The Socioeconomic Aspects of Information Technology for Health Care With Emphasis on Radiology[1]

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Rationale and Objectives. Information technology is the key to cost effective and error free medical care in the United States and the only problem is that there is not enough of it yet. During the past 15 years, billions of dollars have been spent on information technology for health care with very little benefit but significant adverse effects on patients, physicians, and nurses. The truth about health care information technology (HIT) probably lies somewhere between these extreme statements, representing technophile and skeptical views, respectively.

Materials and Methods. There is no doubt that computer and communication hardware has reached a state of sophistication and availability in which any and all necessary information can be generated, stored, and distributed to health care workers in support of their patient care tasks. The barriers to rapid and widespread development and diffusion of cost effective and practically useful HIT are exclusively related to human factors.

Results. This article explores some of the organizational, cultural, cognitive, and economic forces that interact to influence success of HIT initiatives in health care organizations. A key point to be recognized is that the intrinsically handcrafted nature of health care work combined with high degrees of complexity and contingency make it impossible to "computerize" with the same ease and completeness of other industries. The major thrust of the argument is that designers of information systems and health care informatics managers must meet needs of patients and care providers. The software they create and implement should promote, support, and enhance the existing processes of health care rather than seeking to dictate how direct care providers should do their work.

Conclusions. Instead of looking for "buy in" from physicians and nurses, the informatics community must return the authority over functional specification of patient care information systems to them—where it belonged in the first place. This same lesson about computer technology and organizational politics is also being learned in the business community, where executives are reclaiming responsibility for mission critical informatics decisions.

Key Words. Information technology; health informatics; health economics; radiology; skeptical criticism.

Beginning with an Institute of Medicine report in 1991, echoed in another Institute of Medicine report published some 10 years later, and culminating with the Health Information Technology (HIT) initiative by the US Department of Health and Human Services, computerization of patient care has been advocated for more than a decade at the highest levels of government and by professional organizations (1–4). This advocacy is based the assumption that beneficial transformation of the US health care delivery system can be achieved through the wholesale application of computers and information technology (IT). Although I agree that large-scale adoption of IT to health

Acad Radiol 2005; 12:431–443

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doi:10.1016/j.acra.2005.01.006

care will be transformational, it is far from obvious what the nature of that transformation will be. There is little high-quality evidence of measurable improvement in patient outcomes or cost savings resulting from adoption of HIT (5–8). Most positive evidence is confined to measurement of intermediate outcomes and much comes from outside the United States (9–11). These findings are balanced by disturbing evidence of numerous systematic and specific problems resulting in significant adverse outcomes for patients (12–16). Absent adverse consequences for patients, poorly realized HIT can lead to degradation of the working environment for health care providers (15, 17–20). The consensus of most objective observers is that is that, so far, IT for health care has been very costly and has generated disappointingly few benefits (21–24).

In this article, I will take a critical view of the recent history and current status of IT in US health care. In general, the problems and failures are traceable to sociocultural factors relating to conceptualization, design, programming, implementing, maintaining, and servicing computer programs meant to automate health care processes. The issue is not that the hardware and communications infrastructure cannot do the job. Moore's law holds that computer capability and reliability increases almost exponentially with time while the cost remains stable or even declines (25). As a result, there are very few physical limitations on what is possible in making computer technology that can capture, store, transmit, and present information in any way that developers can think up. The failures have come about because of decisions made by health care IT developers, managers, and vendors based on a fundamental misunderstanding of the nature of medical work and the best way to use IT to support those who practice it. Many such decisions about HIT belie an attempt to industrialize medical work in the same fashion that manufacturing was transformed during the industrial revolution. I maintain that resistance to HIT—as currently conceived—by health care workers is a natural response to policies that threaten their interests and make providing high-quality care to patients more difficult rather than easier.

Despite a fair amount of skepticism born from experience and shaped by the evidence that will be presented in this article, I believe that the prospects for the future of HIT are quite positive. Advances in hardware and communication infrastructure enable increasing amounts of information to be interchanged at high speed to and from various devices that become smaller and more capable all the time. The key to success will be in how these networks and devices are programmed to operate. Rather than trying to replace or redesign intrinsically labor-intensive health care processes, IT should be used to complement and streamline existing work practices. Several emerging trends in IT practice within the general economy warrant attention and adoption as appropriate. These include open source standards, extreme programming, interaction design, and the development of information ecologies. If we can change the way that IT is integrated into health care work, the digital hospital can be realized and it will likely be a safer, more pleasant, and perhaps even a less costly enterprise.

The specialty of radiology provides a paradigm for IT success that should be extended to other areas in health care. The success of IT for radiology came about for two reasons. First, medical images are amenable to workable solutions that enhance the preexisting work process. Technologists and radiologists are relieved of having to produce and handle hardcopy films. Perhaps more importantly, this benefit is realized without interfering with the basic structure of the work of radiologists. Second, a worldwide standard for electronic capture, transmission, storage, and display of medical images was developed rather early and has been adopted by the entire industry (26,27). Interestingly, attempts to computerize radiology reporting and transcription have had less uniform success. Again, human factors define the problem because the new solutions put transcriptionists out of work and shift part of their former tasks to radiologists.

In the following discussion, I hope to draw on explanatory models and empiric evidence from several diverse fields of inquiry. These include history, economics, philosophy, cognitive psychology, and sociology. History and economics can help place the nature of health care work in perspective with respect to other industries. I will describe how and why industrialization has seemingly bypassed health care and the economic consequences of the resulting differences in productivity. Philosophy and cognitive psychology can offer insight about the origin and consequences of the fact the medicine is perhaps the most complex, variable, and contingent field of study and practice that humans engage in. Failing to understand the intrinsic value and central role of interpersonal communication between experts to the process of delivering health care results in poorly designed software that is often rejected or resented by those forced to use it. I believe that the way in which information technology is introduced and ultimately functions in health care facilities is profoundly affected by organizational culture and social interactions.

The concept of information ecology will be introduced to show the transcendent importance of an open, collegial, and cooperative atmosphere to the successful diffusion of computer technology into health care organizations.

INDUSTRIALIZATION OF HEALTH CARE

Industrialization of manufacture and distribution of goods was realized through three major trends beginning in the 19th century. These include mechanization, scientific management, and the assembly line. A second "industrial revolution" began in the late 20th century, driven almost exclusively by IT. Medical care has only been marginally industrialized with little substantive change in work practices. Many of the core functional and social characteristics of health care, especially as performed by physicians, still resemble preindustrial guilds of artisans or craftspeople. If health care professionals are asked to characterize their roles in more modern terms, they make analogies with managers of patient care (executives), designers of process (engineers), or navigators of the course of medical care (airline pilots, ship captains). Role models that most physicians and nurses would likely reject include customer service representatives, technicians, and production line workers. However, many of the strategies articulated by IT vendors, hospital executives, agents for payers, and government bureaucrats sound very much like those favored by factory owners and managers in the past. These include standardization of process, stepwise decomposition of work, interchangeability of workers, and strict control over all actions of the workers by management. In both health care and manufacturing, the stated goals are improved quality, reduction of errors, decreased cost of production, and increased efficiency.

In the case of durable goods manufacturing, largely a physical process, industrialization was astoundingly successful. No one would doubt that specialized workers tending a modern automated production line can produce far more goods of uniformly higher quality at lower cost than their preindustrial counterparts. Perhaps even more remarkable has been the recent large increase in efficiency brought about by using IT to implement "just in time" transport and supply of raw materials and finished goods within the market. Those who assert that the same strategies and techniques will necessarily apply to health care work are essentially arguing by analogy. The problem is that the analogy does not hold. Health care is performed not on inanimate objects, but rather on humans who are characterized by being highly variable among themselves and even within the same individual over time. Further, the primary tasks of health care work are cognitive rather than physical. They include diagnosing treatable disease, determining the best therapy, educating and motivating the patient about the treatment, monitoring the conduct and success of therapy, and modifying practice based on prior experience. These tasks involve gathering, sorting, verifying, evaluating, synthesizing, and recording tremendous amounts of information. Finally, medicine is a "contact sport," meaning that personal interaction between patients, their families, and health care workers is integral to the process. In fact, many patients view the amount and character of these interactions as the hallmark of quality of care.

These unique functional aspects of health care have caused it to remain mostly a handcrafted type of work. Ironically, medical practice has become highly technical with sophisticated, computerized, and rather costly equipment used in all aspects of care. Physicians, nurses, and other direct care providers use these technologies in a manner analogous to an artist's palette to treat individual patients with unique and individually tailored diagnostic and therapeutic "compositions." The patient encounter and an episode of care represent the basic substrates of work (the units of production). One or, at most, a few primary providers "own" the responsibility for care during a given encounter or episode and they supervise the patient's progress through many if not all stages of the process spanning multiple episodes.

The handcrafted or "job shop" organization of preindustrial work was precisely the attribute targeted for change by Henry Ford and others in designing production lines. Industrialized workers typically interact with every production unit to perform a specialized task and then pass the unit on to next worker on the line. In medical care, assembly line type specialization is realized for small parts of the process of care (eg, phlebotomy, electrocardiogram, laboratory tests). Production of radiology examinations by technologists has also enjoyed remarkable increases in efficiency because of computer technology, which has eliminated film (28–30). However, these are mostly physical actions, whereas cognitive tasks and personal interaction (as outlined previously) comprise the great bulk of effort required for medical care. This distinction between the basic nature of health care work and that of other economic sectors leads directly to significant and persistent differences in relative productivity growth during periods of industrial innovation.

BAUMOL'S COST DISEASE AND HEALTH CARE

William Baumol, a New York University economics professor, recognized that some portions of the economy tend to be resistant to industrialization and the resulting increases in productivity (31,32). He termed these the *nonprogressive* sector. They consist of labor-intensive activities and include policing, fire protection, education, performing arts, and health care. On the other hand, the *progressive* sector is made up of the portions of the economy that are amenable to industrialization. Basically, these are the manufacture, distribution, and disposition of durable goods, commodities, and consumables. Baumol maintains that growth in productivity within the progressive sector consistently and persistently outstrips that of the nonprogressive sector. As a result, over decades and even centuries, the relative cost of progressive sector goods (and some services) declines with respect to services (and some goods) in the nonprogressive sector. Consider that wages are a proxy for the entire economy's willingness and ability to reward a worker (let's call her Jane) with a bundle of goods and services in exchange for whatever it is that she produces. If this bundle of goods and services uses relatively less labor and capital to produce, more is available to Jane; this translates into a higher wage for her. Jane is no more productive than she was in the past; everyone else is. It is vital to understand the causal flow of the preceding explanation. Nonprogressive sector wage increases are caused by relatively higher productivity in the rest of the economy and not the other way around.

Dr Baumol used two now-classic examples to support his thesis. The first is that of a string quartet producing (playing) a Mozart concerto. In 1793, a particular piece might take four people 30 minutes to perform. Today, to perform the same piece still requires four people and takes 30 minutes. However, in aggregate, most other goods and services can be produced with fewer people or in less time in the 20th century. Therefore, for 20th-century musicians, the relative cost of their services is much greater than in the 18th century. This increase in the musician's wage is considerably larger than can be accounted for the general rate of inflation from 18th to 20th centuries. Performing arts are notorious for this phenomenon. Another example used by Baumol has to do with the number of plays produced in 1 year in New York City. In 1923, there were 228 shows on Broadway, a drop from 1,500 in 1910. Today, there are no more than 25 major shows produced each year in the Theater District. The relative cost of production (largely driven by salary for actors and other skilled workers) accounts for almost all of this difference and is reflected in the ticket prices (now reaching more than $100 for many shows). In the case of performing arts and other discretionary services, the quantity produced simply moves down the demand curve to maintain equilibrium with the higher cost, as perfectly exemplified by our Broadway shows.

In contradistinction to the performing arts, several members of the nonprogressive sector have rather less elastic demand because they are considered to be—and actually are—vital to social and personal well-being. As with the performing arts, there is no way to reduce the number of contact hours required to produce high-quality output. Not only are these services themselves indispensable, but maintaining quality in their provision is politically nonnegotiable. Health care is notable among these and is joined by police, fire protection, postal service, and education. Baumol notes that many such indispensable personal services suffering from "cost disease" become increasingly less profitable to provide, have constant demand, and tend to migrate into the sphere of government. Even after moving into the public sector, the cost of these services continues to rise (albeit more slowly) and requires a larger share of the gross domestic product. This movement to the public sector is already partly true for health care in the United States. Despite a general aversion to "socialized medicine." about half of personal health spending is paid through state or federal programs (33). Federal, state, or local governments generally provide for the other indispensable functions mentioned previously, with small profitable subsets carved out to for private firms (eg, package delivery and private schools). The late Senator Moynihan of New York was a great proponent of Dr Baumol's theories. In a now famous editorial, Senator Moynihan laid out these economic realities at the same time that the Clinton Health Care Plan was being hotly debated (34). Despite a considerable amount of money and a great deal of effort invested in HIT during the past decade, health care remains a handcrafted, labor-intensive endeavor, and this is not likely to change any time soon.

BAUMOL'S COST DISEASE AND IT

Triplett and Bosworth from the Brookings Institution have measured and analyzed non–farm labor productivity since the 1970s (35). They conclude that after a sustained period of slow growth between 1973 and 1995 (1.3% per year), the growth of output accelerated to 2.6% per year after 1995. During this same period (late 1990s), IT investment surged. The authors estimate that the increased IT capability was responsible for just over half of the productivity gains. They cite several other studies that reached similar estimates for IT contribution to productivity in the United States. Similar trends in productivity growth and IT contribution were noted in all other G-7 countries, with the United States having the most robust numbers. In a subsequent article, these same authors looked specifically at the service sector of the US economy with respect to productivity growth and IT contribution (36). The found that the overall productivity growth since 1995 in 29 service industries was virtually identical to the overall figure at 2.5% per year. IT investment played a substantial role (up to one third) in service industry labor productivity growth. However, its role in the post-1995 acceleration was smaller, mainly because the effect of IT investment in these industries was already becoming apparent in the productivity numbers before 1995.

In Triplett and Bosworth's findings about service industry productivity growth, health care stands out in stark relief as one of only 4 of the 29 industries that did not enjoy large increases in labor productivity after 1995 (37). The other three exceptions were entertainment, hotels, and education. I believe that this indicates that health care is unique in the way in which IT will interact with social structure and the nature of the work to produce measurable change in volume and quality of output. I do not want to imply that there is no hope for beneficial effects of targeted IT investment on the efficiency and quality of health care delivery. My point is that the form, content, and styles of IT innovation that have been successful in other service industries do not appear to directly apply to medical care. Baumol's cost disease describes an economic reality inherent in the nature of health care. The relative inability of otherwise successful IT solutions to increase efficiency of health care delivery reflects and underlies Baumol's disease. Both of these phenomena can be viewed as social and economic "laws of nature" that are not the result of human failings, but are simply true. On this view, rather than trying to assign blame, we can accept the constraints imposed by these "laws" and work within them. This means learning to design and implement IT solutions that support health care workers rather than trying to reengineer the cognitive and social structure in which they function.

THE COGNITIVE CONTENT OF HEALTH CARE AND IT

A central debate in the philosophy of science concerns explanations for natural phenomenon. One school of thought (scientific realism) holds that physical processes are exactly determined by natural laws. These laws are universal, and we discover rather than invent them. On this view, imperfection (errors) in our causal models stem from incomplete knowledge of the underlying laws (38). The alternate view holds that many natural processes are intrinsically indeterminate, making exact explanation unattainable. This is exemplified by Hempel's Inductive-Statistical model for explanation (39). Now consider the task of explanation, prediction, and control of human disease with all its incredible variety and contingent nature (40). It is difficult to conceive of how we could ever create generalized deterministic models for diagnosis and therapy, even if this were biologically possible. Further, patients come complete with a unique psychology, personal history, and social situation. Thus the cognitive content of clinical care forms at least a score of staggeringly large and constantly changing domains even when parsed into subunits (ie, medical subspecialties). It can be argued that there is no field of human endeavor that rivals medicine in sheer volume and complexity (41,42). It is equally remarkable that using the basic tools of written and spoken language, expert and experienced clinicians can effectively communicate the details of a case with quite high fidelity and accuracy (43–46). In this context, it seems futile to believe that medical care is "computable" in any meaningful sense. Therefore, the optimal way to use IT in health care is to design and implement systems that complement, extend, and support the cognitive efforts of clinicians.

Consider the basic task of codifying diseases and interventions into constrained language or numeric codes amenable for storage in clinical information systems. The two coding systems currently in general use in the United States are the International Classification of Disease and Common Procedural Terminology. When compared with narrative clinical documents, they are demonstrably inadequate to represent the full extent of concepts needed for use in a comprehensive medical records system (47–51). One reason for this is that the basic purpose of these two clinical coding schemes, as currently implemented, is to produce individual bills for medical services rather than represent episodes of care (17). The system that holds the most promise for general utility in representing medical content is the systematized nomenclature of medicine (SNOMED) (48,51,52). Unlike the numerical systems, SNOMED is basically a controlled vocabulary and a semantic network and, as such, mirrors the complexity of clinical medicine (53). Even given an adequate, standardized, and compatible system for representing medical concepts, there is no way to input this data, short of a human domain expert (ie, physician or nurse) directly interacting with the computer. In a recent article, Ash discussed unintended consequences of overemphasizing structured information entry in health care informatics (12). He cites evidence from studies in cognitive psychology and sociology that in a shared context, concise, unconstrained, free-text communication is the most effective for coordinating work around a complex task (12,54). Overly structured data can lead to loss of cognitive focus by clinicians, both during input and review (55). This can cause clinicians experience a loss of overview about the case at hand when they have to attend to data contained in many different fields, sometimes on different screens within an interface (41,46). Further, the act of writing or dictating in narrative form may be integral to the cognitive processing of the case (56).

Clinical radiology reporting provides a preview of the issues described previously because computer solutions for this somewhat limited domain are rapidly gaining ground in practice. For example, 30% of academic radiology practices already use computer speech recognition systems (SRS) to produce reports (57). This trend will likely accelerate, despite residual problems with recognition errors, cumbersome interfaces, and increased time and effort for radiologists. Marked decrease in report turnaround times and cost savings by eliminating transcriptionists will compel adoption (58–62). Another reason for the relative success of SRS is that these systems replicate and support previous methods of working. The radiologist still dictates free narrative text while viewing images.

An alternate vision for improving radiology reporting is to have radiologists use some sort of menu-oriented system to choose report contents from a complex terminology tree or semantic network to build what is called a "structured report." There are several vendors actively marketing these systems, but only limited adoption by practicing radiologists (63–66). In my opinion, the best approach will be to allow radiologists to still dictate in free-form narrative fashion with modest constraints on word choice and content ordering (67–69). An SRS would then perform the translation into text followed by computer processing to automatically extract codified content (70–74). At most, the radiologist (or an expert in coding) would quickly review the computer output to verify accuracy, a far less onerous task than producing the codes de novo. This is a perfect example of using IT to complement and extend human capability with minimal intrusion on well-established work habits.

THE CULTURE OF HEALTH CARE AND IT

Medical care in the United States is carried out within a complex, highly structured, and quite heterogeneous culture. Dense social networks involve health providers, support staff, facility managers, and patients in a rich array of roles and interactions. As with many social systems, there is a combination of formalized/codified roles and rules alongside a potentially more important informal structure. This culture largely determines the functioning of the work processes involved in delivering patient care. The physician has both the primary responsibility and executive authority over patient care decisions. Other workers in health care organizations have equally important and complementary roles that they fulfill in close cooperation with their physician colleagues. One consequence of infusion of HIT into almost any health care organization is disruption of the culture and the work practices previously in place. Although such disruption is not necessarily detrimental, it certainly can be to some participants. For example, clerical workers might be downsized or have their routine responsibilities drastically altered. Later, I will discuss the possible increase in medical error rates brought on by eliminating human interactions that in the past served to check and refine clinical information and orders for intervention.

The social structure of the health care organization serves to bind the workers and patients in a shared mission with mutually understood values and practices. Health care workers provide validation and support for each other in their sometimes-overwhelming duties. They in turn guide patients and their families through the often frightening and painful task of coping with illness and death. Of course, this social function is executed in variable and imperfect ways but it is fulfilled, at least in part through this social network. In contrast, one popular model for patient care information system (PCIS) design is to have individual health care workers interact directly with the computer system rather than with each other. Human interactions are viewed as intrinsically flawed and to be avoided whenever possible. On this view, health care workers at all levels function more like data entry clerks or call center operators mediating between the patient and the PCIS database. At the limit, one might envision patients directly interacting with computer interfaces to input their symptoms, acquire physiologic data, and dispense medication. This dystopian vision might seem extreme but it is not that far fetched. Consider the observation of one physician working in a Veterans Administration clinic who spends 45 minutes with a patient for an initial visit. Although this amount of time may seem more than adequate, the majority is spent inputting data into a computer terminal with, at most, 10–15 minutes left to actually examine and interact with the patient (Rathe R, personal communication, November 2004). The clerks, nurses, and pharmacists that used to support the care of the patient have been removed from the process, leaving the entire burden of documenting the visit, arranging for tests, checking results, and recording medication regimens to the physician.

Until recently, doctors and nurses had considerable autonomy and authority in most hospitals and other health care organizations that provided direct care to patients. Not only were routine patient care decisions made by physicians in cooperation with nurses and other workers, but members of these professions also served in various capacities to direct the structure and process of care. The social structure and labor-intensive processes of care were well-understood by physicians and nurses—who designed them—and thus amenable to their supervision and control. With increasing reliance on computerized methods for conducting patient care, physicians and nurses can be excluded from their roles in organizing and monitoring their own work process.

Members of the hospital IT management team now control many aspects of the process of patient care and relegate physicians, nurses, and other professionals to the role of "users." Hospital IT managers are often not trained in medicine, but rather computer and information science or engineering (75–77). In some cases, nurses or other providers are promoted away from direct patient care to positions in the IT department of their organization. In either event, these people operate in a different environment, mostly isolated from the reality of direct patient care with its attendant ethics and responsibilities (13). The decisions that hospital IT managers make about what functions the local PCIS will support and how they are implemented have profound effects on almost every aspect of the working environment of direct patient care providers. This can lead to alienation and dissatisfaction among physicians and nurses who feel that their core work processes are disrupted and controlled by invisible, unsympathetic, and unresponsive outsiders (78–81). The literature about computerized physician order entry (CPOE) provides an excellent example of the dynamics between clinical and informatics practices. One can scarcely read past the first page of many articles about CPOE without encountering the terms *physician buy-in* and *users* (82–84). Apparently, CPOE is something that must be "sold" as fait accompli to dubious and recalcitrant clinician "users" by hospital administrators. This construct is presumptuous at best and borders on being insulting. The point is that clinicians should be involved in and responsible for the inception, design, and implementation of CPOE and all other functions of PCIS not just to gain their "buy-in" but because it is the right thing to do (76,85–87).

HUMAN INTERACTION AND IT

As discussed previously, medical decision making and the process of care is carried out in a complex and dynamic social structure. Technophiles like to point out the potential for errors with human interaction and tout computers as being superior. However, the human interactions in health care are not confined to simple transmission of information and execution of orders. The process of gathering clinical information and executing diagnostic and therapeutic interventions has traditionally been distributed across a hierarchy of workers including physicians, nurses, other professionals, and clerical staff. Both peers and those at different levels of the structure serve to prioritize tasks, check for errors, and complete processes for each other (43,75). One consequence—and often a goal—of PCIS design is to reduce interactions between humans. The idea is to make clinical information immediately available to physicians and to have them directly—and without mediation—order diagnostic and therapeutic interventions. However, the intrinsic value of the human interactions involved in conducting health care work is essentially ignored. It is uncontroversial that appropriately conducted group decision making is superior to that of individuals for solving complex problems (88,89).

One example is where nurses or pharmacists routinely correct subtle errors in physician's medication orders (12). Alternatively, a radiologist or technologist may read and interpret the written order for an imaging test in light of particular clinical circumstances and tailor the examination to the patient. In both situations, unless the computer system can be invested with equivalent expertise and flexibility routinely employed by nurses, pharmacists, and radiology personnel, direct entry and unmediated execution of orders may actually increase errors. Another classic example is well known to many radiologists and relates to their relationships with transcriptionists in producing interpretative reports. A naive view of the situation is that the only function performed by radiology transcriptionists is that of converting spoken language into text. On this view, replacing transcriptionists with computerized SRS should be accomplished with all possible speed. Indeed, empiric research demonstrates that report turn around times are significantly reduced almost immediately and transcription costs decrease within a year of implementing SRS (60,61,90–92).

The problem is that the benefits of SRS come at the expense of increased radiologist effort to edit and verify reports during clinical interpretation and these tasks increase reporting times by 50–100% even after considerable experience with the systems (61,91–94). Radiologists quickly recognize—much to their chagrin—that SRS can and does introduce errors during recognition with no warning to the user. A commonly recurring example occurs when the radiologist dictates, "There is no evidence of X" only to have it transcribed as "there is evidence of X." This is the kind of error that is much less likely to be made by a transcriptionist and if detected and pointed out to a human employee, they will rarely, if ever, recur. On the other hand, a SRS will go on making the same mistake over and over again. Further, an experienced and motivated transcriptionist can spot potential errors or inconsistencies in the dictation and point them out. Unlike a computer program, humans can detect errors of content even in syntactically perfect dictation. Another disadvantage to SRS has to do with loss of the transcriptionist as a support person for the radiologist. This consideration is not documented in the literature but, in my opinion, is very real. Many radiologists are in the habit of making verbal requests directed to the transcriptionist at the end of a dictation. For example, the radiologist might say, "please fax this report to Dr. Jones" and be certain that it would be done. To regain lost radiologist productivity, many practices have replicated the role formerly filled by transcriptionists through "radiologist's assistants." These employees shadow the physician during the day to help them by handling incoming phone calls, expediting result delivery, and performing other clerical tasks.

RADIOLOGY SERVES AS AN EXAMPLE OF IT SUCCESS

As I have alluded to, radiology has some unique features as a discipline that allow traditional industrialization techniques realized through IT to be successful over a sizable portion of the work domain. Specifically, the acquisition, storage, retrieval, and display of medical images are all amenable to standardization, automation, and computer methods. Additionally, the American College of Radiology, along with the National Electronic Manufacturers Association, was quite prescient in its early promotion of a robust and widely accepted standard for handling all aspects of the medical imaging process. This standard, now called Digital Image Communications in Medicine (DICOM), has several very useful attributes (95–99). In addition to being unique—it is the only existing standard in the world—DICOM is complete in the domain, open-source, constantly updated, and easy to understand. This means that manufacturers of imaging source equipment, storage systems, distribution networks, and display workstations all know exactly how to interchange images, clinical/demographic information, and even interpretive results. This interoperability allows hospitals and imaging centers to purchase various components for a complete picture archiving and communication system (PACS) in a competitive marketplace with much greater information symmetry than other medical equipment types.

Even with a ubiquitous and fully specified standard, manufacturers build and program equipment with different "flavors" of DICOM. This can require a considerable amount customization during integration of different vendor's components at a single site. The radiology department at The University of Florida committed to fully implementing PACS in the late 1980s and has been quite successful. The key to this success was to hire full-time, specifically trained, doctoral-level informatics experts to guide the process of building and expanding the system. These individuals are intimately familiar with the DICOM standard and know how to work with vendors to ensure that they provide and maintain compliant products. When incompatibilities between equipment types persist or emerge, these local experts modify the integration software to work around the problem. It is important to note that the success of PACS at The University of Florida hinged on two deliberate choices that often conflict with policies favored by many hospital IT managers. The first was to hire expert programmer/analysts that reported directly to the radiology department leadership rather than through the general hospital IT infrastructure. Second was to allow these experts to design software solutions specific to the local environment as opposed to relying solely on commercially available, off-the-shelf software.

The Radiology Society of North America has engaged in an innovative and far-reaching project called Integrating the Healthcare Enterprise (IHE). They are joined by more than 20 professional organizations from around the world in this effort to create standard profiles for critical clinical processes involving images. These profiles ensure availability, usability, and interoperability between image acquisition equipment, PACS, dictation systems, PCIS, and billing systems. The profiles include access to radiology information, basic security, workflow, and charge posting, among others (100). The IHE makes use of preexisting standards (DICOM and HL-7) to describe how these processes will be implemented (101,102). Several vendors have begun to incorporate the IHE concepts into their offerings and pilot/demonstration projects are ongoing (103). The official web site for IHE (http://www.rsna.org/ihe/) contains a wealth of information about the project as well as documentation of all profiles.

LESSONS ABOUT IT FROM OUTSIDE HEALTH CARE

Members of the general business community are well aware of the issues attending IT because they have spent huge sums for equipment, software, and personnel and have realized disappointingly small return on investment. Three influential articles in the *Harvard Business Review* exemplify the hard lessons learned by corporate executives during nearly 20 years of dealing with IT in their organizations. Nicholas Carr's article is provocatively titled "IT doesn't matter," though he means almost exactly the opposite (104). The point is that in the modern business, IT has become vital to routine operation just as transportation and utilities are. Companies no longer can leverage IT for strategic advantage because the core functions are a necessary and ubiquitous commodity. Extending Carr's argument, Feld writes in "Getting IT right" that executives cannot allow themselves to be befuddled by technical discussions and must take firm control of IT in the same way that they manage financial resources (105). Finally, Ross details "Six IT decisions your IT people shouldn't make" (106). Strategic decisions include how much to spend and on what business processes. Executive decisions include deciding how good IT services need to be and how to reach a balance between security and usability (107).

Two trends in software design and engineering are worthy of attention because they relate directly to usability of computer interfaces. Unfortunately, poorly designed interfaces seem to be the rule rather than the exception in PCIS software. Extreme programming is a set of software development practices, originated by Kent Beck (108). Developers work continuously with the customer, anticipate frequent changes to the software, and devise rigorous tests to evaluate when a coding goal is achieved. Design, programming, and testing is done in pairs, with the end user in continuous attendance. The second movement, interaction design, is rather more diverse. Many educators and researchers in the field work out of schools of design in addition to computer science departments. Alan Cooper is perhaps the best-known proponent (109). The ideas behind interaction design include defining the form of products as they relate to their behavior and use as well as anticipating how the use of products will mediate human relationships and affect human understanding. These concepts are realized by exploring the dialogue among products, people, and the contexts that they are used in.

The final lesson proscribes an optimistic and practical balance between uncritical acceptance and blanket rejection of IT in the workplace where everyday people can shape technology to their own needs. These progressive working environments are called "information ecologies" by the authors of two influential books (110,111). An information ecology is defined as a system of people, practices, values, and technologies in a local environment. Both authors describe examples from health care settings (eg, an intensive care unit). The spotlight is not on technology but on the human qualities of expertise, judgment, empathy, and cooperation that are served by technology. Workers in a healthy information ecology help each other to use technology and simple things are done with simple tools. Technology is scaled to individuals and locally responsive. Thus IT is integrated into existing habits, practices, and values. A key player in any information ecology is called a "gardener." These people are not consultants, IT managers, or programmers. Gardeners are insiders and active professionals that can easily translate back and forth between the domain of the work and the technology that supports it. They know their fellow workers and possess sensitivity and understanding about the job and its frustrations. Unfortunately, in many hospitals, clinicians that attempt to serve as gardeners are all too often actively discouraged by IT managers who label them as hackers, troublemakers, and security risks. Working clinicians who show interest in and aptitude for IT should be encouraged and empowered. In fact, these are exactly the individuals that should be making strategic and executive decisions about all aspects of IT in their hospitals and clinics (85–87).

CONCLUSION

The huge investments in time and money made so far for IT in health care have failed to broadly increase productivity or improve outcomes. This is attributable to the cognitive complexity, sociocultural aspects, and labor-intense nature of modern medicine. Baumol's economic theory of differential productivity growth provides a useful explication of these trends. I have outlined how IT, as practiced in many health care settings, interacts with these and other attributes of the practice of medicine. This can lead to disruption of existing social structures and established clinical practices. Adverse outcomes for patients can occur despite the good intentions of everyone involved. As PACS replaces film, diagnostic radiology will become a discipline that is performed almost entirely through interaction with computer systems. Therefore, radiologists must continue to be actively involved with all aspects of planning and execution of IT in their workplaces. The wider business community deals with the same issues and they are beginning to come to terms with IT as a basic necessity. I described several useful trends in software design and social theory that are cause for optimism. By learning from experience and employing common sense, I hope that future adoption of IT for health care will be realized in ways that support and empower clinicians in caring for their patients.

REFERENCES

1. Institute of Medicine. The computer-based patient record: an essential technology for health care. Washington, DC: National Academy Press, 1991.
2. Institute of Medicine. Crossing the quality chasm: a new health system for the 21st century. Washington, DC: National Academy Press, 2001.
3. Office of the National Coordinator for Health Information Technology. U.S. Department of Health and Human Services. Available online at: http://www.hhs.gov/healthit/. Accessed January 12, 2005.
4. Detmer DE. Building the national health information infrastructure for personal health, health care services, public health, and research. Available online at: http://www.biomedcentral.com/1472–6947/3/1. Accessed January 12, 2005.
5. Lock C. What value do computers provide to NHS hospitals? BMJ 1996; 312:1407–1410.
6. Mitchell E, Sullivan F. A descriptive feast but an evaluative famine: systematic review of published articles on primary care computing during 1980–97. BMJ 2001; 322:279–282.
7. Friedman CP, Abbas UL. Is medical informatics a mature science? A review of measurement practice in outcome studies of clinical systems. Int J Med Inf 2003; 69:261–272.
8. Litzelman DK, Dittus RS, Miller ME, et al. Requiring physicians to respond to computerized reminders improves their compliance with preventive care protocols. J Gen Intern Med 1993; 8:311–317.
9. Walton R, Dovey S, Harvey E, et al. Computer support for determining drug dose: systematic review and meta-analysis. BMJ 1999; 318:984–990.
10. Shea S, DuMouchel W, Bahamonde L. A meta-analysis of 16 randomized controlled trials to evaluate computer-based clinical reminder systems for preventive care in the ambulatory setting. J Am Med Inform Assoc 1996; 3:399–409.
11. Bennett JW, Glasziou PP. Computerised reminders and feedback in medication management: a systematic review of randomised controlled trials. Med J Aust 2003; 178:217–222.
12. Ash JS, Berg M, Coiera E. Some unintended consequences of information technology in health care: the nature of patient care information system-related errors. J Am Med Inform Assoc 2004; 11:104–112.
13. Gell G. Side effects and responsibility of medical informatics. Int J Med Inform 2001; 64:69–81.
14. Dean M. Unhealthy computer systems. Lancet 1993; 341:1269–1270.
15. Beynon-Davies P, Lloyd-Williams M. When health information systems fail. Top Health Inf Manage 1999; 20:66–79.
16. Kilbridge P. Computer crash–lessons from a system failure. N Engl J Med 2003; 348:881–882.
17. Kleinke JD. Release 0.0: clinical information technology in the real world. Health Aff (Millwood) 1998; 17:23–38.
18. Sullivan F, Mitchell E. Has general practitioner computing made a difference to patient care? A systematic review of published reports. BMJ 1995; 311:848–852.
19. Littlejohns P, Wyatt JC, Garvican L. Evaluating computerised health information systems: hard lessons still to be learnt. BMJ 2003; 326: 860–863.
20. Rigby M, Forsstrom J, Roberts R, et al. Verifying quality and safety in health informatics services. BMJ 2001; 323:552–556.
21. Sailors RM, East TD. Clinical informatics: 2000 and beyond. Proc AMIA Symp 1999; 609–613.
22. Morrissey J. An info-tech disconnect. Even as groups such as Leapfrog push IT as an answer to quality issues, doctors and executives say, 'not so fast'. Mod Healthc 2003; 33:6–8, 40.
23. Dorenfest SI. A look behind the rapid growth in healthcare IS. Healthc Inform 1997; 14:SS29–SS30.
24. Goldsmith J, Blumenthal D, Rishel W. Federal health information policy: a case of arrested development. Health Aff (Millwood) 2003; 22:44–55.
25. Lundstrom M. Applied physics. Moore's law forever? Science 2003; 299:210–211.
26. DICOM reference guide. Health Devices 2001; 30:5–30.
27. Bidgood WD Jr., Horii SC. Introduction to the ACR-NEMA DICOM standard. Radiographics 1992; 12:345–355.
28. Reiner BI, Siegel EL, Carrino JA, et al. SCAR Radiologic Technologist Survey: analysis of the impact of digital technologies on productivity. J Digit Imaging 2002; 15:132–140.
29. Reiner BI, Siegel EL. Technologists' productivity when using PACS: comparison of film-based versus filmless radiography. AJR Am J Roentgenol 2002; 179:33–37.

30. Reiner BI, Siegel EL, Hooper FJ, et al. Effect of film-based versus filmless operation on the productivity of CT technologists. Radiology 1998; 207:481–485.
31. Baumol RJ. Health care, education, and the cost disease: a looming crisis for public choice. Public Choice 1993; 77:17–28.
32. Osberg L, Wolff EN, Baumol WJ. The information economy the implications of unbalanced growth. Halifax, NS, Canada: Institute for Research on Public Policy (Institut de recherches politiques), 1989.
33. Iglehart JK. Expenditures. In: Longest BB, ed. Contemporary health policy. Chicago, Il: Health Administration Press, 2001: 513–526.
34. Moynihan DP. Don't blame democracy: the socialization of slow-growth jobs. The Washington Post. June 6, 1993; C7.
35. Triplett JE, Bosworth BP. Productivity measurement issues in services industries: "Baumol's Disease" has been cured. FRBNY Econ Policy Rev 2003; 23–33.
36. Triplett JE, Bosworth BP. What's new about the new economy? IT, economic growth and productivity. Int Productivity Monitor 2001; 2:19–30.
37. Varian H. Economic scene: information technology may have cured low service-sector productivity. New York Times. December 3, 2004; C2.
38. Empiricism and scientific realism. In: Curd M, Cover JA, eds. Philosophy of science: the central issues. New York: W. W. Norton & Company, 1998: 1049–1289.
39. Models of explanation. In: Curd M, Cover JA, eds. Philosophy of science: the central issues. New York: W. W. Norton & Company, 1998: 675–803.
40. Murphy EA. The logic of medicine. 2nd ed. Baltimore, Md: The Johns Hopkins University Press, 1997.
41. Patel VL, Kaufman DR. Medical informatics and the science of cognition. J Am Med Inform Assoc 1998; 5:493–502.
42. Patel VL, Kaufman DR, Arocha JA, et al. Bridging theory and practice: cognitive science and medical informatics. Medinfo 1995; 8:1278–1282.
43. Coiera E. When conversation is better than computation. J Am Med Inform Assoc 2000; 7:277–286.
44. Coiera E, Tombs V. Communication behaviours in a hospital setting: an observational study. BMJ 1998; 316:673–676.
45. Coiera E. Clinical communication: a new informatics paradigm. Proc AMIA Annu Fall Symp 1996; 17–21.
46. Patel VL, Kushniruk AW. Understanding, navigating and communicating knowledge: issues and challenges. Methods Inf Med 1998; 37: 460–470.
47. Campbell JR, Carpenter P, Sneiderman C, et al. Phase II evaluation of clinical coding schemes: completeness, taxonomy, mapping, definitions, and clarity. CPRI Work Group on Codes and Structures. J Am Med Inform Assoc 1997; 4:238–251.
48. Chute CG, Cohn SP, Campbell KE, et al. The content coverage of clinical classifications. For the Computer-Based Patient Record Institute's Work Group on Codes & Structures. J Am Med Inform Assoc 1996; 3:224–233.
49. Humphreys BL, McCray AT, Cheh ML. Evaluating the coverage of controlled health data terminologies: report on the results of the NLM/AHCPR large scale vocabulary test. J Am Med Inform Assoc 1997; 4:484–500.
50. Elkin PL, Ruggieri AP, Brown SH, et al. A randomized controlled trial of the accuracy of clinical record retrieval using SNOMED-RT as compared with ICD9-CM. Proc AMIA Symp 2001; 159–163.
51. Chute CG, Cohn SP, Campbell JR. A framework for comprehensive health terminology systems in the United States: development guidelines, criteria for selection, and public policy implications. ANSI Healthcare Informatics Standards Board Vocabulary Working Group and the Computer-Based Patient Records Institute Working Group on Codes and Structures. J Am Med Inform Assoc 1998; 5:503–510.
52. Standards for medical identifiers, codes, and messages needed to create an efficient computer-stored medical record. American Medical Informatics Association. J Am Med Inform Assoc 1994; 1:1–7.
53. Campbell KE, Das AK, Musen MA. A logical foundation for representation of clinical data. J Am Med Inform Assoc 1994; 1:218–232.
54. Garrod S. How groups co-ordinate their concepts and terminology: implications for medical informatics. Methods Inf Med 1998; 37:471–476.
55. Cimino JJ, Patel VL, Kushniruk AW. Studying the human-computer-terminology interface. J Am Med Inform Assoc 2001; 8:163–173.
56. Berg M. Practices of reading and writing: the constitutive role of the patient record in medical work. Sociol Health Illness 1996; 18:499–524.
57. Sistrom CL, Lanier L, Mancuso A. Reporting instruction for radiology residents. Acad Radiol 2004; 11:76–84.
58. Langer SG. Impact of speech recognition on radiologist productivity. J Digit Imaging 2002; 15:203–209.
59. Lauderdale D, Broering NC, Cigtay OS. Speech recognition cuts report turnaround time. Diagn Imaging 1991; 13:196–8, 201.
60. Lemme PJ, Morin RL. The implementation of speech recognition in an electronic radiology practice. J Digit Imaging 2000; 13(Suppl. 1):153–154.
61. Rosenthal DI, Chew FS, Dupuy DE, et al. Computer-based speech recognition as a replacement for medical transcription. AJR Am J Roentgenol 1998; 170:23–25.
62. Vorbeck F, Ba-Ssalamah A, Kettenbach J, et al. Report generation using digital speech recognition in radiology. Eur Radiol 2000; 10:1976–1982.
63. Bell DS, Greenes RA, Doubilet P. Form-based clinical input from a structured vocabulary: initial application in ultrasound reporting. Proc Annu Symp Comput Appl Med Care 1992; 789–790.
64. Kuhn K, Zemmler T, Reichert M, et al. Structured data collection and knowledge-based user guidance for abdominal ultrasound reporting. Proc Annu Symp Comput Appl Med Care 1993; 311–315.
65. Langlotz CP. Enhancing the expressiveness of structured reporting systems. J Digit Imaging 2000; 13(Suppl. 1):49–53.
66. Morioka CA, Sinha U, Taira R, et al. Structured reporting in neuroradiology. Ann N Y Acad Sci 2002; 980:259–266.
67. Sistrom CL, Honeyman JC, Mancuso A, et al. Managing predefined templates and macros for a departmental speech recognition system using common software. J Digit Imaging 2001; 14:131–141.
68. Sistrom CL, Langlotz CP. A framework for improved radiology reporting. J Am Coll Radiol 2005; 2:61–67.
69. Radiological Society of North America. RadLex: overview of lexicon organization. 2003. Available online at: http://mirc.rsna.org/radlex/RadLexOverview.pdf. Accessed January 12, 2005.
70. Friedman C, Hripcsak G, Shagina L, et al. Representing information in patient reports using natural language processing and the extensible markup language. J Am Med Inform Assoc 1999; 6:76–87.
71. Hayes JC. 'Natural language' adds structure to radiology reports. Diagn Imaging (San Fran) 1999; 21:51–53.
72. Hersh W, Mailhot M, Arnott-Smith C, et al. Selective automated indexing of findings and diagnoses in radiology reports. J Biomed Inform 2001; 34:262–273.
73. Sager N, Lyman M, Nhan NT, et al. Automatic encoding into SNOMED III: a preliminary investigation. Proc Annu Symp Comput Appl Med Care 1994; 230–234.
74. Langlotz CP. Automatic structuring of radiology reports: harbinger of a second information revolution in radiology. Radiology 2002; 224:5–7.
75. Ash J. Organizational factors that influence information technology diffusion in academic health sciences centers. J Am Med Inform Assoc 1997; 4:102–111.
76. Lorenzi NM, Riley RT, Blyth AJ, et al. Antecedents of the people and organizational aspects of medical informatics: review of the literature. J Am Med Inform Assoc 1997; 4:79–93.
77. Southon FC, Sauer C, Grant CN. Information technology in complex health services: organizational impediments to successful technology transfer and diffusion. J Am Med Inform Assoc 1997; 4:112–124.
78. Geyer S. Physicians: the key to IT success. Trustee 2004; 57:6–11.
79. Miller RH, Sim I. Physicians' use of electronic medical records: barriers and solutions. Health Aff (Millwood) 2004; 23:116–126.
80. Darbyshire P. 'Rage against the machine?': nurses' and midwives' experiences of using computerized patient information systems for clinical information. J Clin Nurs 2004; 13:17–25.

81. Timmons S. Nurses resisting information technology. Nurs Inq 2003; 10:257–269.
82. Lee F, Teich JM, Spurr CD, et al. Implementation of physician order entry: user satisfaction and self-reported usage patterns. J Am Med Inform Assoc 1996; 3:42–55.
83. Schuster DM, Hall SE, Couse CB, et al. Involving users in the implementation of an imaging order entry system. J Am Med Inform Assoc 2003; 10:315–321.
84. Poon EG, Blumenthal D, Jaggi T, et al. Overcoming barriers to adopting and implementing computerized physician order entry systems in U.S. hospitals. Health Aff (Millwood) 2004; 23:184–190.
85. Wyatt JC. Hospital information management: the need for clinical leadership. BMJ 1995; 311:175–178.
86. Ash JS, Stavri PZ, Dykstra R, et al. Implementing computerized physician order entry: the importance of special people. Int J Med Inform 2003; 69:235–250.
87. Hersh W. Health care information technology: progress and barriers. JAMA 2004; 292:2273–2274.
88. Kerr NL, Tindale RS. Group performance and decision making. Annu Rev Psychol 2004; 55:623–655.
89. Mickan S, Rodger S. Characteristics of effective teams: a literature review. Aust Health Rev 2000; 23:201–208.
90. Mehta A, Dreyer KJ, Schweitzer A, et al. Voice recognition—an emerging necessity within radiology: experiences of the Massachusetts General Hospital. J Digit Imaging 1998; 11(Suppl. 2):20–23.
91. Ramaswamy MR, Chaljub G, Esch O, et al. Continuous speech recognition in MR imaging reporting: advantages, disadvantages, and impact. AJR Am J Roentgenol 2000; 174:617–622.
92. Houston JD, Rupp FW. Experience with implementation of a radiology speech recognition system. J Digit Imaging 2000; 13:124–128.
93. Heilman RS. Voice recognition transcription: surely the future but is it ready? [editorial]. Radiographics 1999; 19:2.
94. Gale B, Safriel Y, Lukban A, et al. Radiology report production times: voice recognition vs. transcription. Radiol Manage 2001; 23:18–22.
95. The DICOM standard. Understanding the benefits, recognizing the limitations. Health Devices 2000; 29:398.
96. Bidgood WD Jr., Horii SC, Prior FW, et al. Understanding and using DICOM, the data interchange standard for biomedical imaging. J Am Med Inform Assoc 1997; 4:199–212.
97. Bidgood WD Jr., Horii SC. Introduction to the ACR-NEMA DICOM standard. Radiographics 1992; 12:345–355.
98. Kohn D. Imaging world shows DICOM standard works. Health Manag Technol 1995; 16:20–24.
99. Mildenberger P, Eichelberg M, Martin E. Introduction to the DICOM standard. Eur Radiol 2002; 12:920–927.
100. Channin DS. Integrating the healthcare enterprise: a primer. Part 2. Seven brides for seven brothers: the IHE integration profiles. Radiographics 2001; 21:1343–1350.
101. Henderson M, Behlen FM, Parisot C, et al. Integrating the healthcare enterprise: a primer. Part 4. The role of existing standards in IHE. Radiographics 2001; 21:1597–1603.
102. Cavanaugh BJ, Garland HT, Hayes BL. Upgrading legacy systems for the Integrating the Healthcare Enterprise (IHE) initiative. J Digit Imaging 2000; 13(Suppl. 1):180–182.
103. Channin DS. M:I-2 and IHE: integrating the healthcare enterprise, year 2. Radiographics 2000; 20:1261–1262.
104. Carr NG. IT doesn't matter. Harv Bus Rev 2003; 81:41–49, 128.
105. Feld CS, Stoddard DB. Getting IT right. Harv Bus Rev 2004; 82:72–79, 122.
106. Ross JW, Weill P. Six IT decisions your IT people shouldn't make. Harv Bus Rev 2002; 80:84–91, 133.
107. Davenport TH, Hammer H, Metsisto TJ. How executives can shape their company's information systems. Harv Bus Rev 1989; 67:130–134.
108. Beck K. Extreme programming explained: embrace change. Reading, Ma: Addison-Wesley, 2000.
109. Cooper Al, Reiman R. About Face 2.0: the essentials of interaction design. Indianapolis, In: Wiley Publishing Inc., 2003.
110. Nardi BA, O'Day VL. Information ecologies: using technology with heart. Cambridge, Ma: The MIT Press, 1999.
111. Davenport TH. Information ecology. New York: Oxford University Press, 1997.

AUTHOR'S POSTSCRIPT

As I was reviewing the proofs of this article, the current issue of JAMA arrived in the mail. Much to my surprise and delight, it contained three articles dealing with the same subject matter. In aggregate, the content amplified, reinforced, and complemented my basic thesis that clinicians must approach healthcare information technology (HIT) with a large and healthy dose of skepticism. First was the report of a study of a computerized order entry system (CPOE) for pharmacy in a large teaching hospital (1). The second was a meta analysis of clinical trials testing the efficacy of computerized decision support systems (CDSS) in clinical practice (2). Finally, an editorial used the first two papers as a springboard for a persuasive argument about how fundamental misunderstandings about the nature of clinical work lead to failed HIT initiatives, disruption of work practices, and sometimes, harm to patients (3).

Koppel et al used qualitative and quantitative methods to assess the propensity of a market-leading CPOE system—60% market share—to foster medication error (1). The rather alarming finding that there were 22 separate types of risk was unanticipated by the authors. At the top of a list of 5 recommendations was to focus primarily on organization of work rather than technology. Another key point was that clinicians can and do work around inherent design problems in the CPOE, thus mitigating risk at considerable cost to themselves. Finally, the authors state, "substituting technology for people is a misunderstanding of both."

Garg et al extended their systematic review of randomized trials of CDSS to include 100 such reports (2). Perhaps the most telling pattern was a strong tendency for investigators evaluating decision support software that they themselves wrote ($N = 74$) to find improved physician performance with the system in question. Seven trials reported improved patient outcome measures and these comprised only 13% of the 52 studies where such endpoints were evaluated. I would note that the 100 studies compiled by Garg et al mostly involved CDSS for a single clinical application. An issue not addressed by the authors is cognitive overload for clinicians caused by multiple reminders and queues popping up as they attempt to get their work done. An analogy with those an-