Iowa's National Laboratory for the Study of Rural Telemedicine: a description of a work in progress*†

By Michael Kienzle, M.D.
Department of Internal Medicine
College of Medicine

David Curry, M.S.L.S.
Hardin Library for the Health Sciences

Edmund A. Franken, Jr., M.D.
Department of Radiology
College of Medicine

Jeffrey Galvin, M.D.
Department of Radiology
College of Medicine

Eric Hoffman, Ph.D.
Department of Radiology
College of Medicine

Edwin Holtum, M.S.
Hardin Library for the Health Sciences

Lee Shope, M.S.
Office of Information Technology

James Torner, Ph.D.
Department of Preventive Medicine
College of Medicine

Douglas Wakefield, Ph.D.
Department of Hospital and Health Administration
College of Medicine

University of Iowa
Iowa City, Iowa 52242

As the federal administration advances the idea of the "information superhighway," many disciplines are being challenged to find ways to use advanced telecommunications to improve access to information, enhance learning opportunities, and achieve higher levels of international competitiveness. Telemedicine, the use of communications technology in the practice of medicine, may change the way rural health care is provided by improving access to medical information, diagnostic tools, and consultations. The information and

health care services required by health care professionals are rapidly changing, and dissemination of this information to isolated practitioners has proven to be difficult. By providing support electronically from a central site, the most current information is more readily available. Using test-bed hospitals in rural and urban settings, the National Library of Medicine–funded National Laboratory for the Study of Rural Telemedicine at the University of Iowa is currently developing the necessary infrastructure to support targeted projects studying how telemedicine applications can be made more effective and readily available.

INTRODUCTION

The promise of advanced telecommunications (the "information superhighway") for improving access to information and international competitiveness has been the subject of intense public interest and discussion, inspired, in part, by the emphasis of the current federal administration. The application of emerging communications technologies to health care has been of particular interest to the public and the government, concurrent with a broader debate around reforming the health care system. Among the first to facilitate development of programs applying advanced telecommunications and computing to health care was the National Library of Medicine (NLM), by issuing a Broad Agency Announcement/Request for Proposals entitled "Biomedical Applications of High Performance Computing and Communications" on May 20, 1993. One hundred thirty-seven applications were received in six categories, and twelve contracts were ultimately awarded. The University of Iowa submitted a proposal to establish a "National Laboratory for the Study of Rural Telemedicine" and was awarded a $7.25 million contract of three years' duration. This paper describes selected developmental and philosophical aspects of this work in progress.

THE CHALLENGES OF RURAL HEALTH CARE DELIVERY

The rural practice setting is challenging for several reasons: the population is unique (agricultural, elderly, geographically dispersed); access to providers, allied health services, advanced technology, and public transportation may be impaired; rural hospitals are endangered by current reimbursement and regulatory constraints; the public health infrastructure is lacking, particularly for emergency services, mental health services, and substance abuse counseling; and the health provider workforce is undersized, isolated, and difficult to recruit and retain in the rural setting.

Telemedicine has been held out as an answer to many of the challenges outlined above [1]. There are

many reasons to be optimistic. However, there are many questions that must be answered before widespread implementation of new and often expensive telemedicine applications can be justified.

- Is the specific knowledge of the provider or patient changed or enhanced by telemedicine?
- Has there been a measurable change (better or worse) in the patient's health status, functioning, or quality of life because of the application?
- Is telemedicine a cost-effective alternative to current practice?
- Is it financially feasible to implement telemedicine on a widespread basis?
- What factors facilitate or inhibit rural practitioners' use of telemedicine?
- Does telemedicine help recruit or retain rural health care workers?

These types of questions require a systematic and careful application of specific measurement tools, and the concept of a "laboratory" approach was particularly attractive to the participants in the project. Evaluation of the above variables will be a three-part process. First, each of the proposed projects will track contacts with or access to the telemedicine intervention. Second, each project will systematically evaluate the end users' reactions to and assessments of the user friendliness and usefulness of the information obtained through the telemedicine intervention. Finally, each project will develop pilot data from which information necessary for definitive evaluations can be generated (i.e., refinement of the intervention and the hypothesized effects, specifications of dependent and independent variables, conceptual and operational definitions, and estimates of effect size and variability from which to develop power calculations and sample size estimates).

TELEMEDICINE AT IOWA

Prior to the current project, several types of telemedicine were in place at the University of Iowa Hospitals and Clinics (UIHC), which, along with the Iowa City Department of Veterans Affairs Hospital, serves as the primary teaching hospital for the health sciences

colleges and functions as the predominant tertiary referral hospital for the state. These projects include a teleradiology network serving eight hospitals in three states; an electrocardiographic (EKG) service to a network of hospitals, offices, and state agencies; and a satellite educational network available for health-related programming.

A major impetus for the current project was the availability of the Iowa Communications Network (ICN), a 2,800-mile fiber-optic telecommunications system established by the State of Iowa by legislative action in 1987. This state-of-the-art system has a point of presence in each of Iowa's ninety-nine counties and is currently in use for a variety of educational and state governmental purposes. Recently, Iowa's hospitals and physicians' clinics have been granted access to the ICN, along with selected federal agencies, and representatives are engaged in a statewide planning process to define the details and standards of the state's telemedicine network using the ICN.

COMPONENTS OF THE LABORATORY PROJECT

The NLM contract supports four developmental components: a Resource Center, a test bed of three rural hospitals, two information support projects, and three clinical support projects. Each component will be briefly described below.

Resource Center

The Resource Center will be housed within the Hardin Library for Health Sciences on the main Health Sciences Campus, adjacent to both teaching hospitals. This unit will provide the administrative and technical support necessary to complete the proposed work and to facilitate interactions with other telemedicine investigators on campus, statewide, and eventually on a national basis. The Resource Center staff will consist of individuals with requisite skills in health sciences librarianship, telecommunications, computer systems, instructional design, and research methodology. In addition to implementing program objectives and monitoring the program budget, the Resource Center director (a health sciences librarian) will coordinate activities and interactions with the rural test-bed sites; recruit, train, and supervise personnel skilled in the areas of instructional program design, research methodology, computer science, and telecommunications; present medical education programs, symposia, and workshops to professional groups; implement communications mechanisms (print and online) to distribute and exchange information on telemedicine projects with other investigators and institutions; and create a national clearinghouse and database for a broad range of materials

and formats that fall within the broad scope of telemedicine. We have also added two faculty affiliates to advise the Resource Center in issues related to technology and evaluative services.

The administrative structure of the project has been adapted from that employed in several National Institutes of Health–funded Specialized Center of Research (SCOR) programs active on campus for many years, ensuring appropriate project oversight, interaction among participants, and outside review and consultation.

One unique aspect of the Resource Center is the way it will assist in the design and evaluation of the laboratory projects. Traditionally, such services have been provided via permanent in-house staff. This approach requires that planners know in advance the nature of the work to be done, hire appropriate personnel, and provide them with necessary space and equipment. We have taken a "just in time" (the use of goods and services at the time needed, borrowed from the manufacturing domain) approach by utilizing a faculty affiliate to coordinate and contract for evaluative services on a project-specific and as-needed basis. The authors believe that this approach has several advantages; namely, increased flexibility and synergy and fewer fixed costs for staff and other resources.

Because the proposed subprojects will initially be focused on physically connecting and adapting the projects to the state fiber-optic network, the initial evaluations will tend to be more exploratory in nature. That is, because only three hospitals are being initially involved, there will be insufficient data to comprehensively and conclusively evaluate all aspects of how patient outcomes are affected or to assess all costs, benefits, or effectiveness of rural telemedicine from the initial studies. Further complicating any evaluation is the reality that rural health care facilities are, in general, limited in the information contained in existing databases and medical records as well as in available staff to assist in data collection for research purposes. Therefore, a major supporting role of the Resource Center will be to assist investigators by making projects as efficient and focused as possible so that current experience can be applied to future refinements or broader use of the applications.

Hospital test bed

A conscious effort was made to select representative hospitals. The smallest of the three, Van Buren County Hospital in Keosauqua, Iowa, is classified as a Medicare rural hospital, serves a poor rural county, and is staffed by a handful of primary care practitioners. Ottumwa Regional Medical Center is classified as a Rural Referral facility, serves a more prosperous rural county, and is staffed by a range of primary care pro-

Table 1
Enhanced services available to rural hospitals

Health science databases
  MEDLINE (complete)
  Health (*Hospital Literature Index*)
  CINAHL (nursing literature index)
  Reference Update
  Iowa Drug Information Service
  GRATEFUL MED (via Internet)
  Micromedex (via UIHC)
Ariel transmitting facilities
Hardin Library reference and technical staff

Table 2
Types of information in the Virtual Hospital

Multimedia textbooks and teaching files
Digitized textbooks
Multimedia patient simulations
Current diagnostic algorithms
Historical information
Continuing education materials
Physician and hospital directories
Patient instructional materials

viders and specialists. The largest of the test-bed hospitals is the west campus of the Genesis Health System. Genesis West is classified as an urban facility and provides considerable secondary- and limited tertiary-level services such as open-heart surgery. In the future, additional test-bed hospitals will be added as funding becomes available. The larger test-bed will permit further testing of projects that clear the pilot phase or support studies that require greater numbers or diversity of test sites.

Information support projects

Library services have been shown to be highly utilized and capable of influencing medical decision-making [2]. The first of two information support projects, based at the Hardin Library, will provide enhanced electronic health sciences library services, including document delivery, to rural hospitals. In all cases, the electronic library services made available by the project significantly eclipse the current capabilities of the test-bed hospitals (Table 1). Patterns of use and incorporation into practice will be tracked in this and the second information support project. Practitioners will be assigned a unique password, allowing the tracking of and linkage with specific cases by a brief survey administered at the time of sign-on.

The second information support project, the Virtual Hospital, is a digital multimedia database supporting just-in-time access to information for practice and continuing education, as well as patient instructional materials [3–4]. The Virtual Hospital is currently running as a World Wide Web server on the Internet and may be accessed twenty-four hours a day via the Uniform Resource Locator (URL) http://vh.radiology.uiowa.edu. Since the prototype was brought online on March 1, 1994, it has had nearly a quarter of a million log-ins. Information in the Virtual Hospital consists of locally produced multimedia medical textbooks, faculty lectures, presentations, and patient case studies from the University of Iowa Health Sciences Center and other health information sources (Table 2). NLM funding will provide support for both increased access to the Virtual Hospital and the devel-

opment of more comprehensive content useful to rural practitioners. The multimedia aspect allows the user to view textual, graphical, audio, and even full-motion video information within the same interface. A major strength of this database is its adherence to industry standard protocols, enhancing its widespread applicability and ease of upgrading. The Virtual Hospital relies on Internet, World Wide Web, Wide Area Information Server (WAIS), and network multimedia textbook standards to make information available.

Clinical support projects

Teleradiology is an application with substantial promise, but many (largely technical) questions remain regarding its widespread use [5]. The first of two radiology-related projects will determine cost-effective protocols for interpretation of routine and subspecialty radiographs within a three-tier system of hospitals. Time and cost of care will be compared against similar hospitals using more traditional teleradiology methods. Issues to be investigated include

■ accuracy of diagnosis via teleradiology versus plain film;

■ time and accuracy of delivery of a report to referring physicians, utilizing teleradiology over a fiber-optic network as opposed to traditional "circuit-riding" (traveling) by radiologists; and

■ value-added reports utilizing subspecialty referrals, as well as documenting prevalence of these referrals.

An additional question exists as to whether more advanced imaging capabilities are feasible and effective in more rural practice settings when supported by appropriate tertiary consultants.

A second teleradiology project will support more advanced three-dimensional image analysis (volumetric computed tomography) in the test-bed hospitals, addressing the technical, educational, and clinical requirements for such an undertaking. In the final stages of the project, formal receiver operator characteristics (ROC) methods will be applied to community-based applications of the three-dimensional technology.

A final clinical support project will study the use of rapid computer-based information exchange, linked to medical image-transfer methodologies, between rural and referral hospitals in the triage, treatment, and transfer of rural trauma patients. Traumatic injury is the most common cause of death for Iowans from the age of one to forty-four years. Improvement in the treatment of trauma patients in rural emergency rooms may favorably impact outcome [6]. Comparison to matched hospitals without enhanced communication will be done to assess the available information and condition of the patient on arrival at the UIHC emergency room.

PROJECT TIME LINE

The establishment of the Resource Center and its staff, making connections between the University of Iowa and the test-bed hospitals, and developmental work on each of the projects will take place in the first year of the contract. The project protocols will commence in the second year and run through the final year, with specific project evaluations to run concurrently. It is hoped and anticipated that broader collaboration (state and nationwide) will be possible by the end of the contract period.

ACKNOWLEDGMENTS

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The Virtual Hospital (VH) is a continuously updated medical multimedia database stored on computers and accessed through high-speed networks twenty-four hours a day. The VH will provide invaluable patient-care support and distance learning to practicing physicians, health care workers, and the citizens of Iowa.

The VH information may be used to answer patient-care questions, thus putting the latest medical information at physicians' fingertips. This same information can be used for continuing medical education (CME), delivering CME to physicians' offices and homes at a convenient time and location. Within the VH, we are creating the Iowa Health Book. This will provide the citizens of Iowa and the world with needed instructional information to help them better care for themselves in day-to-day life.

The VH is built on preexisting computer and communication standards and uses the World Wide Web software technology to store, organize, and distribute the multimedia textbooks contained within it. The VH can be accessed by any computer connected to the Internet with a Mosaic or other World Wide Web client. The Uniform Resource Locator for the VH is http://vh.radiology.uiowa.edu. Mosaic clients may be obtained via FTP at FTP.NCSA.UIUC.EDU.