Telemedicine Applications and Challenges

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INTRODUCTION

Telemedicine is a function of information and communication technologies (ICT) that facilitates exchange of medical data to assist the health care industry in providing services to the society more competently. Its applications range from diagnosis, treatment, and prevention of disease, to continuing education of medical professionals, research and evaluation. Telemedicine is not a process aimed to replace traditional practices of medicine. It simply acts as a partner of the industry to reduce inadequacies in time and resources. ICT should not be viewed only as a competitive advantage of health care organizations, but rather a fundamental commodity intrinsic to the delivery of global health care (Iyer & Dey, 2005; Nash & Gremmillion, 2004).

Pedigo (1997) illustrates the essence of telemedicine with the follow example: In April 1995, a student at Peking University sent an e-mail requesting medical assistance for a fellow student, Zhu Ling. Zhu Ling was experiencing rapid hair loss and paralysis. An extensive online network of physicians, toxicologists and other experts collaborated with Ling's physician in Beijing to respond to the SOS e-mail. With the assistance and suggestions from over 2,000 responses, the Beijing physician was able to treat Ling in the best possible way and prevent death. The Zhu Ling case was the first recorded use of the Internet to seek diagnosis and patient care from a distance.

Telemedicine has the potential to help bridge the time and distance gaps that can mean life or death for some patients. It can provide live video conferencing between local, rural doctors and clinics to the necessary specialists at a major hospital or research center. These conferences can provide quick and accurate diagnosis and save both the patient and the doctor time and money.

This article presents a background on telemedicine including components, applications and benefits of telemedicine, challenges and trends in telemedicine, and conclusion with some direction for future research in telemedicine.

BACKGROUND

Telemedicine removes geographic barriers and is anticipated to save money by treating patients on-site rather than in an expensive hospital setting, improve patient care by giving health care providers access to teaching medicine resources, and target services to populations that have been hard to reach (remote rural areas), expensive to serve (prisons, mental institutions), and historically neglected (urban poor). The most important benefit of telemedicine is its ability to access patient data from any remote location (Demiris, 2004). It is impossible to have specialists in all areas available at all times to any given hospital or emergency care service. There are people worldwide that live in rural and remote areas who are not able to receive the type of care they need due to their distance from the nearest facility that specializes in their illness. Moreover, in most developing countries, there is a severe scarcity of medical specialists. Lack of capital, facilities, and systems are some of the common problems faced by developing countries. Telemedicine coupled with telecommunications can provide a solution to some of the above problems.

The U.S. Department of Defense has been using telemedicine technologies to support their operations in Saudi Arabia, Kuwait, Somalia, Haiti, Cuba, Panama, Croatia, and Macedonia (Garshnek, Logan, & Hassell, 1997). The telemedicine project in the Persian Gulf in 1993 had computerized tomography (CT) scanners installed in transportable modular military hospital units and deployed in the Saudi desert just south of the Iraqi and Kuwaiti borders. During Operation Restore Hope, physicians in Somalia were able to communication and share medical data with specialists in Washington DC.

Telemedicine has always played an important role in astro medicine as well. From the 1960s, astronauts have been monitored by groups of medical specialists through telemetry during the space operations. Currently, NASA is making efforts to hold conferences in the micro-gravity environment between astronauts on the orbiting space-crafts and the medical specialists on earth (Garshnek et al., 1997). These one-way video and two-way audio conferences would make a phenomenal difference in the safety and security of the astronauts on board.

Treatment of inmates in the prison (Cooper, 1997) is another application of telemedicine. It helps to maintain a secure prison system by minimizing movement of the prisoners in case of a medical problem. The state of Iowa has implemented a telemedicine project via which medical staff of the prison can consult with doctors at the University of Iowa through a two-way video conference. This system transmits captured images letting physicians located at a remote place view a patient's ears, throat, or skin. It also enables sharing of x-rays and other information to help with diagnosis and follow-up care.

Telemedicine and telehealth also eliminates travel cost as well as travel delay (Jossi, 2005). Moreover, immediate real-time access to patient data gets rid of time lag and accelerates early detection of diseases that can improve overall performance of the health care industry (Jossi, 2005).

Medical information shared over a network can support research collaboration by allowing researchers to exchange findings over the networks at no additional cost. Informational networks online also provide a means to establish official and unofficial educational programs over a wide area across the globe.

Components of Telemedicine

The success of telemedicine depends on how effectively the capabilities of technology have been exploited to benefit the health care industry. Health care industry requirements should be analyzed carefully before considering technology as a solution. Telemedicine systems may be developed using two key dimensions: internal and external integrations (Raghupathi & Tany, 2002). Internal integration refers to technologies that are applied to integrate systems with one another within an organization. External integration refers to systems and technologies interfacing with outside organizations and agency computer systems.

The fundamental telemedicine integration should be planned to allow a scope for future expansion if necessary. Scalability should be used as a valuable measuring rod for every telemedicine project. The basic components of a telemedicine project infrastructure are discussed in the following sections.

Telecommunication

The first step is to ensure a network connecting all remote facilities in order to communicate with each as desired. This could vary from a basic telephone service to broadband Internet. Considering complex operations requiring huge amounts of data being interchanged across the globe in seconds between systems, telemedicine networks often require a high bandwidth. Asynchronous transfer mode (ATM) coupled with resilient synchronous optical network (SONET) has been one of the most popular configurations from the early 2000s. It offers high-quality and low-delay conditions. These systems are supported by fiber optic cables that allow data to be transferred up to 40 gigabytes per second.

Mobile communication systems are also critical to telemedicine industry. This includes cordless, cellular, satellite, paging, and private mobile radio systems (Ackerman, et al., 2002). Wireless technology is the next big step for telemedicine. Wireless end users within a physician's office, hospital building, or even medical campus can be connected with a wireless local area network (WLAN).

Interoperable Systems

Interoperability adds value to the system by ensuring flexibility and cost-effectiveness (Ackerman et al., 2002). The system design should allow stations developed by independent vendors to interact with each other. Medical devices and other peripherals connected to one vendor's station should be able to interact with that of another station created by another vendor. Systems should be further designed to allow creation of individual stations in a plug-and-play

Table 1. Telemedicine interactions and technical requirements (Adapted from Garshnek et al., 1997)

Applications	Interaction Processes	Data Transferred	Min. Bandwidth Reqd.
* Telepsychiatry * Remote Surgery * Interactive Exams	Real time, one-way or two-way interactive motion video	Voice, sound, motion video, images, text	Moderate to High
* Dermatology * Cardiology * Otolaryngology * Orthopedics	Still images or video clips with real-time telephone voice interaction, 'store and forward' with data acquired and sent for later review	Voice, sound, still video images, text	Low to Moderate
* Distance Education * Training	One-way or two-way real-time or delayed video	Voice, sound, motion video, images, text	Full Spectrum: Low to High
* Health Info. Networks * Medical Records	Transfer of electronic text, image, or other data	Text, images, documents, related data	Low to High

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