Effects Of Current And Future Information Technologies On The Health Care Workforce

Health care professionals are assuming the role of “tech support” in explaining medical terms to Internet-savvy patient-consumers.

by Daniel R. Masys

PROLOGUE: The missing lab slip and the missing chart have always been treated as frustrations of medical practice. Jokes about doctors’ bad handwriting are part of popular culture. Textbooks are often not at hand, journals are missing from shelves, and x-rays seem to be misfiled. These, indeed, are all inevitabilities of systems where information is stored dependent on human and logistical consistency.

Medical informatics, the onrushing world of electronically entered, stored, transported, and accessed medical information, will eliminate these “inevitable” imprecisions of the departing world of hard-copy medical information. With this revolution will come an enormous potential to increase the efficiency of clinical practice, reduce human errors, and increase the quality of medical care. Electronic medical information will also democratize medicine. The patient arriving for a consultation with an evidence-based printout is not an unusual occurrence today. Patients contacting—or wanting to contact—doctors by e-mail is becoming commonplace. The role of the “customer” in health care can only grow with the ability to go online to check out a hospital’s performance or a physician’s credentials.

What does this mean for the health care workforce? As with any revolution, there will be winners and losers: those who adapt successfully and those who do not. Daniel Masys, one of the early thinkers and conceptual architects of the medical informatics movement, reviews the stakes and the prospects for the future of the workforce in regard to the changes under way. His description of the coming tectonic changes is compelling, as are his suggestions about the evolving roles of physicians and other health professionals. Recently documented rates of medical errors, he suggests, are the groans of a dying system.

Masys is the director of biomedical informatics and an associate clinical professor of medicine at the University of California, San Diego. From 1986 to 1994 he was director of the Lister Hill National Center for Biomedical Communications at the National Institutes of Health (NIH). In that role he served as the chief program designer and the first director of the National Center for Biotechnology Information, which was established in 1987 to support molecular databases and computer analyses.
ABSTRACT: Information technologies have the potential to affect the types and distribution of jobs in the health care workforce. Against a background of an explosively growing body of knowledge in the health sciences, current models of clinical decision making by autonomous practitioners, relying upon their memory and personal experience, will be inadequate for effective twenty-first-century health care delivery. The growth of consumerism and the proliferation of Internet-accessible sources of health-related information will modify the traditional roles of provider and patient and will provide opportunities for new kinds of employment in health-related professions.

It has been observed that a professional who traveled in time from the nineteenth to the twenty-first century would not recognize many of the tools of a modern business environment, such as e-mail, fax, and microcomputer workstations, but would be instantly at home among the shelves of a hospital’s medical records room. Health care is being overtaken, however, by colossal changes in the environment in which it delivers its services and in the knowledge base of science upon which medical reasoning and health care decisions are made. This paper summarizes current trends in the use of information technologies in support of health care services and envisions how trends in technology and the life sciences will influence the future makeup of the health care workforce.

Health care is an information-intensive activity. From a business-process viewpoint, the health care industry performs only two kinds of actions: medical procedures to support diagnosis, therapy, or disease prevention; and the acquisition, use, communication, and storage of information. Thus, it would be reasonable to assume that changes in the availability and ubiquity of information and information technologies such as computers and the Internet would have disproportionately large effects on health care operations. Instead, the historical record has been one of small or negligible effects on anything other than administrative processes such as billing. While industries that are similarly information-intensive devote 10–15 percent of capital and operating budgets to information technologies, health care organizations have averaged 2–3 percent. Manual, handwritten records are still the mainstay of clinical record keeping, in spite of well-documented problems of legibility, accessibility, and their role in causing avoidable medical errors.

The Flood Of Information And Information Technologies

The terms data, information, and knowledge are often used interchangeably, as if roughly synonymous in the context of the technologies used to manage them. For this discussion, there are differences with important implications. In a health care context, data are those primary facts and observations acquired in the course of providing services, such as the numerical value of a blood pressure measurement or the relating of a family history that a parent died of cancer. Data contribute to and in some cases become information when they inform an assessment or action, such as the diagnosis of hypertension (high blood pressure) or the calculation of risk that a person will develop the same kind of cancer as their parent experienced.
In turn, information can be systematically organized and analyzed to produce knowledge, which is the accumulated understanding of real-world objects and ideas. In this context, knowledge is the framework upon which individual practitioners base their decisions about individuals, comparing the person-specific data and information with the science base of what is believed to be generally true about human health and disease.

These distinctions are important because upheavals driven by information technology occur in the acquisition of data, in the methods for synthesizing data into information to inform decisions, and in the accumulated knowledge base of health-related science. Of these, the most potentially destabilizing to health workforce needs is the explosive growth of scientific publication and growing public access to what had previously been a relatively private reserve.

**Medline and the genome.** Two sentinel markers help to characterize the trends in growth of biomedical knowledge. The first of these is the National Library of Medicine's Medline database, which contains citations to the world's published literature in health-related sciences. Medline includes bibliographic records for articles published in 4,500 journals in thirty languages, dating from 1966 to the present. As of this writing Medline contains about 11.7 million citations and is growing at the rate of more than 400,000 new entries per year. A wry observation about this volume is that a conscientious practitioner who reads two articles each evening will, at the end of a year, be approximately 550 years behind in keeping up with the literature. A more reasonable and disquieting observation is that even if only 1 percent of the new literature is relevant to health care delivery, that same provider is potentially five years behind the current state of knowledge. A variety of studies of the adoption of proven innovations in health care confirm that there is unjustifiable slowness of change and incomplete implementation of best practices, even in the nation's best academic health centers.

This problem, if allowed to persist, will grow worse, because of the other major trend of biomedical knowledge growth: the completion of the “draft sequence” of the human genome in 2001. This event presages a dramatic increase in the amount of data and information that will inform individual health care decisions by providers and patients and a necessary restructuring of the basis on which those decisions are made. The marker for this trend is the volume of molecular data in public databanks such as GenBank, the international repository for genetic sequence data also maintained by the National Library of Medicine and systematically linked to the literature in Medline. Unlike the published literature, which while numbering in the millions of citations is growing at 3 percent per year, molecular sequence databanks are growing exponentially. The most recent full version of GenBank included data on more than fifteen billion molecular subunits, called “base pairs” in molecular genetics parlance, on 14.9 million gene sequences from more than 55,000 different organisms. Human gene information now accounts for about 55 percent of the total molecular data in the database.
**Functional genomics.** GenBank and similar databases of information on the structure of molecules are being supplemented by massive volumes of new information on gene functioning. This is a form of biological science called “functional genomics” that can determine which genes are active in various health and disease states. Laboratory devices called GeneChips and cDNA slide arrays can simultaneously determine, from a few micrograms of tissue, whether each of tens of thousands of genes is “switched on” or “switched off” at a particular point in time. There is provocative early evidence that these molecular signatures of gene activity may be powerful diagnostic and prognostic tools in diseases such as cancer. Some gene activity patterns are more strongly predictive of response to therapy than are any of the clinical tests now performed such as x-rays, blood tests, and tissue examination under a microscope.7

Technologies derived from our newfound ability to understand disease at a molecular level will increase the number of specific types of diseases and the number of therapies from which practitioners must make a selection. For example, instead of two major types of diabetes, we may find that there are dozens based on key differences in the molecular mechanisms that lead to the common finding of elevated blood sugar. Similar kinds of heterogeneity are likely to be found for most diseases. Pharmaceutical companies are using gene sequence information to create new drugs targeted to blocking specific molecules. For common diseases such as high blood pressure, diabetes, and heart disease, a future practitioner may have to select from hundreds if not thousands of potential treatment options.

**“Groans of a collapsing paradigm.”** The dramatic expansion of information to be evaluated, diagnostic alternatives, and therapies to be prescribed is not consistent with the current model of education and information management in the health professions. Effective delivery of health care services will not be able to depend, as it does now, on the clinical decision-making capacity and reliability of autonomous practitioners for classes of problems that routinely exceed the bounds of unaided human cognition. The medical error rates described in recent national studies are the groans of a collapsing paradigm: the traditional model that an individual practitioner’s accumulated personal experience and judgment are the pinnacle of medical effectiveness.8 Embedded in our culture is the notion of “finding a good doctor,” when what we really should be looking for is a “good health care system” that is greater than the sum of its parts and acts on a knowledge base of accumulated best evidence that can change quickly and continuously if necessary.

**The Rise Of Consumerism**

**Impact of the Internet.** Information technologies have fueled another societal trend that will continue to have an impact on the health care workforce. The flag bearer of this trend is the Internet, which brings information access and interpersonal communication on an unprecedented scale to hundreds of millions of persons worldwide. According to the U.S. Department of Commerce, as of September 2001,
143 million Americans, or about 54 percent of the population, were using the Internet, and new users were adopting the technology at a rate of more than two million per month. The continued insinuation of computer and network use into the fabric of society is assured by observations that 90 percent of U.S. children between the ages of five and seventeen now use computers at home and at school. A 1997 survey of Internet users found that 65 percent had sought health information at least once, and more than a third used the Internet to find health information regularly. Among respondents, 77 percent noted that they preferred to get online health information directly from their physician, but fewer than 10 percent of physician respondents had Web pages, and most refused to give out their e-mail addresses.

The sight of a patient sitting in the waiting room reading printouts from health-related Web sites in preparation for presenting them to the doctor has become common in health care settings, a practice that some practitioners encourage and others dread. While serving as speaker of the House of Representatives, Newt Gingrich (R-GA) espoused the vision that sufficiently educated and motivated patients with chronic health conditions will use technical information from the Internet to become more expert than their doctor regarding their condition. Experience suggests that there will also be a substantial number who just think they are. Internet telemedicine services, offshore pharmacies, disease-related chatrooms and e-mail lists, and thousands of conventional and alternative medicine Web sites are the vanguard of a world with many more personal choices than are available today. Anecdotal evidence suggests that for many Internet users with an acute illness, making an appointment to see a doctor has changed from being the first or an early resort to being the last resort, a trend that is strengthened by the rationing of services in managed care environments.

**Digital divide.** The rise of consumerism in health care moves toward positioning the patient as the final authority for choosing among diagnostic and treatment alternatives and the health professional, to a role akin to “tech support” for purposes of explanation of alternatives and interpretation of medical terms and concepts. The replacement of the traditional “doctor knows best” model is far from complete, however. Notwithstanding the publicity given to empowered consumers, there is a substantial fraction of the population who either do not want to or cannot shoulder the responsibility of understanding the intricacies of their health problems and “just want the doctor to take care of me.” This difference in approach has been called a “digital divide,” but it is far more a question of literacy, motivation, and educational level than of access to information technology.

**Effects On The Health Care Workforce**

With so much flux in the roles of patients and providers and in the scope of readily available health-related information, it is perhaps easier to imagine what will not change in the health care workforce than what will. It appears that health professionals who must be licensed to do medical procedures—such as surgeons,
anesthesiologists, radiologists, endoscopists, acute care nurses, and respiratory therapists—could be relatively unaffected by a “knowledge economy” and the open access to information previously accessible only to “members of the guild.” For other health professions, virtually all aspects of traditional roles are potentially in question in a networked global society with a profusion of health-related data, information, and knowledge.

For the foreseeable future, the “graying of America” that will usher the postwar baby boomers into their retirement years will increase the need for health services, both traditional and novel. This demand should fuel growth of all health professions, including physicians, nurses, and allied health professions. The forces of ubiquitous communication and computing technologies and access to information do not appear at this point to be sufficient to cause the extinction of any current type of health professional. Nor does it appear that they will cause the type of downsizing that was experienced in dentistry with the advent of fluoridation and better dental hygiene. Among health professionals there will certainly be winners and losers, however, and the emergence of new categories of jobs. As health practitioners serve as advisers and teachers, their communication and teaching skills will be highly valued by empowered and knowledgeable consumers; failure to communicate effectively will be likely to place a health care provider at an economic disadvantage.

**New Occupations**

Obtaining and synthesizing information from electronic sources are time-consuming tasks, which explains in part why physicians and other health professionals underuse the information sources now available to them. More than thirty years ago a modification of the traditional role of the reference librarian, called the “clinical librarian,” brought an information access specialist into the hospital wards as part of the medical care team, to identify questions related to the care of individual patients for which additional information was needed and to find that information from printed or online sources. Clinical librarian programs have been shown to have beneficial effects on health care outcomes and process measures such as shortened hospital lengths-of-stay. Notwithstanding these benefits, such programs have not come into widespread use, because of lack of reimbursement incentives and physicians’ ambivalence about needing help to find clinical information.

**Informationists.** Frank Davidoff and Valerie Florance recently proposed recasting the clinical librarianship as a new job named the informationist, whose focus would be information retrieval in support of clinical care. They call for the establishment of a national program, modeled on the experience of clinical librarianship, to train, credential, and pay for the services of information specialists in health care practice settings. The countervailing view holds that all health care professionals should be required to have the skills of acquiring and synthesizing the information
necessary to perform their jobs efficiently and effectively, and that knowledge management is so integral to health care decision making that it cannot be usefully segregated into its own subspecialty.

Personal health advocates and advisers. While physicians and other health professionals may not wish to avail themselves of expert help in finding relevant information, it can be predicted that some of the lay public will. Personal health advocate and personal health adviser services targeted at providing tailored education for an individual’s unique combination of health problems and concerns are an obvious commercial opportunity for an educated populace connected by a global Internet. These intermediaries, who would not themselves provide health care services but would help others to understand their medical conditions and also negotiate the complexities of selecting and using appropriate health care services, could eventually have their own basis for credentialing and licensure if viewed by state medical boards as a form of medical practice.

Telemedicine practitioners, presenters, and consultants. New roles and opportunities also exist for telemedicine practitioners. Experience has been gathered for more than two decades on the use of two-way audio and video to provide health care at a distance. Successful “TV doctors” have mastered the elements of diagnostic evaluation via remote technologies and the art of working with geographically dispersed teams of health care providers of various backgrounds to deliver a coordinated set of services. Charisma may not be a prerequisite, but it is already clear that communication styles have a definite impact on patient satisfaction in telemedicine settings, and specialized training is needed beyond that now provided in health professions curricula.

A new role, filled primarily by independent nurse practitioners, is that of “telemedicine presenter.” This is an adaptation of primary care skills where the focus of the activity is to acquire the necessary elements of the medical history and clinical findings so that they can be presented in a telemedicine consultation session with a consultant specialist. The telemedicine presenter is both the patient advocate in the consultation session and the hands of the distant consultant for doing procedures such as placing a stethoscope on the chest or positioning a video camera for a close-up view of a rash.

In support of all of these telemedicine activities, there will be business opportunities for telemedicine process consultants, who advise health professionals on the technologies, methods, and personal communication skills necessary to transform a local practice into a telemedicine-enabled practice. Whether such consultants would need to be credentialed and accredited is yet to be determined.
Continuing Education

The thorniest problem arising from the explosion of medical knowledge and its implications for medical decision making is the retraining of the existing health care workforce. In most practice settings, licensed health professionals can simply avoid information technologies if they so choose. Physicians, nurses, and other professionals who do not use online sources to get up-to-date information are practicing within a professional standard of care that will need to change as the complexity of clinical decision making escalates. In the coming era of “personal genomics,” where one’s own DNA sequence is used to select the correct drug from among hundreds of alternatives, computers will be essential intellectual amplifiers for health professionals. The systematic correlation of treatments delivered with health outcomes, an utterly obvious step for continuous quality improvement that is largely missing from today’s health care environment, other than in research studies, requires the use of standardized electronic medical records. And effective electronic medical records require the direct participation of health care providers in their creation, maintenance, and interpretation.

The health professional who refuses to use a computer is a justifiably endangered species in this emerging environment, but new methods are needed to add competency in information management and technology use for mid-career professionals. This goes beyond simple computer literacy and includes knowledge of the principles of information retrieval, clinical epidemiology, biostatistics, and how to critically appraise the published literature. Since the best teachers are role models, an opportunity will exist for a new specialty within the health care workforce of technology and information science educators, who are themselves health professionals with extensive expertise and experience in the application of these knowledge management tools to health services delivery. Existing short courses and degree programs for already licensed health professionals are harbingers of a more systematic approach to the retraining of mid-career professionals.

How might this process be accelerated? Both carrot and stick approaches could be envisioned. If physicians, nurses, and other providers were permitted to pass on as a reimbursable cost the value of the time spent using information technologies to support diagnosis and therapy, similar to the billable-hours model of the legal profession, there would be a positive incentive to access and apply computer-based information sources. Similarly, regulatory requirements that mandated documentation of the sources used to justify and support a particular diagnostic or therapeutic decision could hasten the more widespread use of information resources. Given the cost containment forces at play in today’s health care environment, regulation appears to be more likely than increased financial incentives.

The growth of biomedical knowledge and the ubiquitous availability of computer-based information access and knowledge management tools will expand the types of jobs in the health care workforce and provide
new business opportunities for support industries. No current category of health professional appears to face extinction, but pressure will mount to abandon the current model of autonomous practitioners depending upon their personal memory and experience to deliver optimal care. Empowered consumers and a glut of health information available via the Internet will lead to continued growth of non-traditional and alternative health products and services and to a remodeling of the relationship between providers and patients. In health care as much as or more than in other human endeavors, knowledge is power, and the redistribution of access to knowledge will mean an inevitable redistribution of power over the decisions that affect the delivery of health care and the makeup of the health care workforce.

NOTES
1. C. McDonald, American College of Medical Informatics Distinguished Lecture, 1996.
11. Newt Gingrich, Health Information Infrastructure 1996 keynote address, Georgetown University, April 1996.