

Information and Communications Technology in U.S.

Healthcare: Why is Adoption So Slow and Is Slower Better?

Michael C. Christensen, Dr.PH
Senior Research Fellow
International Center for Health Outcomes and Innovation Research
Columbia University
600 West 168th Street, 7th Floor
New York, NY 10032
Phone: +1 212 305 9100
Fax: +1 212 305 4256
E-mail: mcc153@columbia.edu

Dahlia Remler, Ph.D
Associate Professor
School of Public Affairs
Baruch College, CUNY
One Bernard Baruch Way, Box D-901
New York, NY 10010
Phone: +1 646-660-6725
Fax: +1 646-660-6701
E-mail: Dahlia_Remler@baruch.cuny.edu
and
Department of Economics
The Graduate Center, City University of New York
and
National Bureau of Economic Research

Abstract

Politicians across the political spectrum support greater investment in healthcare information and communications technology (ICT) and expect it to significantly decrease costs and improve health outcomes. We address three policy questions about adoption of ICT in healthcare: First, why is there so little adoption? Second, what policies will facilitate and accelerate adoption? Third, what is the best pace for adoption? We first describe the unusual economics of ICT, particularly network externalities, and then determine how it interacts with and is exacerbated by the unusual economics of healthcare. High replacement costs and the need for technical compatibility are general barriers to ICT adoption and often result in lock-in to adopted technologies. These effects are compounded in healthcare because the markets for healthcare services, health insurance and labor are inter-linked with each other and the government. Patient heterogeneity further exacerbates these effects. Finally, ICT markets are often characterized by natural monopolies, resulting in little product diversity that is ill-suited to patient heterogeneity. The ongoing process for setting technical standards for health ICT is critical, but needs to include all relevant stakeholders, including patient groups. The process must be careful (slow), flexible, and allow for as much diversity as possible. We find that waiting to adopt ICT is a surprisingly wise policy.

I. Introduction

Amidst all the disagreement about how to solve our healthcare problems, politicians across the political spectrum agree on one thing: greater use of information and communications technology (ICT) in healthcare. For example, Barack Obama's campaign web site proclaimed that his health plan would "[Lower] Costs Through Investment in Electronic Health Information Technology Systems" (Obama 2008), while John McCain in his campaign similarly stated that his administration would support "Greater Use Of Information Technology To Reduce Costs" (McCain 2008). The potential cost-savings—both direct and indirect through better health outcomes—are considered substantial. The economic stimulus package recently passed by Congress includes \$19 billion for investments in health ICT (Kaisernetwork 2009).

While ICTs have dramatically changed the way we work, interact, and entertain ourselves, healthcare lags far behind in adopting ICT (Shortliffe 2005). Visiting a new doctor generally requires completing a whole new medical history on paper. Most physicians still have their notes in paper charts. The results of many kinds of diagnostic tests cannot be shared among physicians electronically. Only four percent of ambulatory care physicians have a fully functional electronic records system, and only 13 percent have a basic system (DesRoches et al 2008). Only 5% of all hospitals have computerized physician order entry (Jha et al 2006).

ICT in healthcare does seem to offer great promise for improving patient outcomes and reducing direct and indirect costs (Lehoux et al 2000; Danzon & Furukawa 2001; White House 2005). Clinical applications include remote diagnosis and surgery, transmission of radiological images, interactive video visits, and continuous remote

analysis of self-monitored data. The most heralded application is the electronic medical record (EMR), which can reduce diagnostic test replication and ensure that all physicians and providers have up-to-date information for every patient encountered in clinical practice. For chronic diseases, ICT has the potential to significantly improve health outcomes over the long-term and thereby reduce direct and indirect costs given the much greater opportunities for continuous monitoring and adjustment of treatment (Shea et al 2002; Christensen and Remler 2007).

While the lack of adoption of ICT in healthcare has been heavily criticized (Kleincke 2000, Ortiz & Clancy 2003; Brailer^A 2005), the reasons for the currently low levels of adoption are not fully understood. Barriers to ICT adoption already discussed include significant legal issues such as licensure, liability, malpractice, and confidentiality (Kuszler 1999; Spielberg 1999; Stanberry 2000; Gottlieb et al 2005) as well as financial barriers such as the lack of reimbursement (Cutler, Feldman, and Horwitz 2005; Christensen and Remler 2007). However, the last point raises the following question: if ICT in clinical care has such potential to improve health outcomes and lower costs, why do insurers, including the government, then not reimburse for its use?

We initially sought to answer two policy questions: First, given the enormous interest in ICT for clinical care and the broad bipartisan agreement on its value, why is there so little adoption? Second, what policies will facilitate and accelerate adoption of ICT? Others have emphasized the need for technical standards (e.g., Walker et al 2005, Brailer^B 2005). We contend that the standard setting process should account for the diverse interests in healthcare. This could be facilitated by a common operating platform

and communication standards that maximally accommodate diversity. During our analysis, we discovered, to our surprise, that the currently low and slow adoption of ICT in clinical care may be desirable for society. Therefore, we added a third policy question: what is the best pace for ICT adoption? To address these questions, we examine how the unusual economics of ICT and healthcare interact and exacerbate each another.

II. Information and Communications Technology Adoption

Competitive market analysis often shapes public policy, including healthcare policy. Those well versed in policy know how market forces create incentives to adopt valuable new technologies. Specifically, consumers in a market economy comparison shop and “vote with their feet” pressuring producers for lower prices, higher quality and more desirable products. Consequently, producers adopt any technology that enables them to lower production costs. Producers also adopt technology to create new higher quality products if the additional amount consumers are willing to pay exceeds new production, adoption, implementation and transition costs. In the long-run, market forces result in the best use of all inputs, including new technologies, through investment, entry, and exit. Of course, those well versed in policy also know the traditional ways that competitive market forces do not produce the best outcomes for society, such as when monopolies prevail or externalities exist like pollution.

However, the same policy savvy individuals are less familiar with how adoption of seemingly private ICT products does not fit the standard competitive market story. First and foremost, most ICT products - from fax machines to word-processing programs to social networking sites - exhibit a particular kind of externality known as a *network*

effect (Katz and Shapiro 1985; Shy 2001; Shapiro and Varian 1999). A network effect occurs when the value of a product depends on its use by other consumers, e.g. the more people who use fax machines the more valuable the *individual* fax machine becomes. Technologies with network effects may refer to both physical networks, such as telephone networks, and virtual networks, such as compatible digital video software. Because an individual does not consider the value they add for others when joining a network there is an externality. Network externalities also give rise to *positive feedback*: the more people who use a network, the more valuable it is, and the more people will want to join that network (Katz and Shapiro 1994; Shapiro and Varian 1999).

Network externalities and positive feedback have several effects. First, in the early stages of a technology launch, adoption starts slowly as each consumer awaits the adoption by other consumers to a point when the technology is sufficiently valuable. Second, while a technology might be valuable if enough consumers choose to buy it, it may never get adopted if the size of the network effect is “big enough”. Third, however, if the network effect is big enough, once adoption starts it accelerates and rapidly reaches saturation—the so-called S-shaped adoption curve. Fourth, because adopters of a new technology naturally seek the network they *expect* to offer the broadest and most valuable connection, *expectations* of a network effect can lead to the realization of that network effect. For instance, in the early days of the market for fax machines, the value of existing fax machines increased as each new customer bought a fax machine and thereby joined the network. Once people believed that enough consumers would eventually buy a fax machine, adoption increased rapidly, and the value of the network increased dramatically.

Potential customers were now more tempted to buy a fax machine and join the network as the value of the network had increased.

Network effects and positive feedback generally reduce product differentiation – diversity in the kinds of products available. In particular, when one product does not work with another product, the network effect and positive feedback can make a single product dominant. Once a product has a significant market share, more people believe that it will become the standard and buy it, driving other products out of the market. In several historic examples, ICT manufacturers have competed for the same market and only one of them has emerged as the winner (Katz and Shapiro 1994; Shapiro and Varian 1999). For example, the spreadsheet program Excel eventually pushed out Lotus 1-2-3 and other spreadsheet programs. This winner-take-all feature of ICT markets limits diversity in the technologies available (Katz & Shapiro 1994). The more limited choices available for ICT may limit adoption to some extent if accommodating diverse tastes is important. As we will see later, accommodating diversity in healthcare is critical.

Adopting ICT is also more complicated than adopting other technologies in several other ways. First, using new technology generally requires training, which significantly increases short-term costs, particularly due to workers being pulled away from productive tasks. Second, other large switching costs are the norm in the ICT market (Shapiro and Varian 1999). Translation of information, for instance, is required when new electronic storage or communication technologies replace old paper records, or old electronic systems. Third, because, information is stored, manipulated, and communicated using inter-linked technologies, i.e. a “system” of multiple pieces of hardware and software, the various technologies must be interoperable—able to work

with one another. The need for interoperability can raise switching costs from training and translation if switching one technology causes changes in how another technology is used.

Fourth, switching costs may be so high that users are effectively locked-in to a specific form of ICT, either at the system or vendor level, and new technologies may never be adopted. Depending on the industry, the risk of system disruption or breakdown makes the risk of using a new vendor or technology, especially an unproven one, potentially huge. Such breakdown may imply irreversible damage to the company or individual user. Because adopting a new technology cannot be easily reversed, adopters of ICT need to think carefully about the added value of adopting the technology far into the future. When there is uncertainty about the future requirements of the technology, ICT users may be very reluctant to adopt a new technology. Fifth, switching costs are non-linear. For instance, persuading five independent, yet highly inter-dependent, banks to switch to a new ICT platform is more than five times as hard as getting one bank to switch, yet all five of the banks need to switch as no single bank wants to be the first to give up network externalities.

Finally, in order not to lose the value of existing ICT, the ability to integrate old and new ICT (backwards compatibility) may be critical for adoption. For example, long after the development of superior CD and jump drive storage technologies, many computers continued to have floppy disc drive readers. Backwards compatibility is also important as it lowers switching costs. Replacing CD players with MP3 players, for instance, was not that costly because the music on CDs could be “ripped” for MP3 players. In contrast, the costs of switching from vinyl record players to CD players were

much greater because entire music collections were not compatible. However, backwards compatibility can reduce the performance standard of the new technology below its potential, e.g. a word processing program that accepts documents in their old format will not run as quickly. The trade-off between better technology and backwards compatibility is one example of the general conflict between innovative technologies and network externalities and their associated switching costs (Shapiro & Varian 1999). The adoption of even vastly superior technologies can be delayed for a long time, due to the need for backwards compatibility.

Technical standards for data exchange can address many of the problems related to ICT adoption. However, such standards do not necessarily emerge automatically in the market place. Incompatible technologies often compete in a high-stakes winner-take-all battle, where the market outcome can either be a truce with multiple producers, a duopoly with only two competing producers, a monopoly, or a fight to death where no technology survives commercially (Katz and Shapiro 1994; Shapiro and Varian 1999). AM stereo radio provides an illustration (Shapiro and Varian 1999). In the early 1980s, the Federal Communications Commission decided to let the market choose among four rival technologies for the AM stereo radio. In the end, none were adopted due to the substantial costs of the new AM compatible radios, the uncertainty about the winning technology, and the limited incremental value to existing radios. The case illustrates that ICT adoption may be especially difficult when multiple groups of adopters need to coordinate and agree on a common technical standard.

To summarize: network effects and positive feedback can delay or inhibit ICT adoption and limit the diversity of products available. Switching costs and the need for

interoperability inhibit adoption or even result in complete lock-in to suboptimal technologies. Technical standards can address many of the barriers to ICT adoption, yet history tells us that these do not necessarily emerge automatically in the market place.

III: Adoption of ICT in Healthcare

The unusual economics of ICT inhibit or slow down all ICT adoption, not just healthcare ICT adoption. Yet the fantastic gains of ICT have outweighed those barriers in most industries and aspects of public and private life. Why does healthcare ICT lag so far behind?

Interlinked Markets

Most healthcare services are covered through health insurance. Therefore, the economic incentives for technology adoption by patients and providers depend on the operations of the insurance market and the interactions between insurers and healthcare providers (Weisbrod 1991). Further complicating matters, health insurance is typically provided by employers, as part of labor compensation, or by government. Consequently, there are, in principle, three interlinked markets in healthcare: (1) healthcare services, (2) health insurance and (3) the labor market, as well as government's role as insurer. Within each of these markets there are, of course, many different types of healthcare providers, insurers and employers creating a myriad of unique linkages across the three principle markets. The result of all these complicated linkages is that the market forces from patients to healthcare providers are far more indirect and blunted than are the market forces from consumers to producers in most sectors. In order for patient preferences to

drive healthcare providers to adopt available technology, the market forces must be transmitted through each stage and each stage brings its own transaction costs.

Consider the example of patients who want to ask simple questions of their primary care physician (PCP) by e-mail. What options exist for such patients to obtain these e-mail services? A patient who tries to persuade his PCP to adopt e-mail will have little leverage, since he is not likely to change PCP for such a small issue as e-mail communication. The patient-physician relationship encompasses so much more. What about persuading the insurer to influence the PCP (through payment or other means)? The patient has even less leverage with the insurer than the physician, since even more services are bundled together in the health insurance package. Moreover, the patient may have limited insurance options. How about trying to influence the employer to influence the insurer to influence the PCP? In this instance the patient has the least leverage to negotiate, because no employee will change job just for the option of e-mail communication with his PCP.

In contrast, conventional market forces do apply to healthcare services not covered by insurance but purchased directly out-of-pocket, and in fact, ICT adoption has been much more rapid for these services. For example, psychotherapy is often not covered by insurance (Zuvekas 2001) and there has been rapid growth in psychotherapy via e-mail and other internet media. Similarly for long-term care not reimbursed by the government (Medicare and Medicaid) “smart technologies” for communications and monitoring of the elderly living alone have been adopted relatively rapidly (Wallace 2003).

What about the incentives of healthcare providers, insurers, employers, or the government for adopting ICT? Any stakeholder will be financially motivated to pay for ICT if its adoption lowers the use of other forms of healthcare sufficiently to result in lower net costs *of that stakeholder*. Health care providers and insurers will also be motivated to adopt and pay for ICT if it substantially improves health outcomes – but only if those choosing and compensating the stakeholder recognize the outcomes. Unfortunately, many of the potential benefits of ICT, both reduced costs and improved outcomes, occur far in the future, when the covered individual will likely have another insurer or provider. For instance, approximately one in five Americans switch health plans every year (Community Tracking Survey 2007). Moreover, if ICT benefits chronically ill patients (or other less healthy patients) more than other patients, an insurer who supports ICT adoption might disproportionately attract less healthy and more expensive enrollees. In that case, the usual selection forces would dissuade insurers from supporting ICT adoption. Finally, because many existing provider payment forms are tied to volume, rather than health outcomes, providers can reap few if any financial benefits from ICT adoption. Different forms of payment to healthcare providers are needed to provide financial incentives to adopt ICT (Miller et al 2005; Christensen and Remler 2007). Interestingly, healthcare systems with a single long-term insurer, such as the Veterans Affairs (VA) or British National Health System (NHS), can internalize the long-term benefits of ICT adoption and consequently they have been early adopters (Evans, Nichol, and Perlin 2006; Greenhalgh et al 2008).

What about the specific incentives of employers and the government? Employers may care about ICT's value in enhancing patient care either because they want to provide

more generous compensation that employees appreciate or because ICT increases employee productivity through better health. The government could value ICT if it provides net savings to the government insurance programs or if voters support the technology. For example, we have seen limited changes to Medicare payment policy for the type of ICT that directly benefits healthcare providers in rural areas (Puskin 2001). However, until recent Obama administration proposals, neither government nor employers took any actions to push for broad ICT adoption in healthcare.

Of course, the interlinked markets in healthcare blunt the market forces for adopting many innovations and technologies, not just ICT. Indeed, many innovations desired by patients, such as scheduling systems that reduce patient waiting time, are not implemented. Yet, healthcare is known for its rapid adoption of many new technologies. Why the difference? Certainly, existing payment structures, and perhaps physician preferences, drive rapid adoption of new diagnostic tests, drugs and procedures. Primarily, however, the slow and limited adoption of ICT is driven by the interaction of the distinct features of ICT and healthcare markets.

Interaction of Barriers to Adoption: ICT and Healthcare Market

The many interlinked markets in healthcare and patient heterogeneity significantly intensify the general barriers to ICT adoption— low product differentiation, high switching costs and technical compatibility. While the standard competitive market only has consumers and producers, producers in the ICT market also encompass manufacturers of add-on products, information goods producers, systems producers, component producers and infrastructure operators. For healthcare ICT, consumers include many kinds of healthcare providers; patients of different diseases, ages, education

levels, and disease severity; and insurers of all kinds. These consumers (or ICT users) differ in their resources for surmounting the barriers to ICT adoption. They also have greatly different needs for ICT, creating demand for product diversity and conflicting with the naturally low product differentiation in ICT markets.

The switching costs of ICT are also likely to be particularly high in healthcare. The EMR, for instance, is difficult to develop and adopt due to clinical complexity and the need to serve many purposes (Lorenzi et al 2008). To implement a new electronic medical record, existing data from paper records must be entered; an extremely time-consuming task. If existing data are not entered immediately, then healthcare providers may have to work with parallel paper and electronic records for an extended transition period. Additionally, the value of integrating data across providers can only be gained if many providers adopt compatible ICTs, yet healthcare providers who stand to gain very differently from adoption will be unlikely to agree on the timing and type of technology adoption.

The switching costs are also likely to be higher given the many different actors involved in health care. Patients, providers, insurers, and producers of software, hardware and communication infrastructure all depend on each other – directly or indirectly – in the use of the same or associated technologies. If technological change or a change in user requirements causes one component of the overall communication and data-sharing infrastructure to be replaced, all agents face switching costs. In addition, patients, in particular those with chronic diseases, who may benefit greatly from ICT adoption, are older on average, raising requirements for user-friendliness. Their needs for ICT are also disease-specific, necessitating different types of ICT. As a consequence, changes to the

operating platform of healthcare ICT could require changes to many disease-specific types of patient software.

Overall, there are three major sources of switching costs that must be addressed to adopt a new ICT in healthcare. First, there are the upfront costs of purchasing the technology. These include the costs of new durable hardware (such as mainframe computers), the operating systems (to store and manipulate information) and any complementary products (such as disease management software). Second, there is the cost of information storage in databases and the cost of moving clinical data from one database to another. Old medical records need to be stored for legal reasons. Hospitals and insurers must transfer massive information encoded in specialized formats to new systems. Third, there is the usual cost of the training involved in using the new ICT (Schuster et al 2003; Bossen 2007). This training is often brand-specific and considerable additional time will be required to become equally efficient with a new technology.

Examples of Difficulties in Healthcare ICT Adoption

A recently released report on early adopters of an EMR in the British National Health System (NHS) makes clear the substantial switching costs involved (Greenhalgh et al 2008). Regarding training, for instance, the report states that effective implementation requires “[e]nough [training] for front-line staff at the right time in a real working environment. The IT literacy of many NHS staff was low. Formal training...did not always have a positive impact on the ability of the staff to actually use the system...This...highlights the need for ongoing, local, on-the-job training” (section 1.19). With regard to data recording, the report states “GPs... worry about workload, especially in the phase 2 of the upload in which selected aspects of patients’ medical

history will be added to the record” (section 1.15) and “the evaluation revealed a more complex and less easily quantifiable picture [of workload]” (section 1.35) The report also noted that switching and adoption costs were exacerbated by a lack of “spare human and technical capacity that could be used to buffer the stress of innovation” (section 1.17).

The high switching costs encountered in the British NHS are likely to be even higher in the US, given the many payers and decision makers in US healthcare. As discussed, the switching costs of ICT adoption rise more than proportionately as new users are added. In health care these non-linear switching costs are likely to be particularly pronounced given its many interlinked markets. A network large enough to overcome collective switching costs is unlikely to emerge automatically.

Because the decision to adopt a system-wide EMR was taken centrally, the Veterans Affairs (VA) health care system was able to surmount the large switching costs (including going from paper records in 150+ medical centers). The VA now has an advanced system of electronic medical records and telemedicine applications linking pharmacy, laboratory, and all other care (Evans et al 2006). The system is now partially credited for the strikingly good outcomes achieved for diabetes and other chronic diseases in the VA patient population (Sawin et al 2004). However, even when the switching costs can be overcome, and compatible ICT extensively adopted, early adoption of health ICT may still be problematic. An annual software upgrade in the VA in August of 2008 resulted in faulty displays of medical records and consequently incorrect doses of drugs, unimplemented treatment cessations and delays in treatments (Associated Press 2009). Such problems make early ICT adoption problematic, as we show in the next section.

A four-internist family practice group described their EMR adoption and the problems they encountered, as well as the benefits, illustrating the barriers we describe (Baron et al 2006). They summarized that “its financial impact is not clearly positive; work flows were substantially disrupted; and the quality of the environment initially deteriorated greatly.” Adoption costs included two full days of on-site training and a 50% reduction in schedule for three days after going live, as well as the \$140,000 purchased costs of hardware, software, training and one year of support. Virus attacks, data service interruptions and untimely technical support interrupted care. They described having to “redesign every office system” and felt like they were “redesigning an airplane in flight.” While they also described many of the long-term benefits predicted, it is little wonder that most primary care doctors have avoided EMR adoption, given the many stresses on primary care doctors.

Both the potential value of and barriers to ICT adoption are illustrated by the use of software to store and analyze information about blood glucose for diabetes patients. If coupled with information about medications, diet and exercise, such information substantially helps diabetes patients maintain good health and avoid disabling or fatal outcomes. Many blood glucose monitoring and data management systems exist (Diabetes Forecast 2008) and have been around for many years (e.g., Diabetes Forecast Resource Guide 2003). Diligent patients now benefit substantially from the information and analysis provided by the software. While providers can review the patients’ self-collected data in hard copy easily (and hence make use of it in their overall disease management), it is much more difficult to receive the information electronically and analyze it. Every meter manufacturer is potentially a different case, implying adoption of multiple software

programs. Moreover, despite the proliferation of blood sugar measurement software, we are unaware of any attempt to integrate that data into an EMR or broader form of healthcare ICT. Thus, even for diligent patients and physicians who collect, analyze and communicate the information, the diversity of methods makes aggregation of information almost impossible.

In summary, patient heterogeneity, inter-linked markets and higher switching costs exacerbate the general barriers to ICT adoption— low product differentiation, high switching costs and technical compatibility. So, network effects do not emerge automatically but require intervention to ensure the required technical compatibility and interoperability.

IV: The Value of Waiting

At any given point in time—now, five years ago, or next year – the potential for ICT to reduce costs and improve outcomes would argue for adopting as quickly as possible. In other words, in a static framework, society loses when potentially valuable adoption opportunities are missed. However, a dynamic perspective that incorporates uncertainty provides a less clear picture. As described, the future value of specific ICT systems is highly uncertain, due to both rapid technological change and uncertainty relating to adoption decisions by other healthcare providers and insurers. Moreover, decisions to adopt ICT are irreversible, due to a variety of lock-in effects, as well as the sunk investment costs. Once system-wide technology adoption has occurred in healthcare, it is hard, if not impossible, to turn back to previous systems of communication and information storage. Observe the resilience of the traditional paper

record. Though the combination of uncertainty and irreversibility of ICT investment reduces the value of all ICT investments, the effect is greater for healthcare.

The real option value theory of investment demonstrates the value of waiting to invest when investments are irreversible and uncertainty about future market conditions exists (Dixit and Pindyck 1994; Luerhman 1998). This theory, used to value capital investments in the corporate world, has also been applied in the social sector as well, including ICT adoption in higher education (Oslington 2004). Briefly, if one invests now, when the future value of the investment is uncertain, the return on the investment may be either high or low depending on future market conditions. Investing now destroys the option to invest at a later time point. However, if one waits until the uncertainty is resolved, the value of the investment will be known and the optimal decision—whether to invest or not and the specific type of investment—can be made. Depending on the upfront investment costs and the level of uncertainty about the future market conditions, the real option approach to investment may dictate that waiting to adopt will result in the highest net present value.

Consider a healthcare provider's decision to invest in a particular ICT without knowing whether a much better technology will come along and/or before he knows what specific type of ICT other providers will adopt. If the provider maintains his option to invest at a later time point, he can invest when other providers have made clear the type of ICT they consider acceptable and when superior technologies are developed. Option value theory interacts with the theory of network externalities and positive feedback. While network externalities in general may delay or completely prevent adoption of technologies, the uncertainty and irreversibility of investment compound the effect. The

value of delaying investment also increases with the cost of adopting the wrong technology. Due to network externalities and positive feedback, the cost of adopting the wrong ICT is generally higher than other kinds of technology. In healthcare, the value of delaying investments in ICT is likely to be so much greater than in other sectors because the costs of adopting the wrong type of ICT will be so much higher.

Why is the penalty for the wrong ICT adoption so much greater in healthcare? First, relative to other industries (such as banking and insurance), the consequences of technical errors in healthcare are likely to be larger in magnitude, more salient, more attention-getting, and engender stronger emotions. The publicity surrounding the VA system software bugs in 2008 illustrates the attention-getting and salience of errors. Most importantly, some health care errors result in death or permanent disability, completely irreversible states. Therefore, technical problems due to poor interoperability or data storage can result in severe consequences for both early adopters and society at large.

Second, the larger switching costs in healthcare, due to the large number of actors and the coordination problems among them, makes the financial losses from adopting the wrong ICT so much greater in healthcare. Individual providers and insurers could face substantial financial losses if their particular ICT system is not compatible with the future standards and requirements for healthcare ICT.

Third, the federal regulation protecting the confidentiality of health information introduced by Health Insurance Portability and Accountability Act of 2003 implies that being stranded with an incompatible technology or losing information due to system failure and breakdown is simply not an option (U.S. Department of Health and Human Services 2003). Many states have introduced legislation that sets even higher standards

for how patient data should be protected and the extent to which it can be shared across providers (Gottlieb et al 2005). The effect of these federal and state regulations is an increase in the cost of adopting the wrong technology.

The uncertainty in returns of ICT investments and the irreversibility of these investments may imply that there are real advantages to approaching ICT adoption carefully and waiting for the right technology to come along before system-level adoption takes place. Again, the recently released report on the early adopter of the British NHS EMR and the very recent experience in the VA system provide evidence in this regard. For instance, the British NHS had originally planned to have an EMR universally in use by 2009, yet they have repeatedly been plagued by many of the problems our theory predicts: lack of interoperability, errors in translation of paper patient files (and resulting slowdowns to avoid such errors), difficulties training staff and extensive time needed to train staff (Greenhalgh et al 2008). The EMR is currently considered “an immature technology which staff have described as ‘clunky’ and which currently interfaces poorly with other ICT systems. Many staff have given up using it ‘until it works better’ (section 1.14).

In the US, the EMR has been adopted by approximately 5% of all U.S. hospitals for computerized physician order entry (Jha et al 2006). The fact that no widespread adoption of the EMR took place ten years ago when the first versions were introduced may actually, from a societal perspective, have been the right decision. The technical standards available at the time did not provide for the kind of interoperability needed today for an optimal use of the technology. If half of all U.S. hospitals had adopted the EMR back then they may have been locked-in to a technology that could not be used for

all the clinical applications needed today. Perhaps the history of telemedicine in the US provides the best evidence on the value of waiting. The technologies used in the early demonstration projects at Nebraska Psychiatric Institute and Massachusetts General Hospital/Logan International Airport Medical Station (Brown 1995), while novel and advanced at their time, would clearly be outdated in today's healthcare environment. Had nationwide adoption of these technologies taken place in the 1960/70s, the healthcare system would have been locked-in to technologies vastly inferior to the technologies available today. Given the large collective switching costs healthcare providers need to be careful about the technologies they lock into and going slowly may in fact not only be a good idea but also the optimal approach in healthcare.

V: Technology Standards in Healthcare

Some of the reasons for delaying adoption, in particular the uncertainty about other providers' adoption decisions, can be alleviated with common technical standards. Such standards facilitate and accelerate adoption and improve the choice of ICT for a number of reasons (Farrell and Saloner 1985; Hammond 2005; Pedersen and Fomin 2005). First of all, standards enhance compatibility, which ensures that the ICT works for all stakeholders, vastly expanding the network, and its value. Secondly, technical standards also reduce the risk that ICT users end up stranded with an incompatible technology that cannot be used in the future (Katz and Shapiro 1994). Finally, technical standards reduce switching costs and thereby lock-in to specific technologies. By reducing switching costs, standards make future switching to superior, yet-to-be-invented

technologies, possible and cheaper. However, standards cannot reduce the value of waiting to see what superior technologies are invented.

How much standardization should there be? Should there be a standard for every single device, every single form of software and every possible interaction between them? Endless and rigid standards may inhibit innovation and the use of certain types of ICT. The socially optimal extent of standardization in healthcare depends on ICT user heterogeneity. The more heterogeneous users' ICT needs, the more important is flexibility in ICT design to meet those needs. Since heterogeneity in healthcare – both across medical conditions and among patients with a given medical condition – is much greater than among consumers or producers in other sectors, product differentiation is particularly desirable. Standardization can have negative consequences if the standards do not accommodate this heterogeneity. A tradeoff therefore exists between seeking more standardization to allow for greater adoption and less standardization to allow for greater product differentiation.

ICT has many diverse possible applications in chronic disease management, for instance, and there are therefore many different forms of ICT for which standards could be required. For example, medical devices can capture patients' physiological data; software can transmit such data to an EMR, and the data can be presented and analyzed in different forms, depending on the audience. In the case of diabetes, blood glucose data could be integrated with data on food consumption, medication and exercise for transmission to the EMR. Standards would be needed for the patient's device, the EMR and the analysis software, to ensure widespread interoperability. The ideal ICT standard will vary across chronic diseases. The technology that will be best for diabetes care is

unlikely to be best for the management of heart disease. Therefore, it is highly unclear how to select a technical standard to work with all ICT applications. A standard EMR, for instance, adopted in all hospitals without regard to the specific infrastructure, medical specialties and patient populations treated could do more harm than good.

The diversity needed for healthcare ICT could be addressed by a common operating platform with communication standards that allow disease-specific modifications. Because new diagnostic tests and new ways of analyzing data will continue to be developed, the capacity to add new modules, new variables and data structures is critical. The means of communicating across new modules should also be flexible. Such flexibility and expandability will make ICT potentially valuable to a variety of different providers, facilitating network expansion and value. The practicalities of how much of the operating platform that should be universal and how much should be idiosyncratic is clearly an open question. The need to enable disease-specific technical modifications implies that full ICT compatibility will not be possible. An open non-proprietary technical platform, like open source software, that allows others to write for it and develop specific ICT systems will go along way for addressing the need for product differentiation.

Connecting for Health has a promising initiative for standard setting (Halamka et al 2005). The organization proposes a minimum set of standards that aims to protect privacy, patient control and data security, while allowing timely access to data across information networks. These standards will facilitate interoperability of standard interfaces and transactions at local, regional and national levels and address secure transport of data, provide the essential components required for the infrastructure,

including secure connectivity, reliable authentication, and formats for health data. By focusing on a minimum set of standards that provides for interoperability, the approach recognizes the heterogeneity in technology needs and applications that is crucial in healthcare ICT.

To reach agreement on specific standards for data recording and exchange formal standard setting is needed. The process needs rules and procedures for reaching consensus on technical decisions. Avoiding dominance by any single group of stakeholders is critical. While the formal process is often criticized for being slow, cumbersome, and political (David & Shurmer 1996), it has historically been absolutely paramount to launching new technologies (Shapiro and Varian 1999).

In 2005, the Office of the National Coordinator for Health Information Technology created the Health Information Technology Standards Panel (HITSP) to harmonize existing health IT standards and the Certification Commission for Health Information Technology (CCHIT) to certify vendor products in reference to these standards. The working procedure of the HITSP is described as “transparent” and “consensus-based” and the panel is considered a “multi-stakeholder coordinating body where private and public sector interests agree to cooperatively address the healthcare information technology needs of the nation” (HITSP website, 2009). Primarily, the panel work to identify missing or incomplete standards and recommend standards that enable interoperability. The first set of interoperability standards was recognized by the federal government in January 2008.

As of November 2008 the panel encompassed more than 450 organizations. While the panel contains IT vendors, organizations representing “general consumer interests”,

healthcare providers, public health agencies, government agencies, and standard developing organizations, its composition is of concern for several reasons. First, patient organizations are almost entirely absent—a breast cancer organization being the sole example. Thus, the chronically ill have no direct voice. Specific disease perspectives are needed to ensure interoperability with all the relevant physical biometric devices and usability by patients. Therefore, all major patient advocacy groups for chronic diseases (e.g. the American Diabetes Association and the American Heart Association) should be involved. Of course, all major types of providers (e.g., represented by the American Academy of Family Physicians and the American Hospital Association) and major health insurers (e.g., represented by American Health Insurance Plans and Centers for Medicare and Medicaid Services) are needed, and they are now members. Involvement of all these stakeholders will make the process slower and more cumbersome, making healthcare less than it could be in the short-run. But in the long-run, their involvement will result in a better solution.

A second problem with the panel's composition is that more than 50% of the organizations are designated as IT vendors. Vendors (individually and collectively) are likely to pursue those standards that give them proprietary advantages. Third, the vendors themselves are dominated by pre-internet vendors (e.g., GE, Siemens, and McKesson) while representatives of emergent or potentially disruptive technologies based on the internet and web-based applications have no chair positions in the various technical committees (Kibbe and McLaughlin 2008). Such pre-internet vendors may not make sufficient use of the internet and other new technologies now widely available and adopted. On the other hand, vendors who have created healthcare ICT, including their

communication standards have technical knowledge that others lack, based on experience with technical limitations and barriers. As a result of this expertise, they should play a prominent role in the process.

Many observers of the standard setting process are disappointed, because after several years of standards documentation and resolution of several standards “disputes”, use and implementation of these standards is still far away. “Not a single data element has been exchanged in the real world healthcare systems using standards this process has developed or deployed,” one noted (Karp 2007). As we illustrated, a slow process could be better than a rapid process. Nonetheless, the current process could be improved. Critics such as Diamond and Shirky (2008) offer suggestions that fit with our own analysis. First, they find the process focused on specifying too much too soon, stating that “only critical requirements for any given increment of improvement” should be adopted. Second, they note that “standards are not really standards unless they are widely adopted, and this step cannot easily be mandated.” The standards-setting process should be more sensitive to what users (providers or patients) want to adopt, rather than trying to dictate what users should adopt. The standards for the internet were simple, minimal and created incrementally.

The government has a key role in standard setting, but that is not its only role. The government was critical in facilitating the internet, which was initially developed and financed by the Department of Defense. The internet also illustrates how the government can develop a clear technical platform needed in order to develop new forms of ICT. In general, by financing, endorsing and adopting technologies, the government can help achieve a critical mass of ICT users, subsequently leading to rapid uptake and widespread

use (Rosenfeld et al 2005; Middleton 2005). While the importance of influential players in ensuring technology adoption has been debated (Chakravorti 2003; Berry & Keller 2003), for healthcare ICT the role of the government is likely to be critical. First, the interlinked healthcare markets and resulting mismatch in financial incentives for ICT adoption is a strong argument for government involvement. Second, the government is both a major payer and regulator of healthcare and its ICT choices will inevitably be quite influential. It is however essential that the government's interests as an insurer (Medicare and Medicaid) and even provider (e.g., county hospitals) are not allowed to overwhelm the broader societal interests. For instance, if Medicare decided to endorse one specific EMR to fit the Medicare population but not other patient groups, then this could be a huge obstacle for more widespread adoption of the EMR.

VI. Conclusions

Politicians across the political spectrum support substantial funding for ICT in healthcare, particularly the EMR, and believe that it will lower healthcare costs and improve health outcomes. This agreement is particularly striking given the general disagreement about healthcare policy. Presently, the proposed stimulus package includes 19 billion dollars for healthcare ICT and it is not controversial (Kaisernetwork 2009). The gains in improved outcomes and efficiency seem self-evident to most citizens.

Government should continue its support for this process. To realize the potential of health ICT, technical compatibility and interoperability standards are critical.

Standards, however, are not the only factors affecting adoption. Financial incentives, i.e. subsidies, are paramount. In earlier work, we described how the form of

payment (payment design) to providers will strongly influence whether and how ICT is used in healthcare (Christensen and Remler 2007). Insurers currently have little reason to pay providers for ICT adoption, because the short-term benefits (financial and/or health improvement) are small. While the long-term benefits of ICT likely justify the upfront adoption costs, private insurers cannot benefit because most individuals will have a different insurer well before the long term benefits materialize. In the US, only Medicare and the VA presently have a financial interest in the long-term perspective. Thus, the long-term and broader societal goals do justify government support. In addition to financial matters, data security and confidentiality concerns must also be addressed, as has been widely recognized (e.g., Diamond and Shirky 2008).

The present standard setting panel, HITSP, has generally the right framework but could be improved in several ways. First, patient organizations have almost no role. Making healthcare information technology accessible and usable for patients, particularly chronically ill patients who need to manage their own disease for their residual lifespan should be a greater priority. Second, vendors, particularly early, pre-internet vendors play too large a role. For both financial reasons and technical familiarity, they could implement lock-in restrictions that are incapable of adapting to more modern innovations. As Diamond and Shirky noted, “it is better to share important but un-codified information between Doctor A and Doctor B so that an informed clinical decision can be made, than to have perfectly formatted data that never leaves Doctor A’s office.” Standards for moving text could be done before deciding on data structures for the EMR.

If interoperable and compatible ICT in healthcare is widely adopted and it allows for data aggregation and integration across regions and diseases, medical knowledge is

likely to substantially expand. Data mining and other methods of data analysis on such large databases could provide valuable information to guide medicine, public health and health services. The ultimate goal of ICT adoption should not just be a computerized health care system but one that can be adapted to realize this potential.

Finally, our analysis suggests that the process should not be forced too quickly and that waiting this long for ICT may not have been such a bad thing. A good standard setting process will be slow and cumbersome. While the government may need to use its regulatory powers and its powers as Medicare payer, to speed up the process, this should not be done too quickly. The value of waiting to adopt ICT in healthcare is greater than in other areas, because the costs of adopting the wrong type of ICT are so much higher: the risks and irreversible consequences of technical errors and the consequences of lock-in into a suboptimal technology.

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