Technology Meets Healthcare: Distance Learning and Telehealth

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In a time of increasing demands on physician productivity, computer and communication technologies allow health professionals to experiment with many applications that may provide opportunities to meet clinical demands while still participating in educational and research activities. "Telehealth" is a comprehensive term for the support of long distance clinical healthcare, patient and professional health-related education, public health, and health administration. Educational opportunities are growing exponentially for those who cannot attend traditional courses because of limited time or geographic considerations. Research and medical information and medical consultations are being delivered instantly across wide geographic areas. Nearly every federal agency has a web site providing health information. Integrated clinical management systems can facilitate the management of patients with chronic diseases and provide an efficient way to integrate consultations and patient education, monitoring, follow-up, and support. Administrative functions can be interfaced with clinical management providing practitioners with the ability to better organize their services. Information systems at all levels are expanding their capacities and capabilities to meet the growing demand for medical knowledge.

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Over the past few years, the explosive development, growth, and use of the Internet has dramatically changed the way America communicates, plays, and does business. The number of households connected to the Internet has increased over 250% in the last 5 years (1), and electronic technologies are now deeply embedded in every aspect of our daily lives. The Internet offers the ability to easily access a wealth of health-related information, directly interact with healthcare practitioners, or purchase medications online. According to the Federal Trade Commission, "Consumer online searches for health information are increasing dramatically; it is predicted that 30 million Americans will seek health information online by 2001 (2).

Analysts believe that the healthcare industry, traditionally one of the least computerized segments of the American economy and one of the most resistant to the incorporation of information technologies, is at least 10-15 years behind other industries in computing (3). Medicine has not been immune to change, however. Computer and communication technologies are converging and developing powerful tools for the healthcare industry.

In 1996, the Institute of Medicine defined telemedicine as the "use of electronic information and communication technologies to provide and support healthcare when distance separates the participants" (4). In January 1997, the Joint

Working Group on Telemedicine (a consortium of 11 federal agencies) further refined the definition of telemedicine as "situations where the physician and patient are geographically separated and rely on electronic devices in the delivery of healthcare" (5).

"Telehealth" has recently emerged as a more comprehensive term defined as "the use of electronic information and telecommunications technologies to support long distance clinical healthcare, patient and professional health-related education, public health and health administration" (1). Telehealth, therefore, includes telemedicine and reflects the multidisciplinary nature of the field and the rapid growth of telecommunications and web-based healthcare resources.

Professional Education: Physician as Student and Teacher

An integral component of telehealth, distance education refers to situations in which the instructor and learner are geographically separated and rely on electronic devices and printed materials for instructional delivery (6-9). Available Internet applications range from web sites with posted materials to virtual classrooms joining 40 or more participants in real-time interactive classes. Continuing education, master's degree courses in public health, and selected course offerings in undergraduate medical education are delivered by distance education technologies, which are growing exponentially as opportunities open for those who cannot attend traditional courses because of time or geography.

Synchronous Education Delivery

In synchronous delivery, students and the instructor interact in a session resembling traditional instruction through electronic media using satellite downlinks, video teleconferencing, or the Internet. Satellite downlinks resemble television programming and are used extensively by the Centers for Disease Control and Prevention's Public Health Training Network, which regularly broadcasts training classes and updates on a range of topics from bioterrorism and immunizations to new developments in laboratory methods and updates on prevention recommendations. While complex uplink equipment is needed by the sender, downlinks are easily received with relatively inexpensive satellite dishes from nearly any location. Questions can be asked of the instructor by telephone, and sessions may be taped for later review.

Teleconferencing allows real-time two-way interactions and most closely mimics a traditional classroom. Special cameras and digital projectors are available to show slides, documents, and web sites. However, digital signal coding/decoding equipment must be available at each participating location.

The Internet is also emerging as a powerful, flexible, and cost effective tool for education and training with the development of virtual classrooms. Students log on to a scheduled class session that provides two-way audio and graphics such as slides or links to web sites. Simultaneous text messaging provides the added benefit of allowing interactions among the instructor and students.

Asynchronous Education Delivery

In asynchronous distance learning, students access self-study modules and materials at their own convenience, primarily via the Internet. The greatest benefit of the asynchronous format is that learners are able to access the materials on their own time and complete exercises independently. This allows significant flexibility to fit the course into a busy schedule and is ideal for continuing medical education. Early web-based courses closely resembled correspondence courses using the Internet to post materials rather than sending them by conventional mail. Course formats have ranged from simple web sites to elaborate multimedia presentations and are becoming more sophisticated. The availability of Internet bulletin boards (both real-time and posted) for discussions increases interactivity among students and instructors.

Technology in the "Traditional" Learning Environment

As computer and communications technologies are incorporated as teaching tools, traditional materials and technologies are being adapted. Histology and pathology slides that previously required a microscope are now digitized for study on a computer. Course management software has become integral for both on-campus and distance learning classes due to its ability to organize syllabi, lecture materials, handouts, and assignments.

Physicians and medical students at a clinical rotation may soon be able to attend on-campus seminars or lectures from a laptop across town, across the state, or across the country. Telehealth programs designed to improve medical education for students in rural healthcare areas are developing rotations that link several community hospitals with a sponsoring medical school.

Distance learning is still in its infancy with little standardization, but most academic medical centers have or are planning some type of distance learning programs. The availability of technical support for both instructors and students is a critical issue for all technology-mediated learning. Two published examples of distance learning with medical education follow:

TETRASUR

The TElematics TRAining for SURgeons (TETRASUR) project investigated the effectiveness of distance learning technologies used to train physicians studying for membership in the Royal College of Surgeons. "When surgical trainees spend time away from the surgical area to attend lectures and seminars, other practitioners must fill the gap. Distance learning via telematics was seen to provide a possible answer to these problems" (6). The TETRASUR course included live interactive lectures, case presentations, and interactive discussions by videoconference and satellite television links. User satisfaction results were positive. Areas of concern (e.g. poor image quality) were identified and addressed.

Educational Service for Rural Practitioners

A pilot study of a telemedicine educational service done for rural mental health practitioners in South Australia involved 46 community mental health workers and 20 general practitioners (8). The educational service consisted of modules developed for different mental health disorders delivered in 60-minute blocks and allowing for interactive discussion as well as secondary consultation. The physicians reported on a scale of 1-5, a higher score indicating greater satisfaction, whether the service had relevance to fulfilling academic needs (mean score 4.1), usefulness to clinical needs (mean score 4.6), relevance to professional development (mean score 4.3), and usefulness with overcoming the problem of distance (mean score 4.8). The authors concluded that there is a potential for telehealth technologies to overcome several barriers to physicians practicing in rural communities. Such technologies could have a positive impact on attracting and retaining physicians in rural practices, which will ultimately benefit patients in rural areas.

Clinical Services: Digital Delivery

Telehealth can improve access to healthcare. The initial thrust of telemedicine has focused on linking primary care physicians with medical specialists located at distant sites and is being utilized by health providers in a growing number of medical specialties (including dermatology, oncology, radiology, surgery, cardiology, and psychiatry). Benefits include:

1) Improved access and faster diagnosis and treatment
2) Improved quality of care through increased consultation and collaboration and increased patient involvement
3) Reduced professional isolation and the promotion of collaborative consultation partnerships
4) Reduced costs from the centralization of resources, reduced travel, and the avoidance of the duplication of services (5)

Asynchronous Healthcare Delivery

As in e-learning, telemedicine applications may use either asynchronous formats or interactive systems; the selection of the technology depends on the specific application. Asynchronous formats are used for medical consultations that do not require direct patient-doctor interaction. Email, for example, is usually one of the first applications physicians utilize to support clinical services and facilitates communications when physicians' schedules make them difficult to reach (10). Email is used to respond to patients' questions, enhance patient education, augment screening programs, and improve adherence to treatment protocols.

Linking patients and physicians increases the patient's involvement with his or her own healthcare. However, certain types of information are more suited to email than others: follow-up, specific questions, and prevention education have been shown to be beneficial (10). Email should not be used to convey abnormal or confusing medical test results or bad news, or for making many diagnoses (10,11).

Some individual physicians have adopted email to communicate with patients, but most physicians still believe it will be too time consuming. Contrary to nearly every national survey, most physicians believe that the vast majority of their patients have no interest in communicating with them online and greatly underestimate their patients' Internet use (12). Preliminary studies show that emails for prescription refills and specific questions are an effective way for patients and physicians to communicate. Answering an email usually takes less time than a phone call (13) and can be done at any time of the day (14). However, patient confidentiality and reimbursement remain issues for most email situations, and those patients with access to computers are not likely to be the underserved community who may have limited income (10).

Store-and-forward systems used for asynchronous telemedicine are capable of transferring images, video or audio clips, medical records, and large data files from one location to another (15). This is particularly valuable for pathology and radiology. Store-and-forward systems may be as simple as a personal or laptop computer fitted with a modem; however, the computer must have sufficient memory and connections to high-bandwidth systems capable of handling images and other large files. More complex systems are optimized for specific telemedicine applications.

Synchronous/Interactive Healthcare Delivery

With interactive telemedicine the physician can interact in real-time with a patient at a remote location through videoconferencing and technology-enabled medical

instrumentation. Physical examinations are performed using portable video units fitted with special scopes that capture images and other information, which are then transmitted to a major medical center to facilitate diagnosis and follow-up care (16). More sophisticated systems allow the physician to access electronic patient records while continuing to interact with the patient. Such systems also store information from the current session for later review or for tracking patient progress. Interactive systems may be built onto a personal computer, which runs the medical record software and integrates videoconferencing and file transfer capabilities (17).

While there are many applications across the spectrum of medical practices, the following clinical settings commonly employ one or a combination of telemedicine technologies: home healthcare settings, rural clinics and community hospitals, and geographically dispersed physicians conducting clinical research (18).

Home Healthcare

Home healthcare has become one of the fastest growing healthcare segments using telemedicine to supplement in-person care (19). In addition to videoconferencing technologies allowing long-distance consultations, applications are available to continuously monitor vital signs and results of home tests that can be transmitted to physicians and healthcare facilities. The 1998 edition of the American Medical Association's *Guidelines for the Medical Management of Home Care Patients* includes a section that addresses telemedicine applications and new technological applications for home healthcare (20).

Rural Clinics and Health Centers

The linking of rural clinics with partner medical centers to support telemedicine and telehealth applications is expanding. This is of great significance to the 61 million Americans living in rural areas, 15% of whom are elderly and prone to the chronic diseases that telemedicine is aptly suited to manage (21). The National Library of Medicine-funded web page, the Telemedicine Information Exchange (TIE, http://tie.telemed.org) lists examples of telemedicine applications and innovative uses of technology (17). In a common example, emergency services across the country are improving through the transmission of images to key medical centers for long distance evaluation/triage by appropriate medical specialists.

In the United States, telemedicine is more common among large state-supported academic medical centers, which are charged with providing access to medical care for patients throughout their states (18). Partnerships are currently developed based on individual relationships; however, once the capability is built and personnel are trained, networks will expand.

Geographically Separated Physicians and Health Centers

Telemedicine is eliminating the boundaries of healthcare globally. In Great Britain, ophthalmic pathology is being linked to create telepathology consultation services. In Germany, the International Union Against Cancer (ICC) launched the Telepathology Consultation Center (TPCC) to facilitate and standardize the procedure for telepathology for tumor diagnostics and to integrate quality and ethical standards. The TPCC is providing telepathology services via the Internet to developing countries and smaller institutes of pathology in Eastern and Western Europe, Asia, Africa, and North and Latin America. Telemedicine is used in Mexico (22), Georgia (23), and Sweden (24) to decrease the obstacle of geographical isolation to timely and quality medical care (17).

Accessibility of Health Information

The Internet has opened access to vast amounts of information, for both the physician and the patient (Table 1). In the last 8 years, several federal agencies have developed health-related web sites, many with search engines to assist both health professionals and the general public (Table 2). The National Library of Medicine web site has several searchable databases that cover the medical literature providing citations and abstracts. The Centers for Disease Control and Prevention has its prevention guidelines online; the Occupational Safety and Health Administration lists requirements for medical surveillance for work-related exposures; the National Cancer Institute has a range of prevention and research findings available online. Most of these web sites also have databases specifically targeting the general public.

Web sites developed and maintained by federal agencies institute policies to ensure accuracy. However, not all web sites are as carefully reviewed. Anyone can post a web site that has the appearance of credibility (25-27). Web sites by private and non-profit companies and organizations have proliferated and range from credible professional organizations, universities, and public service organizations to private companies selling products and organizations with political or other agendas. Web sites of prominent academic health science centers offer resources ranging from excellent, extensive information for patients to meager postings. Other health-oriented web sites offer health education and prevention information, sell pharmaceuticals or other products, and provide medical opinions for a fee. A proliferation of disease-oriented web sites with chat rooms and discussion boards serve as a way for individuals to exchange information about many serious diseases. These web sites may serve as support groups; however, anecdotal and unsubstantiated information is frequently proliferated. The overwhelming volume of information

Table 1. Selected Internet telehealth resources.

American Medical Association	www.ama-assn.org
American Medical Informatics Association	www.amia.org/index.html
Association of Telehealth Service Providers	www.atsp.org
Center for Studying Health System Change	www.hschange.com
Foundation for Accountability in Healthcare	www.facct.org
Health Watch	www.abtassoc.com/newsletters/healthwatch/healthwatch-index.html
Healthcare Financing Administration	www.hcfa.gov
HealthGrades	www.healthgrades.com
Joint Commission on Accreditation of Healthcare Organizations	www.jcaho.org
Medical Outcomes Trust	www.outcomes-trust.org
National Committee for Quality Assurance	www.ncqa.org
National Guideline Clearinghouse	www.guidelines.gov
Pennsylvania Health Care Cost Containment Council	www.phc4.org
SF-36 (Short Form 36) Functional Status Survey Resource	www.sf-36.com
Telemedicine Information Exchange	http://tie.telemed.org

Table 2. Examples of federal agencies' health information web sites.

Agency for Healthcare Research and Quality	www.ahcpr.gov
Centers for Disease Control and Prevention	http://cdc.gov
Department of Commerce	
National Telecommunication and Information Administration	www.ntia.doc.gov
Department of Defense	
Center for Total Access	www.cta.ha.osd.mil
Dept. of Defense Telemedicine Research Center	www.matmo.org
Department of Energy	
Los Alamos National Lab-Telemedicine	www.acl.lanl.gov/telemed
Department of Health and Human Services	
healthfinder7	www.healthfinder.gov
Office for the Advancement of Telehealth	http://telehealth.hrsa.gov
Office of Rural Health Policy (ORHP)	www.ruralhealth.hrsa.gov
National Library of Medicine	www.nlm.nih.gov/research/telfront.html
Telemedicine Information Exchange	http://tie.telemed.org
Department of Veterans Administration	
Telemedicine Projects	www.va.gov/mediauto/telemed/nat.htm
Federal Communications Commission, Health Care and the FCC	www.fcc.gov/healthnet
Food and Drug Administration	
Center for Devices and Radiological Health	www.fda.gov/cdrh/telemed.html
Health Care Finance Administration	www.hcfa.gov
Medicaid and Telemedicine	www.hcfa.gov/medicaid/telemed.htm
Medicare	www.medicare.gov
National Aeronautics & Space Administration	www.nttc.edu/telemed.html
National Cancer Institute	http://nci.gov
National Institutes of Health	www.nih.gov/
National Institute of Mental Health	www.nimh.nih.gov
National Library of Medicine's National Information Center on Health Services Research and Health Care Technology	www.nlm.nih.gov/nichsr/nichsr.html
Occupational Safety and Health Administration	http://osha.gov
U.S. Department of Agriculture	
Rural Development Rural Utilities Service	www.usda.gov/rus/dlt/dlml.htm

that is available on the Internet makes it difficult to determine the quality, accuracy, and authenticity of the web site (26,27). Recent surveys have shown that patients are most comfortable with Internet resources provided by their own physicians or local health centers (28).

Healthcare Management and Administration

With instant communication and data access, distance is minimized as a factor in healthcare. Accessing and retrieving medical records and information from medical libraries are facilitated, as well as communication among and between patients and healthcare professionals. Integrated clinical management systems manage patients with chronic diseases, such as diabetes and hypertension. Such systems provide an efficient way to integrate patient education, follow-up with nurse practitioners, nutritional counseling and support, and consultations with social workers, as well as facilitate the monitoring of patient progress with personal profiling and data tracking (29-31).

Medical informatics is growing to provide systems to handle the volume of medical knowledge available through communication systems. The wide scope of informatics includes the design of decision systems for practitioners, the development of computer tools for research, the management and integration of clinical care, and the collection of data for evidenced based research.

Administrative functions can be interfaced with the clinical management of a patient, providing practitioners with the ability to better organize their services. Systems may include patient education, scheduling capability, electronic prescribing and refills, referrals and authorizations, consultations, clinical trial management, online forms, insurance claims, medical supply sales, and continuing medical education (32).

Developing Telemedicine Standards and Regulations

In spite of the progress that has been made, several major barriers exist and must be resolved before the delivery of clinical services using telemedicine can become standard practice. Tensions between privacy advocates and commercial healthcare interests regarding the practice of telemedicine are being addressed by several national committees in federal agencies and professional groups. Legal issues have been raised involving licensure (33), malpractice, safety and standards, privacy, security, and confidentiality (34). Intrastate licensure as applied to telemedicine is being addressed in several states. Confidentiality of health information and the security of medical records are addressed in the Health Insurance Portability and Accountability Act of 1996 (HIPAA, Public Law 104-191).

The Telecommunications Reform Act of 1996 includes direct provisions (and funding) to support the delivery of healthcare and education to rural and underserved urban areas (35). Over two billion dollars in funding has been directed toward building a national infrastructure, training professionals, and promoting telehealth. Eleven federal agencies form the Joint Working Group on Telemedicine, the interagency group that promotes telemedicine and telehealth by coordinating activities and funding within the federal government, exchanging information, and reducing barriers to the effective use of telemedicine technologies (36). In 1998, the Health Resources and Services Administration (HRSA) established the Office for the Advancement of Telehealth (OAT) to promote the use of telecommunications for technical assistance, training, and knowledge exchange among clinicians and other healthcare professionals, especially those providing services to low-income, medically underserved, or isolated Americans (1). Agencies such as the Department of Defense see telemedicine as a way to enhance and supplement their medical services.

Digital Technology Overview

Three factors are driving the development of telehealth applications: the digitization of information, the migration toward wireless communications, and the globalization of services (37). The digitization of all types of medical information makes it available for transmission and exchange. Digital compression technology allows vast amounts of information to be stored (37). The desktop computers common in most offices and many homes are being supplemented with and may even be supplanted by wireless technologies, which are now more common in telemetry and emergency medical services. As digital wireless phone systems and technologies become more readily available, hand held devices are freeing physicians from fixed computer locations and allowing instant access to stored information and the exchange of information locally within a building, across a region, or across the world (37).

Clinical Applications

Medical instrumentation is being developed to facilitate telemedicine uses, such as diagnostic-quality stethoscopes that capture and digitize the full range of audio frequencies allowing a clinician at a remote site to hear heart and pulmonary sounds (16). This allows consultations from a distance and facilitates learning.

In other applications, digital cameras capture, store, and send images and interface with medical instrumentation. The prefix "tele" is being added to more and more medical applications. Telemammography and tele-ophthalmology, for example, are improving primary care delivery in underserved clinical settings (38).

Behind the Walls

The "information superhighway" that makes all this possible is a combination of various interconnected networks. The technologies underlying these networks vary, but, when combined into a comprehensive global network, they offer widely available and redundant paths to connections that are then interconnected via other paths to other connections—hence the term "web."

Some links within the system are broad, wide, and state of the art while others are older and narrow. The transmission of information is only as fast, and as good, as the connection. Bottlenecks that slow transmission can occur within the national network or at the lower levels of institutions. Behind our walls, the infrastructure of the lines, switches, hardware, and software must be constructed to accommodate telemedicine applications and the magnitude of information being exchanged: the more bandwidth that is available, the greater the speed and the larger the amount of data that can be exchanged.

Conclusion

Distance learning and telehealth are still in their infancy. However, communications technologies available today (though dependent on individual systems' capacities) are able to connect healthcare professionals (with patients and other healthcare professionals) and information systems (for data and information exchange) located at distant sites. Emerging medical applications that can occur between geographically dispersed locations include initial and continuing medical education, clinical services delivery and consultation, patient education, and healthcare management and administration.

With increasing demands on physicians with regards to their knowledge base and productivity, distance learning and telehealth may provide an opportunity for busy clinicians to meet clinical responsibilities to a more dispersed and diverse population while still participating in educational activities. These "tele" programs may take more time and be more expensive in the short term; however, as the technology becomes more prevalent and the number of users increases, these programs may offer an efficient alternative to meet the escalating demands of a rapidly changing healthcare environment.

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