3-2003

Health care informatics

Keng SIAU
Singapore Management University, klsiau@smu.edu.sg

Health Care Informatics

Keng Siau

Abstract—**The health care industry is currently experiencing a fundamental change. Health care organizations are reorganizing their processes to reduce costs, be more competitive, and provide better and more personalized customer care. This new business strategy requires health care organizations to implement new technologies, such as Internet applications, enterprise systems, and mobile technologies in order to achieve their desired business changes. This article offers a conceptual model for implementing new information systems, integrating internal data, and linking suppliers and patients.**
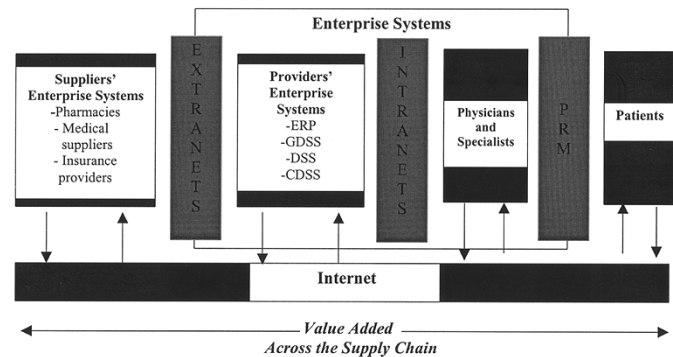
Index Terms—**Bioinformatics, data mining, enterprise systems, health informatics, information warehouse, internet, mobile technology, patient relationship management, telemedicine.**

I. INTRODUCTION

INFORMATION technology has expanded to encompass nearly every industry in the world from finance and banking to universities and nonprofit organizations. The health care industry, which is composed of hospitals, individual physician practices, specialty practices, as well as managed care providers, pharmaceutical companies, and insurance companies, is no exception. The industry's expanded interest in information systems implementation has primarily been fueled by needs for cost efficiency, increased competition, as well as a fundamental change in the health care industry, in which providers have changed their focus from reactive care and treatment to preventive medicine and disease management.

This paper provides a model for health care organizations to utilize the different information system technologies that can be employed to streamline business processes, reduce administrative costs, make organizations more competitive, and ultimately provide better care to patients. Specifically, this study focuses on using the Internet as the backbone to connect suppliers, enterprise systems, physicians, and patients to one value added supply chain.

Fig. 1 depicts that health care organizations can use the Internet to link not only their own operations, but also the operations of suppliers and physicians, and needs of patients. The diagram shows that the Internet facilitates two-way communication between all entities in the supply chain. In addition to general communication and data exchange through the Internet, suppliers, including insurance providers and pharmaceutical companies, can access part of a health care organization's enterprise systems via secure extranets. The model also shows that internal company data can be accessed by physicians and specialists via intranets. Notice also that the Internet is not shown to be a re-

The author is with the Department of Management, College of Business Administration, University of Nebraska-Lincoln, Lincoln, NE 68588-0491 USA (e-mail: ksiau@unl.edu).

Digital Object Identifier 10.1109/TITB.2002.805449

*PRM – Patient Relationship Management

Fig. 1. Health care supply chain.

placement for the physician–patient relationship; instead it is meant to enhance this relationship, by making both physicians and patients better informed.

II. CURRENT USE OF IT IN HEALTHCARE

Current literature on the deployment of information systems in the health care sector shows that most organizations are allocating a relatively small amount of resources toward information systems. In fact, one study showed that the health care industry was generally spending only about 2% of its revenues on technology, while other industries generally average around 10% [1]. This study was echoed by another article [2] showing that the health care sector still lagged behind the financial industry, the telecommunication industry, and the airline industry in terms of the implementation of information technology.

Spinning off of the lack of resource allocation is the finding that the health care industry is lagging behind in terms of e-commerce applications. One study of American health care providers showed that while 92% of health care professionals surveyed had informational Web sites, only 20% were participating in extranets or supply chain networks, and only 15% were currently offering enterprise portals [3]. The general reluctance of the health care industry to adopt IT change, is also highlighted in a study of health care in the United Kingdom [4]. This study shows that while general practitioners were using computers as a part of their daily routine, only 19% of general practitioners in the U.K. were currently linked to NHSnet, a government sponsored network that can be used to link all of the country's general practitioners into central databases via voice, data, and mobile communication media [4]. Although the current use of information systems in the health care industry is minimal, there has been a push to allow information systems to play a more intricate role in health care. This is evidenced by research showing that the percentage of resources allocated

to IT is increasing from the before mentioned 2% to more like 5%–7% [5].

The increase is mainly attributed to those organizations that utilize information technology from a primarily administrative perspective, using transaction processing systems and management information systems, to support billing processes and patient records [6]. This trend is changing as many health care organizations are now starting to use information systems for clinical purposes to improve patient care [7]. The various clinical purposes involve physician-to-physician communication to discuss difficult treatments, and share common knowledge. Also, more and more physicians are beginning to directly communicate with their patients via e-mail. An AOL survey revealed that 33% of surveyed physicians were currently using e-mail to communicate directly with their patients [8].

In addition to utilizing administrative systems and some clinical communication, current health care organizations are also using the Web to disseminate information about their organizations. Most of these sites are simply used as an information medium, and are not highly interactive or personalized, but some are being used in disease management, to reach out and monitor patients diagnosed with chronic illnesses [9].

III. INTERNET APPLICATIONS

Internet can serve as the backbone for implementing supply chain solutions to add value to health care providers, their suppliers, and their patients. Even though health care information systems in some hospitals and clinics have been linked together with a local area network or a wide area network [2], network-based health care systems have not been popular until the advent of the Internet. The three primary Internet applications that the healthcare industry uses, to varying degrees, are the Internet, intranets, and extranets.

A. The Internet

The use of the Internet by health care providers, and certainly their patients, has seen dramatic increases in the past few years. For example, one study shows that 60 million adults sought out health care information on the Web in 1998, and 91% of them found what they were looking for [10]. The estimated 60 million in 1999 has since sky rocketed; a Harris poll in August of 2000 shows that 98 million adults have used the Web to find health information [11]. Based on the results of another study done by the Health Information Management Systems Society, 87% of its members were using the Internet [12]. Another survey noted that most researchers, patients, and doctors had access to medical information systems through the Internet [13]. There are many reasons for this explosive growth, including faster connections, and greater trust in Internet security, as well as the added convenience of the Web.

The dramatic increase in the popularity of the Internet means that health care providers are left with the decision to either capitalize on the new e-world, or being left behind. For those that choose to integrate the Internet into their suite of services, the Internet offers several key benefits. These benefits include allowing physicians and specialists from across the globe to share

vital health care information. Also, the Internet has the capability of allowing patients to self-select themselves to view information on the Internet, and apply their own disease management and prevention. In addition, Internet technology allows patients and physicians to communicate with each other with greater flexibility and convenience, via e-mail. A third primary benefit that the Internet has to offer the health care industry is its unique ability to enable telemedicine, which brings health care to an entire new new level.

1) The Internet as a Physician Tool: Internet technology can facilitate the distribution of important medical information and knowledge to the medical community [14]. This includes use by health practitioners to locate useful medical information on the Web. Online services, browsers, and query languages, allow physicians access to immediate information without having to sift through piles of outdated health care journals. This serves to reduce the amount of time that providers need to spend researching clinical information, and will allow them more time to spend with their patients. The Internet allows quick and seamless information exchange between providers from across the globe. This is already taking hold as a 1999 survey showed that 63% of physicians used e-mail on a daily basis [8]. This percentage is also likely to be much higher now, as many more physicians have adopted Internet technology in the last two years. This communication is enabled by the Internet's open architecture and connectivity. Ruffin [15] claimed that the Internet provided the technical design necessary for standardized, vendor-independent, computer-based patient records to flourish. Thus, with the expanding capability, and quicker connection and transmission speeds, physicians are able to communicate with each other about the best and proper treatment for patients with specific symptoms. This type of collaboration will allow more knowledge transfer, and will ultimately lead to more satisfied customers, as appropriate care decisions are made.

Doctors can use the Internet to do more than download information and communicate with other providers; it can also be used to send complex medical files across the Web. One specific application of this technology is being applied in the Boston area, where neurosurgeons and trauma physicians receive encrypted radiological image files in their homes and offices via a high-speed cable modem [16]. Applying this technology makes use of a virtual private network (VPN), in which private information is encrypted and sent across a public network, thus providing the communication capability of a public network but with the security of a private network. If this technology proves to be successful, it will save doctors' time, because hospital visits can be reduced, and decisions can be made from a remote location. This will provide physicians with more up-to-date information and will free up more of their time to focus on patient care, rather than performing administrative tasks.

2) The Internet as a Patient Tool: The second major benefit to utilizing e-health care initiatives is that online access allows patients to be better informed about how exactly they can manage their own health, as well as prevent diseases. The Internet allows customers to gain up-to-date information so that they no longer have to rely on outdated or irrelevant general health data. Rather, they have immediate access to

health information when they need it. For example, one online health site, WebMD.com, gives patients tools such as access to important health care records, diet and fitness journal, doctor searches, as well as immunization and pregnancy planners [17]. Web sites like WebMD allow a large and growing group of consumers to use the Internet as their primary resource on health and medical matters. This creates an additional benefit for the health information provider, because people seeking out the provider's Web site are "self-selected." Unlike mass advertising campaigns, where information is delivered to everyone regardless of their interest, the provider can be sure that the consumer who accesses the site wants specific information. In addition to allowing patients to search the Web for their own health information, many patients are using the Internet as a means of support.

The Internet's global access allows patients in remote areas who may be suffering from very rare diseases to interact with one another via e-mail and chat rooms. This can be very beneficial to patients because they no longer have to feel like they are in the struggle alone, but rather they have others to share ideas and treatment plans with. These support groups are generally comprised of very skilled e-patients. E-patients are a new breed of patients who are using the Internet to gain specific knowledge about their symptoms and treatments, as well as using the Web to track down nearly every lead they can find on the best type of new treatment [18]. Some patients have even gone as far as starting their own Web sites to give support, information, and advice to other patients suffering from similar afflictions. For example, one patient suffering from lung cancer started her own Web-site which offers access to detailed information about lung cancer, listings of specialists, and clinical trial information, as well as support groups and survivors' stories [18]. The type of initiative displayed by this patient reflects a change in patient decision-making. No longer are patients willing to follow the "Dr.'s orders," they are now using the Web as a powerful tool to keep physicians accountable and to gain access to state of the art treatments that are not yet part of main stream health care. For this reason local health care providers need to be aware of the impact of the Internet, and use the Internet to their advantage by providing their own interactive sites, and not allowing their patients to slip away to other providers who reacted more quickly to the e-revolution.

3) The Internet and Telemedicine: Telemedicine is one of the hottest trends currently engaging the health care industry. One survey found that in 1998, 139 interactive telemedicine programs were found in the U.S., which was an increase from three in 1993 [6]. The idea behind telemedicine is to provide more convenient and more customized care to patients, using such technologies as Web TV, smart phones, and wireless devices to interact with patients in their homes. While this type of technology is currently in its infancy, many health care professionals are seeing the potential benefits of telemedicine. Possible telemedicine services range anywhere from scheduling appointments online, to performing remote surgical procedures directed by a surgeon to a nonsurgeon via high bandwidth technologies and video cameras [6]. These services will allow patients to bring up appointment books online, schedule appointments online, receive custom designed messages on their PDA

or cell-phone reminding them of their appointments, and reminders to refill prescriptions. This interaction allows patients to take a more active role in their health care.

Another important element of telemedicine is its ability to reach remote areas. With video cameras in smart phones and Web TV, doctors can speak with patients and design care plans without requiring patients to leave their homes. This represents the cyber-side of "house-calls," which will benefit both patients and providers. This type of technology proves especially valuable for elderly patients who may not be able to drive to meet a physician, or rural communities where health care is not always available. It is also possible to use telemedicine in this way in underdeveloped nations, because physicians from anywhere can see patients and communicate with them, without having to be in the same room. In addition, telemedicine can be used by physicians as a shared decision making tool, where all information is delivered across the Web, and online conference calls can be held to determine appropriate action plans.

B. Intranets

The second major Internet application that promises to affect the health care industry is the intranet. An intranet is a collection of inter-connected networks within an organization, usually based on Internet technologies. Intranets are important technological tools that can be used by health care organizations to provide efficient and more effective service to their patients. These benefits come from allowing physicians access to comprehensive internal enterprise systems that can store detailed information about possible treatments and patient records. Hospitals are rapidly adopting intranet technology. According to a survey by PriceWaterhouseCoopers and Zinn Enterprises, the number of large hospitals, with 500 or more care beds, with an intranet rose from less than half of the respondents in 1999 to nearly three-quarters in 2000 [19]. The growth in medical intranets can be attributed to its various advantages including: 1) low-cost connectivity; 2) ease of rapid deployment of the technology; 3) use of cross-industry communications standards; 4) user-friendliness; 5) short training times; 6) reduced network administration costs; 7) the ability to extend the value of legacy systems; and 8) the ease of development of strategic links between healthcare organizations and outpatient providers including physicians .

As a pioneering effort in connecting different systems by using Internet technology, a number of medical intranets have been developed and implemented for different purposes. For members of the health care community, offering health care information and sharing data have many benefits. First, physicians can search internal patient medical records that have been stored by the specific organization, use clinical decision support systems, and research specific topics that have been stored by internal enterprise systems. Administrative employees can access the database to deal with billing and insurance. To date, intranet applications have been widely used as a tool of knowledge diffusion within the medical community rather than for patient care. Specific medical intranets have been used mostly to improve knowledge diffusion via the Web. MEDLINE, controlled by the National Library of Medicine, maintains medical literature from the past 30 years [14]. Members of MEDLINE are able to print journal articles, textbooks, diagnostics tests, and health

plan coverage. By storing the information on an intranet, access is only granted to members, which reduces the risk of having patients finding their own data, and applying inappropriate treatments. Another example is CliniWeb. CliniWeb is an index of clinical information, which is designed for retrieving specific clinical topics on the Web. It provides an index of clinical information for health care students, providers, and researchers via the Web [20]. Unlike other search engines (Alta Vista, Infoseek, etc.), CliniWeb is an exclusive intranet that furnishes only clinical information by organizing clinical resources with a specific topic, so that only specified users can access the information.

While most intranet applications in the health care industry are dominantly used for knowledge diffusion, some researchers have started building prototypes not only for sharing information, but also for disease diagnosis and patient care.

C. Extranets

The third and newest Internet application to be used by the health care industry is the extranet. Simply put, extranets are networks, again usually based on Internet technologies, built between a core business and the other members of its value chain, on both the supply and demand sides. Extranets are not currently widely used in the health care industry. An InternetWeek study revealed that while 92% of health care respondents host informational sites, only 20% are currently participating in extranets or supply chain networks [3]. Extranets offer a way to link services in a more timely and efficient manner. Extranets are less cumbersome and restrictive than an electronic data interchange (EDI) system. Extranets can also be used to streamline transactions between providers and their suppliers to the benefit of both. On the downstream end, providers have the opportunity to forge strong links to existing and potential patients, while on the upstream end providers are able to link to their suppliers. This offers significant cost reduction, because inventorying expenses can be reduced. Also, vendors are able to read organizational inventory data, and automatically replenish when necessary. This helps save time in creating order forms, and doing inventory checks because the information is all stored online and automatic messages can be sent and received throughout the value chain.

Extranets offer another unique capability to the health care industry—secured connectivity. This is especially true since Bill Clinton, during his 1997 State of the Union Address, stated that, "we should connect every hospital to the Internet, so that doctors can instantly share data about their patients with the best specialists in the field." What President Clinton was calling for was a virtual data repository, in which pertinent clinical information related to health care providers, such as computerized patient records, health care provider information, and lab test results, would all be connected via extranets. Consequently, heath care providers, including physicians, hospitals, pharmacists, lab researchers, and dentists, would be able to utilize those patient records and information to the betterment of the health care community. Extranets are the key for this integration to occur, because they reduce the need for a centralized database, that would undoubtedly be too large to manage. Using extranets, key patient and clinical data are available on the Web, but accessible only through a secure connection.

In order for data repositories to be implemented, computerized patient records must be developed before anything else. Raghupathi [21] stated that one of the important trends was the move toward a universal electronic patient record. A universal electronic patient record could be defined as electronically stored health information about one individual recognized by a unique identifier. Efforts are already underway to build a universal computerized patient record by the Computer-based Patient Record Institute in Schaumburg, IL. However, because of several obstacles, including costs, lack of network standards, and difficulty of transferring data to systems from charts, no universal method is currently available [22].

On an administrative and inventory control basis alone, extranets should benefit the health care supply chain. With the advent of computerized patients records, extranets can be used to link health care providers together to provide better clinical care. Extranets also play an important role in integrating the supply chain, because they allow different organizations to access a part of each other's internal data via Internet connections. The internal data alluded to above is generally stored in health care providers' enterprise systems.

IV. ENTERPRISE SYSTEMS

Enterprise systems include a company's internal applications, such as enterprise resource planning (ERP) systems, customer relationship management (CRM) systems, data mining and data warehousing programs, as well as the various models of decision support tools that can be used in the health care industry. These different software tools can be used in a powerful way in the health care industry to not only integrate enterprise data, but also to provide important information and forecasting data to provide improved patient care.

A. ERP

ERP technology has made a tremendous impact on the business world in the past few years. What these packages promise is the full integration of an organization's information, from payroll and human resources to accounting and finance; with each functional business unit being represented and supported by an ERP module. Utilizing ERP systems in the health care industry offers several advantages.

One of the primary benefits of ERP systems to the health care industry is its integrated database. This means that all of the organization's information is encapsulated in one place, which makes it possible to reduce administrative costs by eliminating some of the manual processes. ERP information simply needs to be logged once, and every module in the system has consistent information. This can help to solve the problem of overrunning physician's desks with paper, and will free them up to focus more upon patient care. Having the systems integrated also streamlines data entry, which saves office workers' time, and ensures that everyone in the organization is working with the same information. Another administrative benefit of ERP systems to the health care industry is that one system can be used to track inventory, order information, and delivery requirements. This means that health care organizations can better plan and organize for receipt of inventory goods, as well as always

have access to a real time inventory status. In addition, ERP systems can be used to determine equipment usage and maintenance schedules. ERP systems allow information to be stored in a shared database, so that information on maintenance schedules can be automatically retrieved, and crossed with other information such as number of beds in use, to determine when and where demand is greatest for a specific piece of equipment.

In addition to reducing administrative tasks, and streamlining processes, ERP systems can also be used on the clinical side of the business to store useful patient education information. ERP systems allow doctors to store common disease management techniques inside the system, so that this information can be easily accessed and disseminated to patients. This will not only save the physician time, but will also allow for better patient care. An additional piece of an organization's enterprise systems that can be used in the health care industry are decision support systems (DSSs).

B. DSSs

Unlike the earlier healthcare DSSs that focused on financial and scheduling domains, current decision systems can be used for diagnostic situations in health care specialties including pharmacy, emergency, and nursing practices [23]. DSSs can be used to store standard diagnostic techniques for disease management, and can be used as a cross check against a patient's records, in order for a physician to apply the appropriate individualized care for the given patient. For example, clinical decision support systems (CDSS) can be used to send alerts and reminders to patients about preventive care [6]. In this way, CDSS can be used in telemedicine to communicate critical information with patients about their care. For instance, a patient may use the Internet to log-on to their health care provider's Web site and place their current blood pressure readings, as well as diet information, and a CDSS can be used to analyze that information and send information alerts to patients who may be at risk of heart problems. This gives health care a more personalized feel, as patients are able to tailor information sent to them, regarding their specific condition, and can also give information to patients more quickly. In addition to its own ability to store and analyze current medical information and patient records, DSSs can also be utilized on a group basis.

Recently, group DSSs (GDSSs) have been developed in many nonhealth care organizations to assist in the decision making process of group members by broadening the quantity, quality, and structure of data exchange. Currently, the health care industry has made little use of GDSSs, but using the Internet offers the opportunity to change that. Since all of patients information can be stored in one place, and all of that information can be accessed via secure channels, several physicians will be able to view the information, and advise the primary physician of proper treatment techniques. This puts the old adage of "two heads are better than one" into play, in which each physician can analyze his own experience and contribute ideas to the care of the given patient.

C. Patient Relationship Management (PRM)

Another important application that promises to enter into the health care industry is patient relationship management (PRM),

or more commonly known as customer relationship management (CRM). PRM is a software tool that places an organization's primary focus on determining and meeting patient needs. PRM involves tracking patient information from diet and exercise data, to past diagnosis information, to family history, and allergy information. By storing all of this information, health care providers will be able to send e-mails to patients about newly published health care studies that may be of interest to the patient, or offer specialized prescriptions that may fit a certain patient profile. This information could also be used to automate certain call center operations, in which routine advice for certain ailments can be made available at the call center without having to distract nurses or physicians from their primary care duties. Also, as part of the services offered by PRM, patients should be able to e-mail providers with health-related questions, and receive responses with specific treatment options or answers to questions. The general guideline in the business world is that customer e-mails requesting information should be answered within two to four hours [24]. This type of online support will provide better care, because patients will be able to ask questions of their providers whenever they need to, and providers will have time to review pertinent health information and patient records to supply adequate answers. Another important feature of PRM is that it will help to build loyalty between patients and providers. This is possible because in a PRM strategy the health care organization has taken the time to learn about the patient, and the patient has taken the time to give information, therefore with the nature of the time investment and the personalized care, patients are more likely to stick with the health care provider that knows them and their preferences . One key point to make about using PRM software is that organizations should be careful to only collect data that patients do not mind them having. This is especially important in health care, because many patients may not want to have certain details of their health to be made available to sources other than their physicians. Therefore, caution must be exerted before these systems can be utilized.

The bottom line is that an increased understanding of patients needs and wants will help health care organizations to provide better care. This is essential for providers trying to manage and prevent disease, because information can be disseminated much easier without having to mass market all information on a particular disease to all the people accessing a Web site or receiving newsletters. This personalized touch will become a critical success factor in the health care industry, and serves as one more option for health care providers to use information systems to improve the care they provide.

D. Information Warehousing Tool

An information warehouse is a collection of integrated, subject-oriented databases designed to support decision-making. Information warehouse is seeing new applications on the clinical side of patient care. For instance, pharmaceutical makers are using information warehousing for marketing purposes and health care providers are using information warehousing for diagnosis and treatment of patients. One example in the pharmaceutical industry is Glaxo Wellcome in London, who has implemented information warehousing for the analysis of drug demands. Also, Pfizer Incorporated, a pharmaceutical firm based

in New York, has implemented information warehousing that supports 2700 sales representatives in furnishing doctors with detailed and specific drug information regarding the effectiveness of drugs, side effects, and costs.

In addition to using information warehousing for pharmaceutical purposes, information warehouse tools can be used for patient data and care. For instance, Kaiser Permanente, the largest and oldest HMO in the United States, has employed information warehousing containing diabetic data for accurate and proper treatment of diabetics. Taking this initiative a step farther is Patient Infosystems, which uses personal computers, Internet applications, and telephones to allow diabetic patients to enter their glucose levels into an online application that can be monitored by qualified physicians [6]. This information can then be backlogged into an information warehouse, which can be used as an information store for future clinical use by physicians. This represents an exciting new avenue because the information stored in the information warehouse can be stored, mined, and analyzed to provide better and more accurate care to patients.

E. Data Mining Tools

Applying data mining techniques to information warehousing in the health care industry is becoming more and more common. Data mining permits health care providers to save costs, provide better care, and save lives. Sentara Health System at Norfolk introduced a data mining concept to improve the quality and the treatment of pneumonia patients. Bresnahan [25] wrote "there are thousands of services, relationships built over time, and multiple diagnoses and interactions. That complexity will continue to push progressive data mining applications that will rival those in banking or retail." The bottom line is that growth in the use of data mining techniques in the health care industry will provide more information to physicians, so that better care decisions can be made.

V. FUTURE TECHNOLOGY—MOBILE HEALTH CARE SYSTEMS

Mobile communications offer two distinct advantages to the health care world. First, mobile technologies are important for telemedicine success. While certain media that are already in place, such as televisions and telephones, offer avenues for telemedicine deployment, mobile communication offers another avenue that can also be used in conjunction with telemedicine. Personal digital assistants can be used by physicians to send instant messages to patients reminding them when they need to take their medication. This will serve to eliminate certain administrative and insurance costs that are associated with hospitalizations that result from not taking the prescribed medication at the correct time. This is important because a study done by the National Council of Patient Information and Education, revealed that 50% of patients are either not taking their medications at all, or not taking it according to schedule, which correlates to an average of 10% of hospital visits that are caused simply because medications were not taken at the prescribed time [26].

Second, mobile devices and the wireless Internet allow physicians to access information anywhere at anytime. This is an important benefit for providers, because real-time information is essential for physicians and hospitals, and mobile devices provide that capability [26]. One of the most powerful ways that mobile devices can be used in this arena is by utilizing them to access internal company information stored in company intranets and enterprise systems. This allows providers to log on to the system from outside of the organization and view the most up-to-date information that the provider has. This capability is a powerful decision support tool, because all of the information will truly be in the palm of the physician's hand allowing decisions to be made accurately and immediately. Although, this functionality is still not completely developed, Oracle, PeopleSoft, and SAP all have releases that will support a portion of their enterprise software on hand-held devices.

VI. DISCUSSION AND CONCLUSIONS

Three basic sets of tools can be applied to health care industry: 1) Internet applications; 2) enterprise systems; and 3) mobile technologies. These various tools can be used by health care organizations to store internal organizational information based upon its different business modules, including finance and accounting, human resources, payroll information, etc. Also, health care organizations can use these numerous technologies to provide better patient care, by not only obtaining more information from patients, but also giving more information on self-care and disease management to patients. Better care can also be provided using such enterprise applications as decision support tools, PRM applications, information warehousing and mining, as well as Internet applications such as telemedicine, which can be used to personalize care and make care more convenient for patients who can access information from anywhere. Mobile technology will also make physicians' jobs easier, because information will be available on smaller communication devices, such as mobile phones and PDA's. Not only will this help physicians to work from anywhere, and collaborate with other physicians and specialists online, it will also save them administrative time, which will translate into more value added time for the health care provider and ultimately the patient. These tools also promise to link the supply chain, giving suppliers the access to internal information will result in reduced inventory costs, and faster delivery of medicines and other health care devices.

While these technologies do offer health care organizations options to provide better care and reduce costs, none of the technological devices discussed in this research are meant to replace the physician–patient relationship. Instead they seek to enhance that relationship by reducing administrative time and costs, providing more accurate patient record information, allowing for shared decision making, and offering more timely patient care.

REFERENCES

[1] C. Clark, "Healthcare information systems," in *e-Healthcare*, D. E. Goldstein, Ed. Gaithersburg, MD: Aspen, 2000, (1995), 679, pp. 300–301.

[2] A. Maitra, *Building a Corporate Internet Strategy: The IT Manager's Guide*. New York: Van Nostrand, 1996.

[3] T. Wilson. (2000, Oct. 30) The focus is care, not the business: Web data and diagnostics, physician collaboration take precedence over supply chain. *InternetWeek* [Online]. Available: http://www.internetweek.com/transformation2000/industry/healthcare.htm

[4] D. Howcroft and N. Mitev, "An empirical study of Internet usage and difficulties among medical practice management in the UK," *Internet Res.*, vol. 10, no. 2, pp. 170–181, 2000.

[5] M. Blodgett, "Tighter control of medical records urged," *Computerworld*, vol. 31, no. 10, p. 8, Mar. 10, 1997.

[6] D. E. Goldstein, *e-Healthcare: Harness the Power of Internet e-Commerce & e-Care*. Gaithersburg, MD: Aspen, 2000.

[7] J. Anderson, "Clearing the way for physicians' use of clinical information systems," *Communications of the ACM*, vol. 40, no. 8, pp. 83–90, Aug. 1997.

[8] (1999, May 6) Research shows 42% growth in physician use of the Internet in the last three months. *Healtheon Corp. Internet Survey Med.* [Online]. Available: AOLNews@aol.com

[9] L. Nicholoson, *The Internet and Healthcare*. Chicago, IL: Health Administration Press, 1999.

[10] H. Taylor, "Explosive growth of a new breed of cyberchondriacs," *Harris Poll*, vol. 11, 1999.

[11] (2000, Aug.) *Harris Poll* [Online]. Available: www.ada.org/adapco/daily/archives/0008/0811.html

[12] PeopleSoft and A. Anderson, "Intranet: Powerful new tools for healthcare organizations,", White Paper, pp. 1–14, March 1998.

[13] J. Cimino, S. Socratous, and P. Clayton, "Internet as clinical information system: Application development using the World Wide Web," *J. Amer. Med. Informat. Assoc.*, vol. 2, no. 5, pp. 273–284, Sept.–Oct. 1995.

[14] W. Detmer and E. H. Shortliffe, "Using the Internet to improve knowledge diffusion in medicine," *Communicat. ACM*, vol. 40, no. 8, pp. 101–108, Aug. 1997.

[15] M. Ruffin. The World Wide Web is coming soon to an organization near you. *Medical Intranet Forum* [Online]. Available: http://www.mis-forum.org/news/ruffin_soon.html

[16] S. Salamone. (1998, June 16) *VPN Eases Meetings of The Minds* [Online]. Available: http://www.internetweek.com/story/

[17] (2001, Accessed June). [Online]. Available: http://www.WebMD.com

[18] T. Ferguson, "Online patient-helpers and physicians working together: A new partnership for high quality health care," *Bus. Manage. J.*, pp. 1129–1131, Nov. 2000.

[19] K. R. Ong, M. Polkowski, G. McLemore, M. Greaker, and M. Murray, "Building and growing a hospital intranet: A case study," *J. Medical Internet Res.*, vol. 2, no. 1, Mar. 2001. [Online]. Available: http://www.jmir.org/2001.

[20] W. Hersh, K. Brown, L. Donohow, E. Campbell, and A. Horacek, "CliniWeb. Managing clinical information on the World Wide Web," *J. Amer. Medical Informat. Assoc.*, vol. 3, no. 4, pp. 273–280, July–Aug. 1996.

[21] W. Raghupathi, "Health care information systems," *Communicat. ACM*, vol. 40, no. 8, pp. 81–82, Aug. 1997.

[22] E. Fotsch. (1998, Jan.) Medical intranets create virtual healthcare malls. *Medical Intranet Forum* [Online]. Available: http://www.mis-forum.org/news/hfma_jan98.html

[23] F. Niederman, "Data warehousing at an urban hospital," *J. Data Warehousing*, vol. 2, no. 4, pp. 2–12, Winter 1997.

[24] C. Gustke. (2001, Mar. 1) eCRM: Connecting with customers: Six principles that will help you attract (and retain) customers. *Internet World Mag.* [Online]. Available: http://www.internet-world.com/030 101/03.01.01feature3.jsp

[25] J. Bresnahan. (1997, June 15) Data mining: A delicate operation. *CIO Mag.* [Online]. Available: http://www.cio.com/archive/061 597_mining_content.html.

[26] N. Swartz. (2000, Dec. 15) Wireless house calls. *Wireless Rev.* [Online]. Available: http://www.telemedicine.com.

[27] K. Siau, E. Lim, and Z. Shen, "Mobile Commerce—Promises, challenges, and Research Agenda," *J. Database Manag.*, vol. 12, no. 3, pp. 4–13, July 2001.

Keng Siau received the Ph.D. degree from the University of British Columbia, Vancouver, BC, Canada, in 1996, with a major in management information systems and minor in cognitive psychology.

He is an Associate Professor of Management Information Systems (MIS) at the University of Nebraska, Lincoln. He has published five books, 15 book chapters, more than 45 journal articles and more than 60 refereed conference papers. He is also the Editor in Chief of the *Journal of Database Management* and the series editor for the *Advanced Topics in Database Research* book series.