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Binshan Lin
Louisiana State University

Chang-Tseh Hsieh
The University of Southern Mississippi

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Binshan Lin
Louisiana State University - Shreveport

Chang-Tseh Hsieh
The University of Southern Mississippi

ABSTRACT

Health care has long been known as a field that embraces and exploits new information technology, and this trend shows no signs of slowing down. The healthcare industry is likely to be one of the largest beneficiaries of the Internet technology. This paper addresses four critical infrastructure issues: technological infrastructure, intranet development, financial infrastructure, and quality concerns. Service opportunities and practical problems are discussed that will provide managerial implications in health care and future research opportunities.

INTRODUCTION

Two fundamental revolutions now underway are challenging the healthcare industry. One is the profound restructuring of health services, and the other is the information technology revolution. At the core of these challenges is the Internet. The Internet is one important example of how the application of information technology continues to advance health care. The Internet has the potential to change virtually every aspect of health care process, including quality of care, advertising, pricing, word-of-mouth influence, delivery process, and service development.

The role of the Internet in healthcare can be approached in two different ways. First, there are applications based on the Internet by design. This means that the Internet plays a decisive role in the design of the technology application itself. For example, the Internet is essential when there is a need in the real time performance. Such an application would be very difficult to implement without the Internet. Second, the Internet is nice to have, or it is instrumental for participating to the virtual health care world based on different health care conditions.

Since the Internet is evolving from technology-driven to user-driven, it is crucial that the needs in the healthcare industry arise for better identification and definition of such a gear-shift. Two kinds of users can be identified: *end users* and *intermediate users*. *End* users can be

identified mainly with the healthcare providers and professionals (physicians, nurses, etc.) and with the patient-citizens (elderly, disabled, family of patients, etc.). According to a national survey, health care providers are the largest group of customers who access National Library of Medicine (NLM) electronic databases (such as Medline and Grateful Med). Interestingly, almost half (49%) of the health care providers go online from home other than workplace (Wallingford et al., 1996).

On the other hand, intermediate users include managers and promoters of the Internet applications in the healthcare industry. They can be identified mainly as those more or less professionals working in the field of healthcare policy planning over the territory, either at private or public level. It is worth devoting great attention to this kind of users since they can play the strategic role in promoting the Internet in the healthcare industry.

Health care has long been known as a field that embraces and exploits new information technology, and this trend shows no signs of slowing down. With a few notable exceptions, the health care industry has neither been able to quickly adopt the Internet technologies nor to define and measure the value of their use (Nukis, 1997). To understand how health care can accelerate its pace of Internet adoption, much can be gained by examining how the health care industries are using these technologies to increase their organizational value. In the next section, functions of the Internet in health care are investigated. This paper then addresses four critical infrastructure issues. Service opportunities and practical problems are discussed that will provide managerial implications in health care and future research opportunities.

FUNCTIONS OF THE INTERNET

According to the 1996 HIMSS/Hewlett-Packard Leadership survey of 1,200 health care information technology professionals, the Internet is used mostly in health care to support clinical research (55%) and facilitate communication between physicians (33%), as well as offer health care information about providers to consumers (24%). Thirty-seven percent of respondents said that upgrading Internet infrastructure has been the first information technology priority of their organizations. Some providers are even beginning to use the Internet for registering patients, directing patients to alternative care sites and transmitting medical results (Smith & Olson, 1997). Mainly, health care organizations can accomplish several tasks by being on the Internet.

1. *Employ the Internet to circulate information.*

   Health care today depends on timely access to patient medical data and the latest health care knowledge. Millions of people are going online to investigate medical options that they haven't found through traditional channels, arming and empowering themselves with the kind of knowledge essential for sound decisions about their own health. With the explosive growth in the Internet connections worldwide, networked communication has the potential to shrink geographic distance and facilitate health care information exchange among people of varying backgrounds. The Internet can be a powerful tool for consumers seeking medical

information, and some physicians act like medical librarians in helping consumers find resources they need.

It is envisioned in healthcare to provide an online version of an individual's complete medical history. Structured data, as well as X-ray images, physician notes, and a variety of unstructured data, could be made instantly accessible to the appropriate healthcare providers, regardless of the geographic location where treatment is to be administered. Realization of this vision requires that all information about a patient's medical records including treatments, lab results, drug prescriptions, adverse reactions, and links to hereditary medical histories be stored in online databases with instantaneous access around the world.

The American Medical Association (AMA) has a database of 650,000 licensed U. S. physicians, known as "physician select" *(http://www.ama.assn.org)*. Users can look for a doctor by his or her name, location, or specialty. Physicians in Massachusetts who mine the Internet, along with those who don't, are themselves to become the focus of a landmark Web site showcasing the malpractice and disciplinary records *(http://www.massmed.org/media/index.html/)*. Putting more healthcare information on the Internet, as Massachusetts has chosen to do, is the wave of the future.

Sponsored by the U. S. Department of Health and Human Services, Healthfinder serves as a point of entry to a broad range of consumer health resources produced by the federal government and its partners. The site *(http://www.healthfinder.gov)* suites those seeking basic health care information as researchers and clinicians. As another example, people can log on to the Centers for Disease Control of the U. S. Department of Health & Human Services to get information about what shots and pills one needs to take (Brousell, 1997).

2. *Internet as a marketing tool.*

Health care organizations can make their presence known to both patients and physicians in their community by developing a Web site. Consumers are able to use the Internet for information on choosing and using health plans. The Agency for Health Care Policy and Research and the Health Insurance Association of America have compiled an electronic guide at *http://www.ahcpr.gov/* that presents the basics of comparing plans for services, providers, location, costs, and quality.

3. *Provide added value.*

The Internet implies that a culture once based exclusively on physical contact is being transformed into one where health care services are accessible without face-to-face contact with the providers.

The Internet would not only provide full information to users about goods and services, but also lend itself to rich details and added value to the business process. Electronic mail, for example, allows the end users to exchange medical information freely. The Internet transfers many types of information between end users and intermediate users. Users can

browse the Internet searching for medical news, physician records, reference material, commercial and consumer products and services, and other sources of information. Users also become information sources as they transmit information using their keyboards and/or other input devices. Patients can respond to patient satisfaction surveys, send questions and comments to health care providers about services, or download files immediately.

The World Wide Web (or the Web) technology is a subset of the Internet technologies. This multimedia technology, embodied in browsers such as Explorer or Netscape allows an organization or an individual to make information instantaneously available throughout the world at low cost. The Web technology is envisaged to lead to the redesign of health care information flows and service process, to help hospitals capture strategic advantage, to establish new health care distribution channels, and to create new information-based service for patients.

INFRASTRUCTURE ISSUES

An appropriate infrastructure is necessary for the development of the Internet in the healthcare industry. Infrastructure is context for both communication and learning within the computing network (Kling & Scacchi, 1982). The domain of Internet infrastructure can be defined in terms of three dimensions: (1) technological architecture - computer hardware, software, people, and task together make an underlying base or supporting structure, (2) process - concerned with the information processes central to the operations of the Internet, and (3) financial infrastructure - dealt with the transactions and transmission of electronic money on the Internet. In the dimension of technological architecture, the Internet infrastructure involves the hardware, software, databases, and telecommunication services (Kalakota & Whinston, 1996).

1. *Technological Infrastructure*

   Consider hardware and software. Standardization across healthcare providers for critical information is still much less than idea; even the integration of medical, pharmacy, and other health care information is big undertaking for many health care providers since the silo systems exist in most larger organizations.

   In many application domains such as medical imaging, there is a great need for storing, retrieving, and managing vast amounts of image data, as well as descriptions or annotations that correspond to these images. While traditional databases are inadequate for managing data other than textual data, current multimedia database technology can provide satisfactory solutions. The latest trend is to design searchable image dadaists where the user can search for a specific image, or retrieve a set of images that satisfy certain characteristics. Srinivasan (1994) describes an on-line database that has been developed at U. S. National Library of Medicine, a component of the U. S. National Institute of Health. This system stores biomedical information along with medical images. However, it provides only lim-

ited support for retrieving images based on random browsing, searching by frame number, and searching using text expressions.

This new breed of databases allows the end user to store not only structured data, but also non-structured data such as free text, graphics, full motion video, etc. The data stored in these databases often need to be shared by groups of scientists and researchers who are geographically dispersed, and requires a good graphic interface for searching and retrieving.

Providing Web interface to existing databases improves information dissemination. By making these databases accessible through the Web, we not only improve accessibility, but also provide a uniform user interface. This will increase the amount of information available on-line. However, the sheer volume of information makes it difficult to obtain useful information on the Internet. As a result, information retrieval becomes a major problem. For example, in a medical image database environment, the database may contain millions of images which have to be classified using certain facets, and the health care practitioner has to muddle through this classification to retrieve pertinent images.

The infrastructure of the Internet, the current equivalent of a global infrastructure, has acknowledged problems. The issues hinge on the provision of sufficient bandwidth for the surging use, and on the problems fostered by the Internet's decentralization nature. The provision of sufficient bandwidth of the telecommunication infrastructure is considered a serious limitation by many researchers. Currently the Internet 2.0 backbone operates at 45-155 megabytes per second. This capacity may be sufficient to support the World Wide Web (Bell & Gemmell, 1996), but is not adequate for the massive use of video-on-demand in the healthcare industry.

2. *Intranet Development*

An intranet is a corporate network and the business applications that run on it that share the DNA of the Internet computing technologies (e.g., Internet Protocol, browsers, Web servers) and exists behind the corporate security firewall (Guengerich et al., 1997). Intranets, a by-product of the Internet, demonstrate the "any-to-any" connectivity in corporate networks which support the collaborative work and flat organizational structure. Healthcare organizations that have installed or are developing intranets include Columbia/HCA, Kaiser Permenante, Catholic Health Corp., Voluntary Hospitals Assn., Intermountain Health Care, Premina Health System, the Mayo Clinic, and Baylor Health Care System.

The intranet is becoming a vital means of providing documents to support the administration of academic medicine and, in many circumstances, the delivery of patient-specific information (Frisse, 1996). Intranets include Web pages with Continuous Quality Improvement (CQI) procedures, resource information, training materials, idea submission forms, and on-line patient satisfaction surveys. Team communication can be communicated by e-mail and made accessible via news groups. Baylor, for instance, found that their intranet has cut the time and paper that pharmacy contract negotiations once consumed.

Intranets are compelling and beneficial only to the extent that they overcome some cultural inhibitions about the sharing of information (Bernard, 1996). Some hospitals like the idea of information sharing. The intranet thus will fit hand-in-glove with the corporate culture. On the other hand, some hospitals view information as something that must be guarded. For them, an intranet will be molded to restrict information access. How to control, share, and organize an intranet is critical culture topic since it affects key policies such as security, interaction, moral, self-image, and infrastructure limits (Lin & Clark, 1994).

3. *Financial Infrastructure*

Financial infrastructure of the Internet pertains to all necessary arrangements to handle the transmission of electronic money. Healthcare business is just like other business. All transactions must be complete with the payment made in some forms of financial instruments. However, unlike those physical financial instruments, electronic money is in the form of bits. The value of an electronic financial instrument thus can be easily duplicated and stolen.

To provide a mechanism for all parties in healthcare business to fulfill their financial obligations through the Internet, the following must be incorporated into the physical infrastructure supporting the healthcare management (Camp & Sirbu, 1997).

a. Durable Storage--Since value of the electronic money can be duplicated without involving the creation of new money, durable storage for electronic value of a financial instrument must be made available to all parties of the healthcare system. Thus, when one's system crashes, the stored value of the financial instrument will be permanently lost.

b. Interoperability--The selected electronic financial instrument must be widely used or can be easily converted to a standard form.

c. Reliable Transaction Management System--On the Internet, data about payment will travel over an open network. This means a payment could be duplicated, altered, or lost during its transmission.

4. *Quality Concerns*

Almost every facet of health care in America is being reshaped by online access, from prescription facts to experimental treatments for rare diseases. The Internet has potential to become the ultimate self-help resource. However, before one declares the Internet a panacea, its potential for misinformation will remain a cause for concern, especially when it comes to medicine.

Some advice givers have impeccable credentials and offer sound, authoritative information. Others may not even have medical licenses. In any case, it is difficult or impossible for consumers to judge the quality of information they obtain on the Web. For example, when one visits the Virtual Doctors web site, it immediately asks visitors to fill in a credit card

payment form and a questionnaire about symptoms. Nowhere does the site list the credentials of the physician whose name appears prominently on the home page. Virtual Doctors' disclaimer warns that their health care information is "for entertainment and informative purposes only." Even Vice President Al Gore, a seasoned Internet user, cautioned that "Online consumer health information is a mixed blessing because finding high-quality information that is accurate, timely, relevant, and unbiased is a daunting challenge to even the most experienced Web surfer."

SERVICE OPPORTUNITIES

Part of the excitement of the Internet stems from its making possible many types of services that either have not been previously available or have been based on closed systems that never took off to saturate markets (Roche, 1995). Managers must also see how the Internet is changing customers' behavior in order to assess how to meet their demand tomorrow (Lin, 1996). Via the Internet, consumers can trade product/service information with other consumers, experiment with new products before they buy them, or join forums.

Rural health care professionals can have access to medical information equivalent to their urban peers. For example, rural physicians in Vermont and New Hampshire are heading into the online fold with the help of computer-savvy medical students from Dartmouth-Hitchcock Medical Center in Hanover, Vermont (Engstrom, 1996). The program rotates each computer/Internet-literate student through the office of a "preceptor" physician who refers frequently to Dartmouth. As the preceptor provides clinical instruction, the student can demonstrate the use of Dartmouth's multimedia patient records and explain how the physician can communicate with Dartmouth doctors who are seeing his/her patient.

Aetna/U.S. Healthcare saves manual labor and cost with an Internet-based service that allows members to change their primary care providers on-line. The University of Kentucky Chandler Medical Center uses the Internet to provide emergency room personnel with quick access to patient histories.

HealthAnswer, a service of Orbis Technology Group (Chicago) uses push technology to deliver personalized health care information to health plan members. No information is pushed directly to the customers, but when they visit the home page of their HMO and complete a questionnaire on health-related interests, HealthAnswer then creates a personal home page for that member. When accessed, it presents up-to-date information on topics in those interest areas drawn from a resource databank. Information comes from experts such as the American Academy of Family Physicians and the National Health Council. HealthAnswer can also push provider locator maps and notices of local health events using member's postal ZIP codes.

Schering-Plough Healthcare Products is using its consumer-oriented Web site *(http://www.myhealth.com)* to market Vitractin, an over-the-counter remedy for cold sores. The site has generated more than 20,000 requests for free samples. Visitors also obtain news updates and

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peer support via the site, which has a monthly "kiss-n-tell" contest that rewards winners with promotional items.

With the ever-expanding capabilities of the Internet, it would be technically feasible to provide access to the medical expert systems by end-users--that is, patients. Did you hurt your back rollerblading? Try accessing a lower-back pain expert system for some self diagnosis and treatment before contacting a medical practitioner. Some managed care organizations are starting to use E-mail systems to determine whether or not the patient should come in to the doctor's office and in some cases are even treating patients remotely.

CONCLUSION

As the infrastructure becomes more highly developed, nontechnological aspects of strategy become more critical in overall hospital effectiveness (Lin, 1993). Ultimately, the effectiveness of the Internet will depend on its consistency with other aspects of hospital strategy. Most hospital managers appreciate the logic of having a good Internet infrastructure that supports corporate goals. However, many existing Internet infrastructures reflect the ad hoc developments of enthusiastic individuals rather than edicts of a cohesive corporate plan. A shared vision of what is required and how it is to be achieved, along with the commitment from top management, are crucial factors for successful applications of the Internet in the healthcare industry.

The Internet infrastructure could play a positive role within the various medical groups, by allowing horizontal distribution of information and communication, reducing hierarchies and promoting a "democratization" effect.

The management and utilization of the Internet is critical in health care just as in other industries. What may diminish the effectiveness of the Internet is the overall poor quality of available data and the relatively low investment in information technology (IT) infrastructure in the healthcare industry as compared to other industries. A well-developed infrastructure is needed to take full advantage of the Internet in the healthcare industry. For better or worse, the Internet has grown and changed. As we build our bridge to the future, it is a challenge to all healthcare managers to manage this tool in the most positive way.

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