Telemedicine: history, applications, and impact on librarianship

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This paper traces the uses of telecommunications in health care from the Civil War era to the present. Topics include the National Aeronautics and Space Administration's involvement in the origins of current telemedicine systems and the impact of television. Applications of telemedicine discussed include remote consultation and diagnosis, specialty clinical care (including examples from anesthesia, dermatology, cardiology, psychiatry, radiology, critical care, and oncology), and others (including examples of patient education, home monitoring, and continuing education). The concluding section highlights how telemedicine affects health sciences librarianship, beginning with the development of online computerized literature searching. This section also discusses the medical resources available to health sciences librarians as a result of the Internet.

In March 1994, this author began the research for a paper on telemedicine with a search of the MEDLINE database. Not surprisingly, the then-current three years of MEDLINE contained more references to telemedicine (sixty-eight references) than did the previous twenty-four years (forty-three references). These numbers reflect the recent explosion of information available via telecommunications. It was surprising, however, to learn that although *telemedicine* became a Medical Subject Heading term in 1993, it was first mentioned in the medical literature in 1974, some twenty years earlier [1]. Articles appearing early in the MEDLINE database made reference to pre-MEDLINE published articles dealing with the concept of telemedicine, sometimes referred to by other terms. These terms include *telognosis, telepsychiatry,* and phrases such as "consultation via television" and "diagnosis by television." The earliest reference found was published in 1950 [2].

This paper will begin with a definition of *telemedicine* and continue with a brief history and descriptions of clinical and nonclinical applications that have been reported in the literature. The final section discusses telemedicine's impact on librarianship. The literature review shows that the earliest objective of many telemedicine programs was to provide health care consultation to remote populations, which otherwise would have been left without medical care. This consultation often was accomplished by interactive (two-way) television. Many specialized clinical applications of telemedicine also were developed over the years. Although this paper is not meant to be an exhaustive review of every telemedicine program developed, more than forty articles and several textbooks were reviewed that provide a sampling of telemedicine applications from 1950 to 1995.

DEFINITION AND BACKGROUND

Telemedicine can be defined broadly as the use of telecommunications technology to provide medical information and services [3]. The prefix, from the Greek *telos,* implies distance. This technology often is utilized to connect medically deprived or geographically distant areas with medical centers so that less highly trained on-site personnel can provide health services with long-distance help. The term encompasses a diverse collection of technologies and applications. Telecommunications technology also is used by librarians to assist in the delivery of health care by increasing access to medical information.

The typical clinical telemedicine program consists of a two-way communications link between a medical center staffed by one or more physicians and several satellite stations staffed by nurses, nurse practitioners, or physician assistants. This arrangement provides an opportunity for the patient to be seen by a staff member in the satellite station while both patient and

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nurse have full access to a physician at the medical center. Telemedicine enables providers to perform two-way interactive video consultations and transmit digital images such as X rays and magnetic resonance images (MRIs) to other sites. Telemedicine systems can range from telephone networks to sophisticated video systems. One of the benefits of telemedicine is cost savings, because information is less expensive to transport than are people. Other benefits include immediate access to medical expertise regardless of location, more timely diagnoses and treatments than otherwise would be possible, and the elimination of long patient commutes from rural communities to urban centers.

HISTORY OF TELEMEDICINE

The exact date when telecommunications first were used in health care is unknown [4]. The concept may have originated centuries ago if, for example, information about bubonic plague was transmitted across Europe by heliograph or bonfires as was information about war and famine. It is known that the telegraph was used during the Civil War to transmit casualty lists and order medical supplies. By 1900, the telephone was in use, and physicians were among the first to adopt it. The telephone was the mainstay of medical communications for fifty years and remains a major force. About the time of World War I, radio communication was established, and, by 1930, it was used in remote areas such as Alaska and Australia to transfer medical information. By the time of the Korean and Vietnam conflicts, radio communication was used regularly to dispatch medical teams and helicopters.

Current telemedicine systems originated from developments in the manned space-flight program and separately from the pioneering efforts of a few physicians using off-the-shelf commercial equipment. One of the first efforts to overcome time and distance barriers was telemetry research and development (R&D) undertaken by the National Aeronautics and Space Administration (NASA) in its manned space-flight program. Demonstrating that physiological functions for astronauts in space could be monitored successfully by physicians on earth, NASA's scientists, engineers, and contractors developed sophisticated biomedical telemetry and telecommunications systems for biomedical applications [5]. Initially, NASA scientists were concerned with the physiological effects of zero gravity on astronauts. This concern was translated into constant monitoring of physiological functions: heart rate, blood pressure, respiration rate, and temperature. Extended flight times resulted in the development of medical support systems, including means for diagnosing and treating in-flight emergencies. NASA's experience brought into sharp focus the parallel between the needs of an earth-bound physician trying to monitor, diagnose, and treat an astronaut in space and the needs of equally earth-bound physicians trying to diagnose or treat a patient in a remote location.

A second major influence on the development of telemedicine was the introduction of television. By the late 1950s, developments in closed-circuit television and video telecommunications were recognized by medical personnel, who began to use television in clinical settings. The first interactive video link was established in 1964 between the Nebraska Psychiatric Institute in Omaha and the Norfolk State Hospital, 112 miles away. The first complete telemedicine system linking paraprofessionals and physician-patient encounter settings was installed in 1967, linking the medical station at Boston's Logan Airport to Massachusetts General Hospital [6]. During this initial stage of implementation and testing, researchers demonstrated that remote diagnosis was possible through interactive television and that X rays, medical records, and laboratory data could be transmitted successfully.

During the late 1960s and early 1970s, the federal government provided funding to support the implementation of seven telemedicine research-and-demonstration projects. It was hoped that these projects in various settings would help determine capabilities of equipment and their clinical applicability, as well as the feasibility of telemedicine for solving or mitigating specific problems in medical care. Each demonstration program provided opportunities to test the capability of telemedicine to address a specific set of medical care issues, as well as opportunities for further experimentation with equipment capabilities and physical diagnosis.

Many of the programs were developed in rural areas, where medical staffing has been a critical issue. The rural programs were INTERACT, based at Dartmouth Medical School in Hanover, New Hampshire; Rural Health Associates in Farmington, Maine; Blue Hill Memorial Hospital in Blue Hill, Maine; the Puerto Rico telemedicine program in Ponce, Puerto Rico; Lakeview Clinic in Waconia, Minnesota; Alaska Native Program in Alaska and Seattle, Washington; and the Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC) project on the Papago reservation in southern Arizona.

Despite the large number of projects, the hoped-for definitive conclusions were not obtained. Rather, answers were found for some questions, while more research was recommended to find answers for others. The feasibility of establishing the technological base for telemedicine was verified. It was demonstrated that telecommunications could be utilized as a substitute for travel to obtain medical care; to increase coordination and extend medical and admin-

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istrative functions within large institutions; and to establish a vital link in emergency situations where access to a physician was difficult or impossible to arrange.

REMOTE CONSULTATION AND DIAGNOSIS APPLICATIONS

The earliest objective of telemedicine was to assist in the delivery of health care to persons geographically remote from physicians or a medical center. Many of the references in the medical literature describe projects developed to promote remote consultation and diagnosis via various forms of telecommunications. Highlighted here are a few of the many projects reported in the literature, beginning with the earliest reference located.

In 1950, Gershon-Cohen wrote an article entitled "Telognosis." He stated that *telognosis* is a condensation of the three terms *teleo, roentgen,* and *diagnosis,* indicating X-ray diagnosis obtained from facsimiles of original X rays transmitted by radio or telephone wires over short or long distances. He reported that this system had been used routinely in the field for two years over a distance of twenty-eight miles, between the Chester County Hospital in West Chester, Pennsylvania, and Philadelphia. This facsimile procedure could supply expert X-ray service to the staff of a distant rural hospital without the services of a radiologist. Gershon-Cohen also reported that "engineering improvements . . . [were] being pursued to reduce the cost sufficiently to make this procedure economically practicable" [7].

As far back as the 1960s, physicians at Massachusetts General Hospital provided medical care to patients 2.7 miles away at the hospital's Logan International Airport Medical Station using a two-way audiovisual microwave circuit. The diagnosis and treatment of the nurse-selected patients were evaluated by participating personnel and independent physician observers. Inspection, auscultation, and interpretation of X rays were performed readily despite the distance. This study demonstrated that telediagnosis can increase the availability of quality medical care [8].

A 1989 article described how primary health care teams in a remote area of Queensland, Australia, were linked with their base hospital, regional hospitals, a teaching hospital, and an aerial retrieval team. The North-West Telemedicine Project demonstrated that the introduction of new communication facilities can improve the quality of health care for persons living in isolated areas. This project also demonstrated that it is possible to reduce some health care costs in a remote area [9].

Planning for STARPAHC began in 1973, and the program was operational in 1975. Sponsored by NASA and designed by Lockheed Missiles and Space Corporation, this project had several unique attributes. It utilized the most advanced technology available from the private and public sectors. In both hardware and human systems, NASA and Lockheed had a significant amount of experience and resident expertise to apply. Because the project targeted people with significant health problems who had difficulty accessing health care, extensive evaluation criteria, decision points, and benchmark tests were developed during the initial planning stage. The Indian Health Service already had an extensive computer-based health information system into which medical data and systems-performance data could be integrated for purposes of evaluation. The Indian Health Service adopted the telemedicine concept because of its potential advantages to the Papago people in southern Arizona, with their acute lack of access to medical care. The Papago people accepted telemedicine on the basis of their active participation in its design and implementation [10].

The Dunn-Conrath research into the essence of health care in the Sioux region of northwestern Ontario in Canada resulted in the Telemedicine Project, a joint venture of the University of Toronto and the University of Waterloo, in 1977. The two researchers (Earl Dunn and David Conrath) found that audio signals could be transmitted regularly by telephone and then converted by the telemedicine system into a black-and-white picture, which appeared line by line on a closed-circuit television screen at the receiving end. Such transmissions could help doctors consult with each other concerning a diagnosis and provide teaching assistance to nurses in remote locations. The project included the installation of slow-scan video units in seven other locations: the Hospital for Sick Children; the Sioux Lookout Zone Hospital; and five remote northern health care units, each approximately 250 miles from Sioux Lookout. Airplanes were used extensively to transport patients, doctors, and nurses to these remote communities, where there are few roads [11].

In 1990, Maritime Health Services (MHS) in Seattle initiated an occupational health service that allowed the medical officer on board a northern Pacific fishing trawler to communicate directly with a physician as needed around the clock. This telemedicine system, known as the Medical Consultation Network (MedNet), is a customized video communications application based on a video-conferencing system. Using the system, ocean-going vessels (or any remote site) can establish a live audiovisual link to an emergency physician at MHS. The first field test of the MedNet system was conducted on board the *Golden Alaska,* a large fishing trawler. The ship left port in January 1994 for a three-month "beta test" excursion in the north Pacific. With the *Golden Alaska* voyage

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serving as a launch, MHS foresees other MedNet applications for similar maritime situations such as cruise ships and private yachts, as well as remote land-based situations, logging camps, mining sites, and expeditions. By providing on-site visual information to remote patients, the system extends the availability of timely, expert emergency medical attention and can save money and lives [12].

SPECIALTY CLINICAL-CARE APPLICATIONS

In the early 1970s, experiments with modern communication methods were designed to bring the services of specialists to an expanded number of patients. The basic assumption of such projects in many instances is that the physical presence of a specialist is not necessary and that transmitting appropriate data from the treatment room to a remote specialist provides sufficient information for diagnosis and treatment. The following descriptions were selected to illustrate the uses of telemedicine in anesthesia, dermatology, cardiology, psychiatry, radiology, critical care, and oncology.

Anesthesia

In 1974, Gravenstein reported on the use of laser-mediated telemedicine in anesthesia [13]. He reported that several hypotheses required testing before telemedicine techniques could be employed: When a consultant anesthesiologist is needed in the operating room, the situation usually requires general and special medical expertise rather than manual dexterity; the complex manual maneuvers that are a part of clinical anesthesia can be performed by personnel other than anesthesiologists; consultants can provide maximum direction and guidance to remote nonphysicians if the patient and anesthetizing scene can be viewed on color television, rather than simply described by telephone; and a telemedicine system can be successfully employed in the acute and unforgiving environment of an operating room and anesthetizing area.

A two-way telemedicine system employing laser beams was used. The consultant could view the patient, anesthetizing area, and operating room on a color-television monitor and could converse with the anesthetist. The system permitted the consultant to pan and tilt the camera and adjust the zoom and focus by means of a remote-control panel. Favorable clinical experience with this modality was reported.

Dermatology

The Oregon teledermatology project is part of the National Library of Medicine's (NLM) portion of the High Performance Computing and Communications (HPCC) initiative. The project was designed to improve dermatologic care through the innovative use of high-speed computers, wide-area computer networks, and full-color digital image storage. Dermatologic services are improved through the extension of the clinical expertise of metropolitan dermatologists to rural providers and patients and through enhancements in the diagnostic abilities of primary-care physicians [14].

Cardiology

A twenty-four-hour, telephone-based, pediatric echocardiography service was established between a general hospital and a children's hospital 500 kilometers away. In the first nine months of operation, studies were transmitted in real time for interpretation and diagnosis by a pediatric cardiologist for eighteen children with a median age of five months. Image and sound quality was excellent. A complete segmental diagnosis was made in sixteen patients, and further study was needed in two others. In eight of the eighteen patients, a new diagnosis was provided, and in ten patients, a diagnosis was confirmed. Congenital heart disease was found in twelve patients, other heart disease in two, and a normal heart in four. The population included two fetuses whose echocardiograms showed a hypoplastic left heart and an intracardiac tumor. In four patients, transport was avoided. This is the first report of echocardiographic transmission by telephone, which was shown to be feasible, cost effective, and diagnostically useful. The service provides emergency access to specialist expertise and may avoid hazardous and expensive transport of ill children [15].

On June 25, 1989, an alarm sounded in the halls of the telemetry unit of Jewish Hospital in St. Louis, Missouri. Someone had activated the trans-telephonic defibrillator (TTD). As it turned out, that day was the first time anyone would be defibrillated successfully by telephone. The TTD, approved for use by the U.S. Food and Drug Administration in 1987, is an interactive system that provides a patient with almost immediate communication with hospital clinicians, providing the greatest possible chance of survival. Via telephone, trained clinicians can diagnose, monitor, advise the caregiver, and, if appropriate, defibrillate the patient, regardless of the patient's location. The system consists of a base station (located in the hospital emergency department or the coronary-care or telemetry unit) and a suitcase-like portable unit (located in the patient's home), which is connected to the base station via a standard telephone jack. The system is designed to permit defibrillation only if hospital-based clinicians are involved, so the portable unit has no buttons, dials, or controls. All charging and defibrillating is controlled from the base station [16].

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Psychiatry

Consultation services via two-way, closed-circuit television are effective in helping nonpsychiatric physicians improve their knowledge of psychiatry and treat emotionally ill patients. The authors describe such a service set up between Hanover, New Hampshire, and Claremont, a community twenty-six miles away. The service aided the physicians in keeping the majority of their clients in the community while also providing valuable educational experiences. Two-way, closed-circuit television was an effective means of providing day-to-day professional consultation and support to family physicians while alleviating the effects of uneven geographical distribution of psychiatric staff. The project was designed to evaluate the utility of television as a medium of communication in psychiatric interviewing and consultation at a distance and the effectiveness of readily available psychiatric consultation as an educational tool for physicians in the community who ordinarily would not take advantage of formal postgraduate psychiatry courses.

Television has presented almost no difficulties as a medium for psychiatric consultation. It has not proven to be a significant barrier to the establishment of rapport between doctors and patients or to the perception of emotional nuances. Patient acceptance has been impressively high. Even with a number of paranoid patients, the circumstances of the interviews did not seem to foster additional anxiety nor has the television system become the object of psychotic elaboration. Both patient and psychiatrist almost immediately lost awareness of the television medium as they attended to the interpersonal business at hand. Only once—when a severely agitated patient paced unpredictably about the studio—was there a significant problem in keeping the patient in view [17].

Radiology

As mentioned previously, the earliest reference located regarding telemedicine was the 1950 article by Gershon-Cohen describing X-ray diagnosis obtained from facsimiles transmitted by radio or telephone wires. Radiology continues to be an area with increasing telemedicine applications, as evidenced by the number of articles written recently. At least five references dealing with teleradiology appear in the MEDLINE database for early 1995. Following are highlights of the benefits of teleradiology.

Teleradiology systems electronically transmit radiographic images and consultative text from one site to another. These systems are often wide-area networks (WANs) designed to provide prompt interpretation of radiologic images for patients in underserved rural areas, as well as for those in medical facilities lacking a full-time radiologist. A WAN is a communications system that covers great distances (greater than a metropolitan area) and often employs multiple technologies, such as copper-wire cables, coaxial cable, fiber-optic links, digitally switched circuits, and microwave and satellite links. A WAN also can link multiple hospitals or clinics of health maintenance organizations.

Teleradiology systems can improve emergency service coverage. With the transmission of images to the radiologist's home during evenings or weekends, the radiologist is able to provide prompt interpretation of radiologic images to physicians in the emergency room, the intensive care unit, or elsewhere in the hospital. The immediate availability of image data to these physicians leads to early intervention and improved patient treatment. These systems also enable remote consultation with subspecialty radiologists. Radiologists in the community or in rural areas can gain immediate access to large academic centers for help with difficult cases. In addition, patient care can be improved through the forwarding of radiologic examinations via a teleradiology system to the primary referral center or consultation institution prior to the patient's arrival [18].

The July 13, 1994, issue of *USA Today* describes a $6 million remote teleradiology facility being built in Melbourne, Florida, by the Harris Corporation and the University Technology Transfer Corporation. This facility will be able to transfer X rays, ultrasounds, mammograms, MRIs, and computerized tomography scans via fiber-optic lines connected to the University of California Medical Center in Los Angeles, where thirteen radiology subspecialists are on staff.

Critical care

A 1977 article described how telemedicine was used to solve problems related to the scarcity and poor distribution of specialists in critical-care medicine. Using a two-way audiovisual link between a small private hospital and a large university medical center, an intensive care specialist provided daily consultations to patients in the small institution. The project showed that regular consultations in critical care can be provided using the audiovisual link; telemedicine can be a valuable educational resource; telemedicine can influence the process and probable outcome of patient care; the audiovisual link is superior to the telephone for these consultations; and telemedicine can serve as an important link between a small hospital and a large medical center, favorably influencing the quality of critical care of the small hospital [19].

Oncology

The University of Texas Health Sciences Center (UTHSC) in San Antonio initiated a telemedicine pro-

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ject to provide oncology consultations to South Texas Hospital in Harlingen, approximately 250 miles away. The project was designed to increase physician contact with cancer patients and decrease travel expenditures for UTHSC's pediatric oncologists, who made monthly visits to South Texas Hospital. With the telemedicine system, the oncologists will be able to make weekly rather than monthly visits to South Texas Hospital, where there is no oncologist on staff [20].

OTHER APPLICATIONS

Patient education

The Alzheimer's Disease Support Center (ADSC) in Ohio is a telecomputing-based project designed to provide information and support to caregivers of persons with dementia. Inherent features of telecomputing make systems such as ADSC a viable complement to existing efforts to meet caregivers' needs. Logistical factors often hamper efforts to assist caregivers. Dementia-oriented support groups sometimes are hampered by problems in scheduling, location, and physical setting. Telecomputing—the linking of multiple computers by means of telephone lines and modems—has the potential to mitigate some of these problems. The ADSC is a part of the Cleveland Freenet telecomputing system. The ADSC comprises five modules: About the Support Center, Alzheimer's Disease Q&A, Alzheimer's Disease Information Rack, Alzheimer's Disease Bulletin Board, and the Caregiver Forum. Once "inside" the ADSC, a user types in the number of the desired module. The Freenet limits each session to sixty minutes, but caregivers can access the system as many times each day as they wish [21].

Closed-circuit television enables patient educators to program their own or commercially developed videotapes. Such systems can stand alone or be a part of a comprehensive instructional program. Hospitals recognize the potential of this medium to teach, divert, and relax patients and families. It can be used to deliver the fundamental or basic facts needed by specific patient groups, transmit panel discussions or interviews, convey interesting stories about individual patients, describe innovative technologies or treatments, provide health messages, and test learner knowledge. In some hospitals, closed-circuit television provides the information patients need to make an informed decision about a procedure or other aspects of their care. This technology can reduce the time needed for one-on-one teaching; appeal to the visual and audio learner; provide consistent, comprehensive information; incorporate adult-learning theory; help patients relax; expedite the informed-consent process; and facilitate the evaluation of learning [22].

As part of a pilot test, Harvard Community Health Plan in Cambridge, Massachusetts, has patients in approximately 150 households using home computers to receive medical advice and general health information. Information concerning symptoms is collected directly from patients through interactive protocols. After patients answer a series of questions, the computer determines the seriousness of their problems and advises them on the next step to take. Patients may be told to go directly to the emergency department, make an appointment at the health center, or follow self-care instructions, depending on the nature of their symptoms and their answers to the questions. Most of the patients use terminals provided to them for the study. The goal of the system is to improve patient education, raise the quality of health care, and lower costs by reducing the number of unnecessary health center visits. Of the households using the computer system for nine months, 90% gave it a high rating for "the accuracy of its contents, its usefulness, and its user friendliness" [23].

Home monitoring

Home monitoring via telephone and television allows doctors to observe physical signs such as heart rate, blood pressure, and even blood chemistry of patients using transdermal patches that are already available. Some communities are experimenting with "lifeline" programs, in which the elderly or disabled wear a panic-button device that automatically summons emergency help when activated. Pacemakers and cardiac-monitoring devices also are being tied into sophisticated communications equipment to transmit vital data [24].

TeleDiagnostic Systems of San Francisco is a home-monitoring equipment vendor developing a system for recording sleep patterns. Instead of making sleep-disordered patients come into a regional medical center for all-night monitoring, a community hospital will be able to provide this service in the patient's home. Another clever innovation is the "wanderer" device, which, hooked to Alzheimer's and other mentally confused patients, alerts staff when these patients wander outside [25].

Continuing medical education

Continuing medical education (CME) via television and videotape is a natural progression for physicians who, in their formative years, used television as an educational adjunct to classrooms and books. In conjunction with a study guide, medical television programs can offer CME credits, and they do so conveniently in the physician's living room, eliminating the need to leave home for time-consuming medical seminars. These television programs can provide access to resources unavailable in the physician's hometown: top experts, groundbreaking procedures, and

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the latest in diagnostic equipment. Of the physicians who watch medical television, 63% report that they prefer programs that carry CME credits.

Television broadcasts also offer an excellent forum for the dissemination of government regulations and professional standards. Discussions of medical ethics and economics, mandates from the Occupational Safety and Health Administration and the Health Care Financing Administration, news of revised Centers for Disease Control and Prevention (CDC) guidelines, or proposed professional liability legislation can be disseminated quickly and thoroughly via the airwaves. In this era of health care reform, television also provides information and analysis of the evolution of the reform process.

Advances in television and satellite technology allow medical information to flow in both directions. Audiences in far-off locations can participate in programs with experts. This process (called interactive television) allows the physician to do the asking. Medical procedures and surgical operations can be broadcast live to medical centers around the globe, offering students and physicians unprecedented opportunities to learn about breakthrough diagnostics and therapeutic technologies [26].

IMPACT ON HEALTH SCIENCES LIBRARIANSHIP

Telemedicine first began to impact health sciences librarianship with the development of online computerized literature searching via MEDLINE in 1971. The searching of an online bibliographic database fits the definition of *telemedicine* as the use of telecommunications technology to provide medical information and services. Librarians engaged in telemedicine by providing access to information that enhances patient care. With a telephone line, a modem, and a "dumb terminal," health sciences librarians acquired the capability to search many years' worth of medical literature more efficiently than ever before. They also could provide much-needed information for the delivery of health care in a timely fashion, with the assurance that nothing had been overlooked.

Online searching was just the beginning of telecommunications technology in libraries. Gradually, those "dumb terminals" would be replaced by personal computers, which eventually put the world at librarians' fingertips. Resource sharing also was greatly enhanced by the capability to send and receive interlibrary loan (ILL) requests electronically. DOCLINE, NLM's automated ILL-request routing and referral system, began operating in March 1985 among the seven regional medical libraries (RMLs). There are now eight RMLs in the National Network of Libraries of Medicine, and DOCLINE usage has increased steadily. According to the September 1993 DOCLINE manual, more than 2,500 libraries were participating in the system as of June 1993. With the availability of fax machines, libraries are able to receive ILL requests the same day they are made.

Medical information has become increasingly available via the Internet, which has been called "e-mail based telemedicine" [27]. Rather than communicating with one physician through a typical telemedicine system using two-way interactive video, the Internet can transmit messages simultaneously to physicians worldwide. The result is medical consultations via e-mail. An article in the British journal *Lancet* describes how the Internet was used to transmit images of a fetus in London to the Fetal Treatment Program in San Francisco for purposes of a surgical consultation [28]. Medical resources on the Internet provide a vast amount of information that can be tapped by anyone with a computer and a modem.

Both the MEDLINE and DOCLINE databases are now available via the Internet. Online Computer Library Center's (OCLC) FirstSearch, designed for use by the public but used by many libraries, is available through the Internet, as is PRISM, the OCLC ILL system. DIALOG is also available via the Internet. Ariel is a document-delivery software program developed to transmit and receive documents over the Internet. ILL via Ariel is less expensive and higher in quality than is fax-based ILL. The online public access catalogs of many medical school libraries are available via the Internet, as are electronic bulletin boards, discussion groups, news groups, and listservs. (These terms are often used interchangeably.)

Usenet is a collection of more than 5,000 discussion groups on the Internet. Each group is centered around one particular topic. There is a Usenet news group called "sci.med.telemedicine." The discussion in this news group informed readers of the availability of the *Telemedicine Newsletter*. "sci.med.emergency" is a Usenet discussion group addressing topics such as emergency-medicine informatics that are of interest to emergency physicians. Other medically oriented Usenet news groups include "sci.med," "sci.med.aids," "sci.med.occupational," "sci.med.pharmacy," "sci.med.dentistry," "sci.med.nutrition," and "sci.med.physics."

There are many Gopher servers on the Internet containing medical information. The National Institutes of Health (NIH) Gopher contains NIH resources as well as access to the Gophers of the National Institute of Allergy and Infectious Disease and the National Institute of Mental Health. The Center for Advanced Medical Informatics Gopher at Stanford University is a shared computing resource supporting research activities in biomedical informatics at Stanford's School of Medicine. HEALTHLINE, the University of Montana Student Health Services Gopher, offers electronically many of the same types of in-

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formation that one would receive in printed form at any university health center. The Bioinformatics Resource Gopher at the University of West Florida has on its main menu "all the Gopher servers in the world," allowing users to print a seventy-eight-page list of additional Gopher servers.

The World Wide Web is a set of programming techniques used to navigate the Internet by clicking a mouse on a highlighted word. The Web can display images, sounds, and text. A popular Web browser is Mosaic, developed at the National Center for Supercomputing Applications at the University of Illinois at Urbana. The number of Web sites has grown from a few dozen in 1993, when the first version of Mosaic was released, to thousands today. More than 120 of these sites are medicine related, including the University of Pennsylvania's OncoLink, which provides information about the latest cancer research and treatment [29].

The Internet can be used by a health sciences librarian to find answers and locate information for clients by posting questions on MEDLIB-L, the listserv that discusses issues of interest to health sciences librarians. MEDLIB-L has provided answers when all other resources have been exhausted; it has become a valuable reference tool.

How does one know what medical resources are available on the Internet? Many print reference tools are available in local bookstores. There are also several Internet resources that serve as guides to medical information. Most of these resources can be found on more than one Gopher server, FTP site, or Web site and have become almost standard. For example, Lee Hancock's List of Health Sciences Resources can be found on many Gopher servers and FTP sites. Another resource is the Guide to Internet Medical Resources, compiled by Gary Malet, M.D. A third is Emory University's Guide to Biomedical Internet Resources, which can be accessed at NLM's Web site. The NLM Gopher server and Web site are both good starting points from which to explore.

Librarians may find it useful to keep a list of Gopher servers and Web sites next to their computers. The list could note the Internet address and resources of value to be found at each site. For example, on the Library of Congress MARVEL Gopher, one can find the Morbidity and Mortality Weekly Report (MMWR) and the Federal Register. On the CDC Clearinghouse Gopher, I found the CDC Daily Aids Summaries and, again, the MMWR. In exploring, one finds much duplication. Recent issues of the *MLA News* and MLA's Hospital Libraries Section's *National Network* newsletter have been extremely valuable in providing up-to-date listings of Gopher servers, Web sites, and listservs. The October 1994 and January 1995 issues of the *Bulletin of the Medical Library Association* contain several articles highlighting the use of the Internet that are very helpful. Librarians should take time to read and explore.

CONCLUSION

Clinical telemedicine programs are now underway in at least forty states, and it is likely that many physicians in the United States will be involved directly or indirectly with clinical telemedicine by the year 2000 [30]. Applications of telemedicine will continue to grow as television, telephone, and computer technologies advance. Clearly, there will be increased connectivity. In the not-too-distant future, it will be commonplace for sophisticated interactive multimedia programs, linked through television and computer capabilities, to enable the physician user to maximize learning, comprehension, and recall. These programs, which dwarf the capabilities of products currently available to consumers, will be part of the library of resources available one day to educate, communicate, and interconnect the physician and the health care community [31].

Telecommunications technology has made available to the health sciences librarian a multitude of new information resources. Librarians are being challenged to know what resources are available so that they will be able to choose the path that provides the most timely, efficient, and accurate answers to the questions clients ask.

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