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Strategic IT Applications in HEALTH CARE

Information technology plays an increasingly central role in the U.S. health care industry. A survey by Sheldon I. Dorenfest & Associates of Chicago estimated IT spending on health care in 2002 would be \$21.6 billion [9]. Further exponential growth can be expected as the industry implements further large-scale electronic medical record keeping; provides remote diagnostics via telemedicine; upgrades hospital information systems (HISs); sets up intranets and extranets for sharing information; and uses public networks, including the Internet and community health information networks, to distribute health-related information.

Accordingly, using IT in a strategic and innovative manner to support health-related decision making represents a serious challenge for health care organization management, as well as for systems developers. Traditional, nonstrategic IT focuses on information processing, mostly for well-structured, routine task situations and operational work processes (such as patient data management systems for streamlining patient admissions and bed assignments). Such applications are concerned primarily with improving the efficiency of operational tasks, rather than the effectiveness of strategic and integrative decision processes. In this sense, strategic IT focuses on the information requirements of ad hoc and poorly structured decision tasks. The applications concentrate on giving an organization an IT-based strategy for meeting competitive challenges (such as by using emerging Web technologies to integrate health care organiza-

Besides granting ready access to data warehouses full of patient-care and insurance records, as well as critical medical information, they help management cut costs and remote physicians work collaboratively.

tions internally and externally).

Even so, all stakeholders, including profit and non-profit health care providers (such as hospitals, clinicians, health associations, and private health agencies) and payers (such as insurance companies and health maintenance organizations, or HMOs), as well as employers, practitioners, public health officials, educators, systems developers, and consumers, must prepare for coming changes in these technologies and applications.

Health care and computer professionals must concern themselves with how changes in IT might affect them as both facilitators of IT application development and as health care consumers. As IT facilitators, they must focus on the design and development of applications to capture, organize, store, normalize, and present health information in new ways, as well as replace and integrate existing systems with emerging technologies. As consumers, they must focus on the confidentiality of the doctor-patient relationship and the privacy of patient medical data, along with the technology's security, usability, and political and societal effects.

In light of these changes, health care and computer professionals and consumers of health services need a framework for conceptualizing and understanding strategic IT applications. Our purpose in presenting the following integrative framework is twofold: inform health care consumers as to which technologies play a critical role in

health care delivery and address issues relevant to developers of the technologies.

Strategic IT Framework

Two key dimensions of systems integration (see the figure) may be used to develop the framework:

Internal integration. The degree to which systems and technologies are integrated with one another within an organization; and

External integration. The degree to which systems and technologies interface with outside organizations and agency computer systems.

Computerized patient record (CPR) systems, document management systems, data warehouses, and intranets all potentially enhance the information sharing and integration of internal systems in health care organizations. These technologies are used to help eliminate data redundancy and inconsistency toward achieving the paperless sharing of data throughout an organization. The Internet, along with extranets, networking, and ATM technology, can be used to deliver integrated solutions, linking with outside organizations and agencies.

It is difficult, if not impossible, to definitively classify each emerging technology as belonging exclusively to either the internal or external sets of applications; for example, evolving health/medical informatics and telematics may be considered strategic IT support,

whether for internal or for external integration. Several key for emerging technologies serve to illustrate this conceptualization of strategic IT.

Computerized patient records.

One notable trend in health care IT is the move toward a standardized CPR system with common data formats. Defined as electronically stored information about individuals, uniquely identified by an identifier, CPR technology entails the capture, storage, retrieval, transmission, and manipulation of patient-specific health-care-related data, including clinical, administrative, and biographical detail [8]. The intent is to eliminate the need for data duplication, thereby reducing the cost of maintaining multiple databases. For example, an intranet-enabled CPR system installed in 1997 at Cabarrus Family Medicine in Concord, NC, a practice with approximately 26,000 patients in four clinics, was expected to free up record-keeping time for physicians and residents alike by granting access to patient records through standard browsers. Prior to the system's implementation, the practice's physicians were reported to have spent up to 40% of their time going through paper-based patient records to meet HMO requirements.

As patients consult specialists out of network and out of state, many health care providers implement some aspects of this technology on a wider scale through smart cards similar to drivers' licenses and credit cards for storing patient information. The information can be updated periodically, and

patients can take them wherever they go for medical care. Combined with Web-based retrieval, smart cards help facilitate the portability of and access to online information.

The West Palm Beach Veteran's Administration Medical Center in West Palm Beach, FL, began in 1995 to pare down all its medical records and associated paperwork to approximately 200 clinical and 1,000 administrative electronic forms accessible through computers in screening rooms and nursing stations [6]. These forms enable physicians to point and click to enter the results of any type of examination or to issue prescriptions. The system has reportedly made it possible to substantially reduce the Medical Center's physical file storage costs.

Document management and data warehouses. Under financial pressure from managed-care medical services and insurers, health care institutions increasingly turn to such technologies as document management systems and data warehouses to collect

and administer clinical and financial data online. Document management technology includes document imaging, workflow, electronic forms processing, mass storage, and computer output to laser disk. Data warehouses involve large stores of data for strategic decision support; for example, an analysis of patient data can reveal patterns of symptoms related to specific diseases.

Hospital CEOs increasingly realize the only way their organizations can compete in a health care market dominated by managed-care providers is to learn to manage their own information, knowledge, and documentation. Thus, many senior managers, as well as physicians, nurses, and staff, seek quick and affordable ways to tap available information banks of detailed patient records. Data warehouses are becoming crucial, as the industry moves from a business model based on revenue to one based on cost-outcomes information management.

Many hospitals, both public and private, need document management to handle the paper-intensive process of collecting and filing patient information; for example, the San Jose Medical Center in San Jose, CA, began in 1992 to address the challenge of accessing medical records speedily and making record management more efficient by using a LAN to link its document management software, relational databases, and imaging equipment. Management reported dra-

matic results, allowing the center to reduce its staff and increase revenue by handling external record requests directly.

St. Vincent's Hospital in Birmingham, AL, began in 1995 using a new image-based client/server system to reduce the time needed for patient registration and insurance verification, eliminate some business office staff, increase registrations, begin to sort all patient records and insurance information online, and reduce delayed payments into accounts receivable [3]. The system converts paper-based records into electronic images; this data, in turn, was merged with data from a mainframe-based HIS and other departmental, laboratory, and pharmacy

systems to form a comprehensive CPR system.

The Johnson Medical Center in Johnson City, TN, determined in 1996 it would need a data warehouse to enable it to study historical records of patient treatments, especially to spot trends and anomalies.

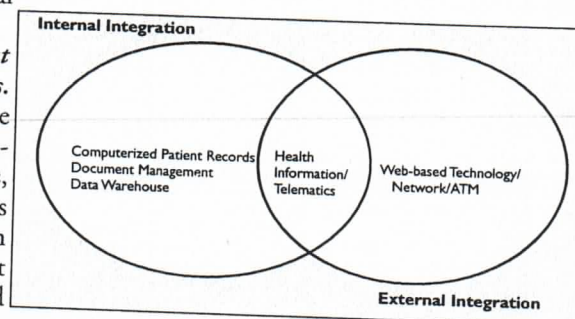
The goal was to generate report cards about physicians, thereby measuring the cost of each one's services at the hospital in terms of types of treatment

An integrative strategic IT framework.

performed, time spent with patients, and other factors. The data could be used to analyze the cost of each treatment vis-à-vis the amount of money paid by insurers.

In 1999, the U.S. Department of Defense planned to deploy what DoD officials said would be the largest known medical data warehouse [2]. Called the Computerized Executive Information System (CEIS), it was expected to eventually hold the records of more than 8.5 million active members of the U.S. military health care system treated at approximately 115 hospitals and 461 clinics around the world. Beginning in 1995, it had already been converting its fixed-cost health care system to a managed-care model to lower costs and increase care for active military personnel, retirees, and dependents.

Web technology. In information-intensive societies like the U.S., health care consumers need and want as much information as possible concerning their consultation and treatment options and therefore increasingly demand access to relevant and personal health information. HMOs have added tens of millions of members over the past several years, driven by competition and the potential for profit. From a provider perspective, they need information to analyze the out-



comes and costs of various treatment plans. The Internet plays a crucial role in bridging the gap between health care providers and consumers by making available the required information.

There are likely many examples of how the Internet provides relevant information to the various health-system constituencies, including consumers, physicians, and health care managers. A notable strategy for an HMO to provide value-added customer service is to give users, including patients, physicians, and hospitals, access to online insurance service data; for example, providers and recipients of a service may track their patients' insurance claim processing via the Web. The advantages of electronic filing of insurance benefits and claims include reduced costs for the HMO and its network of hospitals, physicians, and corporate clients, while improving access and usability for its customers. It may also reduce agency and labor costs while helping provide insights into health care trends and medical practices.

Blue Cross/Blue Shield of Massachusetts began offering Web servers and on-site multimedia kiosks in 1995 in Boston and Worcester, MA, facilitating access to online insurance services; users have access to information about Blue Cross services, as well as about health care and medical issues. The kiosks allow users to search and print physician and hospital database information, peruse details about drugs and treatment alternatives, and learn the specifics of Blue Cross services. The kiosks also provide telephony links to customer-service representative and member services. One aim is to significantly reduce the cost of in-house insurance support and education by directing employees and customers to the Web site and kiosks. A good number of HMOs also provide access to insurance and health data via the public Web.

To date, both intranet and extranet technologies have been tapped by a growing number of hospitals for in-house and external sharing and distribution of medical information. Geisinger Health Care System in Danville, PA, was described in *PCWeek* as an industry leader by leveraging IT networks and intranets to reinvent the health care delivery process [5]. Its system concept includes the extension of intranets for use by patients; for example, a service called Tel-a-Nurse allows patients to call in medical questions to be answered by nurses accessing relevant information via the intranet.

Networking and ATM technology. The benefit of the technologies cited here can be augmented strategically through electronic and digital networking—a logical next step for health service delivery. Understanding and developing the technology is critical, especially from the perspective of managed care, as

multiprovider organizations vie to provide integrated delivery of health services along the entire care continuum; for example, the Orlando Regional Healthcare System in Orlando, FL, began in 1996 to build an integrated delivery network, a form of one-stop shopping for all types of health service in response to its need to reduce costs while continuing to market its services.

On the other hand is virtual health care, or networks of coordinating partners in which each one does only what it does best. As each partner's information needs are often similar, they tend to invest in distributed, client/server networks and OO technology to deliver the necessary links. From a health-organization perspective, the closest thing to a health network is the electronic data interchange hospitals employ internally among their admissions, clinical, and accounting departments, as well as externally with insurers. In some cases, hospitals have given admitting physicians online terminal-based access to patient records; another alternative is a system that follows patients through each encounter with a medical professional.

Asynchronous transfer mode (ATM) network technology handles multimedia applications without degradation—an ideal service for integrated telemedicine through its support for fast transmission speeds and multiple traffic streams. Radiology and teleradiology are among the applications that benefit from ATM technology; for example, Rush-Presbyterian/St. Luke's Medical Center in Chicago began in 1995 developing an ATM backbone network for its radiology department. Meanwhile, St. Paul's Hospital, a teaching hospital at the University of British Columbia in Vancouver, uses an ATM backbone network to connect its pulmonary research laboratory with physicians outside the hospital. The network enables the two groups to study the same test results and speed patient diagnosis (such as when diagnosing diseases of the lungs). The hospital wants to make it possible for researchers in the laboratory and physicians located elsewhere to collaboratively view slides and X-rays, trade data, and compare findings online.

Medical informatics and telematics. Medical informatics (including medical telematics) is concerned with "the cognitive, information processing, and communication tasks of medical practice, education, and research, including the information science and technology to support those tasks" [1]. More broadly, it emphasizes clinical and biomedical applications of the various technologies surveyed here with the added option of integrating the clinical components either among themselves or with administrative-type HISs. In this regard, the field of health/medical informatics and

telematics has evolved rapidly over the past several years.

A number of clinical applications employing artificial intelligence, neural networks, and fuzzy logic techniques are being developed to give physicians clinical decision support. Dealing primarily with information used in medical decision making, they aim to assist physicians and other medical experts in diagnosis and treatment. Health decision support systems and more specifically clinical decision support systems and expert systems are used in many of these applications [10]. Accordingly, we focus first on general applications, followed by more specific expert system applications and more integrated applications; our discussion of health telematics focuses mainly on telemedicine, a key application.

An example is an interactive videodisc system that helps enter personal health data to weigh the pros and

common ailments, including indigestion and allergies, via telephone 24 hours a day. Responses are based on the caller's self-reported symptoms and consultation history, along with the latest medical research. The system tracks the improvement or deterioration of the patient's condition during follow-up calls. An expert system designed to spot irregularities in physicians' bills was implemented in 1992 at Fortis Benefits Insurance Co./Woodbury in St. Paul, MN; it reportedly saves the company an estimated \$540,000 a year in incorrect billing [4]. LDS Hospital in Salt Lake City, UT, uses an automated patient information system to detect adverse drug events, including allergies, unpredicted drug interactions, and dosage problems. The system reportedly flags adverse drug events 60 times better than its human-practitioner counterparts.

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cons of surgery as a treatment option. Such software may promote shared decision making and promise improved quality of care without increasing costs. Richard Foster, MD, medical director of a 40,000-member HMO operated by South Carolina Blue Cross/Blue Shield, implemented such a system in 1992. Patients and physicians who have used it report it enhanced their physician-patient relationships. Others trying similar programs include Massachusetts General Hospital in Boston, Dartmouth Hitchcock Medical Center in Hanover, NH, the Veterans Administration, as well as several regional Kaiser Permanente HMOs. In yet another example, Tufts Associated Health Plan of Waltham, MA, installed a homegrown PC-based system in 1992 to access data more efficiently.

In the area of expert system-based applications in medical diagnosis and treatment, the Patent Watch section of *Computerworld* reported the issuance of a patent for a computerized system for more accurate monitoring of the fetal heart during the human birthing process [7]. Data is fed into a rule-based expert system and neural network that classify the situation as normal, stressed, indeterminate, or ominous. In another such application, a computerized voice-response system provides medical advice for

Telemedicine is a key aspect of health telematics, connecting geographically dispersed health care facilities via videoconferencing, telecommunication, and digital networks to perform long-distance medical diagnoses. One notable use of the technology is to access patient records on film (such as magnetic resonance imaging) to perform remote clinical diagnoses and surgeries. The technologies two major benefits are lower cost of health care and online access to top medical experts worldwide; other benefits include medical education and intercontinental health care.

Allegheny Health Education and Research Foundation in Pittsburgh, PA, began in 1994 to develop high-speed, digital multimedia networks. The aim was to link major health care and teaching institutions throughout Pennsylvania. NeuroLink, a network of 20 domestic and six international sites connected to a central receiving station via public telephone lines expedites emergency neurosurgery consultations. Neurosurgeon Julian Bailes is reported to have remotely diagnosed more than 100 patients and saved more than \$500,000 in transportation costs over several years. Affiliated institutions share computerized tomography scans, magnetic resonance images, X-rays, and other medical data. In a follow-up phase of the project brain surgeons will be able to

interact with medical students in Philadelphia while conducting surgery in Pittsburgh. The network has also been extended to the Medical Consultation Center in Cairo, Egypt, a clinic operated by Egyptian neurosurgeon Amr Mansy.

The telemedicine system at Pathway Health Network uses videoconferencing to link a number of hospitals in the Boston area, fostering strong physician-physician relationships across participating hospitals. Initially used to facilitate consultations among physicians, another newer goal is to improve delivery of patient care by lowering costs and increasing market share.

Conclusion

The health care industry increasingly views IT as a fundamental asset in providing health-related information services and decision support on demand, as well as in managing rising costs and changing organizational needs, improving the quality of health services and patient care, and fighting illness while promoting wellness. Instead of relying on handwritten notes buried in paper files, doctors, nurses, and other health care professionals now turn to various forms of IT, including CPR and document management systems, data warehouses, point-of-care applications, distributed networks, and telematics, to provide the information they need when they need it.

Demand is motivated by recent changes in the health care industry and its approach to delivering patient care. The strategic IT applications reviewed here suggest how far IT has come in the field of health care computing. We expect future breakthroughs in integrated systems, intelligent networks, and robotics. Indeed, the ability to integrate clinical and administrative information about patients means physicians are more able to provide care at lower cost to all parties; for example, integrated decision-support systems can provide health professionals in distributed clinical settings online real-time histories of patients in master patient index databases.

These systems will also let physicians and hospital management track and analyze patient care histories, test results, and cost information. Typically, such applications combine data warehouses, electronic data entry, messaging, and GUI tools. The strategic use of intelligent networks to automate patient recordkeeping and provide integrated patient care, timely decision support, and remote consultation, as well as expert knowledge in specific domain areas, promises to help lower the costs of treating complex case-mix groupings while improving the quality of the care actually delivered [1].

However, these applications also reflect weaknesses

in the security of patient data. The prospect of storing health information in electronic form prompts questions about standards, ethics, patient privacy, data confidentiality, and security. Lacking proper controls, procedures, and policies, these systems might tempt unauthorized users to try to access and even misuse information associated with legitimate users. If such concerns are not addressed, the health care industry could be discouraged from exploiting IT, and health-care consumers will hesitate to share their personal medical information.

Overall, the U.S. health care industry's strategic integration of IT promises to revolutionize health care delivery while opening new areas for applications and research. **C**

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