinical decision support functions and specialized software.

Personal Health Records

Personal health records (PHRs) are systems designed to support patient-entered data. If they are offered to a patient by a provider, they are typically accessed through a patient portal and include a limited amount of data from the patient's EHR—usually as designated by the provider. Provider-offered PHRs are often not very interactive, in that they often do not include the ability for the patient to enter data.

If a patient has multiple providers who are not within a given IDS, the patient could have many different PHRs. These PHRs also generally are not transferable to another provider. It is for this reason that some patients prefer to use a standalone PHR system that is not associated with a provider. In these instances, patients may direct their providers to submit data to the PHR or they may themselves upload the data to the PHR. Many of the standalone PHRs also support structured data entry by the patient. Standalone PHRs may be applications the patient can keep on their own personal devices, or they may be web-based. As noted above, some of these enable connectivity from personal mHealth devices.

Telehealth and Home Monitoring

The terms *telemedicine* and *telehealth* may carry separate connotations or be used synonymously. The "Core Standards for Telemedicine Operations" from the American Telemedicine Association (ATA), defines *telemedicine* as "use of medical information exchanged from one site to another via electronic communications to improve, maintain, or assist patients' health status." In contrast, **telehealth** is "often used to encompass a broader definition of remote health care that does not always involve clinical services" (ATA 2007). Use of this broader term seems to be gaining momentum. Telehealth may include remote monitoring, an actual patient encounter, a consultation, or distance learning. Any use of telehealth for the purpose of care provision requires documentation in the patient's health record. An EHR may facilitate such documentation and may incorporate components of the telehealth encounter that might be considered beyond the scope of the legal health record but useful for other purposes.

Home monitoring may blur the telemedicine/telehealth/mHealth line even further, when it is used for physiological monitoring that is overseen by a healthcare professional. An increasing

number of wearable or implantable devices can be used to monitor diabetes, asthma, pacemaker functioning, medication administration, the location of the individual, and so on. Some types of home monitoring even include direct provision of care in the home, such as home-based dialysis. However, in other instances, home monitoring is integrated with a PHR that is accessible to a healthcare professional only on an occasional basis, or home monitoring may simply entail personal use of standalone devices, such as pedometers, scales, thermometers, smart pill boxes, and home pregnancy tests, which are sold directly to consumers. Health plans may use home monitoring as part of a disease management program. For example, text messages to remind adolescents with type 1 diabetes to test their blood sugar could be part of a home monitoring strategy.

Health Information Exchange

Health information exchange (HIE) refers to seamless exchange of health information across disparate organizations, often where the organizations have signed agreements to participate in an **HIE organization (HIO)**. Some HIOs started as local health information organizations (LHIOs) or regional health information organizations (RHIOs). Today, the federal government is promoting statewide HIEs and supports the development of the eHealth Exchange, which is the national **health information network** initiative intended to connect all HIOs. HIOs provide patient identification functionality, record locator services, identity management and security services, and data exchange management. Some HIOs are managing the release of information functionality via patient consent afforded through the service or via their PHRs.

A healthcare clearinghouse is a special type of HIE that receives health data from a source and distributes them to a recipient. Early healthcare clearinghouses provided exchange services for providers who were sending healthcare claims to multiple health plans. Over time, these healthcare clearinghouses also helped the exchange of health plan eligibility information, claims status, and remittance advice information. In some cases, these healthcare clearinghouses also provide additional services, such as claims scrubbing, for the data they transport. More recently, the healthcare industry has been mandated to use electronic funds transfer for the receipt of reimbursement funds, and clearinghouses overseen by the financial services/banking industry provide such services. Healthcare clearinghouses are also used for the distribution of e-prescribing information.

Big Data, Data Warehousing, Analytics, and Population Health

A clinical data warehouse (CDW) is a database that has been optimized for performing sophisticated analysis. A CDW may be used to conduct **data mining**, which is a process that looks for patterns in information. Data mining of EHRs or other health IT is useful for clinical research. **Predictive modeling** has been widely performed by health plans to analyze information that may suggest the likelihood of patients needing health services. Although most hospitals and providers contribute data to external CDWs—most often via claims, although increasingly in the form of quality measures to registries—some hospitals and large clinics may acquire a CDW of their own, especially if they want to perform analytics for quality improvement or conduct clinical or health services research.

Population health also is facilitated through accurate, complete, and timely capture and reporting of public health data, including data relating to homeland security. Population health data collection may be initiated in the provider setting and linked automatically to a state data collection system. Population health may be served by decision support provided to caregivers through alerts from public health departments, such as a notification of a new strain of virus or a reminder to seek certain information from patients who present with particular symptoms. A precursor to population health may be disease management, wherein providers and health plans share data about patients/health plan members who would benefit from certain educational programs or special monitoring.

Check Your Understanding 1.2

Match the terms with the appropriate descriptions:

A. Bar-code medication administration record
B. Clinical data repository
C. Connectivity system
D. Core clinical system
E. Laboratory information system
F. Smart peripheral
G. Source system
H. Portal

1. Automated infusion pump
2. Form of remote access to EHR
3. Consolidated-Clinical Document Architecture
4. Part of medication management
5. Electronic document management system
6. Supporting infrastructure
7. Results management
8. Departmental clinical application

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Chapter 2
Information Systems Theory and Systems Development Life Cycle

Key Terms

Attributes
Closed system
Cybernetics
Data-information-knowledge-wisdom (DIKW) continuum
Data quality
Electronic systems
Human systems
Human-machine systems
Information systems theory
Inputs
Interoperability
Knowledge
Manual systems
Mechanical systems
Objects
Open source software
Open system
Outputs
Processes
Systems development life cycle
Templates