The concept of computerizing medical records was first introduced in the 1960s. Initially, development and use of electronic health records was slow. However, changes in medical technology, consumer demand, and government initiatives, as well as the need to reduce health care costs while improving patient safety have created rapid growth in the use of electronic medical records in recent years. This article defines electronic health records and describes their evolution, benefits, implementation, and use in radiation oncology.

After completing this article, the reader should be able to:
- Define and distinguish the terms electronic health record (EHR), electronic medical record, and electronic personal health record.
- Describe the influences that have driven the development and adoption of EHRs.
- Discuss the role of government and nongovernmental organizations in EHR expansion.
- List benefits and challenges associated with EHRs.
- Explain the privacy and safety safeguards required for EHR use.
- Describe the implementation and use of EHRs in radiation oncology.

On August 29, 2005, Hurricane Katrina slammed into the U.S. Gulf Coast, destroying beachfront towns in Mississippi and Louisiana. More than 1800 people lost their lives and nearly 1 million were displaced. When the levees were breached in New Orleans, 80% of the city was under water. Although a mandatory evacuation order had been issued the day before the hurricane hit, 20% of the city’s 500 000 residents were stranded in place without food, water, or power.

Patients had to be evacuated from about 2 dozen local hospitals because of loss of power, water, and sewage service. Many of these patients were separated from their medical records during the evacuation. When they arrived at receiving hospitals, vital information about their diagnoses, medical histories, and medications was not available to medical personnel unless the patients could supply that information themselves.

Of the New Orleans area residents who voluntarily evacuated, tens of thousands required urgent care and more than 200 000 had chronic medical conditions that needed attention once they reached evacuation centers. Many had left home without medical documents or medications in the rush to evacuate. Many more were later unable to obtain their medical records because their health care facilities and physicians’ offices had been flooded. Clinicians had to care for ill and unfamiliar patients without access to their medical records.

The exact number of immediate deaths attributed to Hurricane Katrina will never be known, but it is estimated to be between 971 and 1170. There is also no way to determine the latent morbidity and mortality of survivors and evacuees that occurred as a consequence of having their care interrupted or terminated because of lack of access to their medical records.
While most patients and health care providers in Katrina’s wake were frustrated by the inability to access patient files, more than 38,000 veterans and their physicians in Louisiana, Mississippi, and the Florida panhandle were able to get all their records, prescriptions, and test results. Patient information was available for every patient treated at the Southeast Louisiana Veterans Health Care System in New Orleans. The health care system’s use of a computerized patient record system ensured all patient medical information could be accessed by any Veterans Affairs physician in the nation.5

Disaster situations, such as Hurricane Katrina, demonstrate the vital importance of being able to access patient medical records at any time from anywhere. The computerized patient record system used by the United States Department of Veterans Affairs (VA) proved the capability of electronic health records (EHRs) to meet the data needs for continuity of care, even in the worst of conditions. In addition to the capability of immediate access to information in any circumstance, EHRs have other anticipated benefits, including increased efficiency, reduced costs, and improved patient safety.

As society has embraced the digital tools of the information age, it is imperative for health care providers to do the same. The health care system in the United States continues to move into the technological age with the rest of the world, and EHRs are becoming an integral part of every patient’s health care experience.

Defining Electronic Health Records

No universally accepted definition of an electronic health record exists. The simplest description comes from the U.S. Office of the National Coordinator for Health Information Technology, which defines an EHR as a digital version of a paper chart.6 The Centers for Medicare & Medicaid Services (CMS) refined that definition to be an:

electronic version of a patient’s medical history, that is maintained by the provider over time, and may include all of the key administrative clinical data relevant to that person’s care under a particular provider, including demographics, progress notes, problems, medications, vital signs, past medical history, immunizations, laboratory data and radiology reports.7

Generally, EHRs can be considered any part of a patient’s medical record that is stored on a computer and any functional benefits resulting from having an EHR.8 A broader definition describes EHRs as:

any information relating to the past, present or future physical/mental health, or condition of an individual which resides in electronic system(s) used to capture, transmit, receive, store, retrieve, link and manipulate multimedia data for the primary purpose of providing healthcare and health related services.9

The term electronic medical record frequently is used synonymously with EHR. There are, however, significant differences between them. The term electronic medical record was used initially because the first electronic records were used primarily by physicians for recording information about their own patients. They were truly digital versions of the patient’s medical chart used in a physician’s office.10 They contained the medical and treatment history of patients cared for by one physician or medical practice site. The information was not accessible to the patients themselves, nor could it be shared with other health care providers unless it was printed out to be hand-delivered or sent by mail or fax.

In contrast to electronic medical records, EHRs are intended to focus on the total health of the patient and are more interactive. Information can be shared with any authorized care provider, regardless of health care organization. Patients can access their own records and test results. The EHR emphasizes a team approach to health care, including the patient, clinicians, and support staff.

A personal health record, sometimes called an electronic personal health record, is an electronic application patients can use to maintain and manage their own health information.11 Unlike EHRs, in which data is primarily entered and accessed by health care providers, the personal health record is controlled by the individual patient. Patients determine what is included in their personal health records such as contact information, family medical history, immunization records, medication lists, or personal recollections of medical encounters. Personal health records are separate from and not substitutes for a health care provider’s legal medical record. Patients determine whether information in the personal health record is shared with care providers or family members. Personal health records were created to help individuals take a more active role in their own health and wellness.12
It is fairly easy for individuals to create and access a personal health record. They do not need to be in electronic format. Patients who do not feel comfortable using computers or other electronic devices can maintain paper-based personal health records. Personal health records also can be stand-alone files in which patients store their data on an Internet site, their own computers, or other digital data storage devices. Forms for electronic personal health records commonly are made available by health insurance plans, health care providers, employers, and independent vendors. Often personal health records are linked to a health care organization’s EHR, allowing patients to access their information through a secure portal.

History of Electronic Health Records
The concept of computerizing medical records has been around for more than 50 years, but widespread use of electronic medical records occurred only over the past 10 years. The idea of recording patient information electronically instead of on paper was introduced by Lawrence Weed, MD, in the late 1960s. In 1976, Weed collaborated with the Medical Center Hospital of Vermont to develop the Problem-Oriented Medical Information System. Around the same time, a few other academic medical centers developed clinical information systems, the predecessors of EHRs, for their own use. The Lockheed Corporation developed one of the earliest systems, which was noted at the time for its fast processing speed and flexibility in supporting the diverse needs of many users at a single site. Concurrently, the University of Utah, in collaboration with 3M, began developing one of the first clinical decision support systems, called Health Evaluation through Logical Processing.

In 1968, Massachusetts General Hospital, in partnership with Harvard University, developed and implemented COSTAR, the Computer Stored Ambulatory Record. The first adoption of the system was at the Harvard Community Health Plan, which had 9 care facilities. Because of COSTAR’s modular design, individual care sites only needed to install a partial set of modules to meet their needs. For example, scheduling modules and medical records modules could be installed without billing modules, if a site desired. This increased the overall efficiency of the system. Another advantage of COSTAR was the flexible vocabulary that recognized multiple terms for the same medical condition and associated brand name medications with their generic equivalents. This allowed COSTAR to accommodate variations in terminology among individual health care providers and institutions.

The federal government’s involvement with EHRs began in the 1970s, when the VA began to develop VistA, the Veterans Health Information Systems and Technology Architecture, formerly known as the Decentralized Hospital Computer Program. VistA is used at more than 1500 care sites within the Veterans Health Administration, including every Veterans Affairs medical center, community-based outpatient clinic, and community living center. In addition, VistA is available to care providers not affiliated with the Veterans Administration or Veterans Health Administration through the Freedom of Information Act.

The software developed for VistA is grouped into the categories of system/database management, administrative management, and clinical management. The system/database management software supports, develops, and maintains VistA. Administrative management software supports all hospital administrative tasks, including scheduling, and the clinical management software supports clinical information delivery in the laboratory, pharmacy, and other departments such as surgery, medicine, cardiology, and oncology.

The VA also developed the Computerized Patient Record System (CPRS) as an application of VistA. CPRS supports clinical decision making and allows users to enter, review, and update patient information; order tests and procedures; request and track consultations; enter progress notes, diagnoses, and treatments for each patient encounter; and enter discharge summaries. Because 60% of all physicians educated in the United States have rotated through VA facilities for some portion of their training, VistA and CPRS are thought to be the most widely used EHRs in the country.

Because of the groundbreaking development of the VistA information system, the VA and Veterans Health Administration were recipients of the 2006 Innovations in American Government Award by the Ash Institute of the John F Kennedy School of Government at Harvard University. This award program recognizes and promotes excellence and...
creativity in the public sector. It provides grant money to promote sharing of successful government innovations with nongovernmental organizations.21

Over the years, some individual institutions developed EHRs for their own use, and a small number of vendors began to offer systems for sale, but there was little interest in moving away from paper-based medical records. The fairly recent interest in and motivation for adopting EHRs by almost all health care providers in the United States came about when the American Recovery and Reinvestment Act of 2009 was signed into law by President Barack Obama. This law provided government support for development of a national EHR system.

**Key Capabilities of EHRs**

The U.S. government’s role in the transition from paper-based to electronic charts began with a report published by the Institute of Medicine (IOM), an independent, nonprofit organization that researches health and health care concerns and makes recommendations to policymakers and the public.22 Most studies carried out by the IOM are mandated by the U.S. Congress or commissioned by federal and independent agencies. The 1991 IOM report titled “The Computer-Based Patient Record: An Essential Technology for Health Care” called for elimination of paper-based patient charts within 10 years to make important patient data readily available and useable to health care providers.16,23 Following that report, progress toward implementing EHRs was still slow, with only a few health care settings adopting EHRs. There were technical challenges, as well as policy, organizational, and financial challenges. No functional model for an EHR system existed, nor was there much incentive to develop one.

In 2003, the IOM issued “Key Capabilities of an Electronic Health Record System,” a report requested by the U.S. Department of Health & Human Services (HHS). This report identified 8 categories of core functions an EHR should be able to perform to promote better safety, quality, and efficiency in health care delivery (see Box 1).23

The Health Information and Data function of an EHR should have a defined data set that includes items such as medical diagnoses, medication lists, allergies, clinical narratives, test results, and demographics.23 The ability to access laboratory test results can eliminate redundancy in ordering tests, reduce medical costs, and prevent unnecessary procedures. Information on patient diagnoses, allergies, and medications should improve patient safety and increase the efficiency of medical care.

The Results Management function refers to the ability to electronically access laboratory test results and medical imaging reports quickly and easily. Computerized results provide health care practitioners with information when and where it is needed. Reducing the delay in access to this information allows for quicker recognition and treatment of medical problems. Automated displays of previous test results make it possible to reduce redundant and additional testing. Electronic results allow for better interpretation and easier detection of abnormalities, ensuring appropriate follow-up care. Access to electronic consultations and patient consent forms can improve care coordination among multiple providers, as well as between the provider and patient.

Computerized Order Entry/Management capability improves workflow processes by eliminating the problems associated with illegible handwriting and lost orders.23 In addition, related orders can be generated simultaneously, duplicate orders can be detected, and the time required to fill orders can be reduced. Computerized provider order entry (CPOE) systems have been shown to reduce the number of errors in medication dose and frequency, adverse events due to drug allergies, and drug interactions. CPOE systems also diminish the costs of preprinted forms and ensure that prescribing practices are consistent with a facility’s established formulary.

Decision Support systems enhance clinical performance in the areas of medication prescribing, disease

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**Box 1**

**Institute of Medicine Categories of Core Functionalities**23

1. Health Information and Data
2. Results Management
3. Order Entry/Management
4. Decision Support
5. Electronic Communications and Connectivity
6. Patient Support
7. Administrative Processes
8. Reporting and Population Health Management
Computer reminders and prompts have been shown to improve preventive practices in the areas of vaccinations and cancer screenings, as well as improve drug selection and dosing, and screening for drug interactions.

Communication among health care team members and other care partners is enhanced with the Electronic Communications and Connectivity function of EHRs. Improved communication enhances patient safety and quality of care. Email and Web messaging facilitate communication between providers and with patients. Telemedicine allows patients access to care providers when travel to offices or hospitals is not possible because of distance, disability, or illness. Providers also can consult with peers to share expertise.

EHRs can play a role in Patient Support. For example, patients can access computerized educational materials. In addition, telemonitoring that uses electronic devices can display self-testing results and self-care behaviors of patients at home.

The Administrative Processes of health care institutions become more efficient with the use of EHRs, enabling better and more timely service to patients. Appointments can be scheduled electronically. Electronic authorization and prior approvals for reimbursement purposes eliminate delays in care. Insurance eligibility can be verified immediately to improve access to services and expedite payment with minimal paperwork.

The Reporting and Population Health function of EHRs assists health care institutions in meeting the reporting requirements at federal, state, and local levels for data on public health, patient safety, and quality of care. Computers eliminate manual abstracting of data, which can be labor intensive, time consuming, and fraught with potential for errors.

Despite this general guidance from IOM regarding EHRs, and the recognition by both the public and private sectors of the need to improve quality of health care and reduce costs, there has been little incentive for the development and implementation of such systems.

Medical Errors and the Need for EHRs

In 1999, the IOM published a report titled “To Err Is Human: Building a Safer Health System,” which described the need to improve patient safety by reducing errors in health care delivery. Using extrapolated data, the report stated that at least 44,000 and perhaps as many as 98,000 deaths each year in the United States were due to preventable medical errors. Beyond the costs related to the loss of human life, the report discussed the estimated expenditures associated with the additional care necessitated by errors and costs to patients in terms of lost income, productivity, and disability. Patient trust in the health care system and health care providers and customer satisfaction by both patients and health care professionals also were diminished by medical errors. As the health care system and the services provided by the system have become more complex, the opportunities for error have increased. The report recommended establishing systems to make it hard for people to do the wrong thing and easy for them to do the right thing. It also was recommended that information about patients, medications, and treatments be available at the point of patient care. In short, the IOM suggested a computer-based record would help to implement both recommendations.

Because of extensive media coverage, the report received attention from the health care industry and the public. Health care institutions, insurers, government agencies, nongovernmental organizations, and health care consumers responded to the report by taking action. Health care consumers began asking more questions, getting more information about their care, and requesting access to their medical records. The federal government appropriated funding for patient safety research, and nongovernmental agencies issued reports about patient safety issues.

Despite this call for improved patient safety, recent data indicate medical errors are now the third leading cause of death in the United States behind heart disease and cancer. A study published in 2013 determined that between 210,000 and 400,000 patients experience preventable harm that contributes to their deaths.
care providers and institutions. Following the release of the IOM report in 1999, the Leapfrog Group began to work to provide more market reinforcement for the quality and safety of health care. The organization now helps employer members provide incentives and rewards to the best-performing hospitals, either directly or through their health plans. One of the means to reduce health care costs advocated by Leapfrog was the use of CPOE systems, a component of most EHRs. This recommendation was based on studies looking at the costs associated with adverse drug events. In 2007, the IOM Committee on Identifying and Preventing Medication Errors issued a report that estimated at least 1.5 million preventable adverse drug events occur in the United States each year. This estimate was based on research showing that 380,000 to 450,000 preventable adverse drug events occur in hospitals each year, with another 800,000 occurring annually in long-term care facilities, both of which were considered to be underestimates. The IOM report also discussed the additional health care costs related to injuries caused by adverse drug events in hospitals. A conservative estimate was calculated to be $3.5 billion in 2006.

Aside from a reduction in care costs because of medication errors, additional savings from the use of EHRs in large hospitals have been estimated to range from $37 million to $59 million over a 5-year period. Some of these cost savings occur as a result of automating time-consuming and labor-intensive paper-based activities such as transcription, chart pulling, storage, coding, and billing. Reducing duplicate medical tests and procedures also reduces costs.

**Consumer Demand for Electronic Medical Information**

Technology has changed the way people communicate and access information. According to a 2014 Pew Research Center survey, 87% of adults in the United States use the Internet, 90% of adults own a cell phone, and 58% own a smartphone. Further, 72% of Internet users said they researched health information online in the past year. An additional 31% of cell phone users and 52% of smartphone users indicated they used their phones to access medical or health information. Another national study indicated that more than 4 out of 5 patients with online capabilities accessed their medical records at least once in the past year, and 55% of respondents accessed them 3 or more times per year.

As health care consumers have become more comfortable with sharing and accessing sensitive health information securely on the Internet, many want to access their medical information and use that information to make decisions about their personal care. EHRs make patient access to their personal medical records possible.

**Government Influence on EHRs**

President Bill Clinton issued an executive order in 1998 to establish the Quality Interagency Coordination Task Force to ensure all federal agencies involved in purchasing, providing, studying, or regulating health care services would work in coordination and with the common goal of improving the quality of health care. In response to the 1999 IOM report, in 2001 the U.S. Congress allocated $50 million annually for patient safety research to the Agency for Healthcare Research and Quality, the lead federal agency for health care safety. President George W Bush, through a 2004 executive order, created the Office of the National Coordinator for Health Information Technology (ONC) under the HHS. The purpose of Executive Order 13335 was to “provide leadership for the development and nationwide implementation of an interoperable health information technology infrastructure to improve the quality and efficiency of health care.” The executive order identified the responsibilities of the national coordinator as developing, maintaining, and directing the implementation of a strategic plan to guide nationwide application of interoperable health information technology in public and private health care sectors to reduce medical error, improve quality, and increase value for health care expenditures. At that time, the president called for the majority of Americans to have interoperable EHRs within 10 years.

The American Recovery and Reinvestment Act of 2009 included the Health Information Technology for Economic and Clinical Health (HITECH) Act. The HITECH Act promoted the adoption and meaningful use of health information technology by offering financial incentives to physicians and hospitals for demonstrating meaningful use of EHRs up until 2015 and penalties for failure to demonstrate such use. When David J Brailer, MD, PhD, was appointed as the first national coordinator, he outlined a strategic
framework that included 4 major goals, each with a corresponding set of strategies (see Box 2). The first goal was to inform clinical practice. This goal centered on bringing EHRs directly to clinical practice, consequently reducing medical errors and duplicate work. Achieving this goal would enable clinicians to focus their energy and effort on improving patient care. The strategies developed to reach this goal included incentivizing EHR adoption, reducing the risk of EHR investment for clinicians who attempted to change their clinical practice and office operations using EHRs, and promoting diffusion of EHRs in rural and underserved areas.

The second goal was to connect clinicians to allow them to share information and move patient data from one point of care to another. To achieve this goal, the ONC proposed strategies to foster regional collaborations, develop a national health information network, and coordinate federal health information systems. The strategies developed to accomplish this goal included encouraging the use of personal health records, improving consumer choice by providing information on clinicians and health care facilities, and promoting the use of remote communication technologies such as telehealth systems.

The third goal was to personalize care by allowing individuals to manage their own health and wellness and assist them in making personal health care decisions. The strategies developed to accomplish this goal included encouraging the use of personal health records, improving consumer choice by providing information on clinicians and health care facilities, and promoting the use of remote communication technologies such as telehealth systems.

The final goal was to improve the health of residents of the United States by collecting timely, accurate, and detailed information to allow evaluation of health care delivery and reporting of data to public health officials, researchers, and clinicians. The strategies for this goal included unifying public health surveillance architectures, streamlining quality and health status monitoring, and accelerating research and dissemination of evidence.

In 2008, with a new national coordinator, the ONC updated the strategic plan for 2008 to 2012. This plan had 2 goals: patient-focused health care and population health. These goals were organized around the core themes of privacy and security, interoperability, adoption, and collaborative governance. The patient-focused health care goal was to promote electronic health information access and use by health care providers, patients, and their designees to achieve higher-quality, more cost-efficient, patient-focused care. The goal of population health was to enable appropriate, authorized, and timely access to and use of electronic health information to benefit public health, biomedical research, emergency preparedness, and quality improvement.

The strategies were characterized by a commitment to include both the private and public sectors; concern for reliability, confidentiality, privacy, and security in the exchange, use, and storage of electronic health information; and the focus on the health care consumer as an essential participant in achieving the plan’s goals (see Box 3).

Since the publication of these first 2 strategic plans, the ONC has issued updated strategic plans for 2011 to 2015 and 2015 to 2020. In each of these plans, the ONC continued to commit itself to promoting the adoption of information technology in health care settings, enabling the interoperability of information and advancing the safety and quality of care for patients.

Box 2

Summary of Goals and Strategies for National Adoption of Health Information Technology from the Office of the National Coordinator for Health Information (ONC) 2004

Goal 1: Inform clinical practice
Strategy 1. Incentivize EHR adoption.
Strategy 2. Reduce risk of EHR investment for clinicians who purchase EHRs to reduce risk, failure, and partial use of EHRs.
Strategy 3. Promote EHR diffusion in rural and underserved areas.

Goal 2: Interconnect clinicians
Strategy 1. Foster regional collaborations.
Strategy 2. Develop a national health information network.
Strategy 3. Coordinate federal health information systems.

Goal 3: Personalize care
Strategy 1. Encourage use of personal health records.
Strategy 2. Enhance informed consumer choice to select clinicians and institutions based on what they value, including but not limited to the quality of care providers deliver.
Strategy 3. Promote the use of telehealth systems.

Goal 4: Improve population health
Strategy 1. Unify public health surveillance architectures.
Strategy 2. Streamline quality and health status monitoring.
Strategy 3. Accelerate research and dissemination of evidence.
Despite the promotion of EHRs by the ONC, there has been little incentive for health care practitioners and institutions to invest financial, time, and personnel resources to develop and adopt health information technology. With the passage of the HITECH Act of 2009, HHS was given the authority to establish programs to promote health information technology, including EHRs and private and secure electronic health information exchange. Individual sections of HITECH provide HHS’s directive to improve privacy and security provisions for exchange and use of electronic health information and establish grant and loan programs to assist providers in effectively adopting and using EHR technology. The HITECH Act also established the Medicare and Medicaid incentive programs for providers to adopt, implement, upgrade, and demonstrate meaningful use of certified EHR technology.

To receive an incentive payment, eligible professionals (see Box 4) must demonstrate use of an EHR that is certified for the incentive programs. The ONC established a certification program to test and verify that health information technology products meet established standards for a structured data format and other criteria for technological capability, interoperability, functionality, and security. Certification provides confidence that health information technology products and systems are secure and interoperable.

Meaningful use must be documented to receive the incentive payments. The ONC defined meaningful use as the use of certified EHRs for improving quality, safety, and efficiency of health care and reducing health disparities; engaging patients and their families; improving care coordination and population and public health; and maintaining privacy and security of patient health information. The stated purpose of the meaningful use incentive was to improve individual patient clinical and population health outcomes, increase transparency

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<td><strong>Health Information Technology Goals and Objectives 2008-2012 From ONC</strong></td>
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**Goal 1**

**Patient-Focused Health Care**

**Objective 1.1: Privacy and Security**
Facilitate electronic exchange, access, and use of electronic health information, while protecting the privacy and security of patients’ health information.

**Objective 1.2: Interoperability**
Enable the movement of electronic health information to support patients’ health and care needs.

**Objective 1.3: Adoption**
Promote nationwide deployment of EHRs and personal health records and other consumer information technology tools.

**Objective 1.4: Collaborative Governance**
Establish mechanisms for multistakeholder priority setting and decision making.

**Goal 2**

**Population Health**

**Objective 1.1: Privacy and Security**
Advance privacy and security policies, principles, procedures, and protections for information access in population health.

**Objective 1.2: Interoperability**
Enable exchange of health information to support population-oriented uses.

**Objective 1.3: Adoption**
Promote nationwide adoption of technologies to improve population and individual health.

**Objective 1.4: Collaborative Governance**
Establish coordinated organizational processes supporting information use for population health.
EHR Benefits

The use of EHRs and the ability to share information electronically promises to create a health care system that provides higher quality and safer care for patients. Some of the recognized benefits of EHRs are care coordination, safety, improved processes, clinical decision support, improved care management, and reduced malpractice.48

Because EHRs are not physical objects that only can be in one place at one time like paper charts, they can be available immediately wherever and whenever an authorized care provider needs them. In addition, they can be used by more than one person at a time. Chart pulling is eliminated, and reports no longer need to be copied, mailed, or faxed. The capability to retrieve rapidly and exchange information efficiently allows enhanced coordination of patient care.

Handwritten notes in paper records can be illegible, leading to misinterpretation of clinical care notations, physician orders, and medication and treatment orders. Paper-based reports might not be filed in the chart promptly, or they might be filed in the wrong part of the chart and inaccessible to the care provider, potentially causing clinical decisions to be made with incomplete information. Both of these are potential sources of medical error that affect patient well-being.49

Although the safety of patients is paramount, maintaining the physical safety of paper records is also necessary. A considerable amount of patient data can be lost if paper charts are damaged through careless handling or the deterioration of paper over time. Paper also is susceptible to damage from fire and water.50

The limitations of paper-based charts affect the process of health care, which includes both medical and business practices. Paper records require large, secure areas for storage. They must be kept organized for easy location but also must have limited access and some type of logging system to record access and removal.50

The capability to retrieve diagnostic test reports and prescription records from EHRs can lower health care
costs by reducing service duplication. It is estimated that administrative costs account for 25.3% of total hospital expenditures in the United States, a far higher percentage than in other developed nations. EHRs can reduce redundant paperwork, interface with coding and billing programs, and reduce the time spent by health care providers and support staff in locating, photocopying, and filing records. All of this allows care providers more time to focus on direct patient care.

A clinical decision support system (CDSS) is: software designed to be a direct aid to clinical decision-making, in which the characteristics of an individual patient are matched to a computerized clinical knowledge base and patient-specific assessments or recommendations are then presented to the clinician or the patient for a decision.

CDSSs support the practice of evidence-based medicine, which allows integration of the best available research evidence with clinical expertise and patient values. These systems can provide alerts such as warning prescribers about patient drug allergies or potential drug interactions. CDSSs also can deliver reminders to providers and patients, for example, when follow-up appointments need to be scheduled or prescriptions need to be refilled. More sophisticated CDSSs provide clinical care guidelines, condition-specific order sets, focused patient data reports, diagnostic support, and contextually relevant reference materials. Benefits of using CDSSs are increased quality of care, reduced errors and adverse events, and improved efficiency.

According to a 2010 study, patients in the United States have seen an average of 18.7 different physicians during their lifetimes. For patients 65 years and older, the average increases to 28.4, including primary care physicians, specialists, hospitalists, and urgent care providers. EHRs enhance the capability to coordinate and manage patient care by allowing care providers to communicate with each other easily and share patient-related information.

Well-designed and appropriately used EHRs can reduce the risk of malpractice by providing clinical alerts and reminders; improving aggregation, analysis, and communication of patient information; and gathering all relevant patient information in one place.

Other potential benefits of EHRs are improvement in job and customer satisfaction. EHRs can improve intra-office communication, reduce “chart chasing” activities, and make it easier for health care providers and support staff to comply with regulations. Patients have quicker access to their records, easier access to patient education materials, and faster turnaround times for returned messages and prescription refills.

**Privacy and Security Issues**

One of the biggest concerns associated with EHR use is maintaining confidentiality of patient data. Health information privacy rights are protected by the Health Insurance Portability and Accountability Act (HIPAA) of 1996. HIPAA required the Secretary of the HHS to develop regulations to protect the privacy and security of health information. The HIPAA Privacy and Security Rules were published in response to this mandate. The Standards for Privacy of Individually Identifiable Health Information, better known as the HIPAA Privacy Rule, established national standards to protect certain health information. The Security Standards for the Protection of Electronic Protected Health Information, also known as the HIPAA Security Rule, created a set of national standards to protect certain health information that is stored or transferred in electronic form. The HHS Office for Civil Rights is responsible for enforcing both the Privacy Rule and the Security Rule.

Health care organizations required to follow HIPAA rules are called covered entities. These organizations include health plans, health care providers, and health care clearinghouses (see Box 5). Health care clearinghouses are organizations that process nonstandard health information received from one entity into a standard format for transmission to another entity. An example of a health care clearinghouse is a business that transmits insurance claims and billing information between a hospital and an insurance company.

The HIPAA Security Rule is intended to allow covered health care entities to adopt new electronic technologies to improve the quality and efficiency of health care while protecting the privacy of each individual’s health information. While the Privacy Rule protects against disclosure of individually identifiable health information, called protected health information, the Security Rule covers a subset of that data. Electronic protected health information is defined as all individually identifiable
health information an entity creates, receives, maintains, or transmits in electronic form.\textsuperscript{49}

In general, the Security Rule requires covered entities to safeguard the confidentiality, integrity, and availability of all electronic protected health information they create, receive, maintain, or transmit; identify and protect against reasonably anticipated threats to the security and integrity of information; guard against reasonably anticipated prohibited uses or disclosures; and ensure compliance by their workforce.\textsuperscript{49} Confidentiality refers to making sure electronic protected health information is not disclosed or made available to unauthorized people. Integrity of electronic protected health information is maintained by ensuring information is not altered or destroyed in an unauthorized manner. Availability refers to electronic protected health information being accessible and usable on demand by any authorized user.

The HIPAA Security Rule requires 3 basic protections: administrative, physical, and technical safeguards.\textsuperscript{59} Administrative safeguards are internal organizational policies and procedures and maintenance of security measures that protect patient health information. Physical safeguards protect physical equipment from being stolen or rendered inoperable, and technical safeguards protect against electronic threats such as hackers who would steal or maliciously alter data (see Box 6).

As technology evolved and health care entities began to move away from paper-based systems to share and store medical information, data breaches started to become more common.\textsuperscript{59} One notable case occurred in May 2006, when the personal information of more than 26 million veterans and American military personnel was stolen when a VA employee’s home was burglarized and his personal laptop computer stolen. Although the employee had authorized access to VA databases for a work project, he was not authorized to have the data on a personal computer at home.\textsuperscript{62} In January 2015, Anthem, the second largest health insurance provider in the United States, discovered that hackers had broken into a database containing up to 80 million records.\textsuperscript{63} These are 2 examples of many health care database breaches that have occurred in the past decade. Ninety-one percent of all health care organizations have reported at least one data breach in the past 2 years, and it is estimated that the health care industry accounted for 42.5% of all data breaches over the past 3 years.\textsuperscript{64}

HIPAA regulations were designed for the health care system and processes that existed in the 1990s. Because the HITECH Act anticipated the massive expansion in

<table>
<thead>
<tr>
<th>Box 5</th>
<th>Health Insurance Portability and Accountability Act (HIPAA) Covered Entities\textsuperscript{59}</th>
</tr>
</thead>
</table>
| **Health Plans** | Health insurers  
Health maintenance organizations  
Company health plans  
Medicare and Medicaid |
| **Health Care Providers** | Physicians and dentists  
Clinics and hospitals  
Psychologists  
Chiropractors  
Nursing homes  
Pharmacies |
| **Health Care Clearinghouses** | |
the exchange of electronic protected health information that would come with meaningful use of health information technology, the scope of HIPAA privacy and security protections needed to be broadened. The final HIPAA Omnibus Rule, issued in 2013, expanded many privacy and security requirements to cover business associates of covered entities that receive protected health information. Maximum penalties for noncompliance were increased and clarification was made regarding when breaches of unsecured health information must be reported to the HHS.65 A breach is considered an impermissible use of disclosure under the Privacy Rule that compromises the security or privacy of personal health information.66

Covered entities must now notify individual patients upon discovery of a breach, and the media and HHS must be notified when more than 500 patients are affected. HHS must investigate data breaches to determine whether they were caused by willful neglect, defined as the conscious, intentional failure or reckless indifference to the obligation to comply with HIPAA regulations.67

The final rule allows patients to ask for a copy of their EHR in electronic form, prohibits the sale of individuals’ health information without their consent, and allows individuals who pay cash for their medical care to instruct providers not to share information about their care with their health plans.

EHRs in Radiation Oncology

Radiation oncology is a health care discipline that always has relied on cutting-edge technologies. Historically, these technological advances created a need for more accurate ways to monitor and record daily radiation treatments.68 Some of the first uses of computers in radiation oncology were introduced in the 1980s. To ensure the accurate and safe delivery of daily radiation treatments, record and verify systems (R&Vs) were developed to check treatment parameters set by radiation therapists.68,69 When treatment parameters were matched and approved by the computer, the treatment could be delivered and the treatment settings recorded.

R&Vs were computerized systems added to individual treatment units designed to capture treatment parameters using sensors and compare them with intended parameters before treatment was initiated. The intended parameters were entered either manually or automatically transferred to the treatment unit from simulator or treatment planning system computers. Some R&Vs captured parameters used on the first day of treatment to use as a reference for subsequent treatments.

At treatment time, sensing hardware on the treatment unit detected collimator, gantry, and table positions and relayed those values to software that compared the intended and actual settings.69 A warning that required human intervention to override was issued if there was a mismatch exceeding tolerance levels.

R&Vs were developed to reduce the risk of daily treatment errors.70 Over the years their importance and necessity in the safe and efficient delivery of modern radiation therapy has been proved.68 Technical advancements since the 1990s have transformed simple R&Vs into sophisticated treatment management systems capable of automatically setting many treatment parameters, such as field size and shape and collimator and gantry positions, with minimal intervention by the radiation therapist.

Traditionally, R&Vs have been unique to radiation oncology and have only contained data related to daily patient treatment. Similarly, radiation oncology treatment planning systems usually have been set up as separate entities containing only data related to patient dose calculations. Access to patient clinical data, such as pathology and laboratory reports or consultation and progress notes, was not part of these systems. Nor were patient demographics and scheduling information accessible with these systems.

For years radiation oncology departments typically generated and used department-specific paper charts.71 These charts contained daily treatment records and treatment planning data in addition to demographic and disease-specific information for each patient. Almost all of the information contained in the chart was inaccessible to health care practitioners outside the radiation oncology department.

As computer systems were integrated into radiation oncology departments, different systems were developed for different tasks, such as treatment delivery, treatment planning, scheduling, and billing. Some of these systems were introduced by radiation therapy equipment vendors and others were created in-house to meet the needs of specific institutions. In many instances, even within the radiation oncology department, it was difficult to obtain all the data on a
particular patient at once because the different systems did not communicate with each other.\textsuperscript{69,70}

In the 1990s, radiation oncology vendors began to introduce electronic medical records systems that integrated R&Vs with treatment planning, scheduling, workflow management, and document storage.\textsuperscript{69} Radiation oncology departments began to adopt these new oncology information systems even before the HITECH incentives were put in place. Today, most radiation oncology facilities use an EHR system.\textsuperscript{72} In a 2012 study that surveyed 40 academic institutions and private practices, all respondents indicated they used an electronic R&V, and 81% said they used at least one EHR system.\textsuperscript{73}

Varian’s ARIA and Elekta’s MOSAIQ are 2 commonly used systems in radiation oncology. Both have been certified for stage 2 meaningful use.\textsuperscript{74,75} ARIA enables the radiation oncology department to connect with pathology, radiology, pharmacy, lab, and billing departments.\textsuperscript{72} It also links and provides access to the patient’s treatment chart and images, treatment planning modules, physician modules, the R&V, and EHR. The radiation oncology information system can interface with the medical oncology information system, which allows medical and radiation oncologists the benefit of coordinating care and the capability to determine the patient’s phase of treatment at any given time.

MOSAIQ also can centralize radiation and medical oncology patient data into a single user interface that can be accessed by multidisciplinary team members in various locations.\textsuperscript{72} It is interoperable with a wide range of treatment planning and treatment delivery systems.

**System Integration**

Usually, individual radiation oncology information systems have been specifically designed for radiation oncology. Some have interoperability with other oncology systems, but typically they have not been easy to integrate with hospital- or enterprise-wide information systems. This has been one of the challenges to EHR adoption. Historically, individual hospital departments have used stand-alone systems selected to meet their individual needs.\textsuperscript{76} This “best of breed” approach has resulted in hospitals having a collection of systems rather than one system for the entire hospital. Developing a single integrated system for an entire health care organization requires connecting each department’s software installations to the others in a manner that operates seamlessly. Much of the difficulty encountered with EHR system setup is a result of trying to mesh several systems to create one that operates well for all users. To create an interoperable health care environment, 4 areas of EHR technology need to be addressed: the way computer applications interact with the users, the way systems communicate with each other, the manner in which data are processed and managed, and the methods consumer devices and applications, such as mobile devices, integrate with other systems.\textsuperscript{77}

The struggle to interweave currently used systems that have multiple and noncommunicative EHRs has led many health care systems to switch from a multiple vendor to a single comprehensive vendor approach.\textsuperscript{78} Epic Systems Corporation currently leads the market in the sale of integrated software for large health care organizations. The EpicCare Inpatient Clinical Systems, based on software developed at Massachusetts General Hospital in 1968, had more than 50% of new large hospital contracts in the United States in 2014 and was reported in 2013 to have included at least partial health information on 50% of the U.S. population.\textsuperscript{79} Epic’s success has been attributed to its single product solution, better physician buy-in, standardization of governance and processes, reduced demand on information technology staff for customization or best of breed solutions, built-in integration across institutions, and compliance with meaningful use regulations.

The biggest advantage of using a single-vendor product is that data flow is more reliable because the same technical platform is used across a health care system. This enables better workflow management.\textsuperscript{80} Disadvantages to a single product include an inability to meet the specialty requirements of individual health care disciplines and the potential downtime of the entire system when upgrades are needed to one part of the system.

**Current Trends in EHR Use**

Despite the factors driving EHR use, not only in radiation oncology but the entire health care industry, some concerns about potential hazards remain, and many health care providers are still not adopting EHRs. Each year the ECRI Institute, an independent non-profit organization that researches approaches to improving patient care and safety, issues a report that identifies
potential sources of danger to health care consumers from health technology. The "Top 10 Health Technology Hazards for 2015" report identified 2 hazards related to the use of EHRs: data integrity and cybersecurity.\textsuperscript{81} The report acknowledged that when EHRs function well they provide the information clinicians need to make appropriate and accurate treatment decisions. However, when faults exist, incomplete, erroneous, or outdated information ends up in the patient's record, potentially leading to poor treatment decisions and injury to the patient. The integrity of data in health information technology systems can be compromised in many ways and can be difficult to recognize and correct once compromised. Some examples of data integrity issues cited in the report are the entry of one patient's data in another patient's EHR, missing data or delayed data delivery, default values being used by mistake or fields being prepopulated with incorrect information, and outdated or inappropriate information being copied and pasted into new reports.

The other hazard identified by the ECRI Institute’s report is insufficient protections for medical devices and systems.\textsuperscript{81} Networking and connectivity of medical devices increases the devices’ susceptibility to malware and malicious attacks. Although the report indicated there is little evidence to date of direct harm to patients from poor cybersecurity, patient safety must always be a consideration when addressing the vulnerability of health information systems. The U.S. Food and Drug Administration noted that, just like other computer systems, medical devices are susceptible to security breaches. When medical devices are connected to hospital networks, other medical devices, or the Internet, that vulnerability increases, potentially leading to equipment malfunctions, disruption of health care services, inappropriate access to confidential patient information, or compromised data integrity within the EHR.\textsuperscript{82}

Since the IOM recommended the use of EHRs and other health information systems in 1991, studies have focused on their benefits and successes, not potential risks. The ECRI Institute report noted that technology hazards can arise from many different sources, such as poorly configured systems, incomplete data, improper malware protection, inadequate device maintenance, design flaws, quality issues, and failure of devices to perform as they should.\textsuperscript{81} It is important to recognize hazards and address them before they become complications. Additional research should focus on areas of needed improvement related to the implementation and use of EHRs.

In a 2014 study released by the ONC, 8 in 10 physicians reported they were using an EHR or planned to adopt one.\textsuperscript{83} More than half of the physicians who indicated they planned never to adopt EHRs cited a lack of financial resources as one reason for their decision. Other reasons frequently cited for nonadoption of EHRs were lack of time and staff and security and privacy concerns. Fewer physicians indicated that an EHR system suited to the needs of their specialty was not available.

The adoption of EHR systems by nonfederal acute care hospitals increased more than fivefold between 2008 and 2013.\textsuperscript{84} In 2013, 59% of hospitals were using a basic EHR system, and 93% of hospitals possessed a certified EHR technology that met meaningful use requirements. Adoption of EHRs continues to rise. Hospitals and physicians are responding to market and policy pressures and are investing time and resources toward adoption.\textsuperscript{85} However, there is still much to be done. Ongoing effort is needed to achieve HITECH’s purpose of building a nationwide health information infrastructure with the ultimate goal of improving health care delivery and population health outcomes in the United States.

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References


1. According to the Centers for Medicare & Medicaid Services, an electronic version of a patient’s medical history that is maintained by the provider over time and can include all of the key administrative clinical data relevant to that person's care under a particular provider defines a(n):
   a. electronic health record (EHR).
   b. electronic medical record.
   c. personal health record.
   d. radiation oncology information record.

2. An electronic medical record contains the medical and treatment history of patients cared for by one physician.
   a. true
   b. false

3. An electronic application that allows patients to maintain and manage their own health information is called a(n):
   a. medical chart.
   b. electronic medical record.
   c. personal health record.
   d. radiation oncology information record.

4. The recent motivation for adopting EHRs in the United States is the:
   a. Institute of Medicine (IOM).
   b. Leapfrog Group.
   c. Office of the National Coordinator (ONC).

5. Telemedicine is an example of which core function of EHRs?
   a. Population Health Management
   b. Health Information and Data
   c. Electronic Communication and Connectivity
   d. Decision Support

6. “To Err Is Human: Building a Safer Health System” is a report issued by the:
   a. IOM.
   c. ONC.
   d. Leapfrog Group.

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Electronic Health Records

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7. The ONC for Health Care Information Technology was created by an executive order by:
   a. Bill Clinton.
   b. Barack Obama.
   c. George W Bush.
   d. Ronald Reagan.

8. Which act gave the HHS the authority to establish programs to promote health information technology?
   a. Health Information Technology for Economic and Clinical Health (HITECH)
   b. Freedom of Information
   c. American Recovery and Reinvestment
   d. Health Insurance Portability and Accountability Act (HIPAA)

9. Which of the following is a requirement for demonstrating meaningful use?
   1. improving care coordination
   2. maintaining privacy and security of patient health information
   3. engaging patients and their families
   a. 1 and 2
   b. 1 and 3
   c. 2 and 3
   d. 1, 2, and 3

10. Which software application supports the practice of evidence-based medicine?
    a. EHR
    b. record and verify system
    c. computerized provider order entry
    d. clinical decision support system

11. According to the article, which of the following is an example of an administrative safeguard as required by HIPAA?
    a. limiting physical access to facilities
    b. training and management of the workforce
    c. restricting access to only authorized personnel
    d. establishing policies covering the transfer and disposal of electronic media

12. Whenever a data breach affects more than 500 patients, HITECH requires notification of:
    1. area physicians.
    2. the media.
    3. the HHS.
    a. 1 and 2
    b. 1 and 3
    c. 2 and 3
    d. 1, 2, and 3

13. One of the earliest uses of computers in radiation oncology was to:
    a. check treatment parameters.
    b. digitize portal images.
    c. create electronic medical records.
    d. computerize order entry.

14. Examples of EHR data integrity concerns identified by the ECRI Institute include:
    1. missing data or delayed data delivery.
    2. prepopulating of data fields with incorrect data.
    3. outdated data being copied and pasted into new reports.
    a. 1 and 2
    b. 1 and 3
    c. 2 and 3
    d. 1, 2, and 3