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The Canadian Experience: Using Telemedicine for the Support of Medical Care at Remote Sites

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INTRODUCTION

While the majority of Canadians live in a narrow strip about 200 miles wide just north of the 45th parallel, a significant proportion of the population lives in non-urban, remote and sometimes isolated areas. Given this widely dispersed population, the provision of health services has always been a challenge.

A list of non-urban health needs include the following: consulting services; clinical laboratory resources; investigative techniques (e.g., EEG, radiology, ultrasound, nuclear medicine); continuing education for physicians, nurses and other health professionals; teaching and training programmes for administrative and support staff (dietary, housekeeping, maintenance); community health education and improved general education for health workers and families.

For nearly three decades physicians and other health care professionals in the United States and Canada have been exploring the application of telecommunications to health care in rural and remote areas. The terms telemedicine and telehealth are used interchangeably to describe this activity. Here the prefix "tele" refers to distance and now includes all types of communication over distance that support health care and health educational programmes. Actually, telemedicine is as old as the telephone, which is still the most widely used communications technology in health care.

EARLY DEVELOPMENTS

The United States' Applications Technology Satellites ATS I and ATS VI were used for a number of impressive demonstrations in the late 1960s and early 1970s; the Communications Technology Satellite (called Hermes in Canada), which was a joint American/Canadian project, was used in experiments in Canada as well as in the United States. The Moose Factory experiment at the University of Western Ontario in London demonstrated the value of live television and interactive audio systems in the provision of consultations and transmission of medical data, particularly x-rays. The WAMI (Washington, Alaska, Montana and Idaho) project of the University of Washington in Seattle was mainly an educational project. For a number of years there has been distance monitoring of cardiac pacemakers, the transmission of electrocardiograms, and one or two tele-EEG services.

CTS Satellite (Hermes). Memorial University of Newfoundland (MUN) has had a tradition of outreach since it was established and was an early participant in the Canadian Space Programme. The Telemedicine Centre's experiment with the Hermes satellite involved a one-way television/two-way interactive audio configuration. Four remote hospitals were linked to the University in St. John's. There were 150 hours of programming over a period of 3 months. There was also a telephony channel which we used for a slow scan television trial.

Continuing education courses for physicians and other health professionals were offered, administrative and committee meetings were facilitated, and there were limited numbers of transmissions of medical data, including electrocardiograms (ECG), x-rays and other images by slow scan television (SSTV).

While this project demonstrated clearly the effectiveness of one-way live television and interactive audio, it was concluded that most of the educational material could have been delivered by audio alone. It was clear that multipoint television with interactive audio would not be economically feasible in the province for the foreseeable future. Efforts were turned to the development of a mainly terrestrially based teleconference system, which I will describe later.

Anik B Satellite. After Hermes, Canada's Anik B satellite was launched and there were a number of health and education experiments. Memorial University's Anik B experiment was in two phases.

Phase I. The objectives of the first phase were (1) to design and demonstrate a hybrid terrestrial/satellite narrowband network to expand the existing land-based Teleconference System (TCS) to more remote communities, and (2) to evaluate the effect of a dedicated telephony channel link between a drillship sick bay and an emergency department, in a tertiary care hospital, on offshore medical services.

The hybrid satellite/terrestrial network, which linked three land-based sites to the existing teleconference terrestrial network, functioned successfully throughout 1980 and 1981.

Phase II. In this phase, a manually steerable terminal, designed by the federal Department of Communications (DOC), was utilized in conjunction with dedicated audio channels on the Anik B satellite for transmission. Audio equipment and an SSTV unit were placed on a drillship. Although successful SSTV and audio transmissions were received while the drillship was under sail, mechanical problems with the terminal precluded completion of the offshore activities in this phase.

During Phase II, which was a joint project with DOC and the Newfoundland Telephone Company, a prototype gyroscopically stabilized terminal designed by DOC for use offshore was placed on a semisubmersible oil rig. Through this terminal the rig had access to two dedicated satellite audio channels. One was used in a two-wire mode as a standard telephone link and the second, a dedicated four-wire circuit, linked the sick bay to the emergency department of a tertiary care hospital, as in the first phase. In this phase the rig medic was supplied with ECG transmission equipment, as well as audio and SSTV units.

Terrestrially Based Systems. From 1977 Memorial's Telemedicine Centre has directed its efforts toward the development of interactive audio networks for the delivery of educational programmes and the transmission of medical data. In developing Memorial University's telemedicine projects a number of guidelines were followed:

- Use the simplest and least expensive technology that will meet needs.
- Develop a flexible system.
- Involve users (participants, audience, clients) from the beginning of the project.
- Seek the support of administrative personnel in hospitals, clinics, and other agencies.
- Plan carefully for coordination of the system at all levels.
- Develop a consortium of users within and outside the health field.
- Plan for continuity of service beyond the demonstration project.
- Include evaluation.

Memorial's Teleconference System. Established in 1978, Memorial's Teleconference System is a province-wide audio network linking 170 sites in 80 communities. This is primarily a four-wire network and can be divided into seven separate divisions for simultaneous programming. Twenty communities use a two-wire, dial-up configuration. A 20-port teleconference bridge, located at the Centre, accommodates these sites.

The two-wire bridge allows the inclusion of external resource people in conferences, permits access to other teleconference networks, and provides a link for international activities. This bridge can be divided into four sections, each of which can be joined to any of the four-wire circuits.

The teleconference network, with a staff of 10, is financially fully self-supporting with costs shared on the basis of use patterns. In 1990, there were 5,000 hours of programming.

MEDICAL DATA TRANSMISSION

Slow Scan Television. Slow scan technology has been available for 15 years and permits the transmission of a picture over an ordinary telephone line. A television camera captures a single frame of a television transmission and converts this to an analogue signal for transmission over a period of time (15-70 seconds depending on the resolution required). This technique is also called freeze-frame or captured-frame video. With the advent of digital equipment, there has been an increase in image quality and a shortening of transmission time. Resolution offered by earlier equipment such as that used in the offshore telemedicine experiment, was considered by many radiologists as unacceptable, although promising. Current digital equipment appears to be more satisfactory for many types of images. Slow scan television is now in a pre-operational mode among three remote hospitals and the University's Centre, with applications in radiology, ultrasound, nuclear medicine, and clinical consultations.

Electroencepalography (EEG). Six peripheral hospitals are currently transmitting a total of approximately 1,200 EEG tracings per year to the University's main teaching hospital. Remote equipment consists of an electrode cap and a transmitter. A receiver converts the multiplexed eight channels of the EEG which, transmitted on the four-wire telephone network or by regular two-wire, dial-up lines, are recorded on a standard EEG machine. At the remote site technical work is done by an ECG technician, x-ray technician or a nurse. Training of the remote technician requires about 10 days in the EEG department of the urban hospital. This EEG service, after 8 years of experience, is acceptable to referring physicians, hospital administration, and electroencephalographers. Examinations can be done as an emergency, urgently or routinely. Referring physicians receive reports immediately if required. Approximately 7,000 tracings in all have been transmitted in the past 9 years.

Electrocardiography (ECG). A number of remote sites have ECG transmitters which allow a standard ECG to be transmitted, around the clock, to the ECG department or coronary care unit of the University hospital. This is an inexpensive service, which can be used as a clinical laboratory service or as part of a consultation.

Telewriters. For education and training, audio teleconferencing can be greatly enhanced by the use of this computer-based system. This electronic "blackboard" is of particular value where real time visual information, such as writing, printing, symbols, diagrams and graphics, are required to support a given lecture or presentation. Telewriters are equally effective for business and research meetings. Freehand writing and graphics can be presented and exchanged, annotated, altered, and discussed during a conference or teaching session. Telewriters are of particular value in distance teaching of mathematics, engineering, and physics as well as in other service applications, such as community health programmes.

Electronic Mail Project. Because the circuits of Memorial's Teleconference System are not used between 2200 hours and 0800 hours, it was logical to consider the automatic transmission of data between and among the 80 communities on the network. To this end, a computer software programme was developed to permit compatible personal computers to deliver electronic mail (e-mail) messages throughout the system. This project is now in a pre-operational phase.

External Projects. In 1982, the Royal College of Physicians and Surgeons of Canada and the Toronto General Hospital jointly conducted a national teleconference trial project which lasted 2 years. All 16 medical schools in Canada were given a teleconference kit and access to a 20-port teleconference bridge. The objective of the project was to determine the value of teleconferencing at the national level in one health field. The project was jointly funded by the Royal College and the Donner Canadian Foundation. The project, which was done in collaboration with Memorial University, was followed by Telemedicine for Ontario, which is now called Telemedicine Canada.

INTERNATIONAL PROJECTS

International Satellite Organization (INTELSAT). Canadian medical academics, along with those from other countries, played a significant role in the development of the School of Medicine at the University of Nairobi, Kenya, in the 1960s and 1970s. Subsequent to this a MUN project, supported by the Canadian International Development Agency (CIDA), was initiated to provide support for the Paediatric Department at Makerere University in Kampala, Uganda. This was called the Child Health and Medical Education Programme (CHAMP).

In 1985 the International Satellite Organization (INTELSAT) and the International Institute of Communications established the Satellites in Health and Rural Education (SHARE) project to celebrate the 20th anniversary of the establishment of INTELSAT. The Telemedicine group at MUN saw this as an opportunity to establish a link not only between Nairobi and Kampala, but also to provide a teleconference link between those two East African cities and Memorial University in Canada. With the involvement and collaboration of Teleglobe Canada, Post & Telegraphs of Kenya and Uganda, and INTELSAT, a four-wire dedicated system was put in place in December 1985 with Nairobi, and with Kampala in February 1986. Funding, in part, for this project came from the Toronto Hospital for Sick Children's Foundation.

Programming—The system was used for teaching sessions, administrative meetings, transmission of EEGs, and a variety of other applications. The Hospital for Sick Children in Toronto and paediatric faculty of the University of Toronto contributed many programmes using the telemedicine teleconference bridge. The Janeway Child Health Centre in St. John's and MUN's discipline of paediatrics were responsible for the majority of programmes. EEGs were transmitted from Nairobi for 2 months and from Kampala for 10 months; approximately 100 tracings were transmitted and the majority of these were interpreted with confidence by electroencephalographers in St. John's.

In June 1986 the MUN SHARE project was extended to include the six Caribbean countries on the University of the West Indies Distance Education (UWIDITE) Teleconference System. These sites were accessed through the UWIDITE control centre at the MONA campus in Kingston, Jamaica. The technical configuration allowed the Telemedicine Centre to switch automatically the Teleglobe gateway signal between Africa or the West Indies as required. Because of the nature of the existing UWIDITE system there were some technical problems, but these did not interfere with active programming using voice and in many instances slow scan television. The four-wire dedicated link to the West Indies was terminated at the end of December 1986.

Subsequent to the SHARE project, MUN's Telemedicine Centre developed a radio-based teleconference system in Jamaica. The project was jointly carried out by MUN and the University of the West Indies (UWI) and was supported by the Canadian International Development Agency in the amount of $625,000. The Jamaica network has been designed so that it can be interfaced with the existing satellite network that connects seven island countries. It is anticipated that this design will be used as a model for expansion of UWIDITE in other Caribbean islands. In addition to developing the technical system, MUN is cooperating with UWI in developing appropriate course design techniques for Jamaica.

<u>SatelLife</u>. SatelLife is a non-profit, international organization committed to using modern communication technologies to link medical centres and physicians throughout the world for information sharing. SatelLife, with an international board of scientists and physicians, is an East-West partnership with offices in Boston and Moscow.

One of the projects of SatelLife, HealthNet, will transmit medical information, including the contents of *The New England Journal of Medicine*, to five university medical libraries in East Africa using a low-orbit satellite called HealthSat. HealthSat was built by Surrey Satellite Technology Ltd. of Britain with the payload being owned by SatelLife. The satellite (UoSat-5) weighs about 50 kg and makes a north-south orbit every 100 minutes. As it passes over a given point on the earth, signals can be sent to and received from groundstations. The messages are stored in the satellite's computer until the satellite, a few hours later, passes over the addresses elsewhere on earth. The groundstation consists of a radio, a modem, and a computer. Memorial has the North American gateway station for this satellite e-mail pilot project. E-mail messages received by terrestrial networks will be transferred manually to the satellite ground terminal. The satellite passes over a given point on the earth at least twice daily. There will be a 2-18 minute "window" during which time information will be received and sent to the satellite with delivery to other transmitting/receiving stations anywhere in the world. Obviously, the applications will be in areas where limited or no communication system now exists. HealthNet, the current project of SatelLife, will have 15 terminals located worldwide with six in East Africa. This project has received financial support from a number of granting agencies.

It should be noted that amateur radio operators have been using this low-orbit satellite technology for some time and there are a number of commercial programmes in the planning stage or under development. Motorola with its plans for iridium and its 77 interconnected small satellites, and Russia with its "Small Sat" project, have certainly raised the profile of low-orbit communications. SatelLife's low-orbit satellite project is experimental and Memorial has an experimental license. It may be an understatement to say that it will be some time before the regulatory considerations governing low-orbit satellite communications.

Digital Communications Technology. While Canada has been slower than some other countries (U.S. and Scandinavian countries) to digitize its telephone networks, this process is now underway with substantial digitization expected by the mid-nineties.

With digitization it is possible to transmit large amounts of data without the need for broadband circuits. There has been an increasing use of intermediate bandwidth circuits (up to 2 megabits) in the U.S. and in Scandinavian countries. This technology is referred to as T-1. In June 1990 Nymo and Engum, in a presentation at an OECD conference in Kiruna, Sweden, described the use of T-1 technology to transmit medical data from remote to urban hospitals. The Norwegian Telephone Company had, by early 1991, a 30-point T-1 network with many sites having the capacity to transmit compressed video. There is currently an interest in a T-1 trial between Canada and Europe using the European Space Agency's Olympus satellite, which covers Eastern Canada with its 20/30 gigahertz "footprint." Memorial University will shortly have a 20/30 gigahertz terminal to access Olympus in Eastern Canada. This is expected to be used for telescience and space medicine projects between Europe and Canada. These may include telescience simulation experiments using the space station module at Noordwijk in the Netherlands and hyperbaric chambers at Memorial in St. John's. The projects will include teletraining and a range of data transmission to support science and health care in space. A relationship between Memorial and the European Astronaut programme in Cologne, Germany, is under development.

Currently, at Memorial we are jointly, with the Newfoundland Telephone Company and DOC, starting a terrestrially based T-1 project with several components, including health and education applications.

The provision of health care in space is of concern to space agencies internationally; and it is, in part, because of the European Space Agency's needs that the ESTEC projects mentioned above were supported. Canada has been involved in the NASA Space Station, and as a result of this, the Canadian National Research Council carried out a study in 1985 on the feasibility of Canadian participation in the development of the Health Maintenance Facility.

Broadcast Television. There is an increasing use of satellite television programming in the health field, especially to reach large audiences. A number of networks in the U.S., Canada, and Europe offer health education programmes to professionals as well as to other specific interest groups. It seems likely that compressed video using codecs (encoder/decoder) will play an important role in health education in the future. The recent agreement on an international standard for codecs will undoubtedly stimulate international usage.

This technology is still relatively expensive; and audio conferencing and narrowband transmission of medical data will continue, for some, to provide the most cost effective method of supporting health needs in rural and remote areas.

CONCLUSION

Telemedicine and distance education programmes require the whole range of terrestrial and space-based communication systems. Only satellites can provide reliable communications in some geographic locations and offer the easiest method of providing international links.

Space research will most certainly contribute to the development of technology that will be of benefit not only for space activities, but also more broadly for terrestrial applications in health and education.

The range of telemedicine activities in Canada over the past 15 years has clearly shown its value in the health field. Despite this, the actual use of the technology, with a few notable exceptions, is limited. Health needs that can be satisfied by telecommunications technology are increasing, and it is expected that the next decade will see a more widespread application of telemedicine to non-urban, remote, and isolated areas.