

Chapter 2

Medicine Enters the Computer Age

Lekshmi Santhosh and Raman Khanna

You have to know the past to understand the present. – Carl Sagan, astronomer

The best way to predict the future is to invent it. – Alan Kay, computer scientist

The 1960s and 1970s: The Dawn of Computerization in Health Care

In October of 1960, the *New York Times* reported on a three-day symposium in Endicott, New York, devoted to gathering the “nation’s experts in the medical and biological applications of computers [1].” The article temperately warned that the “emphasis... was not on ways of replacing the specialist by a specialized machine, but on ways of using machines to extend and increase the effectiveness of physician and biological scientist alike.” Perhaps this decades-long fear of replacing M.D. with machine has subliminally hindered medicine’s journey into the digital age. The sponsor of that symposium was none other than IBM, which has now developed Watson Health, a multimillion dollar effort to use “cognitive computing” to diagnose, manage, and treat diseases across populations [2].

The 1960 *Times* article goes on to cite Dr. Joseph E. Schenthal, head of the Hutchinson Memorial Clinic at the Tulane University Medical School, predicting

L. Santhosh, MD

Division of Pulmonary and Critical Care Medicine, Department of Medicine,
University of California San Francisco, San Francisco, CA, USA
e-mail: Lekshmi_Santhosh@ucsf.edu

R. Khanna, MD (✉)

Division of Hospital Medicine, Department of Medicine, University of California San
Francisco, San Francisco, CA, USA
e-mail: Raman.Khanna@ucsf.edu

that “a person’s entire lifetime of ‘medical history’ can be stored on a few feet of magnetic tape,” thus replacing written records of medical patients altogether. Other early conceptualizations of an EHR occurred throughout the 1960s, and one survey reported that at least 73 hospitals had “clinical information projects” and 28 projects for health record storage and retrieval of health records were underway [3]. All across the country, various academic medical centers tried to develop homegrown systems, with Mayo Clinic being one of the early adopters [4]. A film clip from 1966 showcases the limited capabilities of the then-groundbreaking Akron General Hospital’s earliest electronic health record, with the narrator exhorting, “It is going to be possible to relieve the nurses and the doctors of some of the paperwork [5].”

Meanwhile, in Boston in the 1960s, collaboration between the government, industry, and academia led to the development of a programming language—the Massachusetts General Hospital Utility Multi-Programming System (MUMPS) [6]. Dr. Jerome H. Grossman and Dr. G. Octo Barnett from the Massachusetts General Hospital’s Laboratory of Computer Science used this language to found the Computer-Stored Ambulatory Record (COSTAR), one of the first computer systems that included functions for patient registration, health records management, and practice management. Within 20 years, records from approximately 550,000 patients were generated and tabulated using the COSTAR system, and both MUMPS and COSTAR are currently still in use, albeit in different iterations [7]. Flaws in these systems became obvious at the same time as their benefits, soon after their dissemination to other institutions “in real-life practice.” As will be eerily prescient to any physician practicing today, difficulties included customizing the software to their own clinical setting [8].

A few states away in Indiana, the Regenstrief Institute in Indianapolis was already considering how to make the data it collected even more useful. It created the Regenstrief Medical Record System (RMRS) in 1972, which aimed to “make the informational ‘gold’ in the medical record accessible to clinical, epidemiological, outcomes and management research [9].” The technology was thought to be revolutionary at the time but deemed too expensive to spread too widely outside Indiana. These pockets of innovation such as MUMPS and RMRS were occurring in—and were relatively limited to—stand-alone cities or academic medical centers.

At the same time in the 1970s, the federal government started to get more involved in the creation of its own EHR for the care of veterans. Its initial effort was called the Decentralized Hospital Computer Program (DHCP), launched across 20 Veterans Administration (VA) clinics. This homegrown VA computer system initially struggled to gain internal legitimacy and bureaucratic clearance [10], and it would take decades to become the Computerized Patient Record System (CPRS) physicians and physician trainees across the country continue to use. The VA EHR’s well-known limitations—minimal search functionality, minimal attention to billing—have not prevented physicians from reporting high levels of satisfaction with its use nor driving the medication error rate there to a shockingly low 7 per 1 million prescriptions as compared to the national average of 5% of prescriptions [11, 12].

These early EHR successes represented glimmers of hope at the dawn of medicine’s computer age. As these innovative tinkerers succeeded locally, the digital

revolution was just getting started, with the invention of the cell phone and the personal computer in the 1970s. Both Epic and Cerner—which today remain two of the largest EHR vendors [13]—were founded in 1979 [14]. Everything seemed poised for a perfect convergence of the medical and digital worlds.

The 1980s and 1990s: Growing Heterogeneity, Lofty Goals, and the Arrival of HIPAA

In the 1980s and 1990s, the explosion of personal computing transformed American homes and workplaces alike. As homegrown EHRs matured and computers became more ubiquitous in doctors' offices and hospitals, the health IT industry started to "commercialize," and the customer base for EHR began to expand rapidly, with vendors focusing on physician-specific workflows and billing [15]. More and more companies, including big corporations such as General Electric, began to throw their hat into the health IT ring.

In 1991, the Institute of Medicine published *The Computer-Based Patient Record: An Essential Technology for Health Care* [16]. The computer-based patient record (CPR) was the term used before "Electronic Health Record" came into vogue. The report advocated for "prompt development and implementation" of EHRs and recommended that public and private sectors join to establish a Computer-based Patient Record Institute to facilitate this. The report recommended congressional funding for this institute, national standards for data and security, and cost-sharing between the public and private sectors. The report went on to systematically delineate the numerous disadvantages of paper records that we all know and take for granted and recommended a goal of 100% adoption of EHRs by physicians by the year 2000. The report noted the minimal technologic requirements for the EHRs on page 101, which we have adapted into Table 2.1.

Although these technological requirements were clearly delineated, the report emphasized that the barriers to EHR implementation were not technology related but were systems-related. Perhaps prophetically, they noted:

...Informational, organizational, and behavioral barriers must also be addressed. Barriers to CPR development include development costs and lack of consensus on CPR content. CPR diffusion is adversely affected by the disaggregated health care environment, the complex characteristics of CPR technology, unpredictable user behavior, the high costs of acquiring CPR systems, a lack of adequate networks for transmitting data, a lack of leadership for resolving CPR issues, a lack of training for CPR developers and users, and a variety of legal and social issues.

As the digitization of the health records began to ramp up nationally, the aforementioned "legal and social issues" began to profoundly influence the development of EHRs as the groundbreaking 1996 Health Insurance Portability and Accountability Act (HIPAA) was passed [17]. Since the act regulated the use and disclosure of protected health information (PHI), comprised of "any information held by a covered entity which concerns health status, provision of health care, or payment for

Table 2.1 1991 IOM report of minimal technological requirements for EHRs

Minimal technological requirements for EHRs
1. Databases and database management systems
2. Workstations
3. Data acquisition and retrieval
4. Text processing
5. Image processing and storage
6. Data exchange and vocabulary standards
7. System communications and network infrastructure
8. System reliability and security
9. Linkages to secondary database
From Dick RS et al. Institute of Medicine. 1997 (revised version), page 101

health care,” the interpretation was very broad. In the historical context of the burgeoning HIV/AIDS epidemic in the 1990s, the HIPAA act sought to protect patients’ private health information and establish penalties for breaching patient privacy, especially related to sensitive conditions such as mental illness or HIV status [18]. Moreover, with increasing use of consumer technology, HIPAA also aimed to protect against theft of private health information by companies or individuals by eventually levying multi-thousand dollar fines for violations of patient privacy [19].

In his book *The Digital Doctor*, Dr. Robert Wachter interviewed Dr. John Halamka, the CIO of Beth Israel Deaconess Medical Center, who lamented HIPAA thus: “I spend 50 percent of my time on [HIPAA]. Not on, ‘How can I create innovative mobile devices for doctors?’ Or, ‘How can we engage patients and families with new IT tools?’ Instead, it’s ‘How can I prevent your iPhone from downloading a piece of personal health information should you lose your phone?’ [20]” Although HIPAA was passed when the Internet was still in its early days, it continues to have profound implications on the development of health IT and to cause anxiety among technology companies entering the health care space. While the 1960s and 1970s were characterized by hope for an emerging technology to cure health care’s ails, the 1980s and 1990s showed a more cautious expansion of EHRs despite the IOM’s exhortations for progress.

The 2000s and Early 2010s: The Alphabet Soup of ONCHIT, HITECH, and MU

At the turn of the twenty first century, we were very far from achieving the IOM’s call for universal EHR adoption; only 18% of office-based physicians used an EHR, according to the CDC [21]. In President George W. Bush’s State of the Union address in 2004, there was one line where he mentioned, “By computerizing health

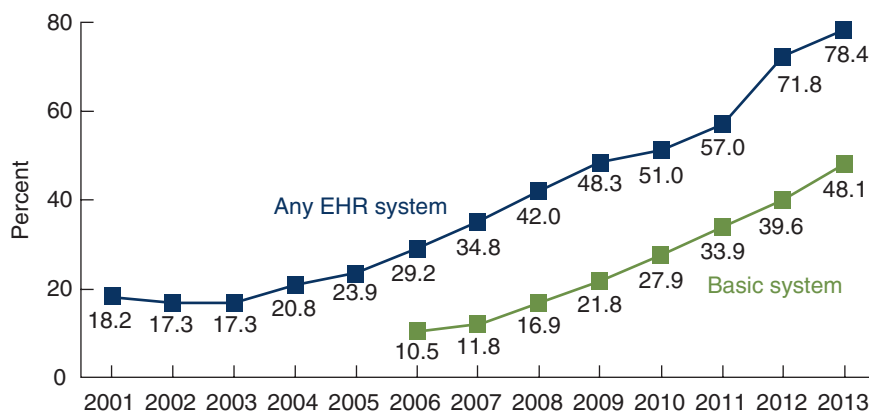
records, we can avoid dangerous medical mistakes, reduce costs, and improve care [22].” Later that year, he called for a comprehensive effort to digitize American health care within the next 10 years and announced the creation of a new Office of the National Coordinator for Health Information Technology (ONCHIT). Initially armed with a relatively small budget of \$42 million and headed up by the first “health IT czar” Dr. David Brailer, it strove to set universal EHR standards by ensuring interoperability, that is, the ability for different health care computer systems to talk to each other [23]. In the early years, ONCHIT started to make slow progress toward the goal of interoperability. For example, ONCHIT as well as the Health Level 7 group have been trying to incentivize interoperability by offering developers prize money to improve readability of complex documents (such as discharge summaries) so they can readily be accessed between health systems [24]. However, interoperability between our many health records—even those by the same vendor—remained a challenge.

Despite the establishment of ONCHIT, the EHR adoption rate in hospitals was still vanishingly rare in the late 2000s. One study showed that only 1.5% of hospitals had a comprehensive electronic-record system present in all units, and only 17% of hospitals had computerized provider-order entry (CPOE) for medications by the year 2009 [25]. The Agency for Healthcare Research and Quality described barriers to implementation of CPOE in a detailed report, including staffing and training issues, workflow issues, computerized order set design, interoperability or lack thereof, customizability or lack thereof, technical support issues, and alert fatigue [26].

The transition from the Bush years to the Obama years would coincide with a massive transformation. Along with the economic stimulus bill came the Health Information Technology for Economic and Clinical Health (HITECH) Act, which allocated potentially over \$100,000 for each doctor and between \$2 and \$10 million per hospital to become “meaningful users” of EHRs, ultimately investing more than \$36 billion over 10 years to accelerate EHR adoption [27].

Meaningful use (MU) had a very specific meaning—a series of standards that EHRs, doctors, and hospitals had to meet to be eligible for the incentive payments. The meaningful use criteria span multiple appendices and tables that health systems have to decipher, as seen for Stage 1 in Table 2.1 [28].

The law mostly served as a strong incentive to promote adoption of EHRs, both in rewards for early adoption and penalties such as decreased reimbursement for late adopters, including those who could not meet the first MU criteria by 2015. These criteria were perceived to be so onerous that even large health systems such as Intermountain Healthcare in Salt Lake City, Utah and Partners HealthCare in Boston, Massachusetts worried that they would be unable to comply with them [29]. Despite the perceived issues, meaningful use rolled out in 2011–2012 and Stage 2 in 2014–2015. Stage 1 included criteria such as providing discharge summaries to patients within 3 days of hospitalization and transmitting a proportion of prescriptions electronically, which was “precisely how Blumenthal had planned it: to use [MU] to gently raise the bar without having the rules inhibit adoption [30].” Stage 2 was even more ambitious, focusing as it did on health information exchange and interaction between local EHRs and cancer, immunization, and other registries [31].



NOTES: EHR is electronic health record. “Any EHR system” is a medical or health record system that is either all or partially electronic (excluding systems solely for billing). Data for 2001–2007 are from in person National Ambulatory Medical Care Survey (NAMCS) interviews. Data for 2008–2010 are from combined files (in-person NAMCS and mail survey). Estimates for 2011–2013 data are based on the mail survey only. Estimates for a basic system prior to 2006 could not be computed because some items were not collected in the survey. Data include nonfederal, office-based physicians and exclude radiologists, anesthesiologists, and pathologists.
SOURCE: CDN/NCHS, National Ambulatory Medical Care Survey and National Ambulatory Medical Care Survey, Electronic Health Records Survey.

Fig. 2.1 Growth in EHR in primary care practices from 2001–2013 (From Hsiao CJ, Hing E. 2014 Jan)

Indeed, Dr. Blumenthal’s goal of incentivizing EHR adoption did achieve its intended effect: adoption of basic EHR systems by office-based physicians increased dramatically between the final passage of HITECH in 2009 and 2013, as shown in Fig. 2.1 [32]. The paradoxically named “basic EHR systems” actually have significant functionality in the data below, including patient history and demographics, patient problem lists, physician clinical notes, comprehensive medication and allergy lists, computerized order entry for medications, and ability to view labs and imaging electronically.

Medicine and Computers Today: Is Waiting for “Disruption” the Only Answer?

Despite, or perhaps because of, the unprecedented adoption of the EHR of the last years, EHRs have yet to live up to the promise of the Endicott Symposium or the IOM report. In our current decade, the average health care consumer is often (but not always—especially in the case of seniors [33]) also an avid personal technology consumer. She or he uses a smartphone for email, music, news, pop culture, and social media. Yet as our personal electronic devices are becoming smaller, faster,

and smarter, our EHRs have not progressed beyond clunky interfaces, numerous extraneous alerts, and onerous demands on physician and patient time. Though Wachter points out examples of EHR “disruptors” that might be forthcoming, such as cloud-based EHRs like athenahealth, the arrival of “medical scribes” to ease the burden of physician paperwork, and OpenNotes software that enables patients to read and even edit their own health records, there is not yet anything on the scale of an Uber, Lyft, Blue Apron, or TaskRabbit [34].

Meanwhile, as physicians, patients, and the country at large await the beneficial disruption that was promised, in clinic rooms and hospital rooms across the country, the not-so-beneficial disruption is all too real. One time-and-motion study following outpatient physicians in four different specialties showed that for every hour physicians spent with patients, nearly two additional hours were spent on documentation in the EHR [35], with other similar studies replicating the burden of constantly “feeding the beast” [36]. Moreover, physicians also have to sort through clinical messages from patients (secure emails or physician-to-patient messaging services) during nonclinical time, spending almost an extra hour a day in one study [37]. Physicians also report that having EHRs with more functionality actually increases stress levels and can contribute to burnout [38]. This phenomenon of decreased time at the patient bedside and increased time at the computer has led to a phenomenon that Dr. Abraham Verghese has coined the “iPatient,” where providers obsessively track lab and data trends while spending precious little time with the actual human being the iPatient represents [39].

These changes in the fundamental patient-physician dyad are simultaneously ubiquitous and completely novel and have set us up for distraction and medical errors. Constraints on physician time, coupled with documentation burden, have led to the copy and pasting of vast portions of notes with the propagation of old or even false information and distrust in the very integrity of the record [40]. Moreover, meaningful-use-related requirements for clinical documentation do not always correspond to clinically useful ones. For example, Table 2.2 shows that one requirement is to provide discharge summaries or copies of the EHR within 3 days of discharge. While this seems easy to operationalize, it could come at the cost of leaving out critically important information, such as a pending pathology result, so as to avoid a time-based penalty. Additionally, multiple levels of alerts for medication interactions have led to widespread alert fatigue. One famous study catalogued 2,558,760 unique alarms in a 31-day-study period in the intensive care unit—about one audible alarm per bed every 8 min [41]. The cognitive overload from too much data in the EHR contributes to medical errors of both the diagnostic and treatment variety. The net result of all of the changes of the computer age, arriving in a rush in the last few years, has placed us in a complex transition state where we are documenting more, copy-pasting more, clicking through more alerts, and spending less time with our patients than we would like, all in a haze of constant distraction. This transition state took decades to enter fully; hopefully it will not take decades to exit it into the land of time-saving, safety-providing, and distraction-free digital health care that computers continue to promise.

Table 2.2 Summary overview of meaningful use (MU) stage I in HITECH

Health outcomes policy priority	Stage 1 objective	Stage 1 measure
Improving quality, safety, efficiency, and reducing health disparities	Use CPOE for medication orders directly entered by any licensed health care professional who can enter orders into the medical record per state, local, and professional guidelines	More than 30% of unique patients with at least one medication in their medication list seen by the EP or admitted to the eligible hospital or CAH have at least one medication entered using CPOE
	Implement drug-drug and drug-allergy interaction checks	The EP/eligible hospital/CAH has enabled this functionality for the entire EHR reporting period
	EP only: Generate and transmit permissible prescriptions electronically (eRx)	More than 40% of all permissible prescriptions written by the EP are transmitted electronically using certified EHR technology
	Record demographics: preferred language, gender, race, ethnicity, date of birth, and date and preliminary cause of death in the event of mortality in the eligible hospital or CAH	More than 50% of all unique patients seen by the EP or admitted to the eligible hospital or CAH have demographics as recorded structured data
	Maintain up-to-date problem list of current and active diagnoses	More than 80% of all unique patients seen by the EP or admitted to the eligible hospital or CAH have at least one entry or an indication that no problems are known for the patient recorded as structured data
	Maintain active medication list	More than 80% of all unique patents seen by the EP or admitted to the eligible hospital or CAH have at least one entry (or an indication that the patient is not currently prescribed any medication) recorded as structured data
	Maintain active medication allergy list	More than 80% of all unique patents seen by the EP or admitted to the eligible hospital or CAH have at least one entry (or an indication that the patient has no known medication allergies) recorded as structured data
	Record and chart vital signs: height, weight, blood pressure, calculate and display BMI, plot and display growth charts for children 2–20 years, including BMI	For more than 50% of all unique patients age 2 and over seen by the EP or admitted to the eligible hospital or CAH, height, weight, and blood pressure are recorded as structured data

(continued)

Table 2.2 (continued)

Health outcomes policy priority	Stage 1 objective	Stage 1 measure
	Record smoking status for patients 13 years old or older	More than 50% of all unique patients 13 years or older seen by the EP or admitted to the eligible hospital or CAH have smoking status recorded as structured data
	Implement one clinical decision support rule and the ability to track compliance with the rule	Implement one clinical decision support rule
	Report clinical quality measures to CMS or the States	For 2011, provide aggregate numerator, denominator, and exclusions through attestation; for 2012, electronically submit clinical quality measures
Engage patients and families in their health care	Provide patients with an electronic copy of their health information (including diagnostic test results, problem list, medication lists, medication allergies, discharge summary, procedures), upon request	More than 50% of all unique patients of the EP, eligible hospital or CAH who request an electronic copy of their health information are provided it within 3 business days
	Hospitals only: Provide patients with an electronic copy of their discharge instructions at time of discharge, upon request	More than 50% of all patients who are discharged from an eligible hospital or CAH who request an electronic copy of their discharge instructions are provided it
	EPs Only: Provide clinical summaries for each office visit	Clinical summaries provided to patients for more than 50% of all office visits within 3 business days
Improve care coordination	Capability to exchange key clinical information (e.g.: problem list, medication list, medication allergies, diagnostic test results), among providers of care and patient-authorized entities electronically	Performed at least one test of the certified EHR technology's capacity to electronically exchange key clinical information
Ensure adequate privacy and security protections for personal health information	Protect electronic health information created or maintained by certified EHR technology through the implementation of appropriate technical capabilities	Conduct or review a security risk analysis per 45 CFR 164.308(a) [1] and implement updates as necessary and correct identified security deficiencies as part of the EP's, eligible hospital's or CAH's risk management process

Adapted from CMS Meaningful Use Stage 1 Requirements Overview 2010, pp. 11–13

The next chapters will explore different lessons physicians are learning from the perils and promises of technology in other industries and how to apply them to health care. In this era of distracted doctoring, it will take more than a simple technological fix to return physicians' focus from the all-consuming documentation requirements on the computer screen to the heart of the patient-doctor relationship.

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Distracted Doctoring

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