Telemedicine and Remote Patient Monitoring

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DEFINED BROADLY, *TELEMEDICINE* is the use of electronic information and communications technologies to provide and support health care when distance separates the participants.[1] The term is also applied more narrowly to medical applications that use interactive video, typically for specialty or subspecialty physician consultations. Sometimes the term *telehealth* is used to encompass educational, research, and administrative uses as well as clinical applications that involve nurses, psychologists, administrators, and other nonphysicians.

Telemedicine using interactive video made its debut about 40 years ago to support neurologic and psychiatric services in Nebraska.[2] Through the early 1990s, telemedicine mostly involved specialty consultations via videoconference technology. Recently, more attention has focused on noninteractive applications, including those that use relatively inexpensive store-and-forward technologies to save and then transmit text and images (essentially, multimedia e-mail).

Both interactive and noninteractive technologies are increasingly used or promoted for remote monitoring of health status in homes and other settings.[3] Given the range of applications and technologies, evaluating the effectiveness of telemedicine means individually evaluating different combinations of technologies and clinical or other uses.

Slow Dissemination of Telemedicine

Despite decreasing equipment costs and rapidly evolving computer and telecommunications technologies, telemedicine, especially interactive video, has grown relatively slowly and unevenly. According to a national survey of telemedicine activity in 1998 (excluding radiology), 30% of the activity was concentrated in a small subset of state prisons and 20% involved mental health.[4] In a survey of 1999 activity, only 15 of 132 responding programs (again excluding radiology) reported more than 1000 telemedicine encounters per year. Most involved a handful of high-volume specialties (mental health, orthopedics, neurology, dermatology, and cardiology).[5] The average number of teleconsultations per year per referring site in 1998 was less than 40, and in 1999 the number of physicians participating in the surveyed programs was less than 4000.[4,5]

The noteworthy exception to the pattern of telemedicine's slow adoption is radiology. Radiologists have generally viewed telemedicine as a faster and easier way to send images than by mail or courier, and diagnostic and consultative teleradiology is almost universally reimbursed. Unlike most medical services, reimbursement for radiology services, which emphasize the study of images, has not required direct patient-physician contact.

The slow adoption of telemedicine has been attributed to several factors, including concerns about liability and medical licensure for physicians in one state who provide telemedicine services to patients in another state.[1,3] Licensure is a particularly contentious issue and most existing telemedicine programs do not offer services across state lines. A number of models for interstate licensure have been proposed, but none has prevailed and a uniform approach seems a distant prospect at this time. State legislatures have pursued various directions, ranging from strict limits on out-of-state practitioners to limited telemedicine certification for physicians holding licenses in other states. The primary factors limiting the growth of telemedicine appear to be insurer reluctance to pay for telemedicine services and physician reluctance to use new and often inconvenient telemedicine technologies.

Medicare and Other Coverage

Since the last Contempo article on telemedicine,[3] Congress acted to expand Medicare coverage of telemedicine to include a broader range of geographic regions and physician services (effective October 1, 2001).[6] Now consultations, office visits, individual psychotherapy, and pharmacologic management are covered when they involve interactive audio and video. Store-and-forward technologies are, however, only covered in federal demonstration projects in Alaska and Hawaii. Congress continues to limit coverage almost entirely to rural areas, although certain telemedicine services are covered for some urban Medicare or Medicaid demonstration projects. An increasing number of state Medicaid programs and private insurers also cover telemedicine in certain circumstances. A few states, including California, Texas, and Louisiana, have passed laws that prohibit insurers from having different reimbursement policies for telemedicine and regular medical services.[7]

The most common medical use of telecommunications technology—triage, consultation, and diagnosis over the telephone—continues to be excluded by

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Medicare and most other payers. Evidence suggests that telemedicine using 2-way audio transmission alone (ie, telephone or radio) may be safe, effective, convenient, and cost-effective for many purposes.[8-13] Thus, restricting payment to interactive video and audio applications may drive telemedicine services toward unnecessarily expensive and inconvenient technologies.[14]

Transmission Costs

Another limitation of telemedicine growth is high data-transmission costs. Competition in the telecommunications industry has not increased services or significantly decreased transmission costs, as many had predicted, but instead has driven many providers, especially digital subscriber lines (DSL), out of business. Digital subscriber lines, a relatively inexpensive alternative to costly, wide bandwidth T1 telecommunications lines, can transmit high-quality video images in real time, which is not yet possible with most ordinary telephone lines. In addition to disruptions caused by the loss of some DSL providers, DSL service has proved somewhat unreliable; DSL is unavailable in most rural areas.

Remote Monitoring and Home Health Care

No hard data document the diffusion of telemedicine in home health care, but informal conversations with equipment vendors suggest that home health care via telemedicine is currently used on a limited basis by fewer than 200 home health care agencies nationwide. Technological developments and reimbursement changes may make telemedicine more attractive. Continuing improvements in technology have made home monitoring applications more clinically useful and easier for patients to use without onsite help from health care personnel, although some individuals will need the assistance of a caregiver. Monitoring devices connected to specialized computer modems now can reliably measure and transmit such physiological parameters as blood pressure, heart rate, blood glucose level, and pulse oximetry data. Transmission by ordinary telephone is practical and relatively inexpensive, and studies indicate that even patients with limited education can successfully use these technologies.[15]

Telemedicine may prove cost-effective if it provides equivalent or better (eg, more timely) monitoring of patients' medical condition at home while substituting for and costing less than home care visits that are needed only for monitoring.[16,17] Existing data do not make clear the extent to which telehealth visits substitute for rather than augment in-person visits, which may involve physical services in addition to monitoring. The business case for home telemedicine services is still being developed.

Medicare will not reimburse directly for an individual home telemedicine visit, but such services may be encouraged by Medicare's recent move to prospective payment for home health care. Home health care agencies can use telemedicine when approved by a patient's physician.[18] Their incentives are somewhat similar to those for hospitals, which are usually paid on a per-case basis and have considerable latitude in choosing how to deliver inpatient services, including using telemedicine. Two interesting examples of the latter involve intensive care units (ICUs).

Remote Monitoring and ICUs

Pilot studies suggest that remote monitoring of ICU patients by intensivists can be medically and economically effective.[19] In initial commercial applications, physicians and nurses backed by decision support software are providing 24-hour remote monitoring to several community ICUs normally staffed during day shifts only.[20]

In a quite different application, parents can check from home on their infants in the neonatal ICU obtaining daily photographs, progress reports, live video visits, and e-mail access to physicians. Based on a controlled trial of this technology in the neonatal ICU, researchers report improved family satisfaction and lower costs for hospital to hospital transfers for the intervention group.[21]

Remote Monitoring for Disease Management

Capitated managed care organizations are exploring telemedicine to support formal disease management programs for high-cost, high-risk chronic conditions such as congestive heart failure, diabetes, and chronic obstructive pulmonary disease.[17] These programs emphasize explicit guidelines for intensive monitoring of patients' health and support for patient adherence to sometimes demanding self-care regimens.[22]

In addition to providing medical monitoring hardware and software, these telemedicine applications may include individual patient Web sites to link patients with physicians, nurse practitioners, and other personnel. Some systems automatically analyze transmitted data and alert patients and physicians to abnormal findings. Easy Internet access to focused clinical and educational information is intended to support and reinforce patients' self-care activities.

Congestive Heart Failure. Heart failure is highly prevalent among elderly individuals, causing significant morbidity and mortality. Remote in-home monitoring of patients with congestive heart failure has included transmission of such parameters as body weight, heart rate, pulse oximetry data, and blood pressure.[23] Some systems are interactive and rely on regular telephone calls by a nurse. Other systems under development automatically store, forward, and analyze data collected on a regular basis by the patient. These systems automatically alert physicians when results indicate a potential problem; otherwise, the data are archived. Further evaluations will help determine whether such remote monitoring delivers reduced hospitalizations and stabilized or improved health care.

Diabetes. Strict patient adherence to a regimen of blood glucose monitoring, insulin use, skin care, diet, and exercise can reduce the incidence and severity of complications of type 1 diabetes and may also help patients with type 2 diabetes.[24] In addition to remote monitoring of blood glucose and blood pres-

sure levels, some remote monitoring systems provide automated data analysis and sound alerts when readings suggest a problem. Others offer Web-based information to support self-care or allow patients to take and transmit photographs of their feet and other sensitive skin sites. A federally funded randomized controlled trial at Columbia University is evaluating telemedicine services for 1500 low-income patients with diabetes in selected urban and rural areas of New York.[25]

Astronauts and Athletes

Some remote monitoring applications focus on basically healthy individuals. Much of the impetus for the development of telemedicine technology has come from the National Aeronautics and Space Administration (NASA).[26] Since Project Mercury in the 1960s, NASA has had the capacity to monitor real-time physiological parameters of astronauts. This technology is particularly important as the agency contemplates sending a space crew to Mars for approximately 2 years. Also, NASA has used its technology to support disaster relief efforts on Earth[27] and to monitor climbers in the extreme environment of the Mt Everest Base Camp.[28] Satellites have transmitted physiologic data from individual climbers to physicians and researchers at Yale University.

Researchers at East Carolina University are adapting relatively inexpensive, off-the-shelf sensors and other equipment to monitor athletes in training. Variables such as core body temperature, pulse, respiratory rate, blood pressure, pulse oximetry data, and electromyographic activity can be transmitted up to 150 meters and then received, stored, and analyzed on a laptop computer. Such technology might help detect early-stage hyperthermia or assess conditioning and recovery from injuries.

Conclusion

Despite the slow growth of interactive and noninteractive telemedicine, technological development continues, and many new applications are under study. Remote patient monitoring programs, especially those based on store-and-forward technologies, are appealing because they are relatively inexpensive, increasingly convenient for patients and providers, and have the potential to cut the costs of care while improving outcomes. Medicare and other insurer reluctance to cover telemedicine has slowed its dissemination, but recent years have seen progressive, though limited, steps to extend reimbursement. Physician disinterest has been a factor, but this too may change as physicians become comfortable with e-mail, the Internet, and other computer uses, and as telemedicine vendors and advocates devise more convenient technology and helpful applications. Important questions regarding the medical and cost-effectiveness of remote monitoring and other telemedicine applications need further evaluation. Nonetheless, experience suggests that telemedicine will continue to evolve slowly but steadily, as research clarifies its benefits, limitations, and costs.

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REFERENCES

1. Institute of Medicine. *Telemedicine: A Guide to Assessing Telecommunications in Health Care*. Field MJ, ed. Washington, DC: National Academy Press; 1996.
2. Benschoter R. Multipurpose television. *Ann N Y Acad Sci*. 1967;142:471-478.
3. Strode SW, Gustke S, Allen A. Technical and clinical progress in telemedicine. *JAMA*. 1999;28:1066-1068.
4. Grigsby B, Brown N. *Second Annual Report on US Telemedicine Activity*. Portland, Ore: Association of Telemedicine Service Providers; 1998.
5. Grigsby B, Brown N. *1999 Report on US Telemedicine Activity*. Portland, Ore: Association of Telemedicine Service Providers; 2000.
6. Health Care Financing Administration. Program Memorandum Intermediaries and Carriers. Revision of Medicare reimbursement for telehealth services. Transmittal AB-01-69. May 1, 2001. Available at: http://www.hcfa.gov/pubforms/transmit/AB0169.pdf. Accessibility verified June 6, 2002.
7. Office for the Advancement of Telehealth. *2001 Report to Congress on Telemedicine: Payment Issues*. Rockville, Md: US Dept of Health and Human Services; 2001. Available at: http://telehealth.hrsa.gov/pubs/report2001/pay.htm#tab1. Accessibility verified June 6, 2002.
8. Bertera EM, Bertera RL. The cost-effectiveness of telephone vs clinic counseling for hypertensive patients: a pilot study. *Am J Public Health*. 1981;71:626-629.
9. Conrath DW, Dunn EV, Bloor WG, Tranquada B. A clinical evaluation of four alternative telemedicine systems. *Behav Sci*. 1977;23:12-21.
10. Johnson BE, Johnson CA. Telephone medicine: a general internal medicine experience. *J Gen Intern Med*. 1990;5:234-239.
11. Moore GT, Willemain TR, Bonanno R, et al. Comparison of television and telephone for remote medical consultation. *N Engl J Med*. 1975;292:729-732.
12. Wasson J, Gaudette C, Whaley F, et al. Telephone care as a substitute for routine clinic follow-up. *JAMA*. 1992;267:1788-1793.
13. Weinberger M, Tierney WM, Booher PA, Katz BP. Can the provision of information to patients with osteoarthritis improve functional status? *Arthritis Rheum*. 1989;32:1577-1583.
14. Perednia D, Grigsby J. Telephones, telemedicine, and a technologically neutral coverage policy. *Telemed J*. 1998;4:145-152.
15. Finkelstein J, Cabrera MR, Hripcsak G. Internet-based home asthma telemonitoring: can patients handle the technology? *Chest*. 2000;17:148-155.
16. Dimmick SL, Mustaleski C, Burgiss SG, Welsh T. A case study of benefits and potential savings in rural home telemedicine. *Home Health Nurse*. 2000;18:124-135.
17. Johnston B, Wheeler L, Deuser J, Sousa KH. Outcomes of the Kaiser Permanente tele-home health research project. *Arch Fam Med*. 2000;9:40-45.
18. Health Care Financing Administration. Home health policy PPS policy frequently asked questions—update (March 26, 2001). Available at: http://www.hcfa.gov/medicare/hhfaqupdate.htm. Accessibility verified June 6, 2002.
19. Rosenfeld BA, Dorman T, Breslow MJ, et al. Intensive care unit telemedicine: alternate paradigm for providing continuous intensivist care. *Crit Care Med*. 2000;28:3925-3931.
20. *eHealthcare Week*. e-ICU cuts Sentara unit's mortality rate 30%. Available at: http://www.ehealthcareweek.com/news/archives/2001/c94d1hy83/10-01-01/VISICU.htm. Accessibility verified June 6, 2002.
21. Gray JE, Safran C, Davis RB, et al. Baby CareLink: using the internet and telemedicine to improve care for high-risk infants. *Pediatrics*. 2000;106:1318-1324.
22. Couch JB, ed. *The Physician's Guide to Disease Management: Patient-Centered Care for the 21st Century*. Gaithersburg, Md: Aspen Publishers Inc; 1997.
23. Shah NB, Der E, Ruggerio C, et al. Prevention of hospitalizations for heart failure with an interactive home monitoring program. *Am Heart J*. 1998;135:373-378.
24. The Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. *N Engl J Med*. 1993;329:977-986.
25. Starren J, Hripcsak G, Sengupta S, et al. Columbia University's Informatics for Diabetes Education and Telemedicine (IDEATel) Project. *J Am Med Inform Assoc*. 2002;9:25-36.
26. Nicogossian AE, Pober DF, Roy SA. Evolution of telemedicine in the space program and earth applications. *Telemed J E Health*. 2001;7:1-15.
27. Third US-USSR Joint Working Group on Space Biology and Medicine. *US-USSR Telemedicine Consultation Spacebridge to Armenia and Ufa: Final Project Report, 1989*. Washington, DC: National Aeronautics and Space Administration; 1989.
28. Angood PB, Satava R, Doarn C, Merrell R, and the E3 Group. Telemedicine at the top of the world: the 1998 and 1999 Everest Extreme Expeditions. *Telemed J E Health*. 2000;6:315-325.