Perspective

Prototype Database for Telerehabilitation

KAWALJEEET KAUR, M.S., 1 PAMELA G. FORDUCEY, Ph.D., 2 and ROBERT L. GLUECKAUF, Ph.D. 3

ABSTRACT

Telerehabilitation is a promising alternative health-care delivery system, but currently lacks broad-based empirical support for the efficacy and cost utility of its interventions. This article describes the development of a database at INTEGRIS Jim Thorpe Rehabilitation Center (IJTRC) that will link the delivery of telerehabilitation services, reimbursement, and outcomes evaluation. The database is a culmination of the combined efforts of administrators, clinicians, and information technology professionals. Feasibility of the project was first established from technical, economic, and organizational perspectives. The current workflow and documentation processes were analyzed and enhanced. This was followed by data modeling and design of the database architecture in terms of network, security, scalability, and system specification. A prototype was created in Microsoft Access with the final product planned in Structured Query Language (SQL) with a front-end in JAVA JSP. The initial results with the database have been encouraging in terms of increased efficacy and security, process streamlining, error reduction, and collection of comprehensive standardized data for statistical analysis of clinical and research outcomes.

BACKGROUND AND RATIONALE

MEDICAL REHABILITATION is migrating toward evidence-based practice. In this historical context, proposed new methods with apparently high potential are being evaluated against objective standards for outcome. Among advances in rehabilitation technology, “telerehabilitation” tools and methods appear to have the potential to be integrated positively into mainstream allied health practice. The availability and use of a purpose-built database is critical to the systematic and exhaustive collection and processing of strong-inference evidence to support this supposition. This is the central motivation for this project report.

Telerehabilitation technology is a versatile toolbox that is being used experimentally and, to a lesser extent, clinically by allied health professionals to implement and enhance post-acute rehabilitation in home and community settings. Telerehabilitation is defined as the remote delivery, through information and telecommunication technology, of comprehensive rehabilitation services for persons with disabilities. 1 2

There are several factors contributing to the increased attention to and use of telerehabili-
tion modalities. First, rural patients typically receive fewer home health services and attain less favorable discharge outcomes than their urban counterparts, which is primarily attributed to resource constraints and a lower availability of skilled and specialized care disciplines.3 Pilot programs have shown that tele-rehabilitation can be effective in providing services to underserved regions.4 Second, financial constraints imposed by the Prospective Payment System (PPS) mandate inpatient rehabilitation facilities to reexamine resource utilization and organizational effectiveness. According to one study, charges per inpatient stay at rehabilitation facilities are increasing an average of 7% each year, whereas the length of stay is decreasing by approximately 8% annually. It is well established that patients with chronic medical conditions may be leaving acute inpatient rehabilitation facilities before they are functionally ready, resulting in increased reliance on community-based resources to complete the process of rehabilitation.5 Liss et al.6 suggest that telecommunication-based interventions may be used efficiently and effectively for populations with chronic disability, including those who do not have previous experience with the technologies. In addition, Rosen (7) states that:

- Telepractice can make it possible for an individual to stay in his/her community without losing the expertise available in the larger hospitals, potentially resulting improved quality of care with reduced travel expenses for the physician/therapist and patient;
- A greater proportion of therapy can be provided by less expensive community clinicians with as-needed teleconsultation by specialists; and
- The overhead of housing a patient can be shifted from the service provider to the family who are already bearing the cost of housing.

Although telerehabilitation has considerable promise as an alternative health-care delivery system, there is paucity of broad-based empirical support for the efficacy and cost-utility of telerehabilitation interventions. Large-scale randomized trials are required before one can argue convincingly that the medical, psycho-social, functional, and fiscal outcomes of telerehabilitation are positive.8 Nickelson9 cites lack of clinical evaluation protocols as one of the challenges to the field of teledmedicine. When studies are conducted, often the small sample size limits statistical power.9 In addition, there is lack of coordination in the evaluation of alternative rehabilitation delivery systems across both rural and urban settings.

Not only are telerehabilitation clinical evaluation studies often limited as a consequence of inadequate sample size, but inclusion of appropriate comparison groups can be difficult to achieve in real-world rehabilitation environments. Telerehabilitation programs struggle to provide strong objective documentation of successful outcomes, which is critical for influencing legislators and third-party payers who control reimbursement. Securing standard clinical finding streams is paramount for long-term sustainability of telerehabilitation. Many of the current telerehabilitation programs are funded by federal grants (U.S. Department of Education’s National Institute of Disability and Rehabilitation Research [NIDRR] and Rehabilitation Engineering Research Center [RERC]; U.S. Department of Commerce’s Technology Opportunity Program [TOP], and Health and Resource Services Administration’s [HRSA] Office of Advancement of Telehealth [OAT]). Development and deployment of a “model database” linking the delivery of telerehabilitation services, reimbursement, and outcome evaluation can be critical in meeting this challenge.

**PROJECT CONTEXT: INTEGRIS JIM THORPE REHABILITATION CENTER (IJTRC)**

IJTRC provides team-based, individualized restorative treatment for patients at all stages of the rehabilitation continuum of care, with inpatient and outpatient programs for children and adults. IJTRC served 2,825 inpatients and 57,781 outpatients in 2003. The clinical team has effectively used telerehabilitation for 6 years to help individuals with disability reintegrate into community settings, including home, work and school.11,12 INTEGRIS Rural Health received a rural telemedicine grant (1997–2000 and 2000–2003) from HRSA-OAT to improve access to...
health care for rural individuals across the life span, reduce isolation of rural practitioners, and to collect and disseminate this data. IJTRC provides telerehabilitation services for Physical Therapy (PT), Occupational Therapy (OT), Speech/Language Therapy (SLP), Rehabilitation Psychology (Psych), and Vocational Rehabilitation (VR). These sessions have been conducted at bandwidth ranges from T1 through ISDN to analog (POTS). T1 and ISDN connections are used primarily with relatively better-equipped rural school districts and hospitals, providing superior resolution and a higher frame rate. POTS has been the primary telecommunication technology used for therapy services to home-based patients.

CONCEPTUAL ORIGIN OF THE TELEREHABILITATION DATABASE

Over the past 3 years, a group of researchers, clinicians, biomedical engineers, and administrators formed and activated CART, the Collaborative Alliance for Research on Telerehabilitation. Its goal has been the achievement of a “critical mass” of data and observations from telerehabilitation activities by defining and aligning standardized instruments for data gathering and by developing a framework for collection of data across multiple institutions, including IJTRC, National Rehabilitation Hospital (Washington, DC), Allina Health System (Minnesota), Sister Kenny Rehabilitation Services (Minnesota), and Good Samaritan Health System (Nebraska). The genesis of the CART database began when IJTRC undertook development of an in-house database to serve three major purposes:

- digital documentation of patient encounters and generation of clinical reports;
- digital documentation of outcomes from these encounters; and
- seamless connection to statistical packages for retrospective analysis.

DESIGN PROCESS

It has been reported that half of all projects initiated in an organization are abandoned before completion.13 This statistic can typically be traced to inadequate planning, lack of buy-in from upper management, inability to demonstrate the strategic value of the project, and insufficient attention to the probable return on investment. To reduce the possibility of the telerehabilitation database project being aborted, it was approached methodically and formally.

Making a business case

Historically, paper documentation has been the primary medium for patient records maintained by each individual therapist, at IJTRC as elsewhere. Electronic documentation of the patient encounters allows automated generation of reports with probable savings in staff time. Furthermore, electronic export of this encounter data to decision-support and statistical software can be used for analysis of outcomes and refining of clinical programs and testing of research hypotheses. The increased efficiency of retrieval and analysis of outcome findings might accelerate improvements in quality of patient care, patient satisfaction, and competitive advantage. Also, the simplification of therapist workflow seemed likely to enhance morale and offer cost efficiencies. All of these effects could be further magnified if the database came to serve as a centralized data repository for clinical and experimental telerehabilitation activities throughout the United States and if standardized outcome measures for telerehabilitation resulted.

Technical feasibility

In the absence of off-the-shelf database software configured for telerehabilitation, such a system needed to be developed in-house or outsourced. Because the cost of contracting with a custom software developer was prohibitive, the decision was made, by default, to develop the database in house. This posed a challenge since the INTEGRIS Information Technology (IT) team focuses on service delivery and day-to-day operations as opposed to new product development. To function cautiously as a novice design team, IT staff planned to bring development of the database just far enough so that it could be used for data collection and program evaluation by telerehabilitationists. Only when their comments were avail-
able and applied would a more evolved version with more features be attempted.

Technical decisions

On review of the existing options, it was decided that a Structured Query Language (SQL) database would be the best for the final product. Oracle is more robust than SQL, but is also more expensive. SQL is an easily scalable database with dynamic backup capabilities, even when the database is in use. Among other advantages, it also has an automatic recovery mechanism that returns the database to the last state of consistency in minutes without the intervention of a database administrator. It was further decided that the initial prototype would be developed in Microsoft (MS) Access.

Organizational feasibility

The project required collaboration among various internal departments—administrative, clinical, and IT. An executive sponsor and a project sponsor were identified. A project manager was assigned and the rest of the project team and project support group were identified. Device support, networking, system support, and security groups were bought in and formally approved the project. Normally, user buy-in is an important aspect of organizational feasibility because the users are key stakeholders in an organization. However, in this case, the system request came from the users (teletherapists) and was championed by the director of the Clinical Development department at Jim Thorpe, who also acted as project sponsor. The major sources of funding for the project were IJTRC and the Rural Telemedicine Grant from HRSA-OAT.

CRITICAL REVIEW OF WORKFLOW PROCESS AND DOCUMENTATION

Development of a database to meet the needs of the telerehabilitation program provided an opportunity to analyze the existing workflow of the then-current program. Since the IJTRC program began with one area of telerehabilitation therapy and evolved ad hoc to incorporate other disciplines based on consumer need and lessons learned, the telerehab group had never formally analyzed or documented its operation. Information on the current telerehabilitation workflow was collected using a variety of methods, including personal one-on-one interviews, focus group discussions, and electronic mail. The therapists, administrators, coordinators, and business analysts involved in telerehab workflow all took part in group meetings.

Workflow was traced from the point of initial patient referral to the point of patient discharge (Fig. 1). Active problems in the workflow were addressed. The process resulted in the creation of a document outlining the standardized workflow for the teletherapy program. This document is now also serving as the framework on which the authors are currently developing further policies and protocols as the telerehabilitation program matures.

The standard forms currently used to document telerehabilitation practice were critically reviewed in the context of workflow to identify areas for improvement. Redundancies and duplication of content across rehabilitation service areas were identified and eliminated as a means of lowering the probability of error and increasing productivity by better supporting workflow.

An illustration of the findings of this review relates to the initial screening of patients for telerehab program candidacy. The existing IJTRC process did not use a standardized screening form with objective inclusion/exclusion criteria. Clinical judgment and practical feasibility were the primary determinants for patient acceptance. During the process-review phase of database development, the teletherapists were asked to identify explicit screening criteria and the elements of medical history relevant for telerehab program eligibility. This information was converted into a screening form. Similarly, teletherapists reviewed current documents for discipline-specific evaluation of inpatients and outpatients, progress notes, and discharge summaries, and created or revised forms to address the refined understanding of the teletherapy program needs.

One repeatedly identified problem with forms was that the teletherapists required unstructured blocks of narrative and descriptive text. Because this ran counter to the needs of
FIG. 1. Overview of the patient referral work flow.
electronic data analysis, the database development team created a finite list of short-term and long-term goals suitable for drop-down menus on the screen to provide structure while allowing flexibility and uniqueness for individual patients. Similarly, the result of the evaluation notes, progress notes, discharge notes, and recertification notes were also resolved into objective drop-down menus of objective items, in place of traditional subjective narratives, from which the teletherapist could pick and choose.

Another important change was stimulated by the process of creating a standardized digital database tele-rehabilitation practice. Prior to this project, the PT, OT, and SLP professions of the telerehab program tended to focus on discipline-specific goals that are typical of clinical “multidisciplinary” services. As part of the database development, teletherapists were asked collectively to recast their intervention goals in a way that could and would be addressed by several therapies, i.e., a more integrated interdisciplinary approach. In many rehabilitation programs, the most commonly and frequently used outcome measure is the Functional Independence Measure (FIM). However, when applied to individuals with acquired neurological disorders (stroke, traumatic brain injury, and spinal cord injury), the FIM has limitations.14 Because of this, several additional standardized instruments were included in the revised evaluation process for tracking clinical and functional outcomes. Physical and motor functioning were assessed by Range of Motion (ROM), a test for motor functions/strength (MMT), the Berg Balance Test, and the Tinetti Balance Assessment Tool. Language, cognitive, and communication functioning instruments included the Boston Diagnostic Aphasia Examination (BDAE) with all its subcomponents; Rehabilitative Institute of Chicago Evaluation of Communication Problems in the Right Hemisphere Dysfunction-Revised (RICE-R); Scales of Cognitive Ability for Traumatic Brain Injury (SCATBI); and the American Speech-Language and Hearing Association National Outcome Measurement System (ASHA NOMS). In short, the review and rigor imposed by the process of developing the electronic database led naturally to inclusion of more definitive higher-resolution outcomes measures.

DATABASE DESIGN AND DECISIONS

User access to the database

The main considerations influencing the database architecture are the number of users, the physical location of the users, the number of concurrent users, and the type and size of the database. For the prototype, the number of users was anticipated to be less than 20, with fewer than five concurrent users under any likely scenario. It was decided that the database would be housed on a server, and the users local drives would be mapped to the network drive containing the database. This system would only be accessed through the INTEGRIS intranet. If a user is outside the INTEGRIS Health system, for example accessing the database from home, he/she can log in through the Internet, using tools which are provided for remote network access.

Because virtually continuous cycles of feedback and recommendations for changes from the teletherapists were characteristics of the database development process, very little additional user training was needed when the prototype was complete. The interface mainly consisted primarily of drop-down menus of items defined and refined by the team and driven directly by critical review of current workflow.

Security

The current prototype database has two levels of security. First, only users with INTEGRIS network login identification can access the INTEGRIS intranet. The server is protected by a robust firewall. Second, the database is password-protected with different levels of users having different permissions. This is based on standard Windows NT security. No encryption is used at this time. The data on the server are backed up nightly, so that not more than one day of data can be lost, which is minimal and acceptable for the current usage of the telerehabilitation program.

Scalability

MS Access can support a database of up to 2 Gb. Based on the current telerehabilitation utilization and up to 15% increase per year, this
database will be sufficient for up to 2 years. Current plans call for this prototype to be used for less than this time, after which an SQL-server-based database with the front end user interface developed in JAVA JSP is expected to be ready to come on line.

System specifications

The prototype was developed in MS Access with some Visual Basic to simplify system development and user requirements. The system is developed in Access 2000 in keeping with the INTEGRIS decision to migrate all desktop computers to this version of Access. This means that user computers at any site will need to be equipped with Access 2000.

Selective access for streamlined process

The computer-based system provides selective access to the various forms. For instance, only the telerehabilitation coordinator can enter patient referral, admission, and insurance related information (Fig. 2). The teletherapists can read that information but not modify it. Because IJTRC patients are referred through various sources including physicians, community providers, and the grants coordinators, establishing a uniform procedure with a single gatekeeper was imperative for standardizing and streamlining the process. A biweekly report can be generated that lists current patients and the assigned teletherapists, enabling everyone to be aware of the current workload and rationalizing the process of teletherapist scheduling.

Convenient mobile access to patient records

The database provides a central repository of patient records that can be accessed by the teletherapists or coordinators whenever needed. This eliminates the need for one person to maintain the records and make them accessible to others on demand. Per the current regulations, it is still necessary to have a paper copy of the medical records for each patient;

![FIG. 2. Screenshot of patient information form filled by the telerehabilitation coordinator.](image-url)
however, retrieval of records is much faster and easier with the elimination of a middle person. Furthermore, the teletherapists do not have to be physically present in the facility to access the records. Any computer with an Internet connection can be used to login the INTEGRIS intranet, thus enabling the staff to telework if needed.

Reduction in error frequency

Although not objectively measured at this writing, it is speculated that since data will be entered only once on computer-based forms versus multiple times as it was on the paper-based forms, errors will be reduced. In the computer-based system, if information is required at different points, it can be retrieved by the built-in queries.

Electronic signature and data tracking

Patients are assigned to specific teletherapists by the telerehabilitation coordinator during the admission process; each teletherapist can only alter information for the patients assigned to her/him. The electronic medical record can be reviewed by any team member involved in the case; however, each teletherapist can only alter the system records every time a user logs in, and the teletherapists login ID appears on the forms filled in by the teletherapist, thus serving as an electronic signature. This feature also provides an additional layer of security by tracking access to the patient's records, thus aiding compliance with the Health Insurance Portability and Accountability Act (HIPAA) regulations.

Comprehensive standardized data collection for research and quality improvement

Since the teletherapists select objective data-entry fields instead of writing unstructured narrative, the data collected are formatted in a way more amenable to analysis for clinical program improvement and for research publications and proposals. Patient and encounter histories in combination with outcome measures (functional and health changes, subjective and objective quality of life, customer satisfaction) can characterize inherent deficiencies and strengths in the program to support clinical and research evaluation of aspects of telepractice.

Framework for further development

The review, objective analysis, and development stages instituted during the database project have been generalized to other processes, policies, and protocols in the IJTRC telerehabilitation program including referrals, screening, admission, evaluation, recertification, discharge, billing, coding, documentation, and use of data for research purposes. The availability of the database, as well as the process for creating it, have spawned a formal outcomes-management plan in which findings extracted from the database are used for outcomes measurement on a monthly or quarterly basis as appropriate. Satisfaction surveys are now routinely given to providers, patients, and caregivers, and the results are entered into the database.

Billing and reimbursement

Long-term viability of any telerehabilitation program is dependent on its economic and organizational sustainability. Under current Medicare regulations, only physician and psychology telemedicine services are reimbursed. Beginning in 1999, Congress mandate the Center for Medicare and Medicaid Services (CMS) to pay for telemedicine services to patients in health professional shortage areas (HPSA). Similar efforts have also been initiated at the state level to promote reimbursements for telemedicine consultations. At INTEGRIS, teletherapists work with the administrative departments as part of the procedures for billing and compliance assurance. Supported by the database, these processes are more systemic and objective, and are supported by more exhaustive records. Current Procedural Terminology (CPT) codes, therapy procedures, service units, and costs for telerehabilitation sessions are documented for initiating and tracking the reimbursement process, and charge slips are automatically generated for submission to third-party payers or other funding sources.

PILOT COMPARISONS OF DATA ENTRY TIME

Elimination of redundant information and design of drop-down menus of explicit items for all necessary data entries (gender, marital
status, race, type of insurance and coverage, employee status, appointments, etc.) were driven by the development goal of saving staff time. A pilot study was conducted to determine if an actual difference in staff time expenditures could be discerned.

Objective

The objective was to compare the time taken to complete identical case histories using the paper-based forms and the computer-based forms.

Method

Eight mock patient cases were prepared that contained all the demographic and clinical information that is collected by the telerehabilitation coordinator. An initial training case was provided for entering information both in the paper-based and the computer-based forms so that the pilot study participants were familiar and comfortable with both. The two participants had both seen the computer-based system but none had direct experience prior to this training case. One experienced telerehabilitation coordinator and one inexperienced research assistant completed eight paper-based and eight computer-based forms, each yielding a total of 16 paper-based and 16 computer-based completed forms. A single investigator, visible to the participant, timed the data entry utilizing a stopwatch and rounded of to the nearest second. The testing was done under optimum conditions with no external distractions. The paper-based and the computer-based data entry were done on different days to reduce the effect of the participants being familiar with the information they entered via paper method before the computer method.

Findings

The paired-sample t test was used to analyze the within-subject results of completing the paper and computer-based forms for 16 cases. The computer-based form was completed significantly faster [mean (M) = 6.97 minutes, standard deviation (SD) = 1.18] than the paper-based form (M = 8.82 minutes, SD = 1.31); \( t(15) = 11.72; p = 0.0005 \). Furthermore, the data showed that after the initial learning curve, the time taken to complete the forms decreased from the later entries for both the experienced and inexperienced subjects. Besides the limited sample size, it should also be noted that both participants used computers on a daily basis and that results may vary for other users depending on their familiarity with computers. Furthermore, in realistic clinical settings, several forms are not typically completed at one sitting; fatigue may have confounded the present results, perhaps masking more dramatic learning effects.

CONCLUSIONS AND PLANS

The telerehabilitation database is delivering significant benefits in terms of enhanced efficiency, security, and data utilization resulting in improved cost utility. Its success would not have been possible without explicit planning and attention to administrative support and user buy-in at the inception of the project. Additional use of the database at INTEGRIS Health will make it possible to conduct and publish exhaustive fiscal analysis. INTEGRIS Health has recently been awarded a grant from the Oklahoma Center for Advancement of Science and Technology (OCAST) to advance the commercialization of the database. It is anticipated that the final version of the database will be used via the Web for data collection at the rehabilitation facilities involved in the CART initiative. The pooled data will support strong-inference tele-rehabilitation outcomes research leading to new evidence-based practice standards.

ACKNOWLEDGMENTS

We thank Nicholas McDonald, Ph.D., Biostatistician, INTEGRIS Jim Thorpe Rehabilitation Center, Cynthia Scheideman-Miller, M.H.A., Rural Telemedicine Project Director, INTEGRIS Health for administrative support; Bob Hodge, Manager, INTEGRIS Health for technical support; IJTRC teletherapists Steve Dawson (PT), Andrew Heuser (PT), Beki Houston (SLP), Pam Rentschler (SLP), Teresa Tisdell (OT), and Dana Duroy (OT) for their work in developing.
the forms and for providing feedback during the development process.

REFERENCES
1. Bruns RB, Crislip D, Daviou P, Temkin A, Vese-
2. Glueckauf RL, Nickelson DW, Whitton JD, Loomis JS. Telehealth and healthcare psychology: Current develop-
ments in telecommunications, regulatory prac-
3. Scheinker RE, Powell MC, Goodrich GK. Rural urban home health care differences before the Balance Bud-
4. Dawson SJ, Clark PG, Scheideman-Miller C. The new frontier: Telerehabilitation. Physical Therapy Case Re-
5. Schopp L, Johnstone B, Merveille OC. Multidimen-
8. Frueh BC, Deitsch SE, Santos AB, Gold PJ, Johnson MR, Meisler N, Magruder KM, Ballenger JC. Proce-
dural and methodological issues in telepsychiatry re-
9. Nickelson DW. Behavioral telehealth: Emerging prac-
10. Agency for Healthcare Research and Quality. Telemed-
12. Clark PG, Dawson SJ, Scheideman-Miller C, Post ML. Telerehab: Stroke teletherapy and management us-

Address reprint requests to:
Pamela G. Forducey, Ph.D.
INTEGRIS Jim Thorpe Rehabilitation Center
Department of Clinical Development
4219 South Western Avenue
Oklahoma City, OK 73109
E-mail: pam.forducey@integris-health.com