Should Government Subsidize Electronic Health Records?

Michael L. Marlow

March 2017

MERCATUS WORKING PAPER

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Michael L. Marlow. "Should Government Subsidize Electronic Health Records?" Mercatus Working Paper, Mercatus Center at George Mason University, Arlington, VA, March 2017.

Abstract

Health information technology (HIT) innovation focuses on electronic health records (EHRs) that can collect, store, and transmit health information within electronic health information exchanges. HIT innovation holds great promise not only for improving public health, but also for controlling what many believe is out-of-control healthcare spending in the United States. These benefits, along with the perception that providers were too slow in adopting HIT, motivated passage of the Health Information Technology for Economic and Clinical Health Act in 2009. That act authorized government subsidies to encourage the adoption and use of EHRs. This paper examines whether recent government investments in EHR adoption were wise. Theories that market failure in EHR innovation and adoption is caused by network externalities, lack of information, and free-rider problems are found to be not entirely convincing, especially given that the government case for subsidies mistakenly assumed that interoperable mature technologies were mostly in place and that healthcare providers would voluntarily share data among themselves. Government subsidies have thus likely "locked in" immature technology rather than spurred HIT innovations that would otherwise have evolved over time. Lost opportunities for better patient care at lower expense are one major cost of the government subsidy program. The paper concludes with recommendations for government policies that are more likely to promote HIT innovation that will improve public health.

JEL codes: H2, I1, O3

Keywords: electronic health records, EHR, electronic medical records, EMR, public health, healthcare costs, healthcare efficiency, government subsidy, technology

Author Affiliation and Contact Information

Michael L. Marlow
Professor of Economics
California Polytechnic State University
mmarlow@calpoly.edu

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Health information technology (HIT) innovation focuses on electronic health records (EHRs) that can collect, store, and transmit health information within electronic health information exchanges (HIEs). HIEs enable doctors, nurses, pharmacists, other healthcare providers, and patients to gain access to and share medical information electronically in ways that potentially improve the speed, quality, and safety of patient care (ONC 2016). HIT innovation thus holds great promise not only for improving public health, but also for controlling what many believe is out-of-control healthcare spending in the United States. These benefits, along with the perception that providers were too slow in adopting HIT, motivated passage of the Health Information Technology for Economic and Clinical Health Act. That act authorized government subsidies to encourage the adoption and use of EHRs.

The potential for HIT innovation to improve healthcare delivery is clear, given that the practice of medicine frequently relies on seemingly archaic methods of delivery. For example, a national survey conducted in 2012 found that 63 percent of physicians use fax technology to support handwritten notes, insurance forms, and lab test result transmissions (Sharecare 2012). EHRs aggregate information about specific encounters of patients into a single record accessible to a population of healthcare providers. For example, vaccination records would be accessible to patients and healthcare providers that share information within HIE networks. Reduced hospital readmissions, reduced medication errors, improved diagnoses, and reduced duplicate testing are potential benefits of expanded use of EHR technology (ONC 2016).

Recent government subsidies have been provided on the basis of arguments that healthcare markets have failed to efficiently innovate and adopt EHR technology (Kleinke 2005; Middleton 2005). The Health Information Technology for Economic and Clinical Health (HITECH) Act was part of the American Recovery and Reinvestment Act of 2009. The HITECH Act authorized the Centers for Medicare and Medicaid Services (CMS) to provide financial incentives of $30 billion to eligible hospitals and professionals through Medicare and Medicaid to adopt and meaningfully use certified EHR technology. The Office of the National Coordinator for Health Information Technology (ONC) directs the federal government's HIT efforts at promoting nationwide health information exchange. ONC is organizationally located within the US Department of Health and Human Services.

This paper examines whether recent government investments in EHR adoption were wise. It examines theories that market failure in EHR innovation and adoption is caused by network externalities, lack of information, and free-rider problems. The author finds that market failure arguments are not entirely convincing, especially given that the government case for subsidies mistakenly assumed that interoperable mature technologies were mostly or already in place and that healthcare providers would voluntarily share data among themselves. Government subsidies have thus likely "locked in" immature technology rather than spurred HIT innovations that would otherwise have evolved over time. Lost opportunities for better patient care at lower expense are one major cost of the government subsidy program. The paper concludes with recommendations for government policies that are more likely to promote HIT innovation that will improve public health.

What Are EHRs?

Most medical information is still stored on paper—for instance, in filing cabinets at various medical offices or in boxes and folders in patients' homes (ONC 2016). When that medical information is shared between providers, it happens by mail, by fax, or by way of patients themselves, who frequently carry their records from appointment to appointment. Current systems thus require users of information to duplicate past information numerous times. These systems are prone to missing data and to other mishaps that burden the healthcare system.

EHRs can record and store a treasure trove of data, including demographic information; problem list and active and past diagnoses; laboratory test orders and results; current prescriptions; radiological images and reports; hospitalization information; consultant reports; immunizations; pathology reports; social history; allergies; health screening study results; and physician, nurse, social worker, and physical therapy notes (Birkhead, Klompas, and Shah 2015). EHRs also can provide access to clinical and public health guidelines; reminders about routine screenings or disease-reporting responsibilities; and graphical displays of such indicators as blood glucose for diabetic patients or blood pressure measurements in hypertensive patients. Public health agencies and healthcare providers can also potentially receive updates on active disease outbreaks, diagnosis, and treatment recommendations.

Fully interoperable HIE systems are a key assumption behind promises that sharing information will improve health care and reduce costs. Predictions that EHR will ultimately reduce hospital readmissions and medication errors, improve diagnoses, and decrease duplicate testing all rest on the assumption that patient information will need to be recorded only once and will be easily accessible to all future providers through shared HIEs. Secure interoperable HIE networks are thus an essential key to enabling healthcare providers to seamlessly share patient

information. Interoperable systems enable users of EHRs to work with other users, present or future, without any restrictions, in sharing information across and within HIEs.

Fully interoperable networks require three forms of HIE (ONC 2014): (1) directed exchange—the ability to send and receive secure information electronically between care providers to support coordinated care; (2) query-based exchange—the ability for providers to find and request information on a patient from other providers, often used for unplanned care; and (3) consumer-mediated exchange—the ability for patients to aggregate and control the use of their health information among providers.

EHR Subsidy Program Basics

Barack Obama, at the time the president-elect, summarized his support for EHR subsidies in a speech given at George Mason University in Fairfax, Virginia, on January 8, 2009:

> To improve the quality of our healthcare while lowering its cost, we will make the immediate investments necessary to ensure that, within five years, all of America's medical records are computerized. This will cut waste, eliminate red tape, and reduce the need to repeat expensive medical tests. But it just won't save billions of dollars and thousands of jobs; it will save lives by reducing the deadly but preventable medical errors that pervade our health care system. (Obama 2009)

Professionals and hospitals participating in the Medicare and Medicaid programs became eligible for financial incentives in 2011 (CMS 2015a). Medicare-eligible providers include doctors of medicine or osteopathy, doctors of dental surgery or dental medicine, doctors of podiatric medicine, doctors of optometry, and chiropractors. Medicaid-eligible providers include physicians, nurse practitioners, certified nurse-midwives, dentists, and physician assistants.

Professionals and hospitals are eligible for financial support from the CMS Medicare and Medicaid EHR incentive programs. Professionals can qualify for EHR incentive payments totaling as much as $44,000 through the Medicare EHR Incentive Program, or as much as

$63,750 through the Medicaid EHR Incentive Program. Eligible hospitals, including critical-access hospitals, could qualify for incentive payments totaling some $2 million or more. As of September 2015, more than 478,000 healthcare providers had received payments for participating in the EHR incentive programs (CMS 2015b). The federal government has funded $35.2 billion in meaningful use (MU) EHR payments as of July 2016 (CMS 2016b).

Recipients must successfully demonstrate MU for each year of participation in the program. Beginning in 2015, recipients who fail to successfully demonstrate MU become subject to payment reductions. Professionals face reductions that start at 1 percent and increase each year that the professional does not demonstrate MU, to a maximum of 5 percent. Hospitals that do not successfully demonstrate MU of certified EHR technology became subject to payment reductions beginning in 2015.

MU criteria were rolled out in three stages.

- Stage 1 (2011–2012) focused on data capture and sharing with the following objectives: electronically capturing health information in a standardized format; using that information to track key clinical conditions, communicating that information for care coordination processes; initiating the reporting of clinical quality measures and public health information; and using information to engage patients and their families in their care.
- Stage 2 (2014) focused on advancing clinical processes with the following objectives: more rigorous information exchange (HIE); increased requirements for e-prescribing and incorporating lab results; electronic transmission of patient care summaries across multiple settings; and more patient-controlled data.

- Stage 3 (2018) focuses on improved outcomes with the following objectives: improvement of quality, safety, and efficiency leading to improved health outcomes; decision support for national high-priority conditions; patient access to self-management tools; access to comprehensive patient data through patient-centered HIE; and improvement of population health. Stage 3 compliance is optional for 2017, but it becomes mandatory in 2018 (HHS 2015).

Is There Market Failure?

Arguments that markets are clinging to old technology and failing to spontaneously innovate started appearing in 2005. For example, Kleinke argued that market HIT innovation and adoption was a "textbook definition of a market failure":

> Given what is at stake, health care should be the most IT-enabled of all our industries, not one of the least. Nonetheless, the "technologies" used to collect, manage, and distribute most of our medical information remain the pen, paper, telephone, fax, and Post-It note. Meanwhile, thousands of small organizations chew around the edges of the problem, spending hundreds of millions of dollars per year on proprietary clinical IT products that barely work and do not talk to each other. Health care organizations do not relish the problem, most vilify it, many are spending vast sums on proprietary products that do not coalesce into a system wide solution, and the investment community has poured nearly a half-trillion dollars into failed HIT ventures that once claimed to be that solution. Nonetheless, no single health care organization or HIT venture has attained anything close to the critical mass necessary to effect such a fix. This is the textbook definition of a market failure. (Kleinke 2005, 1248)

Markets "fail" when resources are not allocated on the basis of all costs and benefits of EHR technology. Textbook definitions of market failure are commonly believed to stem from problems caused by externalities, free-rider problems associated with public goods, and imperfect information. Arguments for cases of market failure in EHR markets are discussed in the following subsections.

Network Externalities

Network effects occur when an increase in the number of EHR adopters using a product raises the quality of the product for all users in the sharing network. (In other words, benefits rise for all users as the number of users increases.) Telephone and fax technology offer good examples: benefits in the overall sharing network grow with expansion of adopters. Markets fail as long as there are potential adopters who wait for others, because those holdouts are not taking into account benefits that accrue to all others in healthcare markets.

EHR technology appears to fit this profile when individuals determine whether to adopt on the basis of their individual cost and benefit calculations. Fully interoperable HIE networks will not occur as long as network externalities cause potential adopters to delay adoption as they wait for others to adopt first. Businesses that simply focus on how their own costs will change or how treatment will change for only their patients (or both) would fit this profile. Underinvestment in EHR—a symptom of market failure—is predictable as long as individuals narrowly focus on their own situation and ignore benefits to others. Having fewer adopters leads to less-than-fully interoperable HIE systems that fail to capture benefits that would occur with more adopters.

But blanket use of the network externalities argument for market failure is not entirely convincing because there is solid evidence that HIE networks currently lack interoperability. An emerging body of research literature indicates how poorly integrated healthcare providers are in sharing information with one another. The network externalities argument applies to the cases in which fully interoperable systems are available for all potential users. However, this "perfect" scenario does not exist today.

Furukawa et al. (2013) analyzed EHR activity of 2,805 hospitals in 2008 and 2,836 hospitals in 2012. They find that exchanges of clinical information (for example, problem list,

medication list, medication allergies, and diagnostic test results) with outside providers increased significantly between 2008 and 2012, but a majority of hospitals still did not electronically exchange clinical care summaries and medication lists. In other words, the state of electronic exchange of patient information with other providers (for example, specialists' offices, labs, or an emergency room) indicated that the actual sharing of patients' vital medical history remains more of a promise than a reality.

Another study concludes that over 2007–2009, larger hospital systems were more likely than smaller hospitals to exchange electronic patient information internally, but they were less likely to exchange patient information externally with other hospitals (Miller and Tucker 2014). The authors suggest that this finding is evidence that vendors use "marquee" large users to kick-start a platform technology and that those users then create information silos because they are reluctant to exchange information with other users. Researchers also have found that vendors appear to make it easier for hospitals and other providers that use their products to share data with each other than to share data with other vendors' competing systems (Vest, Campion, and Kaushal 2013).

A *New York Times* article documents several examples of systems that lack interoperability (Pear 2015). A physician in Tennessee, for instance, noted that his clinic uses electronic records that can't communicate with a hospital across the street because that second hospital uses a separate system from a different vendor. When admitting patients to the hospital, the Tennessee physician must print out his notes and send a copy to the hospital; only then will those notes be incorporated into the hospital's electronic records. Another physician, in Massachusetts, has been unsuccessful for five years in connecting his electronic records to those of a hospital to which he often sends patients.

Another article states that Epic Systems is a multibillion-dollar company with 2014 revenues of $1.8 billion whose software reportedly manages medical records for 179 million Americans (Caldwell 2015). The author argues that Epic Systems has created a fragmented system that leaves doctors unable to trade information across practices or hospitals because it has not built a nationwide system that allows seamless connectivity to competing vendors. Many vendors reportedly charge for gaining access to information outside of their software.

Madden et al. (2016) find that one major EHR system was missing roughly half of the clinical information for its patients in 2009. This study compared information available in an EHR system for a large medical practice in Massachusetts with more complete data from insurance claims for depression and bipolar disorders for all insurance plan members ages 12 and over. These mood disorders affect roughly 10 percent of the adult population. The study's authors hypothesized that fragmentation might be especially common in mental health care, because patients may protect their privacy by seeking behavioral care at a separate location from their somatic care. The authors suggest that primary care physicians then not only run the risk of medication errors, but also miss opportunities to encourage adherence to mental health visits and medications. Patients with depression and bipolar disorder, respectively, averaged 8.4 and 14.0 days of outpatient behavioral care per year; 60 percent and 54 percent of these cases, respectively, were missing from the EHR system because they took place in another location. Total outpatient care days were 20.5 for those with depression and 25.0 for those with bipolar disorder, with 45 percent and 46 percent of cases missing, respectively, from the EHR system. The EHR system also missed 89 percent of acute psychiatric services.

Everson and Adler-Milstein (2016) examined national survey data to assess how market dominance by EHR vendors was related to hospitals' data sharing in 2012 and 2013. Across all

levels of vendor dominance, hospitals using EHR systems supplied by the dominant vendor engaged in an average of 45 percent more sharing than did hospitals not using the dominant vendor. However, when the dominant vendor controlled only 20 percent of the market, hospitals using the dominant vendor engaged in 59 percent more sharing activities than hospitals using a different vendor. Conversely, when the dominant vendor controlled 80 percent of the market, hospitals using that vendor engaged in only 25 percent more sharing activities than hospitals using a different vendor. Dominant vendors in less competitive markets thus appear to have little interest in facilitating data exchange with hospitals that use competitors' EHR systems because those dominant vendors want to encourage hospitals to switch to their systems.

In sum, today's technology lacks interoperability. Thus, current adoption rates cannot be deemed symptoms of underinvestment as long as businesses that fail to adopt are reacting to concerns that EHR investments today do not guarantee interoperable systems today or tomorrow. The following subsection discusses other examples of cases in which delaying EHR purchases is not clear evidence of market failure.

Free-Rider Problems

A public good is both nonexcludable and nonrivalrous, meaning that individuals cannot be easily excluded from its benefits and that use by one more individual does not reduce availability to others. For example, a business that invests in research may find that it is difficult to exclude other firms from gaining knowledge that stems from its research. One firm conducting research must absorb all costs, but when other firms "free ride" on benefits without incurring costs, such research may exhibit characteristics of public goods. Thus, it becomes less likely that any single firm would find such research profitable. Markets are likely to underinvest

in beneficial research—a symptom of market failure—when such research exhibits characteristics of public goods.

Again, it is important to discuss interoperability. Underinvestment in interoperable systems is likely as long as it remains difficult to exclude nonfunders from the benefits of research in interoperability. Predictably, research is tilted toward non-interoperable systems because of this difficulty in excluding free riders from benefiting from investments in interoperable systems. This logic predicts that EHR vendors are reluctant to fund research on interoperable systems, or that they have incentives to discourage sharing of data with other vendors.

Another free-rider problem can occur for health insurers when healthcare providers and hospitals contract to be in multiple insurance networks. Misalignment occurs when insurers who first subsidize EHR costs would in effect be granting benefits from their EHR investments to other insurers that have delayed investing. Single insurers are unlikely to have sufficient incentives to invest in EHRs for an entire provider or organization when a significant portion of the cost savings, or better patient care, is enjoyed by other "free-riding" payers. Again, market failure—underinvestment in this case—is predictable in environments where it is difficult or impossible to exclude free riders.

Another free-rider problem arises because commercial health insurance is often tied to employment. Misalignment occurs when insurers who invest in EHR technology improve the health of their subscribers but do not fully capture those benefits when workers change jobs and become insured by other firms. Worker mobility thus lessens incentives for insurance firms to invest in EHR systems because benefits may partly spill over to other insurance companies. This case is one reason that the federal government tied financial incentives to Medicare programs.

Medicare does not generally compete with commercial insurers and mainly covers citizens past age 65; thus, worker turnover is not a major issue.

In sum, research on interoperable systems is likely to be underfunded because of problems excluding free riders. Government policies that promote EHR systems should focus only on research into interoperable systems that allow the seamless sharing of health information with all other health providers.

Imperfect Information

Incomplete information—the lack of complete information—is another potential source of market failure. Incomplete information on the benefits and costs of goods and services hampers the ability of markets to allocate resources efficiently. However, it is important to understand that a market failure will arise only when there is information that is known to some, such as government policymakers, but that remains unknown or not effectively communicated to market participants.

Imperfect information clearly fits into the case of EHRs because the technology for these records is not mature. The early assertion that widespread adoption of EHRs would lower costs and raise the quality of health care was mostly backed by conjecture regarding the potential benefits of computerization, or by generalizing from small studies at a few institutions (McCormick et al. 2012). It is not surprising that the assertion was based on slim evidence, given that in 2006, only 11 percent of office-based physicians used basic EHR systems (Hsiao, Hing, and Ashman 2014). Out of necessity, early arguments were guided by theory rather than by evidence.

Indeed, in 2008, the Congressional Budget Office clearly described the lack of knowledge about the potential benefits of health information technology:

> No aspect of health IT entails as much uncertainty as the magnitude of its potential benefits. Some analysts believe that the adoption of such systems could provide substantial savings by lowering the cost of providing health care, eliminating unnecessary health care services (such as duplicate diagnostic tests), and improving the quality of care in ways that might reduce costs (by diminishing the likelihood of adverse drug events, for example). Other analysts expect little effect on costs but some improvement in the quality of care. Another school of thought holds that health IT could bolster the quality of care but also increase expenditures on health care services—because improvements in quality would stimulate demand for additional services. (CBO 2008, 6–7)

It is thus difficult to argue that EHR systems are a classic case of market failure—simply because the benefits and costs of such systems remain more speculative than known. That is, the situation facing potential adopters is not one in which all benefits and costs associated with EHR purchasing are well understood. Moreover, previous discussion also indicates that lack of interoperability makes purchases more of a gamble than a sure thing. So, the market failure argument does not really apply in a world where evidence is more theoretical than empirical regarding benefits and costs of EHRs.

The real-options theory of the value of investment indicates that waiting to adopt EHR systems when investments are irreversible can be a wise decision amid substantial uncertainty over future market conditions (Dixit and Pindyck 1994). Investing in the early stages of EHR innovation is clearly characterized by significant uncertainty over returns given imperfect information on the costs and benefits of EHR adoption. EHR technology also may be initially disruptive, may pose harm to patients, is not interoperable, and is subject to rapidly changing standards.

Waiting on the sidelines may be a much more efficient option for those considering investing in EHR systems. Christensen and Remler (2009) argue that the uncertain nature of risks is especially true for small practices because EHR adoption costs for those practices are probably larger than those for large practices. Hsiao, Hing, and Ashman (2014), for example,

report that in 2012, the difference in adoption of comprehensive EHR systems in practices with 11 or more physicians compared with solo practitioners was a gap of 30.6 percentage points.

Implementation costs also remain much of a mystery because so few studies examine the costs of purchasing and maintaining EHR systems. In a study of 14 small physician practices, Miller et al. (2005) estimate implementation costs of $43,826 per healthcare provider and ongoing annual costs of $8,412 per provider. Another study (Fleming et al. 2011)—this one on a network of 26 primary care practices with more than 450 physicians in Texas—estimates that direct and indirect costs averaged $32,409 per physician through the first two months and another $14,250 per physician for maintenance through the first year after implementation. That same study estimates that for an average five-physician practice, it would cost $162,000 and require 611 hours of work to implement the system. It is safe to say that these case studies exhibited little to no interoperability with large-scale systems. It is also safe to say that these studies offer little relevance to the issue of what interoperable systems would cost average users now or in the future.

A recent study also reports that health records are not entirely safe, thus raising an additional layer of complexity to the uncertainty surrounding EHR adoptions. Medical identity theft occurs when someone uses an individual's name and personal identity to fraudulently receive medical services, prescription drugs, or goods, or attempts to commit fraudulent billing. Research estimates that of the 2.32 million Americans who have been victims of medical identity theft, almost 500,000 cases were in 2014 alone (Ponemon Institute 2015). It is unclear how medical identity theft will change because of EHRs, as there appear to be no studies addressing this issue. Again, waiting on the sidelines before fully committing to EHR purchases may be an efficient choice for those concerned with the many uncertainties surrounding costs and benefits of EHR systems.

In sum, the evidence indicates that the case for market failure because of lack of information is itself lacking. Information, in fact, is quite clear that EHR adoptions can be risky moves for some market participants. The case for universal adoption in the near future would itself appear to be a risky move for the health sector.

Empirical Literature Assessment

Federal subsidies to stimulate EHR adoption were legislated on the basis of predictions that the technology will eventually improve patient care, but at lower costs. As stated earlier, it is clear that these predictions were based on assumptions that systems would become interoperable. However, as discussed, systems lack interoperability. It should therefore not be surprising that the empirical literature has so far not supported predicted improvements in patient care and lower costs.

The empirical literature suffers from numerous problems that all indicate ongoing uncertainty over the benefits and costs of EHR systems. One major problem is that studies—especially those undertaken before federal subsidies—were conducted when EHR usage was rare and opportunities for data sharing were, at best, modest.

Table 1 illustrates the incomplete nature of the EHR market.

Table 1. Percentage of Office-Based Physicians with an Electronic Health Record System, 2004–2014

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Any EHR (%)	20.8	23.9	29.2	34.8	42.0	48.3	51.0	57.0	71.8	78.4	82.8
Basic EHR (%)	–	–	10.5	11.8	16.9	21.8	27.9	33.9	39.6	48.1	50.5

Note: EHR = electronic health record.

Source: Office of the National Coordinator for Health Information Technology, "Office-based Physician Electronic Health Record Adoption: 2004–2014," Health IT Quick-Stat #50, 2015, https://dashboard.healthit.gov/quickstats/pages/physician-ehr-adoption-trends.php.

As of 2014, a majority of office-based physicians had adopted EHRs. Of those physicians, 83 percent had adopted "any EHR" and 51 percent had adopted a "basic EHR." Physicians with a "basic" EHR were those who reported that their practice performs all of the following computerized functions: patient demographics, patient problem lists, electronic lists of medications taken by patients, clinician notes, orders for medications, viewing laboratory results, and viewing imaging results (Charles, Gabriel, and Searcy 2015). Physicians with "any EHR" system were those who reported that their health record system is either all or partially electronic and that it excludes systems solely for billing. Since 2008, office-based physician adoption of any EHRs has nearly doubled, from 42 percent to 83 percent, while adoption of basic EHRs has nearly tripled, from 17 percent to 51 percent. (Note that these statistics do not indicate the degree to which systems are interoperable within HIEs. The importance of this last point is fully discussed later in this paper.)

In 2014, 76 percent of hospitals had adopted at least a basic EHR system—an eightfold increase since 2008 (Charles, Gabriel, and Searcy 2015). Nearly all reported hospitals (97 percent) possessed a certified EHR technology in 2014. A certified EHR system is one that meets the technological capability, functionality, and security requirements adopted by the US Department of Health and Human Services (Charles, Gabriel, and Searcy 2015). This includes the capability to work securely with other certified EHR systems to share information (interoperability). (Note that *capability* does not necessarily mean that users are sharing information with other healthcare providers.)

Another related problem is that studies have mostly examined EHR systems that were unique to the organization being studied and thus had limited ability to share data with other providers. The specifics learned from those studies had very limited application to other users

and little to no application to the broader issue of what a truly interoperable system would yield for costs and quality of patient care across the United States.

Early studies, by necessity, were based on simulations rather than on empirical evidence. One study simulated costs and benefits of primary care physicians in one ambulatory-care setting through heavy use of "expert panel consensus" to estimate how EHRs would lower costs of chart pulls, transcription, drug and ancillary service use, and billing (Wang et al. 2003). Estimated net benefit over a five-year period was $86,400 per provider, with benefits calculated primarily from assumed savings in drug expenditures, improved use of radiology tests, better charge capture, and fewer billing errors. Annual savings of $77.8 billion are predicted in another study that also heavily relied on expert estimates to simulate performance (Walker et al. 2005). Another study predicts at least $81 billion in annual savings from nationwide EHR adoption (Hillestad et al. 2005), although a follow-up to the study deems the empirical data to be disappointing (Kellermann and Jones 2013). Nonetheless, the authors argue that the original promises of EHR technology will be met once it overcame problems with ease of use, interoperability, and reengineering of processes.

The literature also focuses on adult hospitals and emergency departments, with little knowledge uncovered about more diverse settings such as primary care, public health, pediatric inpatient, and long-term care settings (Rahurkar, Vest, and Menachemi 2015). Past studies are also lacking in the area of patient populations with chronic diseases such as diabetes, asthma, cancer, and congestive heart disease, and those with mental health conditions (Rahurkar, Vest, and Menachemi 2015).

Few studies have explored whether MU of EHRs yields a different effect on healthcare utilization compared with typical use of EHRs. Kern, Edwards, and Kaushal (2016) examine

this issue in a cohort study of 213 primary care physicians in New York State (2010–2011) and 127,353 patients. Fifty percent of physicians had achieved MU, as defined by the federal government. A total of seven outcomes (primary care visits, specialist visits, laboratory tests, radiology tests, emergency department visits, admissions, and readmissions) and 11 potential confounders were considered. The authors find 17 fewer primary care visits and 61 fewer laboratory tests for every 100 patients whose physicians achieved MU, compared with patients whose physicians did not achieve MU. There were no differences for other outcomes. This study thus calls into question the results of the many studies that fail to take the level of EHR usage into account. Again, EHR usage does not clearly convey whether data are being shared with other providers, nor the ability of the systems to improve patient care or lower healthcare costs.

Finally, most studies are not randomized controlled trials (RCTs)—the gold standard of research—or double-blind studies in which neither subjects nor researchers know whether a test intervention is the "real" intervention or simply a placebo (Rahurkar, Vest, and Menachemi 2015). There is a general consensus that research questions are best addressed by RCTs because this method is best at reducing spurious causality and bias. Randomization minimizes selection bias. Also, results are more reliable when a study looks at different comparison groups to better determine treatment effects when compared with the control groups that receive no treatment, while holding other variables constant. Of course, RCT studies require that all participants operate under similar settings for all non-EHR factors and are thus difficult to establish. Blind studies also require all participants to be unaware that their involvement with EHRs is being examined—another difficulty when EHR investments are costly and when the examination of pre- and post-EHR periods covers many months or years.

Meta-analysis studies that combine the results of multiple scientific studies offer the best evidence to date. The basic idea is to uncover a common signal stemming from similar studies, but whose results have been measured with errors within each study. In effect, meta-analysis produces a weighted average of results from similar studies and requires researchers to identify a statistical measure common to these studies so that a weighted average can be calculated. Weighting usually considers sample sizes of the included studies, but study quality and other factors can also be considered. Meta-analysis is not without problems, but combining similar studies is believed to yield statistical power greater than that derived by examining studies in isolation (Deeks, Altman, and Bradburn 2008).

Thompson et al. (2015) conduct a systematic review of the literature on whether EHRs influence mortality, length of stay, and cost in hospitals. Of the 2,803 studies screened, 45 met selection criteria (1.6 percent), and the authors extracted data on the year, design, intervention type, system used, comparator, sample sizes, and effect on outcomes. No substantial effects on mortality, length of stay, or cost were determined. The authors note that the pool of studies examined was small because of the heterogeneity of study populations, interventions, and endpoints, and that the size of the pool may have influenced their findings. For example, they could not quantitatively evaluate costs. Better evidence is needed to identify the most meaningful ways to implement and use health information technology before a statement of the effect of these systems on patient outcomes can be made.

Rahurkar, Vest, and Menachemi (2015) examine 27 scientific studies and conclude that the current state of the literature does not provide sufficient rigorous evidence for benefits from HIE. The authors extracted selected characteristics from each study and then meta-analyzed these characteristics for trends that indicate whether HIE has affected cost, service use, and

quality. While 57 percent of these studies reported some benefit from HIE, those employing strong study designs (e.g., RCTs or quasi-experiments) were significantly less likely to report benefits. Among six articles with strong study designs, one study reported paradoxical negative effects, three found no effect, and two reported that HIE led to benefits. The authors conclude that little generalizable evidence exists regarding benefits attributable to HIE.

In sum, the empirical literature suffers from many problems. It remains clear, however, that uncertainty pervades the evidence on what effects EHRs can be expected to exert on patient care and healthcare costs. That the market response to EHRs has been less enthusiastic than what the systems' early proponents had speculated comes as no surprise when so little evidence of their benefits exists.

EHR Subsidy Program Failures

Program Rushed to Policy

Policymakers were apparently in a hurry. Edmunds, Peddicord, and Frisse (2013) argue that the then-new Obama administration coupled a financial stimulus effort with a highly prescriptive agenda emphasizing EHR adoption as part of the administration's response to a major economic recession. The authors view the program as an "arranged marriage" between a Keynesian stimulus effort and a massive introduction of technology. They assert that this "marriage" significantly underestimated the degree of cultural and organizational change that would be required. This perspective suggests that the EHR adoption goals were overwhelmed by the requirement to quickly disperse funds as a fiscal stimulus.

Spurring technological innovation in a healthcare market that accounted for 17.8 percent of GDP in 2015 is undeniably ambitious (CMS 2016a). Consider, as well, some numbers representing different participants in this redesign of our healthcare market:

- 83.2 percent of adults (92.4 percent of children), who had contact with a healthcare professional in 2013 (CDC 2016)
- 929 million physician office visits in 2014 (CDC 2016)
- 126 million hospital outpatient visits in 2014 (CDC 2016)
- 5,627 hospitals in the United States, with 34,878,887 total admissions in 2014 (American Hospital Association 2016)
- Numbers of physicians and surgeons (708,300), medical assistants (591,300), pharmacists (297,100), physical therapists (210,900), dentists (151,500), dental hygienists (200,500), optometrists (40,600), and chiropractors (45,200) in 2014 (Bureau of Labor Statistics 2015)

These numbers represent a subset of the many interactions involved in a nationwide rollout of EHRs. Recall that in 2009, Obama pledged that the immediate investments in subsidies would result in all medical records being computerized within five years and, as a result, this would improve healthcare quality and lower its costs (Obama 2009). Previous discussion indicates that none of the pledges appear to have been realized.

A kind interpretation is that the Obama administration was too optimistic about meeting its various promises by 2015. But, as discussed previously, the theory that government subsidies were needed to overturn market failure is not entirely sound. Moreover, previous discussion also indicates that the case that federal subsidies would improve patient care and lower costs was much more speculative than based on real-world application. And when studies began analyzing

real-world experience with EHRs, it became apparent that the rapidly growing empirical literature suffers from many problems. The only general conclusion one can draw is that uncertainty pervades the evidence on what effects EHRs can be expected to exert on patient care and healthcare costs.

Another perspective is that proponents of the subsidy program continue to base their views on various myths and fallacies surrounding HIT. Karsh et al. (2010) argue that designers and policymakers often rely on fallacies when they hypothesize about the many benefits of EHR adoption. One is the "risk-free" fallacy, which ignores the point that new technology often comes with unexpected adverse consequences that designers and policymakers did not consider.

The "use equals success" fallacy occurs when usage is viewed as an endorsement of technology. An example is when adoption rates of EHR technology are equated with levels of benefits. For example, if a physician's office has adopted an EHR system fully capable of sharing data, that does not necessarily mean that the office uses most of the system's features or that it uses the system to share data with other healthcare providers. This fallacy appears consistent with President Obama's goal that all medical records would be electronic by 2015. Rather, this deadline strongly suggests that adoption speed alone was more important than nationwide adoption of well-thought-out EHR systems capable of interoperability that were also shared with all other health providers. Again, EHR adoption rates do not clearly indicate progress toward interoperability; nor do the rates show definitively whether cost reductions and improvements to public health have occurred or will follow.

Finally, the "father knows best" fallacy arises because most EHR systems are designed to meet the needs of people who do not have to enter, interact with, or manage data: administrators, payers, regulators, and the government. It is the physicians, nurses, staff members, and patients

who have to bear most of the costs of poorly designed technology. This mismatch between winners and losers is an example of Grudin's Law, one form of which is "When those who benefit from a technology are not those who do the work, then the technology is likely to fail or be subverted." Again, EHR adoption rates do not clearly signal the benefits associated with that adoption.

In sum, the rush to policy, the sheer size of the health sector, and the persistence of various myths surrounding HIT partly explain why the subsidy program has so far failed to meet its promises. The rest of this section discusses other reasons that the subsidy program will continue to push resources in nonproductive directions.

Subsidies Locking In Immature and Incentivized Technology

EHRs are more a work in progress than a mature technology. Risks are abundant when pursuing immature technology, and they include costs of not waiting for better technology and instead "locking in" the immature standards of today. Christensen and Remler (2009) argue that the value of delaying EHR investments is considerable because the costs of adopting the wrong type of technology are substantial. The authors also argue that errors inadvertently introduced by immature technology are more devastating, more salient, more attention-getting, and more prone to engender strong emotions in the healthcare industry than in other industries (e.g., banking and insurance). The costs of switching to a different system are also especially large in health care because of the large numbers of many actors—patients, providers, insurers, and government entities.

Aggressive promotion by government may also inadvertently exacerbate existing problems with EHR systems by encouraging the purchase of today's hard-to-use systems that will be costly to replace at a later date. If market forces were allowed to work, providers might

drive vendors to produce more usable products than the current systems that have been rushed to market because of time-limited subsidies. Current technology, for example, requires users to read thick manuals, attend tedious classes, and pay for periodic tutoring so that they can "master" the steps required to enter and retrieve data (Kellerman and Jones 2013). Pushing immature technology is not a wise move when that technology becomes locked in as a result of government subsidies.

Subsidy payments also push technology toward incentivized activities and away from nonincentivized activities. One study examined 143 medical practices that implemented EHRs over 2009–2011, when 71 practices were randomized to receive financial incentives and quality feedback and 72 were randomized to receive feedback alone (Ryan et al. 2014). The authors estimated the associations between exposure to clinical decision support, financial incentives, and quality of care. They also estimated associations for four cardiovascular quality measures that were rewarded by the financial incentive program and four quality measures that were not rewarded by incentives. Incentives were consistently associated with higher performance for incentivized measures and lower performance for nonincentivized measures. The authors suggest that this result is consistent with the "teaching to the test" theory of financial incentive programs. That is, they say that the incentive system may have the unintended consequence of encouraging practitioners to pay less attention to nonincentivized measures that also improve public health. For instance, an incentivized measure such as mandating that a specific percentage of prescriptions be generated through EHR systems may lead to the exclusion of more important, but nonincentivized, measures, such as reducing the incidence of inappropriate prescribing (Karsh et al. 2010). The authors conclude that government incentives likely caused recipients to adapt their practices to suboptimal systems.

Research also indicates that government subsidies merely accelerated EHR adoptions that were likely to have occurred without financial subsidies. A recent National Bureau of Economic Research study finds that subsidies caused one in five nonadopters to adopt EHR technology by 2011 (Dranove et al. 2014). But, the authors conclude that subsidies simply accelerated an ongoing trend, and therefore the rate of adoption realized by 2011 would have been achieved by 2013 without subsidies. Subsidies thus pushed the adoption rates up by at most two years. It is important to remember that EHR technology remains immature. The authors question the incentive program because briefly accelerating adoption is not clearly desirable when waiting for better technology is more prudent, especially given risks that subsidies promote immature and incentivized technology.

In sum, the urge to lock in current technology would appear to be overwhelming given Obama's pledge in 2009 that all medical records would be computerized by 2015 (Obama 2009). Given the lack of interoperability and the fact that subsidies have not clearly improved patient care or lowered costs, one can conclude that subsidies have locked in immature technologies rather than spurred innovation that would take more years to mature through trial-and-error experience.

Subsidies Promoting Adoption of Poor EHR Products

A market test of whether EHR products are ready for the broad marketplace is whether customers are satisfied with those products. A recent study conducted for the American Medical Association concluded that, for every hour physicians provide direct clinical face time to patients, nearly two additional hours is spent on EHR and desk work within the clinic day (Sinsky et al. 2016). Outside office hours, physicians spend another one to two hours of personal

time each night doing additional computer work and other clerical work. This study examined allocation of physician time in ambulatory care in four specialties in four states (Illinois, New Hampshire, Virginia, and Washington) in 2015. Fifty-seven physicians in family medicine, internal medicine, cardiology, and orthopedics were directly observed (time and motion) for 430 hours during office hours; 21 of those physicians also completed after-hours diaries. Measurements were made for proportions of time spent on four activities (direct clinical face time, EHR and desk work, administrative tasks, and other tasks) and self-reported after-hours work. During the office day, physicians spent 27.0 percent of their total time on direct clinical face time with patients and 49.2 percent of their time on EHR and desk work. While physicians were in the examination room with patients, they spent 52.9 percent of the time on direct clinical face time and 37.0 percent on EHR and desk work. The 21 physicians who completed after-hours diaries reported one to two hours of after-hours work each night, devoted mostly to EHR tasks.

Recent surveys indicate that many healthcare providers are unhappy with current products. A study conducted for the American Medical Association gathered data in 2013 from 30 physician practices in six states (Colorado, Massachusetts, North Carolina, Texas, Washington, and Wisconsin) (Friedberg et al. 2013). Physicians generally approved of EHRs in concept, but many physicians believed the current state of EHR technology significantly worsened professional satisfaction in multiple ways. Prominent sources of dissatisfaction include poor usability, time-consuming data entry, interference with face-to-face patient care, inefficient and less fulfilling work content, inability to exchange health information between EHR products, and degradation of clinical documentation.

Satisfaction also appears to be falling. Another survey conducted for the American Medical Association collected data on 940 healthcare providers (physicians, nurse practitioners,

and physician assistants) in 2014 and found that only 34 percent were "satisfied" or "very satisfied" with their EHR system, compared with 61 percent in 2010 (AmericanEHR Partners and American Medical Association 2015). This survey also found that 42 percent thought their system's ability to improve efficiency was difficult or very difficult; 72 percent thought their system's ability to decrease workload was difficult or very difficult; and 54 percent reported that their system increased their total operating costs.

Wylie, Baier, and Gardner (2014) conducted a cross-sectional study that examined Rhode Island physicians over 2009–2013. The study examined which characteristics of physicians are associated with positive experience with EHRs. Most providers believed that EHRs improved billing but had not improved job satisfaction. Physicians with longer and more sophisticated EHR use reported positive effects of introduction on all aspects of practice examined. Older physicians were more likely to have more negative opinions. However, longer and more sophisticated use was associated with more positive opinions. That result suggests that acceptance may grow over time.

Weeks et al. (2015) examined the experiences of a random sample of healthcare professionals (eligible professionals, or EPs) in Washington State and Idaho in 2013. The authors hypothesized that EPs actively participating in the MU program would generally view the purported benefits of MU more positively than EPs not yet participating in the incentive program. The sample included EPs who had registered for incentive payments (MU-Active) and EPs not yet participating in the incentive program (MU-Inactive). MU-Active providers were more positive about the program than MU-Inactive providers were, but the majority of respondents in both groups said that MU would not reduce care disparities or improve the accuracy of patient information. Respondents viewed additional workload on EPs and their staff

as too great a burden on productivity relative to the level of reimbursement for achieving MU goals, and they said the MU program diverted attention from treating patients by imposing greater reporting requirements.

Hanauer et al. (2016) conducted a two-year prospective, longitudinal survey of ambulatory care providers in three clinical areas (family practice medicine, general pediatrics, and internal medicine) at the University of Michigan Health System. The study examined an EHR implementation that occurred within a longstanding, mature HIT environment established in 1998. The authors examined whether perceptions regarding EHR systems follow a J-curve, whereby measures drop at first but are followed by above-baseline readings. Data were collected 1 month before and 3, 6, 13, and 25 months after implementation on August 2012. All physicians received training before implementation of the new system. Researchers did not find a J-curve for any measure, including workflow, safety, communication, and satisfaction. Most measures dropped and remained below baseline (an L-curve). The only measure that remained above baseline was documenting in the exam room with the patient. The authors conclude that future research is warranted to determine whether positive perceptions eventually surpass baseline.

Subsidies Conditional on "Non-meaningful" Use

Recall that subsidy recipients were required to successfully demonstrate MU for each year of participation in the program. Beginning in 2015, recipients who failed to successfully demonstrate MU became subject to payment reductions that started at 1 percent and increased each year to a maximum of 5 percent. MU criteria were rolled out in three stages: stage 1 (2011–2012), stage 2 (2014), and stage 3 (2018).

Writing in *Health Affairs Blog*, Peter Basch and Thomson Kuhn argue that a new MU program should focus on specialty-specific measures of quality and should be based in normal clinical work patterns, rather than rewarding clinicians for meeting artificial "one size fits none" threshold requirements for specific functional uses of EHRs (Basch and Kuhn 2016). The MU program, for example, was based on activities that were measurable (such as use of EHRs) and assumed that value was identical for all specialties and in all settings of care. Such measures were then developed via a political process and largely supported only by belief, self-referential logic, or both. The authors' view is consistent with previous discussion in this paper that the case for EHRs was based more on speculation than on hard evidence. Thus, it makes sense that MU requirements would follow suit by also being based on speculation rather than on evidence. This view is also consistent with the "use equals success" fallacy that the mere meeting of various "check-offs" is proof that EHRs themselves are interoperable and that their adoption is improving patient care and reducing healthcare costs.

Basch and Kuhn also argue that, with strictly defined EHR-functional-use measures, even highly functional EHRs had to be re-engineered. And those that couldn't be easily re-engineered had MU EHR-functional-use measure checkboxes added, in some cases appearing as a parallel and duplicative process in a left or right column of the EHR. Examples of checkboxes include "Did you counsel the patient to stop smoking?" and "Did you refer the diabetic patient for an eye exam?" Both usability and satisfaction with EHRs began to quickly suffer. Further, even when clinicians performed an activity that satisfied the true objective of an EHR-functional-use measure (such as providing patients with appropriate and specific educational resources), the activity did not count unless it met each and every specific step. This approach prompted clinicians to develop workarounds to satisfy thresholds, thus leading Basch and Kuhn to

conclude that time wasted on deriving and using such gimmicks led to angry clinicians and at times disengaged ones.

In sum, MU requirements are examples of regulators' following the "use equals success" fallacy that allows them to tally up the success of their policy by simply counting how many adopters have passed the bureaucratic mandates. Unfortunately, MU standards failed to result in truly interoperable systems or in systems that physicians generally found useful in their ongoing roles in helping patients.

Conclusions

The government case for subsidies rested on assumptions that the marketplace would evolve too slowly toward an efficient outcome because of various market failures. The market response to EHRs has been less than enthusiastic because early adoption of emerging technology is usually more of a gamble than a sure thing. The empirical literature survey clearly indicates that uncertainty pervades what effects EHR adoptions have had on patient care and healthcare costs. Adopters, however, were enticed by subsidies and also likely by belief in the many promises that EHRs would quickly improve patient care. More than 478,000 healthcare providers received subsidies (CMS 2015b). The government has funded $35.2 billion in incentives (CMS 2016b).

The EHR subsidy program is a prime example of how ill-suited government is in attempting to steer technology. Government did not mandate every characteristic of EHR systems, but the MU regulations did not promote actual data sharing. MU requirements are textbook examples of how government regulation is rarely dynamic, flexible, or proactive and is thus ill suited to pushing EHR innovation toward interoperable and useful systems. Time-sensitive subsidies enticed many healthcare providers to purchase poorly functional systems that

will either have to undergo substantial and costly modification or simply be scrapped. Federal officials have only recently admitted that their attempts to steer universal data exchange necessitate redirection, though it remains unclear what system will replace the original program (*CMS Blog* 2016). Meanwhile, the program has wasted resources, locking in immature technologies by enticing adopters into the government subsidy program. It is thus not surprising that promised gains in patient care and reduced costs have yet to appear.

The best that government can do may be to establish a standard, similar to our convention of driving cars on the right side of the road or our system of weights and measures. In this case, a standard simply could be mandating which data must be collected, with the added requirement that all data files must be available for sharing with all health providers at low or zero cost. Of course, the government could err by asking for too much data, or by not requiring the right data. But the point is that setting standards on data collection with interoperability mandates makes sense, provided that the timeline allows the best system to emerge from the market. Government is no match for the ability and incentives of market participants in steering innovation in medical care technology. It is also foolish to mandate deadlines for the arrival of mature technologies. The prudent role for government is patience with an evolving technology that promises to improve the efficiency of our healthcare system. This insight explains why government's attempt at steering interoperability and data sharing was ill fated from the beginning and should be considered a failure.

Government can also contribute to funding research that can guide interoperable EHR innovation and true data sharing. As discussed, most research fails to overcome problems that make it hard to decipher what effects EHR adoptions have actually had on patient care and costs. The same goes for research into how to best make interoperability and data sharing realities. It is

not surprising that MU mandates failed to promote interoperability and data sharing, because lack of research and experience forced government to rely on speculation rather than on hard evidence for their mandates. Future research should increase the use of study designs capable of reducing selection bias and confounding and should include settings, populations, and outcome measures for which little research currently exists (Rahurkar, Vest, and Menachemi 2015). Likewise, government agencies and exchange organizations should support the use of stronger evaluation designs by allocating more resources to data access and cooperation. Markets then will be better able to innovate systems that offer a fighting chance of improving public health and lowering healthcare costs.

References

AmericanEHR Partners and American Medical Association. 2015. *Physicians Use of EHR Systems 2014*. Naples, FL: American EHR Partners. http://www.americanehr.com /research/reports/Physicians-Use-of-EHR-Systems-2014.aspx.

American Hospital Association. 2016. "Fast Facts on US Hospitals." Last modified January. http://www.aha.org/research/rc/stat-studies/fast-facts.shtml.

Basch, Peter, and Thomson Kuhn. 2016. "It's Time to Fix Meaningful Use." *Health Affairs Blog*, January 14. http://healthaffairs.org/blog/2016/01/14/its-time-to-fix-meaningful-use/.

Birkhead, Guthrie S., Michael Klompas, and Nirav R. Shah. 2015. "Uses of Electronic Health Records for Public Health Surveillance to Advance Public Health." *Annual Review of Public Health* 36: 345–59.

Bureau of Labor Statistics. 2015. *Occupational Outlook Handbook*. Washington, DC. http://www.bls.gov/ooh/.

Caldwell, Patrick. 2015. "We've Spent Billions to Fix Our Medical Records, and They're Still a Mess: Here's Why." Mother Jones. October 21. http://www.motherjones.com/politics /2015/10/epic-systems-judith-faulkner-hitech-ehr-interoperability.

CBO (Congressional Budget Office). 2008. *Evidence on the Costs and Benefits of Health Information Technology.* Publication no. 2976. Washington, DC. https://www.cbo .gov/publication/41690.

CDC (Centers for Disease Control and Prevention). 2016. "Ambulatory Care Use and Physician Office Visits." Last modified June 13. http://www.cdc.gov/nchs/fastats/physician -visits.htm.

Charles, Dustin, Meghan Gabriel, and Talisha Searcy. 2015. *Adoption of Electronic Health Record Systems among U.S. Non-Federal Acute Care Hospitals: 2008–2014.* ONC Data Brief, No. 23. Washington, DC: Office of the National Coordinator for Health Information Technology. https://www.healthit.gov/sites/default/files/data-brief/2014 HospitalAdoptionDataBrief.pdf.

Christensen, Michael C., and Dahlia Remler. 2009. "Information and Communications Technology in U.S. Health Care: Why Is Adoption Slow and Is Slower Better?" *Journal of Health Politics, Policy and Law* 34 (6): 1011–34.

CMS (Centers for Medicare and Medicaid Services). 2015a. "Medicare and Medicaid EHR Incentive Program Basics." Accessed November 11. https://www.cms.gov/regulations -and-guidance/legislation/ehrincentiveprograms/basics.html.

———. 2015b. "Data and Program Reports." Accessed November 13. https://www.cms.gov /Regulations-and-guidance/legislation/EHRIncentivePrograms/DataAndReports.html.

———. 2016a. “NHE Fact Sheet.” Last modified December 2. https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NHE-Fact-Sheet.html.

———. 2016b. “*Electronic Health Records (EHR) Incentive Program*.” https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/Downloads/July2016_SummaryReport.pdf.

CMS Blog. 2016. “Comments of CMS Acting Administrator Andy Slavitt at the J.P. Morgan Annual Health Care Conference, Jan. 11, 2016.” January 12.

Deeks, Jonathan J., Douglas G. Altman, and Michael J. Bradburn. 2008. “Statistical Methods for Examining Heterogeneity and Combining Results from Several Studies in Meta-Analysis.” In *Systematic Reviews in Health Care: Meta-Analysis in Context*, 2nd edition, edited by Matthias Egger, George Davey Smith, and Douglas G. Altman, 285–312. London: BMJ Publishing Group.

Dixit, Avinash K., and Robert S. Pindyck. 1994. *Investment under Uncertainty*. Princeton, NJ: Princeton University Press.

Dranove, David, Craig Garthwaite, Christopher Ody, and Bingyang Li. 2014. “Investment Subsidies and the Adoption of Electronic Medical Records in Hospitals.” NBER Working Paper No. 20553, National Bureau of Economic Research, Cambridge, MA.

Edmunds, Margo, Douglas Peddicord, and Mark E. Frisse. 2013. “Ten Reasons Why Interoperability Is Difficult.” In *Healthcare Information Management Systems: Cases, Strategies, and Solutions*, edited by Marion Ball, Charlotte Weaver, and Joan Kiel. New York: Springer Science & Business Media.

Everson, Jordan, and Julia Adler-Milstein. 2016. “Engagement in Hospital Health Information Exchange Is Associated with Vendor Marketplace Dominance.” *Health Affairs* 35 (7): 1286–93.

Fleming, Neil S., Steven D. Culler, Russell McCorkle, Edmund R. Becker, and David J. Ballard. 2011. “The Financial and Nonfinancial Costs of Implementing Electronic Health Records in Primary Care Practices.” *Health Affairs* 30 (3): 481–89.

Friedberg, Mark W., Peggy G. Chen, Kristin R. Van Busum, Frances Aunon, Chau Pham, John P. Caloyeras, Soeren Mattke, Emma Pitchforth, Denise D. Quigley, Robert H. Brook, F. Jay Crosson, and Michael Tutty. 2013. *Factors Affecting Physician Professional Satisfaction and Their Implications for Patient Care, Health Systems, and Health Policy*. Santa Monica, CA: RAND Corporation.

Furukawa, Michael F., Vaishali Patel, Dustin Charles, Matthew Swain, and Farzad Mostashari. 2013. “Hospital Electronic Health Information Exchange Grew Substantially in 2008–12.” *Health Affairs* 32 (8): 1346–54.

Hanauer, David A., Greta L. Branford, Grant Greenberg, Sharon Kileny, Mick P. Couper, Kai Zheng, and Sung W. Choi. 2016. "Two-Year Longitudinal Assessment of Physicians' Perceptions after Replacement of a Longstanding Homegrown Electronic Health Record: Does a J-Curve of Satisfaction Really Exist?" *Journal of the American Medical Informatics Association*. doi:10.1093/jamia/ocw077.

HHS (US Department of Health and Human Services). 2015. Centers for Medicare and Medicaid Services, 42 CFR Parts 412 and 495. *Federal Register* 80 (200). http://www.gpo.gov /fdsys/pkg/FR-2015-10-16/pdf/2015-25595.pdf.

Hillestad, Richard, James Bigelow, Anthony Bower, Federico Girosi, Robin Meili, Richard Scoville, and Roger Taylor. 2005. "Can Electronic Medical Record Systems Transform Health Care? Potential Health Benefits, Savings, and Costs." *Health Affairs* 24 (5): 1103–17.

Hsiao, Chun-Ju, Esther Hing, and Jill Ashman. 2014. *Trends in Electronic Health Record System Use among Office-Based Physicians: United States, 2007–2012.* National Health System Reports No. 75. Hyattsville, MD: National Center for Health Statistics.

Karsh, Ben-Tzion, Matthew B. Weinger, Patricia A. Abbott, and Robert L. Wears. 2010. "Health Information Technology: Fallacies and Sober Realities." *Journal of the American Medical Informatics Association* 17: 617–23.

Kellermann, Arthur L., and Spencer S. Jones. 2013. "What It Will Take to Achieve the As-Yet-Unfulfilled Promises of Health Information Technology." *Health Affairs* 32 (1): 63–68.

Kern, Lisa M., Alison Edwards, and Rainu Kaushal, with the HITEC Investigators. 2015. "The Meaningful Use of Electronic Health Records and Health Care Utilization." *American Journal of Medical Quality*. doi:10.1177/1062860615572439.

Kleinke, J. D. 2005. "Dot-Gov: Market Failure and the Creation of a National Health Information Technology System." *Health Affairs* 24 (5): 1246–62.

Madden, Jeanne M., Matthew D. Lakoma, Donna Rusinak, Christine Y. Lu, and Stephen B. Soumerai. 2016. "Missing Clinical and Behavioral Health Data in a Large Electronic Health Record (EHR) System." *Journal of the American Medical Informatics Association* 23 (6): 1–7.

McCormick, Danny, David H. Bor, Stephanie Woolhandler, and David U. Himmelstein. 2012. "Giving Office-Based Physicians Electronic Access to Patients' Prior Imaging and Lab Results Did Not Deter Ordering of Tests." *Health Affairs* 31 (3): 488–96.

Middleton, Blackford. 2005. "Achieving US Health Information Technology Adoption: The Need for a Third Hand." *Health Affairs* 24 (5): 1269–72.

Miller, Amalia R., and Catherine Tucker. 2014. "Health Information Exchange, System Size and Information Silos." *Journal of Health Economics* 33: 28–42.

Miller, Robert H., Christopher West, Tiffany Martin Brown, Ida Sim, and Chris Ganchoff. 2005. "The Value of Electronic Health Records in Solo or Small Group Practices." *Health Affairs* 24 (5): 1127–37.

Obama, Barack. 2009. Speech on the Economy, given at George Mason University, January 8, 2009. http://www.upi.com/Top_News/2009/01/08/Transcript-of-Obama-speech-on-economy/61161231435966/.

ONC (Office of the National Coordinator for Health Information Technology). 2014. "What Is HIE?" HealthIT.gov website. Last modified May 12. https://www.healthit.gov/providers-professionals/health-information-exchange/what-hie.

———. 2016. "Certified Health IT Vendors and Editions Reported by Hospitals Participating in the Medicare Electronic Health Record Incentive Program." HealthIT Quick-Stat #29. http://dashboard.healthit.gov/quickstats/pages/FIG-Vendors-of-EHRs-to-Participating-Hospitals.php.

Pear, Robert. 2015. "Tech Rivalries Impede Digital Medical Record Sharing." *New York Times*, May 26, 2015.

Ponemon Institute. 2015. *Fifth Annual Study on Medical Identity Theft*. Traverse City, MI: Ponemon Institute, February.

Rahurkar, Saurabh, Joshua R. Vest, and Nir Menachemi. 2015. "Despite the Spread of Health Information Exchange, There Is Little Evidence of Its Impact on Cost, Use, and Quality of Care." *Health Affairs* 34 (3): 477–83.

Ryan, Andrew M., Colleen M. McCullough, Sarah C. Shih, Jason J. Wang, Mandy S. Ryan, and Lawrence P. Casalino. 2014. "The Intended and Unintended Consequences of Quality Improvement Interventions for Small Practices in a Community-based Electronic Health Record Implementation Project." *Medical Care* 52 (9): 826–32.

Sharecare. 2012. *National Physicians Survey 2012: The Health of the Practice*. http://www.thelittlebluebook.com/Research.aspx.

Sinsky, Christine, Lacey Colligan, Ling Li, Mirela Prgomet, Sam Reynolds, Lindsey Goeders, Johanna Westbrook, Michael Tutty, and George Blike. 2016. "Allocation of Physician Time in Ambulatory Practice: A Time and Motion Study in 4 Specialties." *Annals of Internal Medicine* 165 (11): 753–60.

Thompson, Gwen, John C. O'Horo, Brian W. Pickering, and Vitaly Herasevich. 2015. "Impact of the Electronic Medical Record on Mortality, Length of Stay, and Cost in the Hospital and ICU: A Systematic Review and Metaanalysis." *Critical Care Medicine* 43 (6): 1276–82.

Vest, Joshua R., Thomas R. Campion Jr., and Rainu Kaushal, for the HITEC Investigators. 2013. "Challenges, Alternatives, and Paths to Sustainability for Health Information Exchange Efforts." *Journal of Medical Systems* 37 (6): 1–8.

Walker, Jan, Eric Pan, Douglas Johnston, Julia Adler-Milstein, David W. Bates, and Blackford Middleton. 2005. "The Value of Health Care Information Exchange and Interoperability." *Health Affairs* (January–June, supplemental web exclusive): W5-10–W5-18.

Wang, Samuel J., Blackford Middleton, Lisa A. Prosser, Christiana G. Bardon, Cynthia D. Spurr, Patricia J. Carchidi, Anne F. Kittler, Robert C. Goldszer, David G. Fairchild, Andrew J. Sussman, Gilad J. Kuperman, and David W. Bates. 2003. "A Cost-Benefit Analysis of Electronic Medical Records in Primary Care." *American Journal of Medicine* 114 (5): 397–403.

Weeks, Douglas L., Benjamin J. Keeney, Peggy C. Evans, Quincy D. Moore, and Douglas A. Conrad. 2015. "Provider Perceptions of the Electronic Health Record Incentive Programs: A Survey of Eligible Professionals Who Have and Have Not Attested to Meaningful Use." *Journal of General Internal Medicine* 30 (1): 123–30.

Wylie, Matthew C., Rosa R. Baier, and Rebekah L. Gardner. 2014. "Perceptions of Electronic Health Record Implementation: A Statewide Survey of Physicians in Rhode Island." *American Journal of Medicine* 127 (10): 1010.e21–1010.e27.