

# Telemedicine

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**T**elemedicine, in the broadest sense, refers to the application of any telecommunications technology to the provision of health care when distance separates the participants.<sup>1</sup> For this discussion, the term *telemedicine* specifically refers to communication for clinical consultation or education between host and remote sites using technologies other than telephone or fax. The terms *host* and *remote* purposefully imply an asymmetry of resources, as telemedicine fundamentally can be used to distribute technologies or expertise to environments lacking those capabilities. Cutting-edge telemedicine frequently requires sophisticated computer technologies and a high-bandwidth communication infrastructure, but applications are also implemented more modestly. Telemedicine can potentially serve to decentralize scarce resources and provide access to care or education across barriers of time or distance. Programs for patient education, the continuing education of health practitioners, and health professions training have also been successfully implemented. This article reviews clinical applications of telemedicine, supporting communication technologies, and legal and financial policy issues related to the "practice" of telemedicine.

## HISTORIC PERSPECTIVE

The lineage of telemedicine extends over 30 years and can be traced to the beginning of space flight missions by the National Aeronautics and Space Administration (NASA), which developed biotelemetry to monitor parameters of astronauts' health, such as heart rate and rhythm.<sup>2</sup> Biotelemetry is the transmission of biomedical or physiological data from a remote location, in this case a NASA spacecraft, to a host site such as Mission Control that has the capability to interpret and act on the data.

Today, telemedicine extends significantly beyond biotelemetry and involves real-time audiovisual communication between remote and host sites, augmented by the use of electronic diagnostic instruments such as the digital stethoscope. Prototypes of remote control instruments that perform procedures or surgery on a distant patient are now being developed. However, telemedi-

cine has found its greatest use to date in teleradiology with more than 250,000 diagnostic studies completed as of 1997. Other clinical specialties most rapidly adopting the use of telemedicine include psychiatry, cardiology, ophthalmology, and orthopedics.<sup>3</sup>

## INTERACTIVE VIDEOCONFERENCING AND STORE-AND-FORWARD TECHNOLOGIES

In general, telemedicine is considered in two broad categories: real-time or interactive videoconferencing involving concurrent activity at both the host and remote sites, or store-and-forward technologies, which are time-shifted communications that may be likened to a "video e-mail." Store-and-forward technologies can overcome barriers of both geography and time, linking sites that may be quite distant from each other or can provide the ability to shift an after-hours consultation to a more convenient time in the same way that a video cassette recorder is useful to time-shift a television program.

### Interactive Videoconferencing

Interactive telemedicine applications are often used to provide clinical consultation regarding a patient at a remote site from a clinician at a host site. The technologies most often employed resemble interactive television. Each site is equipped with a video monitor as well as a video camera that transmits images to the monitor at the alternate site so that patients and clinicians can interact in real-time, albeit via videoconference (**Figure 1**). In addition to the capacity of behavioral observation, diagnostic "digital instruments" can augment telemedicine consultations. In essence, virtually any instrument

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**Figure 1.** At the telemedicine host site of the Virginia Commonwealth University, Medical College of Virginia, (Richmond, VA), Dr. Michael Wong examines a patient at the Powhatan Correctional Center, located 27 miles away. A nurse places the stethoscope to capture heart sounds, which are transmitted with the video via a high-speed telecommunications link. More than 1500 patient consultations have been provided using this interactive videoconferencing telemedicine system. (Photograph courtesy of the *Richmond Times-Dispatch*; photographer, Kevin Morley)

capable of producing electronic data output, such as an image (digital retinoscope), a sound (Doppler ultrasound), or a waveform (electrocardiograph), can be employed to transmit data as part of the telemedicine exchange. Examples of other telemedicine tools include digital sphygmomanometers and digital dermatoscopes. A fixed video camera for transmitting images of paper-based documentation is also indispensable.

Although installation of the interactive equipment may be beyond the technical capability of average computer users, operation difficulty is on par with programming a video cassette recorder. In practice, a technical support person is typically available to guide clinicians and patients through the operation of the telemedicine equipment until clinical staff are comfortable with equipment operation.

The clinical telemedicine consultation usually involves presentation of the patient at the remote site by a clinician (sometimes a physician, but often not) to a physician providing consultative service at the host site. In

some instances, a nurse both presents patients to the consultant and also serves as the technical support person.

#### **Store-and-Forward Technologies**

Store-and-forward technologies generally couple clinical history with still images, audio recordings, or videos for later review at the distant site. For example, an electrocardiogram might be forwarded with clinical information to a consulting cardiologist. Most telemedicine consultants have developed a consultation protocol to ensure that desired information is available because, in contrast to interactive applications, no capacity to probe for additional data without delaying the consultative response is available.

Although store-and-forward and interactive technologies may seem complementary, most telemedicine programs specialize in one technology or the other. Again, installation of the telemedicine system is generally deferred to technicians, however, operation is on par with use of more sophisticated e-mail, database,

and graphics applications that run on standard personal computers. Store-and-forward technologies are generally more amenable to Internet use for data transmission than are interactive systems which, in contrast, require rapid transmission of large amounts of data, often necessitating the use of multiple dedicated digital communications lines. Start-up and operational costs of store-and-forward systems tend to be lower than high-resolution videoconferencing.

#### CLINICAL APPLICATIONS OF TELEMEDICINE

The ability to communicate with patients in a manner that reveals facial expressions and body language has facilitated the adoption of interactive telemedicine by psychiatrists. In essence, this application of videoconferencing is ideal.<sup>4</sup> However, telemedicine has also been adopted among the most intensive users of sophisticated electronic diagnostic equipment. In cardiology, for example, the digital stethoscope assists in clinical examination and real-time echocardiography has also proven feasible.<sup>5</sup>

Telemedicine may be used as a substitute for the transportation of patients, clinicians, or technologies. As such, telemedicine has found enthusiastic use in situations where transportation is impractical (ie, space flight, ocean-going vessels), expensive (as with care of incarcerated patients), urgent (as in the delivery of emergency medical services), or complicated (as in the care of homebound patients).

As discussed later in this article, more pervasive implementation of telemedicine has been thwarted by complex issues of reimbursement, clinical privileging, and variable licensure regulations in the different legal jurisdictions in which host and remote sites might exist. These challenges have been surmounted in the geographically dispersed, but more coherent Veterans Health Administration (VHA) system. The VHA has emerged as a leader in clinical, administrative, research, and educational uses of telemedicine technologies as summarized in **Table 1**.

#### Prison Telemedicine

Providing health care to prisoners has proven to be a viable use for telemedicine. Plagued with escalating health care expenditures caused by an aging prison population, overall growth in the number of prisoners, the increased number of prisoners with AIDS and other infectious diseases, the placement of most prisons in rural settings, and the costs associated with mitigating the risks of prisoner escape during transport, prisoner health care is problematic. Health care visits away from the prison typically require two security escorts and pos-

sibly additional medical personnel. Thus, bringing health care services to the prison via telemedicine provides economical increased access to rapid specialty consultation and offers the opportunity to better triage the needs of incarcerated patients. Prison telemedicine programs have operated on the scale of both local and statewide jurisdictions and have provided care ranging from general health maintenance to specialty consultation and mental health services.

One of the largest correctional telemedicine programs is operated by the University of Texas Medical Branch Hospitals Program (Galveston, TX). This highly successful program provides access to 18 specialty and subspecialty services for the Texas Department of Criminal Justice (Austin, TX), one of the largest prison systems in the United States. In practical terms, the 133,000 inmates in 104 Texas prison units are largely located in rural settings or, at the extreme, are even more isolated such as at the Galveston Island unit located in the Gulf of Mexico. Telemedicine serves to effectively remove barriers of distance and the expense of transportation to the University of Texas Medical Branch, a round-trip distance of up to 850 miles.<sup>6</sup>

Telemedicine also answers the need for increased health care for the expanding population of prisoners with HIV. In Virginia, for example, improved access and continuity of care for incarcerated patients are provided by the telemedicine program at Virginia Commonwealth University, Medical College of Virginia Campus (Richmond, VA), seen in Figure 1. Formal cost-effectiveness evaluation has revealed the value of this program in the performance of hundreds of infectious disease consultations since the program's inception.<sup>7</sup>

#### Home Care

The emphasis on efficiency in contemporary health care has shifted sicker patients out of the hospital and into skilled nursing and home care environments. Telemedicine has also found a robust role in support of the care of these patients. Although high-resolution interactive telemedicine is not yet practical outside of specialized circumstances, telephonically transmitted data and images using Internet-based or dedicated technologies are becoming an important adjunct to home health care services. Transmission of static images captured by digital cameras has proven useful for home wound care management. Telemedicine has also been effective in decreasing the number of home nursing visits, emergency presentations, and hospitalizations for patients with chronic diseases including congestive heart failure and diabetes.<sup>3</sup>

In the Diabetes Home Monitoring Project at Georgetown University (Washington, DC), patients are

**Table 1.** Select Telemedicine Programs in the Veterans Health Administration System

Clinical Application	Telemedicine Accomplishments
Teleradiology	First "filmless" radiology department at Baltimore, MD, Medical Center; now linked with other hospitals in Maryland and Washington, DC, region
Telepathology	Utilizes hybrid interactive robotic and store-and-forward systems to link medical centers in Milwaukee, WI, with Iron Mountain, MI, and Richmond, VA, with Beckley, WV
Telecardiology	Pacemaker Surveillance Centers in Washington, DC, and San Francisco, CA, provide follow-up pacemaker monitoring for thousands of patients located throughout the United States
Telemental health	Digital videoconferencing for the assessment and treatment of mood disorders (Iron Mountain, MI, and Baltimore, MD, are host sites)
Teledermatology	Videoconferencing and store-and-forward dermatoscopy used to assess skin conditions
Telecare in diabetes	Home-based information tool using clinical workstations to enhance longitudinal care for diabetic patients
Teledentistry	Digital imaging and dental radiology used to enhance delivery of dental services and education
Telenuclear medicine	Cost-effective, "low-tech" image transmission for nuclear medicine consultations between facilities
Health practitioner and patient education	Videoconferencing infrastructure utilized to distribute educational programming
Distributed administration	Videoconferencing infrastructure utilized as a substitute for employee travel between facilities for administrative activity

Data from Telemedicine in Action Web page. Available at <http://www.va.gov/telemed/teleactn.htm>. Accessed September 20, 1999.

provided with a glucometer and personal computer (PC). Each week, patients electronically feed blood glucose readings recorded in the glucometer's memory into the PC for transmission to their physician's office for review and adjustment of therapy.<sup>8</sup>

### Emergency Medicine

The use of telemedicine in emergency care not only removes barriers of time and distance but is also altering the evolution of health care service provision in the pre-hospital environment. Increasingly, more sophisticated diagnostic and therapeutic interventions are being initiated in the field. For example, a telemedicine project at the University of Maryland Medical Center (Baltimore, MD) has focused on early diagnosis of thrombotic strokes. There, the Brain Attack Team (BAT) operates two ambulances ("BAT-mobiles") with digital cell phones that are able to transmit vital signs and real-time video images to emergency physicians who identify patients appropriate for direct transport to the brain imaging center for possible rapid thrombolytic therapy.<sup>9</sup> The San Antonio Fire Department (San Antonio, TX) has already installed telemedicine equipment for interactive audio-video communications in approximately half of its ambulances. Paramedics wear wireless headsets for audio communications and monitor two video screens: one screen displaying video being sent to the emergency department at San Antonio's

University Hospital, and a second screen receiving a live video from the emergency physicians. This system allows "face-to-face" discussion between the paramedics and emergency physicians and extends the range of field triage, diagnosis, and therapeutic interventions.<sup>10</sup>

Emergency telemedicine provides particular advantage in rural settings where the distance to specialty care services can dilute the effectiveness of emergency response. However, the most fundamental limitation to the expansion of telemedicine is expense. Whereas the cost of equipping each ambulance was a relatively modest \$22,000, the overall start-up cost for the San Antonio program (including software and network development) was approximately \$3.3 million. As with home care, a less expensive alternative involves the use of digital cameras. This technology is being implemented in the Knoxville, TN, area where rescue vehicles, including a helicopter, will be equipped with the technology to transmit static images from accident scenes. These photographs will be sent via cellular modem to physicians at a nearby hospital as well as to the University of Tennessee trauma center (Knoxville) with the expectation that emergency physicians can help to determine optimal triage and treatment based on an improved understanding of the mechanism of injury at the accident site. In addition to increasing the speed with which medical evaluation is brought to patients, telemedicine may also help to route patients

in need of less acute service to less costly environments, especially since Medicare reimbursement changed in 1998 from paying for transport of a patient to paying only for the level of care that is medically justified.<sup>11</sup>

### Teleradiology

Radiology was one of the first clinical disciplines to extensively utilize telemedicine technologies. Review of digital radiographs can occur interactively, or images can be pooled to be read in batches. The first completely "filmless" radiology department was installed in 1993 at the Baltimore Veterans Affairs Medical Center (Baltimore, MD).<sup>12</sup> Teleradiology is centered around Picture Archiving and Communication Systems (PACS) that allow digital capture of radiographic images for distribution to clinicians throughout a hospital, health system, or beyond. With the development of relatively inexpensive computer memory for both image display and storage as well as affordable technologies that provide video resolution at levels adequate for diagnostic purposes, PACS became practical. PACS obviate the need for physical retrieval and storage of films. Economically, the cost of silver-based film and the labor and warehousing expense of film filing is eliminated. From a clinical perspective, radiographic images are theoretically available immediately to intensive care units, emergency rooms, or other locations on a PACS network. Moreover, software allows dynamic image manipulation such as screening out distractions, altering contrast, or electronic "coning down" or zooming in. The convergence of PACS with clinical information systems (ie, insertion of imaging into electronic medical records) is an emerging direction in clinical informatics and already available in some settings. Ultimately, this convergence may blur the boundary between telemedicine and consultative communication among clinicians who utilize advanced electronic medical records with the capacity for embedding clinical images, videos, and sounds in computer-based patient charts.

### Telepathology

Telepathology represents another burgeoning avenue of telemedicine. As with radiology, store-and-forward technology enables review of batched images or videos, however, hybrid applications using robotically controlled microscopes at the remote site are now available.<sup>13</sup> In this application, the pathologist can maneuver pathology specimens on a robotically controlled microscope stage, change objectives, and control the focus. Importantly, software is available that creates an image of the specimen in its entirety, upon which a "trail" of the area microscopically reviewed by the pathologist is

drawn, so that unexamined areas of the slide are apparent, allowing the pathologist to examine specimens systematically and entirely. The pathologist also has the ability to manipulate the image electronically, adjusting contrast, color, and magnification. Images from the specimen can be saved independently, forwarded to an electronic chart, or returned to the remote site with interpretation and annotation. This technology can be used in real time for evaluation of frozen sections from surgeries being performed at distant facilities.

### LINKING TELEMEDICINE AND CLINICAL INFORMATION SYSTEMS

Transmitting data and images within and between health care settings requires that all of the computerized information systems in use are able to communicate. A set of data specifications constituting a standard for electronic communication of health care information, the *Healthcare Level 7 (HL-7)*,<sup>14</sup> was published in 1987 with the goal of seamless distribution of clinical, financial, and administrative information among independent computers functioning as hospital, clinical laboratory, pharmacy, and enterprise systems. Clearly, health care is far from total computerization even among acute care hospitals, and many legacy systems predating the HL-7 standard remain in place. Thus, integration of telemedicine and clinical information systems remains an aspiration for the future.

In radiology, the Digital Imaging and Communications in Medicine (DICOM) specifications constitute the industry standard for electronic transmission of medical imaging. DICOM-compliant equipment produced by different manufacturers should be compatible, although admittedly varying degrees of compatibility are still challenging.

### Bandwidth

Interactive telemedicine requires relatively rapid transmission of large amounts of data. In contrast, store-and-forward technologies can send data, even moving images, at a more leisurely pace because the recipient is not waiting moment-by-moment for the next image to arrive. The concept of information transmitted per unit of time is known as *bandwidth*; the more information necessary to transmit and the more rapidly it is required, the higher the bandwidth needed. Data may be described as *analog* or *digital*. Analog refers to the representation of one form of information as some other sort of continuous signal. For example, sound can be represented by the oscillation of radio waves, which, in turn, can be received and reinterpreted back into sound. In contrast, digitization represents complex information, such as

sound, in a binary form, literally a succession of discrete ones and zeros. Rules are used to translate that information into a usable form. Binary information can be transmitted rapidly and accurately because it is so simple. However, the more complex the original information, the greater the amount of digital data generated. Moving images appropriate for clinical telemedicine are composed of static images updated as often as 30 times per second, a process that voraciously consumes bandwidth. Similarly, high resolution digitized radiographs that convey the subtleties necessary for clinical diagnosis are also extremely data intensive and, despite being static, consume bandwidth when transmitted rapidly.

Achieving adequate bandwidth to make telemedicine practical often relies on a communications infrastructure that is more robust than analog telephone lines originally designed only to transmit sound in the limited spectrum of human hearing. Telephones are forced to transmit digital data via the now ubiquitous modem ("modulator-demodulator") that "modulates" digital data for analog transmission in the voice frequency range while a modem on the receiving end "demodulates" the transmission back into digital data. This double conversion of data is slow, and high-bandwidth telemedicine applications require faster digital transmission media. Bandwidth is measured in megabits (one million basic data elements) per second (Mbps).

As clinicians are often called upon to guide the development of telemedicine projects, some familiarity with the arcane terminology of digital communications is valuable. The names and bandwidth capacity of various types of transmission media are summarized in **Table 2**.

### **Start-up and Operational Costs**

State-of-the-art interactive videoconferencing systems can be obtained for less than \$30,000 per site. Store-and-forward systems are generally less expensive and can even be operated from robust personal computers equipped with digital cameras and image management software. Start-up costs for the more sophisticated systems may include development of a high-bandwidth digital communications infrastructure, an expense that can rise into hundreds of thousands of dollars. Development of less expensive systems for the transmission of images using consumer quality video cameras, desktop computers, and standard modems is also possible. The Internet already serves as an inexpensive de facto network for some telemedicine implementations.

Some electronic diagnostic equipment can be utilized without modification for telemedicine; even if the output is analog (as with standard television or video-cassette recorders), most telemedicine systems accom-

modate these signals for subsequent digitization. Equipment that can be adapted includes most endoscopes, ultrasound devices, and other imaging technologies such as video culdoscopes and video cassette recorders. Dedicated telemedicine instruments can range from less than \$200 for an electronic stethoscope to more than \$10,000 for high-quality dermatoscopes or more than \$100,000 for a robotic telepathology system. Operational costs not only include staffing and maintenance, but also the communication costs that vary directly with the bandwidth required (Table 2).

### **Policy and Payment Issues**

A number of policy issues have emerged as interest in telemedicine for clinical care or consultation has expanded.<sup>15</sup> These issues include policy concerning the local, regional, and national telecommunications infrastructure; the licensure of health care professionals for interstate telemedicine programs; issues of medical liability; the privacy and confidentiality of electronically transmitted medical records; and reimbursement for clinical services provided through telemedicine.

**Telecommunications infrastructure.** At the federal level, the "Telecommunications Bill of 1996" provided key legislation assuring that rural, high-cost, or low income areas have access to telecommunication services at affordable rates.<sup>16</sup> A key provision of the legislation was establishment of funding to reimburse rural sites for the additional costs of access to telecommunications services. Although telemedicine is only one component of the broader area of telecommunications and information technologies addressed by this legislation, there are significant implications for health care access in rural areas of the country that are frequently medically under-served.

Although a number of state initiatives have addressed telemedicine planning and development efforts, a great deal of variability exists among the states concerning integration of telemedicine as a component of communications technologies.<sup>17,18</sup> Whereas some states have well developed programs for telemedicine, other states have little or no telemedicine activity. This discrepancy led to the recommendation by the Western Governors' Association (Denver, CO) that all states "integrate information technology planning and development across state agencies . . . to consider the needs of telemedicine and other health care applications."<sup>19</sup> The Southern Governors' Association (Washington, DC) convened a similar group of state representatives to address state telemedicine policy issues.

**Licensure for interstate telemedicine programs.** Licensure and regulation of the health professions has

**Table 2.** Common Transmission Media in Terms of Bandwidth and Cost

Transmission Media	Bandwidth	Cost	Other Notable Factors
Coaxial cable	10 Mbps	Very expensive	As used for cable television; increasingly used for digital data transmission
Unshielded twisted pair cable	Category 1 and 2: 4 Mbps; category 3: 16 Mbps; category 4: 20 Mbps; category 5: 100 Mbps	Least expensive of all cable types	Pairs of copper wires twisted around each other reduce interference
Shielded twisted pair cable	150 Mbps	More expensive than unshielded cable	Metal or foil covering reduces interference
Fiber-optic cable	100 Mbps to 2 gigabits per second	Very expensive	Transmits data as pulses of light; not subject to electromagnetic interference; excellent for security
Infrared systems	4 Mbps	More expensive than cable	Easy installation
Radio systems	2 Mbps	Expensive compared with cable	Electromagnetic interference and interception of signal possible
Microwave systems	10 Mbps	Expensive	Used when a physical connection is impossible or impractical (eg, across a major highway or lake)
Satellite systems	2 to 10 Mbps	Very expensive	Ideal for communication between remote areas
Integrated services digital network	Basic rate interface is up to 128 Kbps; primary rate interface is 1.5 Mbps	Expensive: \$20 to \$30 per hour per line	Digital service increasingly available to the home and small office environment, good for intermittent use
Asynchronous transfer mode	Scalable—variable bandwidth, 100 Mbps is standard	Expensive (approximately \$1000 per port plus line use fees)	High speed data transmission in "packets" for sending voluminous data of variable types across multi-user network
T1	1.544 Mbps	More expensive than integrated services digital network	Data and voice can be transmitted together by "multiplexing;" a leased, dedicated line best for continuous use
T3	4.5 Mbps	More expensive than T1	Fiber-optic trunks that connect large Internet service providers to the Internet
Optic fiber channel link (OC12 to OC48)	2.4 gigabits per second (2400 Mbps)	Very expensive	Fiber-optic trunks for largest scale data transmission

Kbps = kilobits per second; Mbps = megabits per second.

Data from Maran R: *Teach Yourself Networking Visually*. Foster City, CA: IDG Books, 1997 and Simonds F: *LAN Communications Handbook*. New York: McGraw-Hill, 1994.

been the responsibility of state governments and was developed to protect state residents from unqualified health care practitioners. Any out-of-state physician who diagnoses and treats a patient in a state must be licensed in that state. Clearly, if physicians needed to be fully licensed in every state to which they provide (or seek) telemedicine consultation, interstate telemedicine initiatives would be significantly hindered. Again, tremendous variability exists in how states address the interstate use of telemedicine.<sup>20</sup> Some states prohibit out-of-state physicians from practicing without a local license, requiring

full licensure for all out-of-state telemedicine providers. Many states have specific limitations on telemedicine consultations by out-of-state physicians, including exceptions for bordering states, limitations on the frequency or duration of the consultation, and requirements that in-state physicians request the consultation. Possible solutions to these licensure problems proposed by the Western Governors' Association include:

- Exemption of telemedicine consultations from licensing requirements under specific conditions

- Determination that no additional licensure is required because the telemedicine provider is only serving as a consultant
- Development of a uniform state code for telemedicine licensure and credentialing, or licensure at the institutional or network level

The Federation of State Medical Boards of the United States, Inc., (Eules, TX) has developed "A Model Act to Regulate the Practice of Medicine Across State Lines,"<sup>21</sup> which can serve as a model for state legislation addressing licensure for interstate telemedicine practice. This proposal requires that physicians who engage in the practice of medicine across state lines by electronic means obtain a special license issued by the state medical boards. Such a license would not allow the physician to enter the state for the purpose of engaging in the practice of medicine. The prospects for medical licensure of physicians at the national level are extremely unlikely.

**Medical liability issues.** The issue of liability for care provided as a result of a telemedicine contact has not been resolved. Uncertainty about whether telemedicine contacts are covered by malpractice insurance policies also exists. For telemedicine programs that cross state lines, in which state the malpractice suit would be litigated and under which state's laws is unclear. Because of significant differences among states concerning malpractice award limits, these decisions could have large financial implications. Some of these issues can be resolved through legislation at the state level, however, many of the legal issues must be handled federally or by the courts.

**Privacy, confidentiality, and electronic medical information.** Development of electronic patient databases and medical records that can be accessed by a number of care providers located at different geographic sites is an important feature of telemedicine. Therefore, issues related to privacy and confidentiality of medical records must be addressed if telemedicine usage is to expand. The National Resource Council (Washington, DC) has made a number of recommendations to maintain the security of electronic medical information in the report, *For the Record: Protecting Electronic Health Information*.<sup>22</sup> These recommendations include the use of unique identifiers for individuals allowed access to these records, access controls for information retrieved, audit trails to monitor access to electronic records, limitations of physical access to computer systems, encryption of patient-identifying information before transmission, use of "fire-walls" to block unauthorized external access, and the regular reassessment of system security. At a state level, uniform privacy and confidentiality regula-

tions are currently lacking, although many of these issues are now being addressed in proposed federal legislation and regulations.

**Reimbursement for clinical services provided through telemedicine.** Cost and unfavorable reimbursement policies remain significant barriers to the expansion of telemedicine.<sup>23</sup> As described, the start-up and operational costs of telemedicine programs can be substantial. Major restrictions limit fee-for-service payments to physicians for telemedicine services. In general, payors do not currently view telemedicine as equivalent to standard care and have been reluctant to reimburse for telemedicine services.

The Balanced Budget Act of 1997 provided some reimbursement for telemedicine services through the standard Medicare program but only for individuals utilizing telemedicine systems in federally identified "Health Profession Shortage Areas." These areas are designated by the United States Department of Health and Human Services as urban or rural areas with underserved populations or an inadequate number of health care practitioners and facilities.<sup>24</sup> The payment is shared between consulting and referring practitioners (75%:25%), and the total amount paid cannot exceed the current fee schedule of the consulting physician.

Currently, Senate Bill 770, the "Comprehensive Telehealth Act of 1999," articulates new reimbursement policies for consultative telemedicine services performed by Medicare providers.<sup>25</sup> Medicaid reimbursement policies for telemedicine are determined at the state level. Medicaid programs may find telemedicine appealing as a means of decreasing transportation costs for persons in rural areas, although only 10 states presently reimburse for telemedicine as a covered service. Reimbursement for telemedicine services by other third-party payers is very limited.

Telemedicine use has experienced more rapid growth in health systems that are not limited by fee-for-service payment policies, such as the military, veteran, and prison health care systems. The use of telemedicine in the context of bundled payment methods for a package of services or capitation payment methodology offers the opportunity for increased efficiency and access to care, provided that the quality of care can be monitored and maintained. Issues that must be addressed concerning reimbursement for telemedicine services include a general lack of information about the value of telemedicine applications compared to standard medical practice, concerns regarding large increases in utilization and cost if telemedicine services improve access to care, fear of overutilization, and caution concerning the sustainability of telemedicine systems in rural markets.

### Evaluating the Success of Telemedicine Initiatives

Evaluation of both cost-effectiveness and clinical efficacy of telemedicine initiatives relates to the capacity of telemedicine to increase access to and distribute clinical, educational, and administrative resources by removing or reducing barriers imposed by time, distance, or geography in the provision of quality care. An increasing body of literature defines mechanisms for appropriate evaluation of cost-effectiveness, although evaluation of health and social outcomes is difficult.<sup>26,27</sup> The cost-effectiveness analysis of telemedicine is substantially predicated on the concepts of telemedicine as a substitute for travel (either by the patient or clinician) or the alternative expense to providing a clinical resource (clinician and/or technology) at the remote telemedicine site. Although calculation of the cost differential between travel and use of telemedicine technologies is relatively straightforward, rigorous cost-effectiveness analysis is limited by relatively small samples (especially for new initiatives) resulting in a high fixed-cost component of unit cost and difficulty in quantifying health and nonhealth outcomes, including satisfaction. In these circumstances, cost-reduction and cost-minimization analysis may be more accurately applied and are appropriately complemented by analyses of medical efficacy, which focus on the technical capacity to provide effective clinical service.

### CONCLUSIONS

Telemedicine remains an emerging technology and clinical discipline. Telemedicine is apt to be most successful in situations in which access to more traditional health care services is urgent, difficult, or expensive, as might occur with critically ill, rural patients or in the more routine care of incarcerated patients who require that all health travel be coordinated with security personnel and, in some cases, clinicians as well. The range of clinical, educational, and administrative initiatives that utilize telemedicine continues to expand. All clinicians will be increasingly exposed to advanced telecommunications technologies applied to health care, and these technologies will ultimately converge with clinical information systems that support robust electronic medical records. In the meantime, mechanisms for assuring the quality of clinical telemedicine services require further elaboration. Policy issues, including reimbursement, licensure, and privacy remain to be addressed. Further education and experience will be necessary to allay skepticism and recognize the current and potential utility of telemedicine. HP

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