

Telerehabilitation

Authored by
mohammad looti

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Telerehabilitation (or e-rehabilitation) is the delivery of rehabilitation services over telecommunication networks and the internet. Most types of services fall into two categories: clinical assessment (the patient's functional abilities in his or her environment), and clinical therapy. Some fields of rehabilitation practice that have explored telerehabilitation are: neuropsychology, speech-language pathology, audiology, occupational therapy, and physical therapy. Telerehabilitation can deliver therapy to people who cannot travel to a clinic because the patient has a disability or because of travel time. Telerehabilitation also allows experts in rehabilitation to engage in a clinical consultation at a distance.

Most telerehabilitation is very visual. The most widely used modalities, as of 2006, are webcams, tele-videoconferencing over phone lines, videophones and webpages containing rich internet applications. The visual nature of telerehabilitation technology limits the types of rehabilitation services that can be provided. It is most widely used for neuropsychological rehabilitation; fitting of rehabilitation equipment such as wheelchairs, braces or artificial limbs; and in speech-language pathology. Rich internet applications for neuropsychological rehabilitation (aka cognitive rehabilitation) of cognitive impairment (from many etiologies) was first introduced in 2001. This endeavor has recently (2006) expanded as a teletherapy application for cognitive skills enhancement programs for school children. Tele-audiology (hearing assessments) is a growing application. As of 2006, telerehabilitation in the practice of occupational therapy and physical therapy are very limited, perhaps because these two disciplines are more "hands on".

Two important areas of telerehabilitation research are (1) demonstrating equivalence of assessment and therapy to in-person assessment and therapy, and (2) building new data collection systems to digitize information that a therapist can use in practice. Ground-breaking research in telehaptics (the sense of touch) and virtual reality may broaden the scope of telerehabilitation practice, in the future.

In the United States, the National Institute on Disability and Rehabilitation Research's (NIDRR) supports research and the development of telerehabilitation. NIDRR's grantees include the "Rehabilitation Engineering and Research Center" (RERC) at the University of Pittsburgh, the Rehabilitation Institute of Chicago, the State University of New York at Buffalo, and the National Rehabilitation Hospital in Washington DC. Other federal funders of research are the Veterans Administration, the Health Services Research Administration in the US Department of Health and Human Services, and the Department of Defense. Outside the United States, excellent research is conducted in Australia and Europe.

As of 2006, only a few health insurers in the United States will reimburse for telerehabilitation services. If the research shows that tele-assessments and tele-therapy are equivalent to clinical encounters, it is more likely that insurers and Medicare will cover telerehabilitation services.

History of telerehabilitation

In 1999, D.M. Angaran published "Telemedicine and Telepharmacy: Current Status and Future Implications" in the American Journal of Health-System Pharmacy. He provided a comprehensive history of telecommunications, the internet and telemedicine since the 1950s. The Department of Defense (DoD) and the National Aeronautics and Space Administration (NASA) spearheaded the technology in the United States during the Vietnam War and the space program; both agencies continue to fund advances in telemedicine.

Three early adopters of telemedicine were state penitentiary systems, rural health care systems, and the radiology profession. Telemedicine makes business sense for the states because they do not have to pay for security escorts to have a prisoner receive care outside the prison.

Rural telemedicine in the United States is heavily subsidized through federal agency grants for telecommunications operations. Most of this funding comes through the Health Services Research Administration and the Department of Commerce. Some state universities have obtained state funding to operate tele-clinics in rural areas. As of 2006, few (if any) of these programs are known to financially break-even, mostly because the Medicare program for people over age 65 (the largest payer) is very restrictive about paying for telehealth.

In contrast, the Veterans Administration is relatively active in using telemedicine for people with disabilities. There are several programs that provide annual physical exams or monitoring and consultation for veterans with spinal cord injuries. Similarly, some state Medicaid programs (for poor people and people with disabilities) have pilot programs using telecommunications to connect rural practitioners with subspecialty therapists. A few school districts in Oklahoma and Hawaii offer school-based rehabilitation therapy using therapy assistants who are directed by a remote therapist. The National Rehabilitation Hospital in Washington DC and Sister Kenny Rehabilitation Institute in Minneapolis provided assessment and evaluations to patients living in Guam and American Samoa. Cases included post-stroke, post-polio, autism, and wheel-chair fitting.

An argument can be made that "telerehabilitation" began in 1998 when NIDRR funded the first RERC on tele-rehabilitation. It was awarded to a consortium of biomedical engineering departments at the National Rehabilitation Hospital and The Catholic University of America, both located in Washington, DC; the Sister Kenny Rehabilitation Institute in Minnesota; and the East Carolina University in North Carolina. Some of this early research work, and its motivation, is reviewed in Winters (2002). The State of Science Conference held in 2002 convened most of military and civilian clinicians, engineers, and government officials interested in using telecommunications as a modality for rehabilitation assessment and therapy; a summary is provided in Rosen, Winters & Lauderdale (2002). The conference was attended by the incoming president of the American Telemedicine Association (ATA). This led to an invitation by ATA to the conference attendees to form a special interest group on telerehabilitation. NIDRR funded the

second 5-year RERC on telerehabilitation in 2004, awarding it to the University of Pittsburgh. This RERC was renewed in 2010.

In 2001, O. Bracy, a neuropsychologist, introduced the first web based, rich internet application, for the telerehabilitation presentation of cognitive rehabilitation therapy. This system first provides the subscriber clinician with an economical means of treating their own patients over the internet. Secondly, the system then provides, directly to the patient, the therapy prescription set up and controlled by the member clinician. All applications and response data are transported via the internet in real time. The patient can login to do their therapy from home, the library or anywhere they have access to an internet computer. In 2006, this system formed the basis of a new system designed as a cognitive skills enhancement program for school children. Individual children or whole classrooms can participate in this program over the internet.

In 2006, M.J. McCue and S.E. Palsbo published an article in the Journal of Telemedicine and Telecare that explored how telemedicine can become a profitable business for hospitals. They argue that telerehabilitation should be expanded so that people with disabilities and people in pain (perhaps after hip-replacement surgery or people with arthritis) can get the rehabilitative therapy they need. It is unethical to limit payments for telerehabilitation services only to patients in rural areas.

Research in telerehabilitation is in its infancy, with only a handful of equivalence trials. As of 2006, most peer-reviewed research in telemedicine are case reports of pilot programs or new equipment. Rehabilitation researchers need to conduct many more controlled experiments and present the evidence to clinicians (and payers) that telerehabilitation is clinically effective. The discipline of speech-language pathology is far ahead of occupational therapy and physical therapy in demonstrating equivalence over various types of telecommunications equipment.

Telerehabilitation technologies

Plain old telephone service (POTS) with videophones/Phones in telerehabilitation

There are several types of connections used with real time exchanges. Plain old telephone service (POTS) uses standard analog telephone lines. Videophones are used with POTS lines and include a camera, display screen, and telephone. Videophones use telephone lines available in most homes, so are easy to set up; however small display screens make them problematic for individuals with vision problems. This can be solved by using a large screen or television as a screen.

Video-conferencing/Video-conferencing in telerehabilitation

Virtual reality/Virtual reality in telerehabilitation

Virtual reality in telerehabilitation is one of the newest tools available in that area. This computer technology allows the development of three-dimensional virtual environments.

Motion technology/Motion technology in telerehabilitation

Web-based approaches/Web-based approaches in telerehabilitation

Applications that run over the internet, just as if they were installed in your computer (called Rich Internet Applications), represent a new direction in software development. A person subscribes to the website rather than purchase the software. Any updates or changes to the software system are instantly available to all subscribers. The applications can be accessed from any location where one has access to an internet connected computer. Likewise, a patient's data is accessible from where ever the therapist is located. Neither the application nor the patient's data is tied to one computer.

Sensors and body monitoring/Sensors and body monitoring in telerehabilitation

Haptic technology/Haptic technology in telerehabilitation

Artificial intelligence/Artificial intelligence in telerehabilitation

Wireless technology/Wireless technology in telerehabilitation

PDA/PDA in telerehabilitation

Cellular technologies/Cellular technologies in telerehabilitation

Electronic case records/Electronic case records in telerehabilitation

Clinical applications of telerehabilitation

Review of telerehabilitation research on clinical populations

Professional to professional (clinic to clinic applications)

Telehealth - Information access

Clinical approaches

Assessment

Monitoring

Intervention

Telesupervision (of licensed assistants)

Telementoring

Tele-education

Telementoring

Speech-language pathology

The clinical services provided by speech-language pathology readily lend themselves to telerehabilitation applications due to the emphasis on auditory and visual communicative interaction between the client and the clinician. As a result, the number of telerehabilitation

applications in speech-language pathology tend to outnumber those in other allied health professions. To date, applications have been developed to assess and/or treat acquired adult speech and language disorders, stuttering, voice disorders, speech disorders in children, and swallowing dysfunction. The technology involved in these applications has ranged from the simple telephone (Plain Old Telephone System - POTS) to the use of dedicated Internet-based videoconferencing systems.

Early applications to assess and treat acquired adult speech and language disorders involved the use of the telephone to treat patients with aphasia and motor speech disorders (Vaughan, 1976, Wertz, et al., 1987), a computer controlled video laserdisc over the telephone and a closed-circuit television system to assess speech and language disorders (Wertz et al, 1987), and a satellite-based videoconferencing system to assess patients in rural areas (Duffy, Werven & Aronson, 1997). More recent applications have involved the use of sophisticated Internet-based videoconferencing systems with dedicated software which enable the assessment of language disorders (Georgeadis, Brennan, Barker, & Baron, 2004, Brennan, Georgeadis, Baron & Barker, 2004) and the assessment and treatment of motor speech disorders (Hill, Theodoros, Russell, Cahill, Ward, Clark, 2006; Theodoros, Constantinescu, Russell, Ward, Wilson & Wootton, in press) following brain impairment and Parkinson's disease. Collectively, these studies have revealed positive treatment outcomes, while assessment and diagnoses have been found to be comparable to face-to-face evaluations.

The treatment of stuttering has been adapted to a telerehabilitation environment with notable success. Two Australian studies (Harrison, Wilson & Onslow, 1999; Wilson, Onslow & Lincoln, 2004) involving the distance delivery of the Lidcombe program to children who stutter have utilized the telephone in conjunction with offline video recordings to successfully treat several children. Overall, the parents and children responded positively to the program delivered at a distant. Using a high speed videoconferencing system link, Sicotte, Lehoux, Fortier-Blanc and Leblanc (2003) assessed and treated six children and adolescents with a positive reduction in the frequency of dysfluency that was maintained six months later. In addition, a videoconferencing platform has been used successfully to provide follow-up treatment to an adult who had previously received intensive therapy (Kully, 200).

Reports of telerehabilitation applications in paediatric speech and language disorders are sparse. A recent Australian pilot study has investigated the feasibility of an Internet-based assessment of speech disorder in six children (Waite, Cahill, Theodoros, Russell, Busuttin, in press). High levels of agreement between the online and face-to-face clinicians for single-word articulation, speech intelligibility, and oro-motor tasks were obtained suggesting that the Internet-based protocol had the potential to be a reliable method for assessing paediatric speech disorders.

Voice therapy across a variety of types of voice disorders has been shown to be effectively

delivered via a telerehabilitation application. Mashima et al. (2003) using PC based videoconferencing and speech analysis software compared 23 patients treated online with 28 persons treated face-to-face. The authors reported positive post treatment results with no significant difference in measures between the traditional and videoconferencing group, suggesting that the majority of traditional voice therapy techniques can be applied to distance treatment.

Although obvious limitations exist, telerehabilitation applications for the assessment of swallowing function have also been used with success. Lalor, Brown and Cranfield (2000) were able to obtain an initial assessment of the nature and extent of swallowing dysfunction in an adult via a videoconferencing link although a more complete evaluation was restricted due to the inability to physically determine the degree of laryngeal movement. A more sophisticated telerehabilitation application for the assessment of swallowing was developed by Perlman and Witthawaskul (2002) who described the use of real-time videofluoroscopic examination via the Internet. This system enabled the capture and display of images in real-time with only a three to five second delay.

There continues to be a need for ongoing research to develop and validate the use of telerehabilitation applications in speech-language pathology in a greater number and variety of adult and paediatric communication and swallowing disorders.

Physical and Occupational Therapy

Disciplines and therapies

Speech-language pathology
Audiology
Physical therapy
Occupational therapy
Psychology
Nursing
Social work
Rehabilitation counseling/Vocational rehabilitation

Standards and training requirements

Telerehabilitation standards
Reimbursement policies/Reimbursement in telerehabilitation
Legislative activities/Legislative activities in telerehabilitation
Ethics and privacy issues/Ethics and privacy issues in telerehabilitation
Clinical and technology training issues

Research

Related organizations

American Telemedicine Association (ATA)

American Speech-Language-Hearing Association (ASHA)

Association of Telehealth Service Providers (ATSP)

National Institute on Disability and Rehabilitation Research (NIDRR)

Rehabilitation Engineering and Assistive Technology Society of North America (RESNA)

Special Interest Group on Telerehabilitation (SIGOT)

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