11 Electronic Health Records: Origination, Adoption, and Progression

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Learning Objectives

1. Define the origins and goals of the electronic health record (EHR), and how they complement other information systems in the healthcare continuum, such as those in public health.
2. Describe the public health influence upon, and impact by, EHRs.
3. Identify the positive and negative impacts legislation, standards, and technologies have had on the success and failure of EHR implementation efforts.
4. Describe the concept of Meaningful Use, and its importance to the success of current efforts in the United States toward implementing a national EHR, promoting interoperability, and increasing the flow of data to public health information systems.
5. Explain the limitations, disparities, and unintended consequences of EHR adoptions and progressions globally.

Introduction

The United States (US) has ventured on the path of creating a national system of electronic health records (EHRs) that is able to exchange patient data seamlessly and securely. Extensive emphasis has been on the standardization of data, and the infrastructure and methodologies to ensure the extensibility of the system as a whole. After witnessing the difficulties encountered by other nations that mandated a singular solution for all providers, programs have been created that provide paths for EHR vendors and customers to have their implementations certified as compliant with the programs' standards. This approach allows customers to have the ability to choose EHR products that meet the needs of their healthcare practices and facilities. Additional measures provide incentives for adoption and still others call for making progress on reporting to public health and evidence-based medicine repositories.

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These programs are moving the medical community ever closer to the ultimate goal of EHR technology, providing clearer pictures of the conditions affecting individuals and the effects of these conditions upon the population as a whole. Globally or more narrowly, in various geographic or socioeconomic sectors, the impact of the EHR and its myriad uses are only beginning to be discovered.

The public health community continues to benefit immensely from the emergence of EHRs. Using the standardized, digitized, and databased health records enable public health professionals to better perform their services. For example, public health professionals often use surveillance for notifiable health conditions that warrant control of existing, and prevention of future, outbreaks, epidemics, and pandemics. The readily searchable and sharable data in EHRs can facilitate this service by overcoming the time and labor-intensive gathering and parsing of paper health records. As a further example, another service often undertaken by public health professionals is to provide preventative recommendations to maintain public and population health and well-being. To support these preventative recommendations with evidence, the big data available in EHRs can provide analytically meaningful numbers of health histories and interventions among populations for data mining and analytics. For these, and many more services, the use of EHRs continue to be transformative for the practice of public health.

The Uses of an Electronic Health Record System

In 2003, the US Department of Health and Human Services (HHS) called on the Institute of Medicine (IOM), a part of the National Academy of Sciences, to define the core functionalities for an EHR system [1, 2]. In doing so, primary and secondary uses of an EHR system were identified by the IOM (Fig. 11.1).

Enable Primary and Secondary Uses

As shown in Fig. 11.1, the primary uses of the EHR system center around the patient, delivery

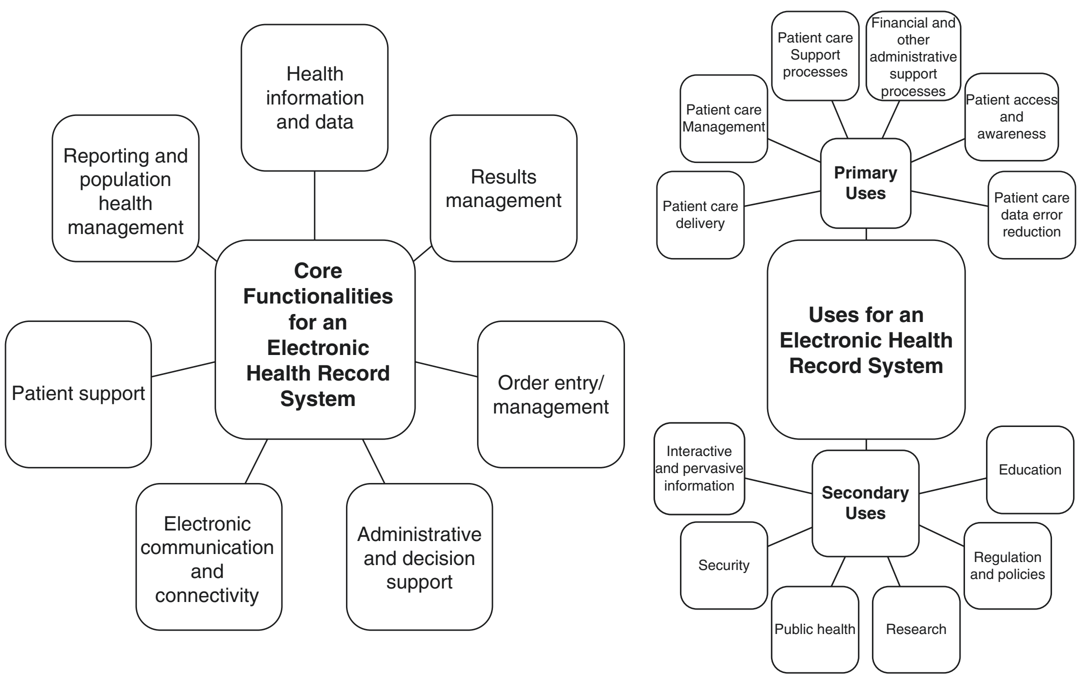

Fig. 11.1 Core functionalities and uses of an EHR system [1, 2]

of care to the patient, management of that care, and the financial, administrative, and support processes that enable it. Providing data to public health is currently considered a secondary use. Also included as a use is the vital component of patient education to facilitate patient self-management. The resulting effects could be the provision of a comprehensive record of care for the lifetime of every patient, and a higher level of ongoing healthcare quality, or more simply stated, continuity of care. The existence of such comprehensive records creates the means by which this continuity of care can be imparted, both to the individual and to the population.

In practice, this record would include every element of medical data obtained on an individual, from prenatal genetic testing to postmortem autopsy results. Laboratory tests and results, imaging, surgical reports, current medication listings, dental screenings, eye exams, high school physicals, and vaccinations would all be collected and included in the record. Every patient encounter in a medical setting throughout a patient's lifetime would be captured, cataloged, and made available to the patient and their authorized healthcare providers.

Provide Secure Access and Control of the Flow of Information

Secure access to such continuous records by those who might require it (e.g., patients, healthcare providers, public health surveillance, employers, payers, and insurers), and a means of controlling such access are fundamental to the success of the EHR. Without widespread availability, all that is accomplished is a localized, digital copy of patient data, with little more functionality than the paper chart it replaced. With widespread availability and interoperability, the flow of information can be controlled, audited, and shared safely. Standardization and organization are additional fundamentals that are fostered by this digitization, which further build on the foundation provided by the EHR.

Reduce Data Errors in Patient Care

By eliminating handwritten ordering and documentation, the functionality of EHRs remove concerns about legibility and misinterpretation of provider orders. Electronic prescribing (e-prescribing) and computerized provider order entry (CPOE) functionalities ensure accurate and timely delivery of physician orders. EHRs' uses include monitoring and alerting users, such as health care providers and public health professionals, to drug-to-drug interaction validations, cross-referencing of drug allergies, and the patient's vital statistics. These uses further reduce risk to the patient by closing the loop on dosage and prescribing errors previously attributable to printed records and manual methods.

Increase Patient Access and Awareness

The inclusion of patient access portals in a comprehensive EHR implementation brings an unprecedented level of access for patients to their medical records data. This access for patients generates a heightened awareness of their health, medical conditions for which they are being treated, treatments they receive, treatment results, and the patient's progress while undergoing treatment. This can make more prevalent new types of patients in the marketplace: those who have greater awareness of and connection to their treatment, are better educated about their conditions and outcomes, and can more finely scrutinize medical practices.

Align with Regulation and Policies

An increased level of scrutiny from patients and providers is one of the ultimate benefits of the EHR as it pertains to the health of the population. Additionally, collection of EHR data aids in the development of new and more effective techniques and methods of treatment. By developing connected databases of patient medical data for increasingly large portions of the global population, medical practitioners and researchers can track symptoms, conditions, treatments, and outcomes over long periods through large aggregates of patients. This data resource can potentially result in enormous gains; the gathering of evidence-based treatment data can provide the medical community at large with a more comprehensive perspective on patient medical histories that could guide improved medical and public health practices.

Provide Interactive and Pervasive Information Systems

EHRs can perform as interactive and pervasive information systems that imbue the business environment with an always-on, always-aware set of features for rapidly transforming data into action. These features can serve as clinical decision support [3], ambulatory services [4], financial services [5], coding, and billing [6], health insurance [7], messaging services, referral services, and other services that require interactions among multiple, distributed systems [8] (see Fig. 11.2).

Gather Accurate Data for Research, Education, and Public Health

All of these data—responsibly structured, curated, and maintained—equate to accurate and efficient stewardship that can support public health surveillance of communicable illnesses and chronic conditions. The EHR is useful in identifying and tracking outbreaks and public health trends. Leveraging discrete geographic and demographic data captured within the EHR when combined with electronic reporting of laboratory data can assist public health professionals with identifying environmental factors in epidemics and pandemics. These factors can affect individuals, and families, locally in neighborhoods, regionally across states and territories or even internationally across borders. By identifying these factors, public health professionals can also better study related chronic or communicable conditions endemic to specific geographic or demographic divisions of the population. Notification and sharing of information on treatments and outcomes through syndromic surveillance and electronic case reporting elevates the efficient and effective practice of public health, and can provide valuable decision support to the patients, healthcare providers, policy makers, and public health professionals.

Achieving Portability

For an electronic health record to be effective, the data must be portable. Unless there exists a means to accurately and securely transfer the health data of a patient from one healthcare provider or facility to another in a timely and efficient manner, the community may fall back to printed records and manual methods that are less portable. Although maintaining many printed records and manual methods for mitigation of periods where electronic systems may be unavailable is important, the main focus of EHR technologies for the foreseeable future will be standardization and connectivity.

The Ideal Scenario

The ideal scenario for global use of the EHR would be one where all data for every patient is collected, shared, protected, and maintained seamlessly. All measurable points across the continuum would be recorded, analyzed, and used to identify outbreaks, trends, and anomalies in every aspect of the world population's health. This prospect is one the healthcare community at large has chosen to undertake nationally and internationally. In the US in 2011, 54% of physicians had adopted EHR technologies; in physicians under 50 years old, that number increases to 65% [9]. Nations have embraced this goal and are striving to achieve a universal health record for their populations. Progress is visible incrementally as the community gradually implements

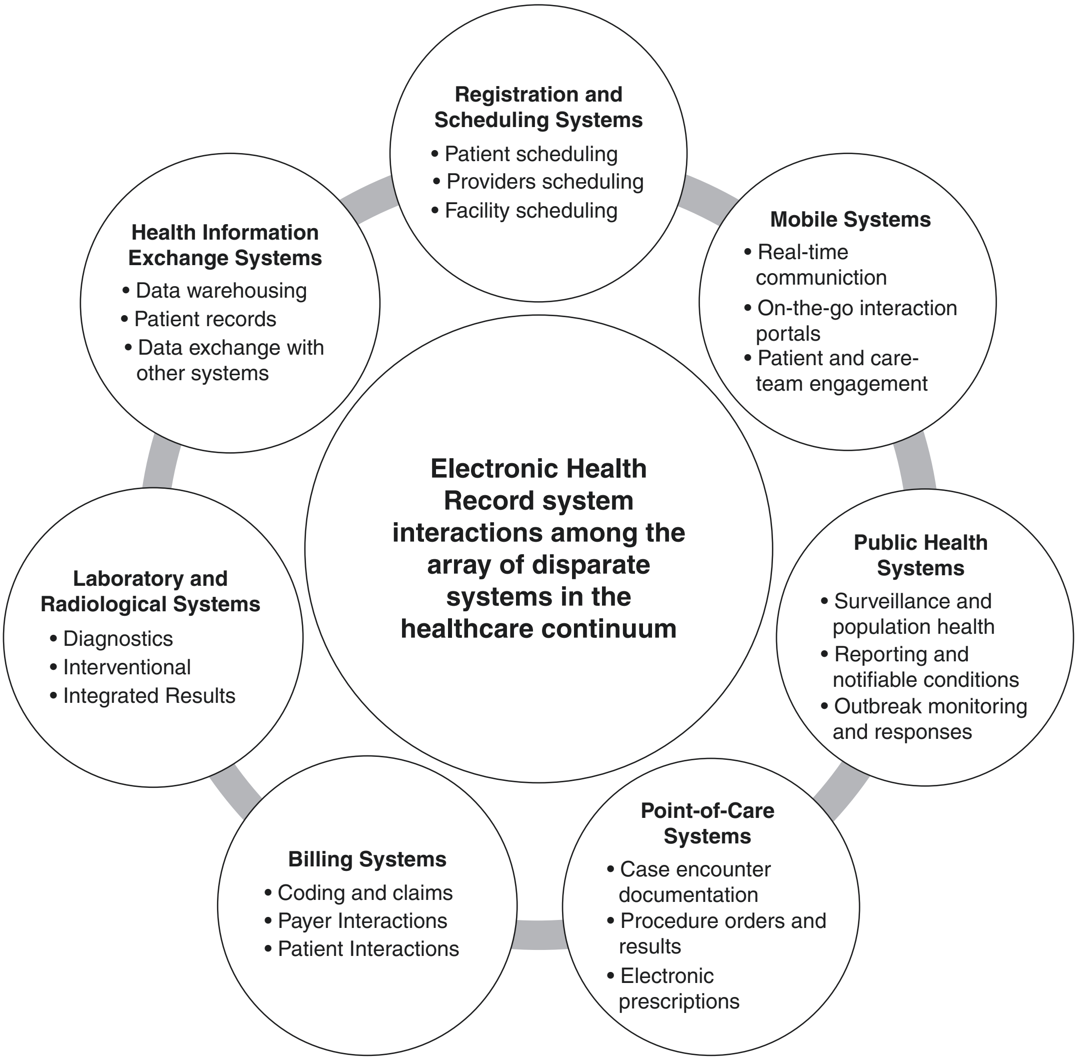

Fig. 11.2 EHR system interactions among multiple, distributed systems in the healthcare continuum

records that collect subsets of available data and make them available in increasingly useful ways.

Barriers to Success

However, the barriers to the success of EHRs are many, including usability challenges encountered by the healthcare professionals as they transition from the printed records and manual methods to an EHR workflow. Legislation and negotiation, at the highest levels of government and policy, have been vital in helping EHR adoption and advancement to overcome hurdles. Equal and greater efforts of this kind will continue to be necessary to reach the ideal scenario.

Integration, the Evolution of the EHR

Integration within and outside the healthcare facility constitutes a successful EHR deployment. Seamless connectivity between multiple, distributed systems (Fig. 11.2) in the healthcare continuum is the cornerstone of delivering a complete and accurate picture of the patient, their condition, treatment received, and subsequent outcomes. These connectivity challenges have been approached through the computerization of the world's healthcare operations and resulted in environments that are increasingly interoperable. In these environments the EHRs serves as the hub of patient data within integrated delivery systems in the healthcare continuum.

Origins of the EHR

The origins and evolution of EHRs began with the development of computerized billing systems designed solely to generate paper claim forms to be adjudicated by insurance carriers. As insurance carriers and their information systems became more robust, the inclusion of methods for capturing supporting claims documentation evolved from scanning of the printed forms to regular electronic data interchange (EDI) transactions. The EDI format was developed originally by the steamship and railroad industries to better exchange data about their transportation businesses within their respective companies and across great distances. It evolved over decades to become several different sets of standards used in varying industries that were not entirely compatible. To address the incompatibilities in EHRs, the United Nations created a committee to identify and standardize EDI transmissions globally, which developed the Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT) [10]. During the same timeframe, the introduction of computerization for medical billing also led to advances in clinical systems and their ability to read, analyze, store, and report vital clinical data for the treatment of patients. Market forces and competition led to a best-of-breed marketplace, where systems designed for each medical specialty and subspecialty battled for market share in niche markets, catering to specialized audiences.

Laboratory processes that had been performed manually were now integrated into instruments that were designed to analyze blood, urine, and other indicants of human physiology. The sheer volume of data available in laboratories necessitated the creation of Laboratory Information Systems (LIS) to connect with instruments for the aggregation and reporting of results. Magnetic resonance imagers, computerized tomography scanners, radiography machines, mammography suites, and all forms of ultrasonic and radiographic imagers were now connected to Picture Archiving and Communications Systems (PACS) for storing images and generating of patient reports. An endless array of medical technologies, each generating their own sea of reports, came into being (and often remain). However, without the means to connect these systems and a centralized repository for aggregating patient data, each system had to generate a printed report to be shared with other facilities, healthcare providers, and the patient. These reports then needed to be stored in the patient records at every hospital, physician office, or diagnostic facility the patient visited.

Origins of EHR Interoperability

The previously described lack of connectivity led to development of the integration engine. During the 1980s, evolution of health information technology (HIT) was occurring, and the demand for more specialized documentation to support medical claims expanded to include diagnostic data. With almost every department of the hospital maintaining and operating its own specialized HIT system, it was necessary to devise means of transporting and more importantly translating the data from ancillary systems into the hospital information system (HIS). Interface or integration engines provided this capability to the HIS, by builing on the Health Level 7 (HL7®) messaging standard formed in 1987 for EDI transport and delivery of healthcare data between systems [11]. Along with the PACS standard of Digital Imaging and Communications in Medicine (DICOM), developed in 1983 by the American College of Radiology and the National Electronics Manufacturers Association [12] and updates to the United Nations Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT or X12) for eligibility and insurance claims transactions, integration engines began the task of integrating the healthcare enterprise and creating interoperability among systems and healthcare organizations.

To gain further market share, and diversify their offerings from solely billing solutions, the larger vendors of hospital billing and physician practice management software systems began to acquire or develop their own clinical software solutions. These clinical software solutions were obvious extensions of the functionalities of their billing solutions, because even the most novel procedures must be billed. Given that the billing solutions were already digitized, clinical documentation logically followed, thus creating nascent EHRs. The collections of applications that each vendor now possessed were eventually assimilated. Through continued development and acquisition, these collections grew into suite offerings that arose as competition to the traditional best-of breed market. By offering these suites of applications, large vendors were able to market turnkey hospital and integrated delivery system solutions by incorporating integration engines of their own or rebranding third party interface solutions.

Integration engines provided the solution to a series of issues that had plagued information systems previously. As stated earlier, they fundamentally established and ensured reliable and secure standards-based communication among disparate systems. Standards regulations control conformity to versions or specifications of a standard, but adoption of standards in the absence of regulations allows for interpretation beyond the letter of the specification. Fortunately, integration engines not only establish, monitor, and maintain standards-based communications among disparate systems, they incorporate data transformation, translation, or manipulation to adjust for the variations that can occur in the interpretation of the standard specification from one software vendor to the next.

Another issue that hospital information technology departments encounter on a regular basis is temporal robustness of interoperations, or lack thereof (i.e., downtime). Occasionally, each computer system needs to be brought offline for maintenance. These can be planned events for upgrading software or hardware or catastrophic in nature that is due either to system failure or some other outside force. Whatever the cause, the integration engine provides handling of a planned or unplanned system downtime by incorporating queuing and acknowledgement logic. Successfully sent messages are acknowledged by the receiving application during normal operation by a series of acknowledgement messages, both at the application and protocol level. If an acknowledgement is not received, the message is queued, along with subsequent messages. These messages remain in sequence in the queue to ensure that updates and revisions to orders and results remain in correct order to safeguard proper message delivery and patient safety. Interoperability is not merely the ability to understand the data presented, but also to ensure it can be presented regardless of planned or unforeseen external factors.

Origins of EHR Privacy and Security

Messaging security is the cornerstone for extension of the EHR beyond the enterprise. With the ability to adequately ensure that the data contained within each message is encrypted during transmission and uniformly unreadable by any but the intended recipients, sharing sensitive patient information becomes realistic. The integration engine again provides the solutions necessary to accomplish this necessary service. The mechanisms necessary to transform, queue, and secure messages to ensure proper delivery also provide multiple monitoring points. Sophisticated monitoring systems have been created to ensure the overall health of the enterprise and the extended network of the EHR. The advent of middleware, integration or interface engines and the enterprise service bus, have introduced these layers of security, monitoring, and control from measuring quantities and timing of messages to identification of bottlenecks in processing or problems with connectivity.

Legislation, Regulation, Policies, and the Importance of Standards

The Health Insurance Portability and Accountability Act (HIPAA) of 1996 focused on the regulation of developments surrounding the exchange of Protected Health Information (PHI). The Standards for Privacy of Individually Identifiable Health Information ("Privacy Rule") "establishes, for the first time, a set of national standards for the protection of certain health information." The US Department of HHS issued the Privacy Rule to implement the requirement of the HIPAA. The Privacy Rule standards address the use and disclosure of individuals' health information—called "protected health information" by organizations subject to the Privacy Rule—called "covered entities," as well as standards for individuals' privacy rights to "understand and control how their health information is used" [2]. PHI is essentially any information that can positively identify an individual or connect them to a medical condition, health record, or billing related to the provision of healthcare. PHI can be found, for example, in explanation of benefits statements, prescription medication records, encounter charts, room or bed assignment rosters, or laboratory results that might be viewed by persons not directly related to the individual's care or approved to do so by the individual. Previously most patient data circulated within the confines of the facilities or providers that the patient visited. Advances in technology and information flow have made data ubiquitous and vulnerable. As a result of these advances, it became necessary to create legislation to codify a definition of PHI to provide penalties for its misuse as well as for negligence involving its handling. HIPAA provided such protections and added civil and criminal penalties for their violation that included fines of up to US $250,000 and up to 10 years in prison per instance for various types of offenses.

Standardization

HIPAA also codified established national standards surrounding EDI transactions for claims, benefits, and eligibility. The National Council for Prescription Drug Programs (NCPDP) [2] standard for pharmacy transactions and the National Drug Codes (NDC) [2] listings were also adopted. HIPAA mandated that the Health Care Financing Administration (HCFA), which was renamed in 2001 to the Centers for Medicare and Medicaid Services (CMS) [2], oversee the identification and maintenance of standard code sets to be used for the codification and description of medical procedures. CMS revised the Healthcare Common Procedure Coding System (HCPCS) [2], identifying two major areas of concentration as follows:

- HCPCS Level I comprised of the Current Procedural Terminology (CPT-4) [2] maintained by the American Medical Association (AMA) for physician procedures and services.
- HCPCS Level II intended for products, supplies, and services generally provided by suppliers other than physicians and their staff.

Additional provisions were also made to mandate the codification of diagnoses and hospital inpatient procedures according to the World Health Organization (WHO) International Statistical Classification of Diseases and Related Health Problems (ICD), Revision 9 (ICD-9), with a deadline for conversion to Revision 10 (ICD-10) by October 1, 2013 [2]. Subsequent changes to this ruling had postponed this date until October 1, 2014, a year before ICD-11 was to be released by WHO. HIPAA mandated the US Department of HHS to transition to ICD-10 on October 1, 2015 for medical coding and billing [13]. Compared with ICD-9, which for the previous 20 years included 14,000 codes that were now out of date and missing codes for more recent procedures and diagnoses, ICD-10 provided approximately 70,000 up-to-date codes for more granular details that captured the continuum of healthcare and research. To ease the transition, general equivalence mappings were developed to link ICD-10 to ICD-9 codings, to "create a useful, practical code to code transition reference dictionary for both code sets, and offer acceptable translation alternatives where possible" per the CMS with updated crosswalks between

ICD-10 and ICD-9, and national variants (e.g., the US ICD-10 Clinical Modification [ICD-10-CM] or ICD-10 Procedure Coding System [ICD-10-PCS]) maintained by the Centers for Disease Control and Prevention (CDC) [14, 15]. Furthermore, development of ICD-11 includes a peer-reviewed comments period for finalization and inclusion in EHR information systems [16]. Additionally, HIPAA also identifies the code on Dental Procedures and Nomenclature which is the Current Dental Terminology (CDT) [2], maintained by the American Dental Association (ADA), to be used for identification of dental procedures on all dental claims submitted for payment. These CDT dental procedure codes are expected by the ADA to use diagnosis codes from ICD-9-CM and ICD-10-CM to minimize audits and maximize reimbursements [17].

Provider Access and Identification

The final aspect that HIPAA required was the standardization of employer and provider identification. It called for employers to be nationally identified by their IRS issued Employer Identification Number (EIN) and for the creation of a National Provider Identifier (NPI). While the EIN is a 9-digit identifier that uniquely identifies the employer as a taxable business entity by the IRS, the NPI is a 10-digit identifier that uniquely identifies an individual as a recognized health care provider, and should not contain any other identifying information about the provider [2].

The focus of administrative changes enacted by HIPAA were for the purposes of standardization of insurance billing regulation. However, the result was to lay the necessary foundation of interoperability within the healthcare system and ultimately creation of EHRs.

Office of the National Coordinator for Health Information Technology (ONC)

In April 2004, President George W. Bush signed the following Executive Order: Incentives for the Use of Health Information Technology and Establishing the Position of the National Health Information Technology Coordinator. It called for the establishment, role, and expectations of the Office of the National Coordinator for Health Information Technology (ONC) and further defined the Coordinator position as being appointed by the HHS Secretary [18, 19].

Health Information Technology for Economic and Clinical Health (HITECH) Act

The Health Information Technology for Economic and Clinical Health (HITECH) Act was enacted as part of the American Recovery and Reinvestment Act of 2009 [20], which was signed by President Barack H. Obama. The mandate built on the previous executive order, by amending the existing Social Security and Public Health Service Acts to provide ONC with US $1.2 billion in incentive programs for Medicare and Medicaid providers and hospitals for the adoption and Meaningful Use of certified EHRs. Furthermore, it provides a definition of a qualified EHR.

The HITECH Act additionally calls for the formation of federally matched educational grants that involve the safe and effective use of EHR technology. This call encompasses clinical environments and fields of nursing and information technology, and focuses on the effective use, implementation, and maintenance of EHR systems and infrastructure. HITECH funds supports: (1) state-level health information exchanges (HIEs); (2) "Regional Extension Centers" that provide technical assistance to eligible health care providers; (3) colleges that train workers in HIT; and (4) community coalitions that support regional "Beacon Communities" demonstrations for improving health outcomes using EHRs and HIEs. Other funds support efforts to harmonize electronic standards and to solve technical issues. Little direct funding is dedicated to upgrading public health information systems to the new information exchange standards. Among recipients were state healthcare providers, health plans, patient or consumer organizations that represent the population to be served, HIT vendors, healthcare purchasers and employers, public health agencies, health professions schools, universities, and colleges, clinical researchers, and other users of HIT. This includes the support and clerical staff of providers and others involved in the care and care coordination of patients [21].

EHRs in Public Health and Healthcare

The benefits of EHR include making complete patient information more available when and where needed. Timeliness and completeness of information available to public health will also likely increase, along with data quality issues that may pose new challenges. For example, as structured data replaces unstructured text, the information supplied to public health departments may lose some of its richness of meaning. Public health programs will also be challenged by the need to manage growing volumes of incoming data. Fortunately, with standardized data, the work of delivering, sorting, and interpreting information can be shared by interoperable information systems, rather than by public health professionals alone.

Public health will benefit when standardized and secured EHR data are able to be shared among local, state, tribal, territorial, and federal stakeholders and partners in the US from across the healthcare continuum. These data can be aggregated and analyzed by public health organizations on the basis of any number of situational, environmental, or demographic factors. The public health community has often had to manage non-standard data on printed records, manual methods, or incompatible systems, which makes standardized data in EHRs using automated methods and interoperable systems highly valued.

Meaningful Use

The '5 pillars' of health outcomes policy priorities are the basis of Meaningful Use, which include: (1) improve quality, safety, efficiency, and reducing health disparities; (2) engage patients and families in their health; (3) improve care coordination; (4) improve population and public health; and (5) ensure adequate privacy and security protection for personal health information [22].

The single greatest measure to support the implementation and effective use of EHR technology is the Meaningful Use of Certified EHR Technology clause, in Subtitle A: Medicare Incentives: Incentives for Eligible Professionals, of the HITECH Act. This clause details the method by which eligibility, certification, and subsequent compensation for participation in the incentive program are achieved. In doing so, it outlines clearly how providers can receive up to US $44,000 [8] worth of incentives over a period of five years, and makes additional provision for incentives under the Medicaid program. More importantly, the clause explains what will constitute the Meaningful Use of the EHR, providing distinct guidelines for the recording, storage, and exchange of medical data with attention paid to the operations of systems within and between hospital systems. Additional incentives are provided by the measure to foster adoption and expansion within hospital organizations. Compensation can be obtained by institutions to defray the costs of implementation of qualified EHR systems, with the amount dependent upon the size and patient volumes of the respective institutions. Incentive funds set aside by HITECH total US $1.045 Billion for Medicare and Medicaid combined, and these will be made available until expended by the reimbursement schedule outlined in the Act for incentive distribution [8].

Incentives for Adoption of EHRs

The incentive payment structure for adoption of EHRs is tiered to promote early adoption, with the early adopters garnering the majority of funds. The implementation strategy is structured in ongoing stages (Fig. 11.3), which provides incremental incentives to encourage the growth necessary to achieve the HITECH Act's goals. In 2018, the CMS renamed the EHR Incentive Programs to Promoting Interoperability (PI)

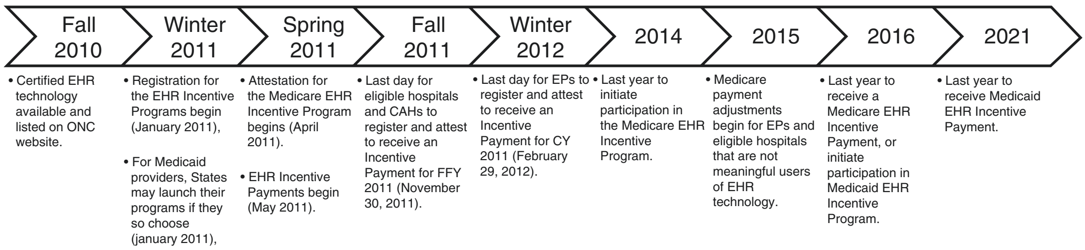

Fig. 11.3 EHR incentive payment implementation strategy. (Adapted from [23])

Programs with a focus on improving patient access to health information and reducing the time and cost required for providers to comply with the programs' requirements.

The specific measures included under the Public Health Registry and Clinical Data Registry Reporting objective in the EHR Incentive and PI Programs are [22]:

1. Immunization registry reporting
2. Syndromic surveillance reporting
3. Electronic case reporting
4. Public health registries reporting
5. Clinical data registries reporting
6. Electronic reportable laboratory test reporting (for hospitals only)

To deter delays in executing mandated policies, the HITECH Act includes tiered reduction of incentive payments for late adopters. After expiration of the five year tiered incentive program, measures have been included to reverse the cycle to impose significant penalties on providers that fail to comply with the electronic filing and reporting standards set forth by Meaningful Use.

Maintenance of EHRs

The HITECH Act also implemented a structure to ensure that the infrastructure and the technologies supported by ONC are maintained through sustained review and refinement. The Act mandated the creation of two committees—the Health Information Technology (HIT) Policy Committee and the HIT Standards Committee. These committees advised ONC and CMS on the HITECH regulation, with public comments from individuals and associations representing stakeholders, including patients, hospitals, medical associations, insurance companies, and EHR vendors. These committees reviewed and suggested the best policies and methods of standardization for HIT. The Act gave power to the HIT Policy Committee to request standards, implementation specifications, and certification criteria that are necessary for the accurate and secure exchange and use of health information [8].

Extensibility of EHRs

Another committee required by the HITECH Act is the HIT Standards Committee. The Act states the HIT Standards Committee shall develop, harmonize, and recommend standards, implementation specifications, and certification criteria to the ONC, as requested by the HIT Policy Committee [8].

As a result of the creation of the HIT Standards Committee, rulings have been filed amending the HITECH Act with the initially recognized standards designated for certification for Meaningful Use. These approved standards involved transaction security to person authentication, as follows.

- HL7® version 2.5.1 (Health Level 7) [24]
  Founded in 1987, Health Level Seven International (HL7®) is a not-for-profit, ANSI-accredited, standards developing organization dedicated to providing a comprehensive framework and related standards for the exchange, integration, sharing and retrieval of electronic health information that supports

clinical practice and the management, delivery and evaluation of health services.

- Logical Observation Identifiers Names and Codes (LOINC®) version 2.38 [25]
- LOINC, or the Logical Observation Identifiers Names and Codes, was initiated in 1994 by Clem McDonald, then an investigator at Regenstrief Institute. The Regenstrief Institute organized the LOINC Committee to develop a common terminology for laboratory and clinical observations to send clinical data electronically from laboratories and other data producers to hospitals, physician's offices, and payers who use the data for clinical care and management purposes.
- Systematized Nomenclature of Medicine-Clinical Terms (SNOMED-CT®) International Release January 2012 [26]
- SNOMED-CT®, is a standardized, multilingual vocabulary of clinical terminology that is used by physicians and other healthcare providers for the electronic exchange of clinical health information.
- National Council for Prescription Drug Programs (NCPDP) version 10.6 [27]
- NCPDP, is an ANSI-accredited, standards development organization providing healthcare solutions.
- International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) [28]
- The National Center for Health Statistics (NCHS), the Federal agency responsible for use of the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10) in the US, has developed a clinical modification of the classification for morbidity purposes.
- Healthcare Common Procedure Coding System (HCPCS) [29]
- HCPCS is a standardized coding system that is used primarily to identify products, supplies, and services not included in the CPT codes, such as ambulance services and durable medical equipment, prosthetics, orthotics, and supplies (DMEPOS) when used outside a physician's office. Since Medicare and other insurers cover a variety of services, supplies, and equipment that are not identified by CPT codes, the level II HCPCS codes were established for submitting claims for these items.
- Current Procedural Terminology, 4th Edition (CPT-4) [30]
  CPT-4 is a numeric coding system maintained by the AMA. The CPT is a uniform coding system consisting of descriptive terms and identifying codes that are used primarily to identify medical services and procedures furnished by physicians and other healthcare professionals. These healthcare professionals use the CPT to identify services and procedures for which they bill public or private health insurance programs.

To ensure the ability for health information to be gathered and shared is maintained appropriately throughout the nation, additional wording specifies that a Nationwide Health Information Network (NwHIN) was recommended. The HIT Standards Committee is tasked with ensuring that the standards used by the NwHIN are aligned with current technologies employed by the industry, and are updated accordingly to exist within that environment. This includes advancements in the formatting of future versions of existing coding and standards bodies (e.g., HL7®, ICD, LOINC®, or SNOMED®), and the inclusion of new standards as the market adopts them [8].

Security of EHR Information Systems

An information system can grow while maintaining security of the data within it. As such, the HITECH Act addresses the security of EHR systems, including user authentication, positive patient identification, and encryption of patient records and transactions that are used to exchange data between providers, facilities, insurance carriers, and systems within the enterprise. Along with the standardization of security protocols and transactions, severe penalties and protections for privacy and confidentiality violations are included in the HIPAA for individuals or institutions that knowingly and willfully misuse PHI.

EHRs and Health Outcomes

EHRs are increasingly being used by the public health community to improve population and public health outcomes. To achieve this aim, the Public Health 3.0 paradigm fosters partnerships among stakeholders from various entities that are designed to engage the medical and non-medical determinants of health. Furthermore, functionalities in EHRs are being expanded and leveraged to perform public health missions as part of broader healthcare visions.

Population and Public Health Outcomes Improvement

The definition of population health varies, but has been proposed as "the health outcomes of a group of individuals, including the distribution of such outcomes within the group" [31]. From this definition arise a field that comprises health outcomes, patterns of health determinants, and policies and interventions that link them [31].

It is posited that improvements in population and public health outcomes can materialize through efficient collection of data in a form that can be shared across multiple healthcare and public health organizations [32]. This sharing and mutual awareness should be combined with a data-to-action approach for these prevention activities and quality improvements to materialize. EHRs can improve reporting and surveillance capabilities through standardized and systematic data that improve ability to prevent disease by providing information on entire populations and appropriate alerts and protocols. It also can improve communications among multiple stakeholders in the health and well-being continuum, including healthcare providers, public health professionals, and patients and caretakers [33, 34]. To realize these improvements, further advances in EHR development are necessary, including population-level coverage and tools that standardize the content and reporting, and improve policy and legal streamlining of data access, sharing, and use among stakeholders [35]. Some examples of EHRs as a resource for public health surveillance have been piloted to various levels of success, and these successes are indicative of possible consequences, intended and unintended [36].

EHRs and Public Health 3.0

Public Health 3.0 (PH 3.0) encourages governmental health entities to form partnerships with non-governmental, non-health entities in their community and invest in the upstream, non-medical determinants of health [37].

While EHRs have introduced functions that deal with patient's nascent social determinants of health [38, 39], there is a lack of consensus on standards for capturing or representing social determinants of health in EHRs, thus resulting in varying implementations [38]. Furthermore, after data regarding these social determinants are collected, the promise that these data can drive actions to improve health and well-being remains to be demonstrated. Providers and administrative staff in health systems now routinely collect information about housing status, insurance type (commonly used as a proxy for economic status), employment status, and among other pieces of information in patients' EHR that should lead to more accurate, equitable and culturally relevant healthcare decisions. Further strategies are under way for improving social determinants through health data standardization, collection, presentation, and subsequent action mechanisms in EHRs [39].

PH 3.0 recommends timely and locally relevant metrics and analysis. These are typically generated by local health departments and partners, but more granular and real-time data are available from EHRs in healthcare systems. To support the PH 3.0 paradigm, new partnerships must allow extended, secure, and HIPAA compliant access to these data. CDC's BioSense Platform, provides an early example of this paradigm by providing "public health officials a common cloud-based health information system with standardized tools and procedures to rapidly collect, evaluate, share, and store information" [40].

Lessons Learned from EHR Developments and Implementations

Legislation such as HIPAA and the HITECH Act have laid the groundwork for the US to join a global movement of EHR adoption that has been in motion since President William J. Clinton's administration, as evidenced by the international community's continued development and implementation of the latest versions of global standards. Countries have been working to achieve a state of readiness where health information can be easily exchanged and studied. There are successful examples of this in Denmark, Sweden, and New Zealand, where EHR adoption and use by practitioners is at or approaching 100% [41]. There are also several examples where efforts at the introduction of a national EHR system struggled to succeed. Nations directly involved with, and other nations peripheral to, those struggles have gleaned valuable insights into implementation of national EHR systems.

One example is Great Britain's National Programme for Information Technology (NPfIT), that began in 2002. It was originally dubbed "the world's biggest civil information technology program." With approximately £6 billion in initial budgeting for the major contracts that year, the program continued for nine years through numerous stops, starts, and challenges as described later. The British government's ambitious goal of identifying, procuring, configuring, customizing, and implementing a set of systems for all health providers and facilities in the country was a difficult challenge [42].

A similar attempt took place in Australia, in its smallest and most densely populated state of Victoria. Given its size and density, the state began the process of implementing a statewide, data-dense EHR, and modeled it closely after the British effort in its top-down structure. The process of selecting and defining the system began in administrative offices, far removed from the clinics it would serve. In 2012, after five years of work with only 40% completion, hundreds of millions of dollars in overruns, and similar outrage from the medical community as expressed in England, the Victorian government ended the effort because of negative outcomes [43].

In both instances, the key element of medical and public health communities' involvement and acceptance was not sufficiently understood and implemented early enough in the process to enfranchise the physician and public health communities with the benefits of the efforts, even as they continued to indicate areas where patient safety and quality of care were of concern. In addition, the practice of dictating the configuration and usage of EHR systems by national governing groups proved to be controversial, because of the varied operating procedures that existed among facilities.

Clinician engagement at the onset is vital to the success of EHR implementation. Efforts focused on the administrative functions of the system, before the clinical aspects, will affect the usability and adoption of the product. Medical procedures and functions are too specialized and precise in their design to have change dictated by functions such as billing and personnel management. Solutions are more easily defined and implemented when overlaid on codified processes that constitute clinical workflows, evidence-based medical guidelines, and exchange of PHI data in a manner that maintains focus on health and well-being outcomes.

The Good News

Implementation of EHRs is becoming commonplace in the world. Nations, states, counties, hospital systems, clinics, and single-physician medical practices are all increasingly using EHR technologies. The infrastructures and standards required to support the free exchange of individual patient PHI are now in place and being modified, updated, and maintained regularly to keep pace with the burgeoning growth of informatics and information technology. The barriers to an integrated EHR for all individuals are not (and never were) fully technological or clinical.

The Anticipated Progress

Adoption of EHRs will continue to gain acceptance as people's lives become increasingly infused with a myriad of technologies. Informatics and information technology departments continually support the progression of EHRs by, for example, responding to the expectations of their institutions' employees and customers, who use their information network with an array of computerized devices. The ubiquitous nature of data at the fingertips of users, such as those from social media, electronic banking, online shopping, and mobile device management, continue to evolve the expectations of how EHR information and services are developed, delivered, and used.

Limitations, Disparities, and Unintended Consequences of EHR Adoption and Progression Globally

There are limitations, disparities, and unintended consequences of EHR adoption and progression globally. Among them are the adoption imbalance within the US, the EHR progress in developed countries, the lagging behind in developing countries, the economics of EHRs, and other effects. These limitations, disparities, and unintended consequences are articulated as follows.

Adoption Imbalance Within the US

EHR adoption rates are not homogeneous across the US. In the US, EHR adoption is affected by the heterogeneous, hybrid healthcare system and regulation subject to federalist principles (that powers are shared between federal and state jurisdictions, and vary widely across states). The Health IT Dashboard from the ONC showed that approximately nine in ten office-based physicians had adopted either a basic or a certified EHR by 2017. However, a deeper look reveals variabilities. In Minnesota, nearly all office-based physicians, versus approximately half in California or Nevada, demonstrated Meaningful Use of certified HIT in 2016 [44].

Studies have identified variables that affect EHR adoption rates. For example, physicians in solo practices and non-primary care specialties lag others in adoption rates [45]. Furthermore, EHR adoption is more likely to occur as a practice becomes more rural, with certain types of practices being less affected (e.g., radiology) than others (e.g., psychiatry and orthopedic surgery) by the degree of rurality [46].

Disparities in rates of EHR adoption might exacerbate inequalities in health outcomes [45], which makes them a potential public health concern. Rates should homogenize as stages in Meaningful Use progress, but policies and efforts to support health information exchange, patient engagement, and equity will need ongoing commitment and vigilance.

EHR Progress in Developed Countries

Notable differences exist in EHR adoption rates among developed countries. Despite pitfalls in Great Britain's NPfIT, the United Kingdom (UK) was managing almost 100% coverage of EHRs in primary care at a time when the US rate of adoption was 10–30% [47]. Canadian EHR adoption rates have increased from about 20% of practitioners in 2006 to an estimated 62% of practitioners in 2013, with substantial regional disparities [48]. In Germany, about 90% of physicians in private practice are using EHR systems [49]. In New Zealand, a distributed EHR system can be accessed from virtually any entity across the nation, since it has achieved an EHR adoption rate of 97% [50].

Differences also exist in how EHRs are used. Previous studies have tried to assess specific dimensions, such as usage of EHR portals by patients, in various countries. For example, usage patterns of EHR patient portals are higher in the US than Portugal [51].

However, more importantly, political and societal contexts determine how, and when, EHR systems are supported. The European Union (EU) is working to allow cross-country interoperability of EHRs. According to a public consultation on digital health in 2017 [52], the heterogeneity of EHRs was recognized among the main obstacles to exchanging health data and advancing digital health and care in Europe. In February 2019, the European Commission published recommendations for a European Electronic Health Record exchange format [52]. The goal was "to facilitate the cross-border interoperability of EHRs in the EU by supporting Members States in their efforts to ensure that citizens can securely access and exchange their health data wherever they are located in the EU."

In an ideal world, patients should be able to freely consult, modify, transfer, use, and share or deny access to their data, regardless of their physical location in the world. EHR systems should help, but according to an international survey study, "more efforts should be made for the integration of the most widely supported standards, and the enhancement of interoperability among health information systems" [53].

Developing countries lagging behind

Developing countries have lagged in EHR adoption. In many Latin American countries, printed records are pervasive. The latest EHR recommendations from the Pan American Health Organization [54] still involve implementation issues at early stages of EHR feasibility assessments, such as creating unique patient identifiers [55]. As reported in the literature, the case is similar in many Sub-Saharan African countries [56] or Saudi Arabia, where a need for creating a new model for EHR adoption exists [57].

Market forces might drive EHR progress in developing countries as major vendors expand operations globally [58]. However, countries can take a more active role in their EHR futures by learning from successful and failed experiences throughout the world. In France, privacy laws, health information exchanges, and interoperability are key components of EHRs that create suitable frameworks for future systems to successfully connect and operate with advanced capabilities [49]. The UK experiences showed that implementation of EHRs can only happen when appropriate, well tested EHR systems actually exist [47]. In the US, implementation of the HITECH Act also offers valuable lessons in integrating HIT as a component of healthcare and public health [59]. In India, a 2016 publication proposed a roadmap to EHR adoption that includes the creation of secure health networks, health information exchanges, privacy laws, and an agency for HIT, among other recommendations [50].

Economics of EHRs

In the US, a few certified EHR vendors which are listed in Health IT Dashboards from the ONC, hold the majority of the market share and have the ability to drive development and implementation. Like other products that follow network economics, functioning EHRs generate lock-in effects, leading to considerable switching costs in healthcare ecosystems. Changing from one EHR system to a different one requires reconfiguring systems, rewriting contracts, retraining staff, and creating new workflows, among other consequences that might discourage health organizations from switching to an alternative. As investments are made in certification and training requirements for staff to be able to access data and advanced features, EHR-powered healthcare ecosystems encounter these costs and consequences from the initial decision of choosing a solution. The existence of collaborative, open source efforts, such as OpenMRS, can democratize the EHR for healthcare ecosystems and reduce dependency on major vendors. All stakeholders, but particularly from regulators, policy makers, and users of EHRs, will need to promote equitable and cost-effective options.

Other Effects of EHR Adoption

Although EHRs can potentially improve care, they can also have unintended effects. This is not a new idea, and issues were anticipated at least by 1998 [60]. Many issues with EHR adoption have been reported. Among these issues are less time for patient and provider interactions, thus compromising patient and physician relationships, and additional laborious data entry tasks performed by providers [60, 61]. EHRs may be contributing to professional dissatisfaction and burnout among providers in the US [61].

The study of unintended consequences of EHRs in clinical contexts is an ongoing and growing area of research, with recent work trying to address—rather than just assess—consequences with technology-based interventions [62–64]. However, published studies have been more limited in unintended consequences of EHRs in public health contexts. EHRs hold great promise for public health and, as noted herein, they could enable PH 3.0. As EHRs become ubiquitous, and public and population health problems are formulated with their use in mind, an EHR-savvy workforce will become invaluable to public health practice.

Conclusion

The impact that EHRs will have on human health and well-being, or the provision of healthcare, is not yet fully apparent. However, the evidence is clear that EHRs continue to affect, and in many ways define, the communities they serve. In addition to the patients themselves, other users, such as physicians, nurses, allied healthcare workers, medicolegal experts, archivists, insurance workers, public health professionals, informaticians, and data scientists have benefitted from the advent of EHRs. The pervasiveness of EHR technology has created new fields of study and specialization within the marketplace. These users focus on the development, implementation, maintenance, and enhancement of EHR technologies, along with the stewardship and effective use of the data contained in EHRs.

Public health and medical informaticians are instrumental in a modern organization in defining the course of EHRs. As EHR technology matures, and innovation continues, the numbers and types of new career paths that will emerge is immeasurable. Harnessing the power of the people, processes, and data convened by EHR technologies promises to lead to new and innovative thinking, planning, solutions, and policies that care for the individual health and well-being of a patient, as well as the collective health and well-being of the public and population as a whole.

Review Questions

1. Describe some of the positive and negative effects legislation can have on the success of EHR implementation for the establishment of a national EHR. Provide examples of effective and ineffective legislation. What are the primary factors that determine the success of legislation surrounding EHR technology implementation?
2. Discuss the importance of utilizing standards and portability technologies for health data in the interoperability of EHRs.
3. What effect does the standardization of health data have upon the effectiveness of public health surveillance? What are the benefits and disadvantages?
4. What is meant by the term, ‘Meaningful Use’? How does the concept of Meaningful Use differ from other EHR implementation strategies?
5. What are some of the measures that HIPAA, HITECH Act, and ONC have in place to ensure EHR policies, standards, and technologies are modified, maintained, and updated in accordance with the progression of technology and the marketplace?
6. How can EHRs improve population and public health outcomes? What are the consequences, intended and unintended?

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