HEARRT

Healthcare and Education Access for Remote Residents by Telecommunications

Economic Evaluation

Submitted to the

University of Ottawa Heart Institute

K. V. Nagarajan, PhD
John C. Hogenbirk, MSc

Centre for Rural and Northern Health Research
Laurentian University

May 2000

Table of Contents

Acknowledgements

The Centre for Rural and Northern Health Research wishes to acknowledge the assistance of a number of key personnel at the University of Ottawa Heart Institute and Pembroke General Hospital as well as the physicians and nurses who continue to express interest in and support of the telehealth system. In particular we would like to thank Dr. Tim Cheung, Roy Marsh, Sharon Ann Kearns, Heather Sherrard, Kirsten Woodend, Dr. Richard Davies and Kelly Price, at UOHI, Dr. Frank Murphy at Almonte General Hospital, as well as Dr. Kong Li and John Wren at Pembroke General Hospital. The research team acknowledges the help of Dr. Ron Baigrie, Hôpital regional de Sudbury Regional Hospital. Our thanks to the many others in Ottawa, Pembroke, Red Lake, Almonte, Chapleau and Sudbury who helped collect data and answer our questions.

Introduction

HEARRT Demonstration Project – an outline

Over the last few years, telehealth activities in Canada have picked up pace. Currently, many telehealth demonstration projects are underway from coast to coast. An overview of many of these projects can be found in a special issue of *Telemedicine Journal* (1998, Volume 4, Issue 3).

What is telehealth? As Watanabe (1998) puts it, the term "telehealth" refers to the "use of information and communications technology and networks to deliver health information, services, and expertise across distances" (p. 197). Among such telehealth initiatives is the HEARRT Demonstration Project led by the University of Ottawa Heart Institute. The project is described in Cheung *et al.* (1998).

Rationale for the HEARRT Demonstration Project

It is well documented that residents of rural and remote areas of Canada often have difficulties accessing medical care, especially specialist care, in the patients' communities. If rural and remote residents are in need of specialized care, they often have to travel long distances in order to receive care. Telehealth technology has the potential to provide timely care for these patients and thereby avoid stressful trips to distant health care facilities.

The same problem of distance also adversely affects the physicians who are located in rural and remote communities. One of the problems they face is a sense of professional isolation. In those rural and remote communities, they often do not have ready access to specialist consultants. Telehealth technology could reduce this isolation. Furthermore, with the use of this technology, physicians in the rural and remote areas can participate in continuing medical education (CME) sessions without having to leave their communities. Such CME Programs can be delivered to other health care providers as well.

Another aspect of telehealth technology is the potential to provide patient education designed for the purpose of disease prevention and health promotion. Courses designed to prevent the onset of chronic conditions such as coronary heart disease and Type-2 diabetes can be transmitted to the rural and remote communities. Thus residents in these communities would have the same knowledge base to take care of their own health as their urban counterparts have now.

Thus, the rationale for the HEARRT Demonstration Project is the improvement of access to health care and health education for residents of rural and remote communities.

Objectives and Goals

The objectives of the HEARRT Demonstration Project were to:

(1) demonstrate the feasibility of providing clinical and educational services to residents by means of telehealth to rural and remote communities in Ontario;

(2) evaluate the technology in terms of clinical applications;

(3) evaluate the technology in terms of patient satisfaction and acceptance; and

(4) evaluate the technology in terms of its costs and benefits.

The goals of the HEARRT Demonstration Project were to:

(1) rigorously test technology relevant to cardiology consultations;

(2) demonstrate the capabilities of providing such consultations; and

(3) prepare the ground for consultations in other clinical areas.

The Equipment

The system includes a telemedicine platform and signal processor. The platform includes a close-up video camera, a document reader, an electronic stethoscope, a high-resolution videotape machine capable of playing back echocardiograms and other video material and a x-ray viewer. Signals are being transmitted both via terrestrial and satellite communication links.

The telehealth consultation room is equipped with specialized lighting and paint scheme in order to allow the cardiologist to examine the patient in sufficient detail. The video and audio transmissions are synchronised, allowing the cardiologist to compare the visual and audio signals emanating from the diagnostic equipment. Consultation sessions are assisted by a telehealth nurse trained to position the patient, apply the stethoscope and transmit results of the diagnostic tests.

The telehealth platform is versatile and can be used for patient consultation, delivery of continuing medical education sessions and for conducting patient education. Its video-conferencing capability can also be put to use for conducting administrative meetings.

Sites

The University of Ottawa Heart Institute (UOHI) is the hub of the HEARRT Demonstration Project. UOHI is a major cardiac clinical care teaching and research centre in Canada. There are four spoke sites within this project: Pembroke, Almonte, Red Lake and Chapleau/Sudbury.

Pembroke: UOHI has established a telehealth link with the Pembroke General Hospital located in Pembroke (1996 population ~14,200). This town is located approximately 150 km northwest of Ottawa.[1] A direct point-to-point terrestrial communication system is used to link these two sites. The major health care facility is the Pembroke General Hospital (PGH). This is a 116-bed facility, serving about 100,000 people in its surrounding area. The town does not have many specialists and there are no cardiologists. However, PGH has an active Visiting Specialist Program that includes UOHI cardiologists. Patients needing acute cardiologist care are usually transported to Ottawa via ambulance. This trip can take anywhere from 2 to 4 hours depending upon road conditions. Winters in this area tend to be severe at times, thereby lengthening road travel time.

Almonte: UOHI is also connected to the Almonte General Hospital, first via terrestrial communication and later by satellite. Almonte (1996 population ~4,600) is a small town approximately 50 km from Ottawa. This site was primarily used as a proving ground for the telehealth platform and communication equipment.

Red Lake: UOHI has established a satellite-based link with the Red Lake Margaret Cochenour Memorial Hospital. This hospital is a 29-bed facility with five beds allocated for long-term care. Red Lake (1996 population ~2,300) is located in northwestern Ontario and is approximately 2000 km from Ottawa. It takes about 5 hours to reach Red Lake by air from Ottawa. Normal referral is

[1] All distances are road distances between city halls as reported by the Ontario Ministry of Transportation, 1992.

to Thunder Bay (555 km) or to Winnipeg, Manitoba (475 km). This site was an ideal testing ground for telehealth service to a remote community.

Chapleau: UOHI has also established link with Chapleau. This town (1996 population ~3000) has a small hospital (called services de sante de Chapleau) with about 39 beds. Patients who cannot be treated in this hospital are transferred either to Timmins (200 km) or to Sudbury (410 km) (1996 population ~92,000). Timmins is about two-and-a-half hour drive from Chapleau in good weather. Sudbury is about a five-hour drive away. For emergency cases, air ambulance is used. Chapleau is located about 900 km from Ottawa. Chapleau is also another excellent site to test telehealth service to a remote community.

Sudbury: UOHI established a link with l'hôpital regional de Sudbury Regional Hospital when the link was established with Chapleau. When finalized, Chapleau, Sudbury and UOHI will be connected as a network. With the consolidation of hospital resources in the Sudbury Region into a single entity, Sudbury is rapidly emerging as a regional referral centre. Sudbury has good expertise in cardiac care and thus the expectation is that Chapleau will link to Sudbury for most cases while the Sudbury-UOHI link will involve complex cases.

In keeping with the objectives, it is important that all aspects of the HEARRT Demonstration Project are evaluated. The findings from such an evaluation will prove useful for making decisions about the adoption of telehealth technology. This report will focus on the economic aspects of this project – other research teams have evaluated the technological and clinical components.

Economic Evaluation: Methodology and Design

This chapter discusses telehealth economic evaluation methodology and design issues and presents the evaluation methodology used for the HEARRT Demonstration Project.

Complexities of Economic Evaluation of Telehealth Demonstration Projects

Economic evaluation of telehealth demonstration projects is a complex task. The reasons for the complexity can be traced to the nature of telehealth technology itself, sample size problems, the inability to test the system in a "real world" operational setting and inadequacies of evaluation methodologies. We briefly discuss these issues, in turn.

Telehealth technology: Telehealth technology, hardware, software and communication equipment is undergoing continuous review and improvement. Thus, even over the duration of the HEARRT Demonstration Project, technology has undergone rapid change. In fact, one of the purposes of a demonstration project is to test and demonstrate various technological choices (Phillips *et al.* 1998; Julsrud *et al.* 1999). Economic evaluation during rapid technological change is difficult, since many of the key assumptions made in developing the evaluation methodology are not likely to remain valid for very long.

Sample size: Telehealth demonstration projects often suffer from inadequate sample size due to the nature of the projects (Office of Rural Health Policy 1997; Hassol *et al.* 1997; Project Steering Committee 1998). Project managers have to handle a lot of issues: setting up the system, testing the equipment, persuading the clinical staff and patients to participate in the project and dealing with a variety of government policies and professional regulations. In practice, it is not always possible to have everything work simultaneously. Instead, the project pathway may take a step-by-step approach, leading to inadequate sample sizes on which to base economic evaluations.

Lack of "real world" setting: This refers to the fact that demonstration projects often lack "real world" conditions (e.g., Bashshur 1997). If telehealth is part of the integrated system of health care, it will be a routine feature of the system. In such a situation, the features and costs of the system would be very different from what they are likely to be in a demonstration project. For example, in an operational system, there may be no need for a separate administrative staff to operate and manage the system. These conditions would translate to fewer staff to administer a routinely operating system. Hence the cost structure of the demonstration project is likely to be more expensive than that of an operational system. Therefore, economic evaluation results of demonstration projects must be viewed with caution in making decisions about the introduction of telehealth.

Inadequacies of the evaluation methodologies: Conventional economic evaluation methodologies are of four types: cost analysis (CA), cost-effectiveness analysis (CEA), cost-utility analysis (CUA) and cost-benefit analysis (CBA). As Drummond *et al.* (1997) note, all these techniques require that the point of view of the evaluation be clearly defined. That is, one must define from whose point of view the evaluation is being undertaken. Is it the point of view of the Ministry of Health? Is it the point of view of the health care providers? Or is it the point of view of the public at large? The point of view is important because defining it will help in deciding which cost items will be included during the evaluation process. Once this issue is resolved, one can proceed to examine which evaluation technique to adopt.

Cost analysis simply measures the cost of the program or technology. CEA compares two or more ways of providing the same or similar service in an attempt to choose the most effective (the least expensive) way of delivering a program or service. CUA is similar to CEA, except that the outcome is measured in terms of “utility” generated by the program. The “utility” measure includes some dimension of the quality of life. CBA is the broadest technique and the “Gold Standard” of economic evaluation. This technique requires that we capture all costs and benefits of a program or technology in dollar terms and compare them to evaluate economic viability. CBA typically requires that the point of view of society be adopted for evaluation, since we are looking at what society gets in return for the resources committed to the program under evaluation instead of using the same resources for some other alternative program or technology.

While CBA remains the most comprehensive technique, it is not always possible to convert all costs and benefits into dollar terms. For example, health programs in general and telehealth programs in particular have several benefits which are intangible and they cannot be fully captured even by the most sophisticated data-gathering methods. Furthermore, in the context of telehealth demonstration projects, it is not always clear which of the evaluation techniques is most appropriate. Thus, the methodology of economic evaluation of telehealth is itself evolving side by side with the technology. This situation explains the observation that telehealth demonstration projects use widely different methods of evaluation.

Towards An Economic Evaluation Framework

Telehealth demonstration projects have been proliferating all across the globe in recent years (e.g., Grigsby & Sanders 1998, Wright 1998). This rising interest can be partly attributed to the coming together of various strands of technology: computers, satellites, telecommunication, digitalization of signals and software. It is now possible to combine these developments into one package of telehealth services with clinical, educational and administrative uses. The need for these services is driven, in part, by persistent problems of access to health services, particularly specialized medical resources in under-populated and remote areas of North America and elsewhere.

While the promises of telehealth are many, it is not always known whether they are being realized. The reason is the virtual absence of hard economic data about the costs and consequences of telehealth programs. Most evaluations of telehealth systems have been focused on clinical efficacy and acceptability of the technology to clinicians and patients (e.g., Office of Rural Health Policy 1997). Although financial considerations are mentioned, very few studies report economic evaluation results. Thus, we are faced with a “feast-and-famine” situation. There is plenty of clinical evaluation data, which are largely favourable to the adoption of technology. On the other hand, the economic picture of telehealth technology remains blurry, with many fundamental issues remaining unresolved and, perhaps, not even well understood.

Most of the available evidence on the economics of telehealth is from demonstration projects conducted in the United States (Bashshur *et al.* 1997). The evidence on the costs and benefits of telehealth is too slim to form definitive judgement about the economic viability of telehealth at this time. Most studies mention favourable economic effects, but very few studies have undertaken detailed economic evaluation.

Among studies which report favourable economic results are those programs which provide telehealth services to special groups of patients, such as prisoners. Brecht *et al.* (1996) report on their findings from the initial year of a telemedicine project involving the University of Texas Medical Branch and the Texas Department of Criminal Justice. A total of 1715 telemedicine consultations took place between October 1994 and November 1995 through 18 scheduled clinic sessions. A variety of specialty consultations, ranging from cardiology to urology, took place. The economic data from this study are not strong. The authors state their "belief" that "telemedicine care can be delivered" at a cost that is "substantially less than the real costs of transporting inmates to ….specialty clinics" (p. 31).

McCue *et al.* (1997) report on the telemedicine link between Powhatan Correctional Center and the Medical College of Virginia. The patient population was HIV-positive inmates who attended regularly scheduled telemedicine clinics between October 1995 and April 1996. Although the study purports to be a cost-benefit analysis, only calculations of cost savings are reported. Based on data covering 165 consultations over 7 months of the demonstration project, the study reported a "net benefit" (difference between cost savings and total operating costs) of $14,486. A major consideration in favour of telehealth applications to prison populations is the cost of transporting patients to specialty clinics. Such trips cost prisons a lot of resources to assure security.

Cost savings from applying telehealth technology to patients drawn from the general population, however, are not that obvious. Preston (1995), for example, investigated the viability of telemedicine for a rural network in Texas. Phase I of this project, conducted in 1989, involved planning the network and developing methodologies for data collection. The network was implemented in Phase II starting April, 1991. The methodology used was "a simple comparison of aggregated costs with aggregated savings" (p.130). Based on Phase I experience, the author projected that annual savings would exceed annual costs. In practice, however, the project remained in deficit during the first year. She notes that there were several reasons for the state of financial deficit of the demonstration project. Among these was insufficient volume of usage of the network. Given the high initial fixed costs, the economic viability of the project would improve if the network use increased. Another key observation is the difficulty of identifying benefits. As she puts it: "Whereas costs can be attributed to a single project using a specified set of equipment at a specific point in time, quantification of savings is more complex" (p.131). On the basis of this study, the author recommends a review of telemedicine policies with a view to increase use.

Bartolozzi *et al.* (1996) studied a teleradiology project. Echoing the point made by Preston, they note that while it is relatively straightforward to measure project costs, measuring effectiveness would require a longer time period, sufficient enough to absorb the high start-up costs. Unfortunately, most demonstration projects are of short duration. Hence, the volume of use and sample size are not always high enough to demonstrate viability.

In recent years, there has been a concerted effort to remedy this situation and move towards a framework for evaluating the non-clinical and non-technical side of telehealth. Bashshur and Grigsby (1995) emphasized the need to look at cost, quality and accessibility of telehealth technology. In their review of telehealth technology, Grigsby *et al.* (1995) also emphasizes the need to undertake detailed evaluation of all aspects of this technology.

Lobley (1997) suggests that in addition to cost and accessibility, the evaluation framework should consider acceptability and the effect on practice patterns. With respect to cost savings, they suggest the following as the types of savings that might result from telehealth:

(1) reductions in the costs of patient movement, including the costs of ambulances, aircraft and so on – such savings are likely to depend on the distance between the patient and the specialist and the mode of transport;
(2) reductions in the costs of moving staff, including direct costs of travel, accommodation and subsistence for specialist staff;
(3) reductions of the opportunity costs of time spent by specialist staff in travelling, which would be more effectively spent working in their profession;

(4) savings through not undertaking laboratory tests which might be deemed unnecessary as a result of a telemedicine consultation;
(5) savings from the increased use of highly skilled medical staff at a specialist centre;
(6) savings due to better scheduling of patient diagnosis and treatment;
(7) savings due to patients receiving more effective treatments and recovering more quickly as a consequence;
(8) reduced costs of travel for patients, including the direct costs and the opportunity costs of time spent travelling. (p. 123)

Lobley recognizes that some of the potential benefits of telehealth, although present, are not quantifiable. Nevertheless, these intangibles must be taken into account. What are these intangible benefits? Lobley identifies them as follows:

> They include qualitative improvements in patient care through improved treatment, faster and more accurate diagnosis, reduced need for patient referral due to remote consultation, improvements in patient referral through better knowledge and preparation, improved training and education, reduced disruption to patients through reduced travel, improved training due to knowledge transfer from specialist to the remote site, the reducing need for specialist consultation as a result of knowledge transfer, and more interesting and high-quality referrals for specialist consultants, leading to greater opportunities to undertake research. (p. 123)

Along similar lines, McIntosh and Cairns (1997) suggest that all possible costs and consequences of telehealth should be taken into account in the evaluation framework. Their suggested list of costs and savings includes:

- Hardware
- Software
- Consultants' time
- Travel costs
- Communication costs
- Administrative changes
- Number of referrals and
- Treatment costs

On the consequences of telehealth, they divide potential benefits into health and non-health categories. Their list of health benefits includes:

- Effect of bringing treatment forward in time (e.g. changes in patient management);
- Clinical confirmation (e.g. second opinion)

Their list of non-health benefits includes:

- improved quality of service
- transfer of skills
- speed of service
- education, and
- reassurance.

Despite these calls, the evidence supporting cost-effectiveness of telehealth is at an early stage of accumulation. As Grigsby and Sanders (1998) note:

> Many claims have been made about the cost-effectiveness of telemedicine, but telemedicine applications must be examined individually. Cost-effectiveness has not yet been studied for any application… (p. 126)

The HEARRT Project Economic Evaluation Methodology

The economic evaluation methodology of the HEARRT Project was designed to add to the available evidence on the economic viability of telehealth from a societal perspective. The evaluation design proceeded along several steps.

Identification of costs and benefits: The costs and benefits expected to accrue to various stakeholder groups in the HEARRT Demonstration Project are detailed in Appendix 1. There are many real and potential costs and benefits to be realized with the introduction of telehealth. Some costs and benefits were beyond the scope of this study, others were very difficult to quantify and still other costs and benefits lack established data collection procedures. The present study focussed on short-term costs and benefits of large-magnitude that are of prime importance for pilot projects evolving towards the operational stage.

Data collection instruments: In an attempt to capture some of the important benefits, we developed several data collection instruments. We developed a logbook to capture descriptive data on each telehealth encounter (Appendix 2).

Several authors have drawn attention to the benefits accruing to patients and their families in terms of travel costs savings. We attempted to capture these savings with a set of questions included in a questionnaire used for patient interviews after the telehealth encounters (Appendix 3).

Another important use of telehealth is providing CME to physicians in rural and remote sites. The remote site physicians who participate in these sessions benefit by not having to travel for CME sessions. We tried to capture these savings through questions included in a questionnaire distributed to physicians (Appendix 4).

A fourth questionnaire was developed to capture information on the effect of telehealth on in-patient disposition, LOS, etc. (Appendix 5). This questionnaire was completed by an internist at PGH who had participated in the telehealth clinical sessions.

Additional data for economic evaluation came from the HEARRT project's administrative database, HEARRT's quarterly reports to the Ontario Ministry of Energy, Science and Technology, the Canadian Institute for Health Information (CIHI) Discharge Abstract Database (courtesy of PGH), ambulance costs from the Ontario Ministry of Health, and length-of-stay data from the Ontario Case Costing Program/Joint Planning and Policy Committee .

Evaluation Viewpoint and Approach: The economic evaluation was conducted from a societal viewpoint using a cost-benefit approach. The evaluation of in-patients focused on the health care system with extension to society as a whole. It was not possible to measure all the costs and benefits. Nonetheless an attempt was made to capture the major costs and benefits of telehealth versus non-telehealth modes of health care and education delivery.

A major assumption of the economic evaluation was that clinical efficacy as well as short- and long-term heath outcomes were similar between the telehealth and non-telehealth modalities. Evidence from the literature suggests that clinical efficacy is similar or being driven towards acceptable levels of similarity (e.g., Bashshur 1998). The Clinical Evaluation team at UOHI studied clinical efficacy. It is not known whether there any significant differences between telehealth and alternative modes of delivery with respect to short- and long-term health outcomes. For purposes of the economic evaluation, we assumed health outcomes to be equal between telehealth and alternative modes of delivery.

Pattern of Utilization

The precursor to the HEARRT Demonstration Project began in April, 1997 with a link between University of Ottawa Heart Institute and Pembroke General Hospital (PGH). The HEARRT Demonstration Project officially started on November 3, 1997, continuing the link to PGH and establishing new links to Almonte General Hospital, the Margaret Cochenour Memorial Hospital in Red Lake, services de sante de Chapleau and l'hôpital regional de Sudbury Regional Hospital. Almonte was chosen as the testing ground for the telehealth technology because of its proximity to Ottawa. Given its status as a testing ground, the Almonte cases were not included in this report. In this section, we report the pattern of use of the system during the pilot period from November 1997 to September/October 1999.

Use of any telehealth system is the sum of predictable, steady use and unpredictable or urgent use. Steady uses would include scheduled out-patient clinics, educational sessions (e.g., CME, Grand Rounds) and administrative meetings. Use for in-patients is particularly unpredictable on a week-to-week basis due to the pattern of disease onset among the capture-area population. Unlike the out-patient clinic where appointments are made, in-patient use depends on the arrival of patients to PGH and their health status. Thus, it should not be surprising if the numbers do not steadily show a steady upward trend. Such an uneven pattern of use is likely to be found in a fully operational system as well.

There were three areas of activity using the HEARRT telehealth system: clinical consultations, education (including medical, nursing and patient education) and administrative use. In this chapter, we describe the pattern of use of the HEARRT system in all these areas.

Clinical Consultations

Pembroke

The link between UOHI and PGH, established prior to the project, was continued throughout the demonstration period with only minor interruptions due to technical upgrades and problems. This can be attributed to the support of the PGH administration as well as the relationship that had existed between the two institutions long before this project got underway.

Cardiology Clinics

Cardiologists from UOHI have been conducting a visiting specialist clinic at PGH long before the introduction of the HEARRT Demonstration Project. At the PGH site, both in-patients and out-patients have been seen through telehealth. For ease of calculation we consider the total number of patient-sessions, regardless of whether or not the patient was a repeat patient.

Although there was quite a bit of fluctuation, the over-all trend of use for out-patients was a steady increase (Table 1, Figure 1). The in-patient cases started in May 1998 and their numbers remained at less than 10 per month. The in-patient cases showed no discernible pattern. In contrast, the out-patient cases were scheduled telehealth clinic consultations and hence numbers were more predictable. The average number of in-patients and out-patients seen per month of operation steadily increased over the three years of operation.

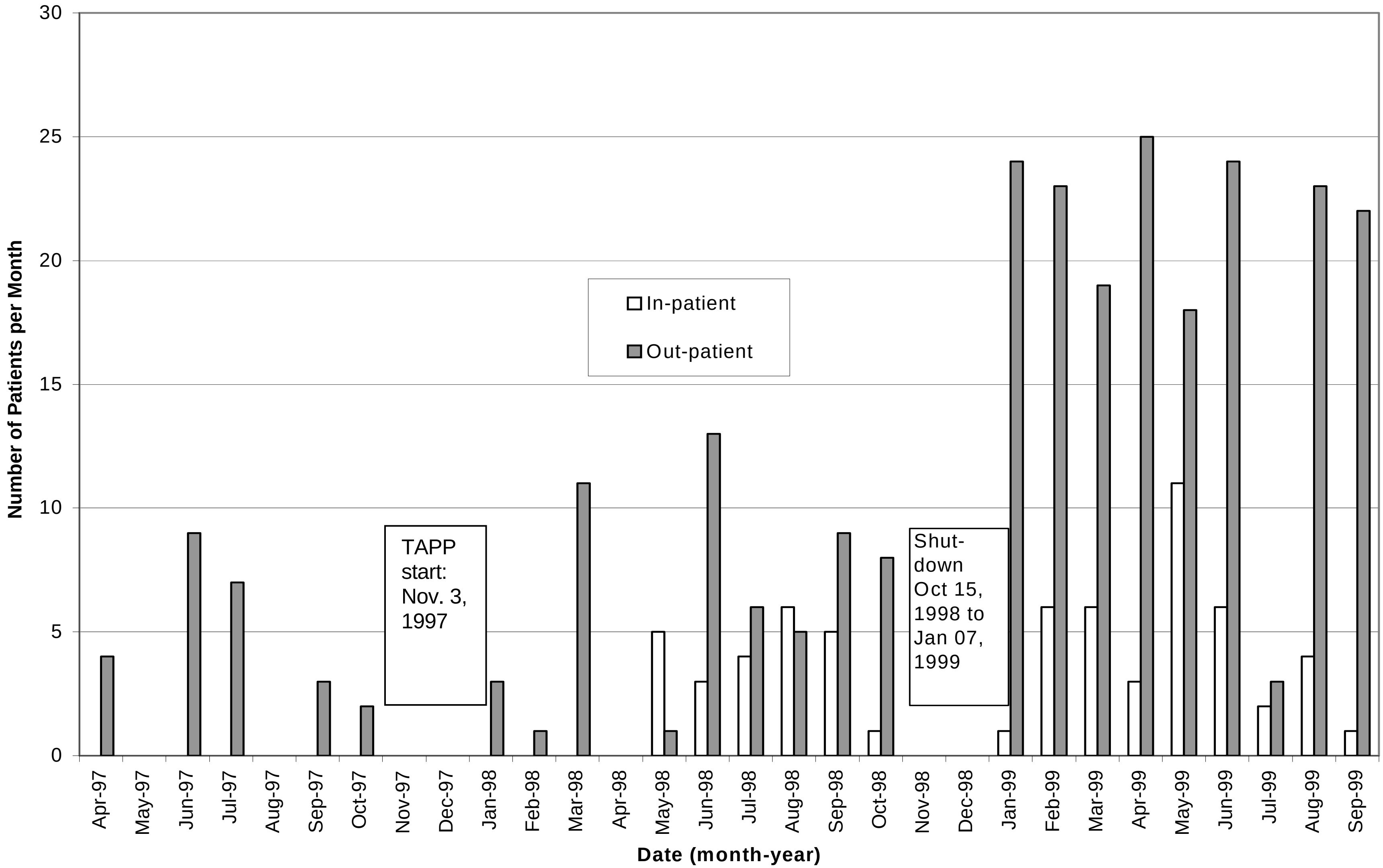

Figure 1. Total number of in-patients and out-patients per month participating in telehealth sessions between the University of Ottawa Heart Institute and Pembroke General Hospital from April 15, 1997 to September 24, 1999.

TABLE 1. Number of tele-cardiology patients at Pembroke General Hospital.

Year	In-patients		Out-patients		Total	
	Total	Per Month *	Total	Per Month	Total	Per Month
1998 (excluding Nov. & Dec.)	24	2.4	57	5.7	*81*	*8.1*
1999 (ending Sep. 24)	40	4.4	181	20.1	*221*	*24.6*
Total	**64**	**2.3**	**263**	**9.4**	**327**	**11.7**

* Average number of patients per month of operation. There were 10 months of operation in 1998 and 9 in 1999.
NOTE: In 1997 there were 25 out-patients seen by telehealth, for an average of 2.8 patients in each of the 9 months of operation.

The use of the telehealth system was influenced by patients' needs, tempered by system availability and the participation of physicians or specialists. The telehealth system was in use for 10 days in 1997, 33 days in 1998 and 51 days in 1999. The average number of patients per day of use was about two in 1997 and 1998, and four in 1999 (i.e., 221 patients / 51 days of use=~4.3).

Rheumatology Clinics

Beginning January, 1999, the telehealth link between UOHI and PGH saw the addition of another speciality clinic when rheumatology consultations were added. In this link, a rheumatologist at the UOHI site provided clinical consultation to out-patients at the PGH site. A total of 21 rheumatology out-patients were seen in 4 separate telehealth sessions, from January 28, 1999 to October 7, 1999. The number of out-patients seen per date ranged from 4 to 8 with an average of 5.

Red Lake

The community of Red Lake is connected to UOHI via a satellite link. Use of telehealth services by patients in Red Lake is shown in Table 2. These relatively small numbers can be attributed to the small size of the base population of Red Lake (~2,300 people in 1996). Telehealth sessions were held on one day in 1998 and 5 days in 1999, with 1 to 3 months between days. The number of patients seen per day ranged from 3 to 6 with an average of 4.

TABLE 2. Number of tele-cardiology patients at Red Lake.

Year	In-patients	Out-patients	Total
1998 (starting Nov. 27)	0	3	**3**
1999 (ending Oct. 08)	2	18	**20**
Total	**2**	**21**	**23**

Chapleau

Chapleau is connected to both Sudbury and UOHI through terrestrial ISDN communication lines, using CDC and CIFRA telehealth platforms. The first 5 patients were seen via telehealth on September 24, 1999.

Non-Clinical Sessions

Medical Education

The advantage of the telehealth system is that, while not in clinical use, it is capable of supporting administrative or educational sessions. Meetings involving parties at different locations can be held. Such meetings can be quickly arranged and efficiently conducted, avoiding delays and costs of travel. This convenience is especially critical for rural and remote facilities.

Several education sessions were conducted via telehealth in order to demonstrate the capability of the system in providing continuing medical education (CME), nursing education and other training sessions. There was a total of 21 non-clinical sessions involving a total of 46 people at the hub site and 89 people at the remote (spoke) sites (Table 3). For those sessions with complete data, there was an average of 3 people at the hub and 4 people at the spoke site. In all, 14 of the 21 sessions were transmitted from UOHI to PGH; other remote sites had 1 session each, with the exception of Sudbury, which had 2 sessions. The 14 sessions between UOHI and PGH served a total of 34 and 65 people at the Ottawa and Pembroke sites, respectively. One session was held in 1998, on December 15, with the remainder in 1999. The last session recorded for this evaluation was held on October 27, 1999.

In total there were 12 education sessions and another 6 sessions that were used to demonstrate the capabilities of the telehealth system for long-distance health education. These 18 sessions served 39 people at the hub site and 75 people at the remote sites (primarily Pembroke). The remaining 3 sessions were used for committee meetings with UOHI forming a bridge between the Sisters of Charity (Ottawa) and Pembroke General Hospital.

TABLE 3. Total number and duration (hours) of non-clinical sessions held between the University of Ottawa Heart Institute and Pembroke General Hospital or between UOHI and all remote sites.*

	Number of Sessions		**Total hours ****	
Type of Session	*UOHI-PGH*	*UOHI-Remote*	*UOHI-PGH*	*UOHI-Remote*
CME	5	5	3	3
Education	1	4	1.5	6.5
Grand Rounds	3	3	3.5	3.5
Demonstration	2	5	2.5	6
Demonstration / Meeting	0	1	0	1
Committee Meeting	3	3	5	5
Total	**14**	**21**	**15.5**	**25**

* December 15, 1998 to October 27, 1999
** Duration was missing for two CME sessions held between UOHI and PGH.

The duration of the sessions, reported to the nearest half hour, averaged 1.3 hours for CME/education/demonstrations and 1.7 hours for the three committee meetings with an overall average of 1.3 hours for the 19 sessions with recorded duration (Table 3).

In the 18 sessions with attendance data there was a total of 22 physicians, 7 nurses (including the telehealth nurse at UOHI) and 17 others at the hub site and 24 physicians, 7 nurses and 46 others in attendance at the remote site (primarily Pembroke) (Table 4). Individuals in the “other” category included educators, administrators, social workers, members of religious orders, the telehealth manager (at UOHI), and may have included some physicians and nurses.

Most sessions involved one hub and one remote site. Exceptions occurred when the Sisters of Charity linked to PGH via UOHI. In addition, one session involved a simultaneous audio-visual link to two spoke sites plus an audio-only link to a third spoke site.

TABLE 4. Total number people who attended non-clinical sessions held between UOHI and PGH and between UOHI and all remote sites.

Type of Session	**Number of People at Hub Site**		**Number of People at Remote Site**	
	UOHI- PGH	*UOHI- All Remote Sites*	*PGH*	*All Remote Sites*
CME *	6	6	21	21
Education	2	8	6	23
Grand Rounds	12	12	3	3
Demonstration	7	11	23	25
Demonstration / Meeting	0	2	0	5
Committee Meeting *	7	7	12	12
Total	**34**	**46**	**65**	**89**

* Attendance figures were missing for one CME session and one committee meeting held between UOHI and PGH.

Patient (Public) Education

There were three public lectures presented in a lecture hall at UOHI and broadcast to PGH. All public lectures occurred in May 1998. There were 52-86 people in attendance at UOHI (average of 70). Lecture topics and duration, as well as attendance figures for PGH, were not available.

Analysis of Telehealth Out-Patients

The UOHI-PGH Link

In this section, we report results from an analysis of the data collected on out-patient cardiac clinics. PGH has an active program of clinics staffed by visiting specialists. Under this program, cardiologists from UOHI have held regular clinics at PGH for several years. The HEARRT Demonstration Project was able to see some of these out-patients using the telehealth system. This analysis provided a comparative economic assessment of seeing out-patients through telehealth or seeing them through the Visiting Specialist Program. The costs of the tele-cardiology consultation service (Telehealth Program) were compared with a Visiting Cardiologist Program (monthly visits by UOHI cardiologists to the Pembroke General Hospital).

Costing Method

In this analysis, we keep the fixed and variable costs separate. Fixed costs were those that do not vary with the patient load. Variable costs were those that vary directly with the patient load. This distinction becomes critical in evaluating telehealth, since its initial capital outlay is high and the patient load is likely to play an important role in determining the economic viability of telehealth.

Costs of telehealth consultation services: In this analysis, all costs were reported on a pre-tax basis. Provincial Sales Tax (PST) and Goods and Services Tax (GST) were calculated for subtotals, as appropriate. PST exemptions and GST rebates were not included because these tend to be unique to pilot projects and not to operational stages.

In-kind contributions were not included. We reasoned that many of the in-kind costs, such as product development, were often incurred by suppliers and would not be characteristic of the operational system. In addition, in-kind costs might be unique to the HEARRT Demonstration Project. It is reasonable to expect that other pilot projects would test different kinds and combinations of hardware and software. This assumption is controversial and thus we note in our data tables when in-kind contributions might substantially affect costs or benefits.

The telehealth equipment cost was valued at the invoice price quoted during the summer of 1999. The equipment cost was part of the fixed cost of the project. This lump sum payment needs to be converted to an annual cost. A simple way to do this was to divide the total cost by the assumed number of years of useful service. This procedure, however, ignores the presence of the opportunity cost of capital and time preference. The opportunity cost of capital refers to the next best alternative use of the funds and the potential earnings that were associated with that use. Time preference refers to the observation that amounts paid/received over time are not equal. In general, people prefer to postpone payments (costs) to a later date, but would like to receive rewards (benefits) now. These considerations lead economists to recommend using a discount rate to costs and benefits in order to adjust for differential timing (Drummond *et al.* 1997)

The link between UOHI and PGH is terrestrial, based initially on VideoRoute that allows for the transmission of video, audio and other data on the same circuit. The communication link was changed to ATM in January 1999. UOHI and PGH use the CDC telehealth platform, peripherals and medical devices, multi-purpose patient camera and document scanners. The UOHI site was assumed to use one-quarter of a computer for telehealth purposes. It is important to repeat that we used prices quoted during the summer of 1999 and that we include only the medical devices and peripherals deemed to be essential for tele-cardiology so as to more accurately reflect costs and configuration of a fully operational system

In this analysis, it was assumed that the equipment has a useful service period of five years. The total cost was annuitised using a five percent interest rate. Warranty and maintenance costs, as well as certain communication costs, were included in the fixed costs because they have fixed annual values. Technical assistance was assumed to be included in the warranty/maintenance costs.

The variable costs associated with this component were assumed to be associated with the service of a telehealth nurse and a cardiologist. An average telehealth session was assumed to last 30 minutes. An hourly salary/wage rate was applied to the actual service use time.

Costs of Visiting Cardiologist Clinic Program at PGH: The travel costs of the visiting cardiologists were calculated on a per visit basis. These costs were payments for distance travelled, opportunity cost of lost working time due to road travel and allowance for food expenses. Other variable costs were the wage/salary cost of an attending nurse/receptionist. Costs such as office space, furniture and other overhead that were common to both telehealth and the Visiting Cardiologist Program were not included.

Results

Number of Out-Patients

A total of 57 telehealth sessions were conducted on an out-patient basis during 1998 as part of the pilot project (Table 5, Figure 2). In comparison, in 1998 there were a total of 215 out-patients seen by the visiting cardiologists at PGH. Patient numbers increased by over 300% for telehealth sessions in 1999 and decreased by 25% for the Visiting Cardiologist Program, perhaps reflecting a re-direction of out-patients from one modality to the other. It is, of course, premature to assume a trend based on two years of data, particularly when the Telehealth Program is in a transitional stage.

In this analysis, we compare the costs of these programs at the current level of usage for 1998 and 1999. Breakeven points were calculated and costs (savings) were estimated for different levels of use and for different equipment and communication configurations. For ease of calculation we use the total number of patient-sessions, regardless of whether or not the patient was a repeat patient.

TABLE 5. Total number of out-patients per year for Telehealth and for the Visiting Cardiologist Clinics held at Pembroke General Hospital.

Year	Number of Out-Patients	
	Telehealth *	**Visiting Cardiologist Clinics ****
1998	57	215
1999	181	162
Total	**263**	**557**

* January 1998 to September 24, 1999
** January 1998 to October 8, 1999
NOTE: Prior to the start of the TAPP funded Project, the telehealth system saw 25 out-patients in 1997 while the visiting cardiologists saw 138 out-patients during the same time.

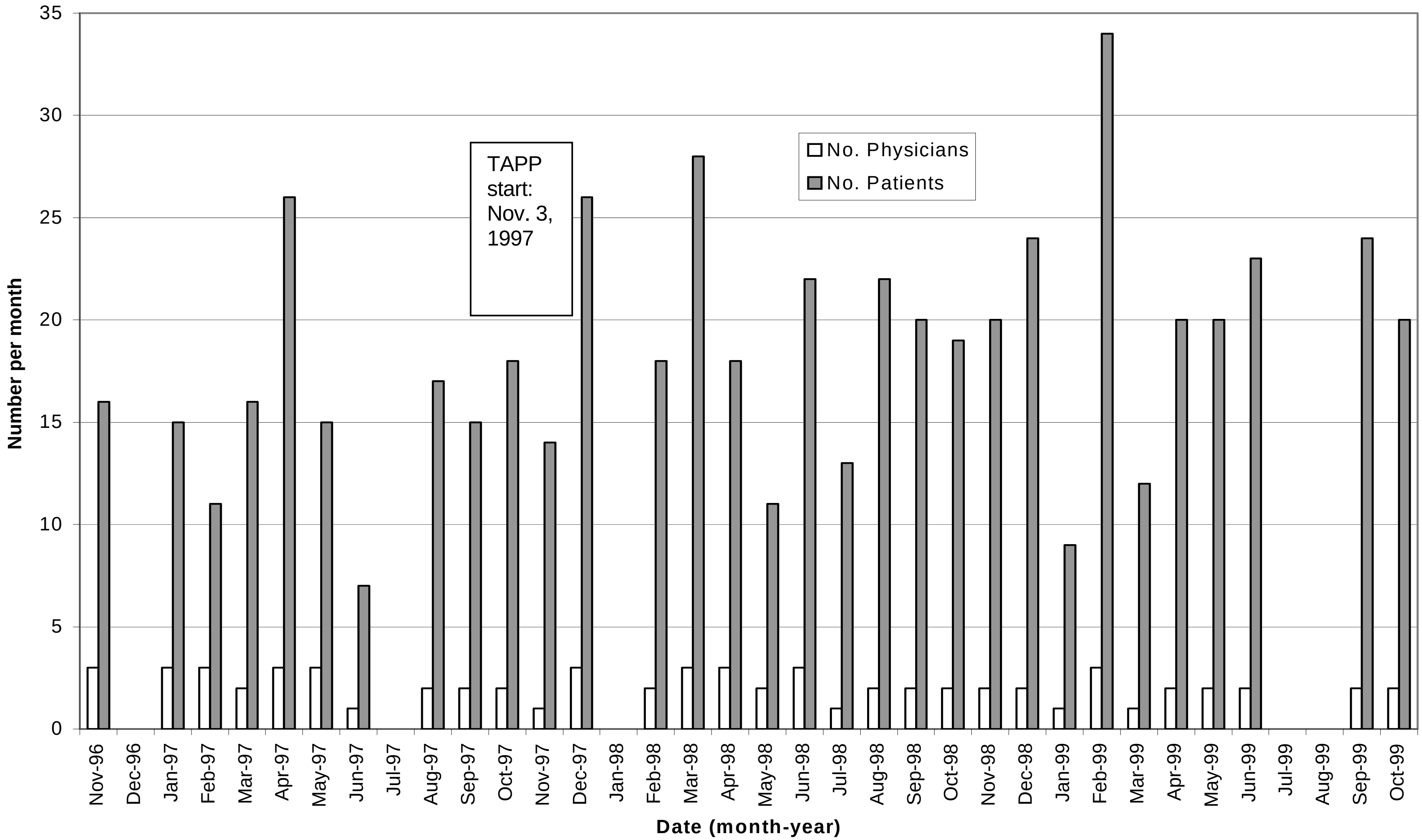

Figure 2. Number of physicians and out-patients per month participating in the Visiting Cardiologist Program at Pembroke General Hospital for November 1996 to October 1999. There was one clinic per month with the exception of April, June and August 1998, and February and June 1999, which had 2 clinics per month.

Telehealth and Visiting Cardiologist Program Costs

The estimated total annual cost of providing tele-cardiology consultation by UOHI at PGH for 57 out-patients in 1998 would have been $267,834 (Table 6). Of this, about 99% could be attributed to fixed and the rest to variable costs. In the case of the fixed costs, a notable feature was the relatively high cost of terrestrial VideoRoute line charge. The computer, printer and associated software are deemed to reside at UOHI and used only 25% of the time for telehealth related work. The total annual cost in 1999 would have been $363,515 for 181 out-patients, with the increase in cost caused by an increase in fixed costs due to higher communication charges for ATM and an increase in variable costs due to higher patient numbers (Table 7). In 1999, fixed costs accounted for about 98% of the total costs of running the telehealth system for 181 out-patients.

TABLE 6. Costs of tele-cardiology consultation between UOHI and PGH for 57 out-patients in 1998 using a CDC platform and a *VideoRoute* communications link. *

Cost Item	Unit Price	Quantity	Cost
Telehealth Platform (CDC)	$ 48,800	2 sites	$ 97,600
Electronic stethoscope	$ 3,200	2 sites	$ 6,400
Patient camera	$ 7,300	2 sites	$ 14,600
Flatbed document scanner	$ 1,100	2 sites	$ 2,200
SVGA to NTSC converter	$ 3,500	2 sites	$ 7,000
Computers, printer and software (25%)	$ 1,500	1 site	$ 1,500
Renovations and lighting	$ 3,000	2 sites	$ 6,000
System installation	$ 5,850	2 sites	$ 11,700
Shipping and Handling	$ 2,400	2 sites	$ 4,800
Subtotal, equipment costs			*$ 151,800*
Tax (GST & PST)	15%		*$ 22,770*
Interest rate	0.05		
Years of useful life	5		
Annuitizing factor	0.2309748		
Annuitised equipment costs (includes tax)			**$ 40,321**
Warranty/maintenance (10% of equipment costs, pre-tax)	$ 12,930	2 sites	$ 12,930
Terrestrial VideoRoute	$ 16,486	12 months	$ 197,834
Subtotal, other fixed costs			*$ 210,764*
Tax (GST)	7%		*$ 14,754*
Total, fixed costs (includes tax)			**$ 265,839**
Telehealth nurse (at remote site)	$ 35	28.5**	$ 998
Telehealth co-ordinator (at hub site)	$ 35	28.5	$ 998
Total, variable costs			**$ 1,995**
TOTAL COSTS			**$ 267,834**

* Using summer 1999 prices and configurations.
** Based on 0.5 hours per patient.

TABLE 7. Costs of tele-cardiology consultation between UOHI and PGH for 181 out-patients in 1999 using a CDC platform and an *ATM* communications link.

Cost Item	Unit Price	Quantity	Cost
Telehealth Platform (CDC)	$ 48,800	2 sites	$ 97,600
Electronic stethoscope	$ 3,200	2 sites	$ 6,400
Patient camera	$ 7,300	2 sites	$ 14,600
Flatbed document scanner	$ 1,100	2 sites	$ 2,200
SVGA to NTSC converter	$ 3,500	2 sites	$ 7,000
Computers, printer and software (25%)	$ 1,500	1 site	$ 1,500
Renovations and lighting	$ 3,000	2 sites	$ 6,000
System installation	$ 5,850	2 sites	$ 11,700
Shipping and Handling	$ 2,400	2 sites	$ 4,800
Subtotal, equipment costs			*$ 151,800*
Tax (GST & PST)	15%		*$ 22,770*
Interest rate	0.05		
Years of useful life	5		
Annuitizing factor	0.2309748		
Annuitised equipment costs (includes tax)			**$ 40,321**
Warranty/maintenance (10% of equipment costs, pre-tax)	$ 12,930	2 sites	$ 12,930
Terrestrial ATM	$ 23,600	12 months	$ 283,200
Subtotal, other fixed costs			*$ 296,130*
Tax (GST)	7%		*$ 20,729*
Total, fixed costs (includes tax)			**$ 357,180**
Telehealth nurse (at remote site)	$ 35	90.5	$ 3,168
Telehealth co-ordinator (at hub site)	$ 35	90.5	$ 3,168
Total, variable costs			**$ 6,335**
TOTAL COSTS			**$ 363,515**

The total annual cost for the visiting cardiologist alternative was calculated to be $9,222 for 57 out-patients in 1998 and $28,014 for 181 out-patients in 1999 (Table 8). All of the costs of this service were in the form of variable costs.

For the travel costs, we used the 1997 Canadian Automobile Association (CAA) rate that includes fuel, oil, maintenance, tires, insurance, depreciation and financing costs. Food costs were based on the UOHI *per diem* allowance. The opportunity cost of the physicians' travel time was charged at $200 per hour and it was assumed that it takes an average of four hours to make the round trip between Ottawa and Pembroke. During 1997-1999, there was an average of 2 cardiologists at each clinic. Thus the opportunity cost of return travel to Pembroke was calculated as $200/hour x 4 hours x 2 cardiologists.

There was an average of 16 out-patients for each day that a visiting cardiologist clinic was held during 1997-1999. This rate was consistent over the three years and thus was used to estimate the number of clinics given the number of out-patients to be seen by the visiting cardiologist. For example, 57 out-patients / 16 out-patients per clinic=~4 clinics. The number of clinics was always rounded up.

With the 1998 usage rate of 57 out-patients, the annual cost of tele-cardiology consultation (at $267,834) was almost 30 times the cost of a Visiting Cardiologist Program. The total cost per patient was calculated by dividing the total annual costs by the total number of out-patients who used the service. Based on 57 out-patients, the cost of a telehealth consultation cost was $4,699 per patient and the cost of the Visiting Cardiologist Program was $162 per patient.

For 181 out-patients in 1999, the Telehealth Program was about 10 times the cost of the Visiting Cardiologist Program. Cost per patient was $1,504 for the Telehealth Program and $155 for the Visiting Cardiologist Program. The trend of declining costs per patient with increasing number of out-patients will be explored in the section on sensitivity analysis.

TABLE 8. Costs of the Visiting Cardiologist Program at Pembroke General Hospital.

			1998	**1999**
	Unit Price	**Quantity**	**57 patients 4 Clinics**	**181 patients 12 Clinics**
Variable costs for each clinic				
Travel cost (CAA rates)	$ 0.415	300 km	$ 498	$ 1,494
Food (UOHI *per diem*)	$ 41	2 people	$ 328	$ 984
Opportunity cost **	$ 200	4 hours x 2 cardiologists	$ 6,400	$ 19,200
Subtotal			**$ 7226**	**$ 21,678**
Variable costs by hour				
Clinic nurse (at spoke site)	$ 35	***	$ 998	$ 3,168
Clinic co-ordinator	$ 35	***	$ 998	$ 3,168
Subtotal			**$ 1996**	**$ 6,336**
TOTAL COSTS			**$ 9,222**	**$ 28,014**

* Number of clinics calculated as the product of number of out-patients divided by 16 out-patients per clinic, rounded up.
** Opportunity cost estimated as lost earnings for 2 cardiologists x 4 hours of travel (return) for each clinic.
*** Based on 0.5 hours per patient.

Pembroke Patient Travel Cost Savings

It is also important to recognise that one of the major benefits of introducing the telehealth system is the saving in the cost and time of travel for rural and remote residents. The alternative for the out-patients in the PGH catchment area in the absence of either the visiting cardiologist clinic or the telehealth consultation system is to travel to Ottawa to see a cardiologist. We estimated the travel cost savings that would result by not having to travel to Ottawa for the consultations. These cost savings were common to both the Visiting Cardiologist Program and the Telehealth Program.

A survey of 179 out-patients from Pembroke found that 73% would have made the trip to Ottawa and back in one day (see Appendix 2 for questionnaire).[2] The remaining 27% would have stayed overnight and returned the next day. On average, one family member or friend would accompany each patient. To estimate lost wages we assumed an eight-hour day and calculated the total number of hours as the proportion of out-patients missing 1 day of work plus the proportion missing 2 days, etc., multiplied by 8 hours. An identical calculation was made for accompanying persons. We assume an average wage of $15 per hour and that lost leisure/volunteer time was also valued at $15 per hour. Our estimate for lost wages of $120/day (8 hours/day x $15/hour) was similar to that estimated by out-patients: average lost wages of $118/day and $122/day for patient and accompanying persons, respectively (n=5). Note that 88% of out-patients and 59% of accompanying persons were retired or not working, as reported by the out-patients in the telephone interview.

Approximately 97% of the out-patients would have travelled by private car and thus we use the CAA rate for 1997. We used the UOHI *per diem* meal allowance. Number of days was calculated as the proportion of out-patients staying 1 day plus the proportion staying 2 days, etc., multiplied by 2 people (patient and accompanying person). Incidentals, such as parking, were assumed to be $10 per day. Approximately 12% of out-patients would stay over one night in a hotel and 15% would stay with friends or family. The accompanying person was assumed to stay with the patient at no extra charge and cost of staying with friends or family was not included. Accommodation charge was the average price for an Ottawa hotel in 1997 (Pannell Kerr Forster Consulting Inc., *Globe and Mail*, April 01, 1998). The total cost of patient travel was estimated as $570 per patient. If lost wage/leisure time was excluded, then the value drops to $265 per patient.

Total savings for all out-patients from not having to travel to Ottawa to consult the cardiologists amount to $32,483 for 57 out-patients (Table 9). These costs make the net cost of Telehealth Program to be $235,351 for VideoRoute line or $362,692 for ATM line. In the case of the Visiting Cardiologist Program, the net cost becomes ($23,262): the parentheses indicate a saving generated by the program.

In 1999, the total savings would equal $103,148 for 181 out-patients. The net cost of Telehealth Program becomes $169,026 (VideoRoute) or $260,367 (ATM) and ($75,135) for the Visiting Cardiologist Program.

The estimated cost savings do not include many of the intangible benefits such as the comfort of receiving care in a nearby community and avoiding the anxiety of making a trip to a distant, unfamiliar city. These intangibles are hard to measure in financial terms, but must be considered as part of any evaluation.

[2] The telephone survey, conducted by Sharon Ann Kearns of UOHI on behalf of CRaNHR, asked each telehealth patient what they would have done if they had had to travel to Ottawa instead of receiving a telehealth session at Pembroke. Thus results are hypothetical but based on previous travel experience.

TABLE 9. Estimated cost saving for 57 out-patients and accompanying persons travelling between Pembroke and the University of Ottawa Heart Institute.

Variable Costs	Unit Price	Quantity	Cost
Wages foregone ($/hour)	$ 15	10.2 hours *	$ 152.40
Accompanying person wages foregone	$ 15	10.2 hours	$ 152.40
Travel cost (roundtrip at CAA rate per km)	$ 0.415	300 km	$ 124.50
Food (per day)	$ 41	2.5 days **	$ 104.14
Incidentals (per day)	$ 10	2.5 days	$ 25.40
Accommodation (per day)	$ 92	0.12 ***	$ 11.04
Total (per patient)			**$ 569.88**
Total cost savings (for 57 out-patients)			**$ 32,483**

* Number of hours estimated as the proportion of out-patients missing 1 day of work plus the proportion missing 2 days, etc., multiplied by 8 hours. Estimated similarly for accompanying persons.

** Number of days estimated as the proportion of out-patients staying 1 day plus the proportion staying 2 days, etc., multiplied by 2 people (patient and accompanying person).

*** Estimated as the proportion of out-patients staying one night in a hotel plus the proportion staying two nights, etc.

Sensitivity Analysis

In the previous section we reported that the telehealth consultation service between UOHI and PGH was relatively expensive. This finding was based upon the analysis of the first two years of the pilot project. It was also based upon several assumptions. Changing these assumptions will lead to different results. We conducted a sensitivity analysis by changing the assumptions and studying the impact on cost-effectiveness.

A key assumption was that the telehealth system was dedicated to cardiac out-patient consultations and was not used for any other purpose. It was on the basis of this assumption that we allocated the entire fixed costs to the 57 out-patients who used the system in 1997. This assumption is, of course, not likely to apply at the operational stage of the telehealth system. Even at the pilot stage, it can be argued that this allocation was inconsistent with the way in which human resources were allocated to the program. When the physician and other personnel costs were allocated only to the extent of their participation, why should the fixed costs not be allocated on that basis? That is, why not treat all costs as variable costs?

With this argument in mind, we calculated the 1997 usage rate, which was about 1.4%. To calculate percent usage we first assumed a maximum usage of 40 hours per week x 50 weeks per year to give 2000 hours or 4000 out-patients per year. Percent usage was calculated as 57 (number of out-patients in 1997)/4000 (maximum number of out-patients per year) or 1.425%. Applying this figure to the total fixed costs, we obtained $265,839 x 1.425%=$3,788. Adding this to the total variable costs of $1,995, we obtained a grand total of $5,783. Thus, allocating only the operating part of the fixed costs to the telehealth project greatly reduced the cost difference between the telehealth and Visiting Cardiologist Programs from $258,613 to $(22,230)[3] per year for the VideoRoute link. A similar calculation for the 181 out-patients who used the telehealth system in 1999 with the ATM link yielded a 4.5% usage rate, which reduced the cost difference from $244,161 to ($5,516). In other words, based on percent usage, telehealth consultations would become cheaper than the visiting cardiologist clinic. Basing the calculations on percent usage

[3] Values in parentheses represent savings.

reduces the telehealth cost but it raises the question of who or what program will pay for the 95-99% of non-telehealth use.

Another way to look at the issue is to keep the fixed costs fixed, but consider the impact of increased usage on cost-effectiveness. In 1997, only 28.5 hours were assumed to be used. Maximum usage was assumed to be 2000 hours (4000 out-patients at an average of 0.5 hour each).

In Table 10, we display the behaviour of telehealth costs as the hypothetical patient load increases up to full capacity. In this table, the starting point of 57 out-patients was the actual number of out-patients seen through telehealth during 1998 as part of the pilot project. Per patient cost was high at $4,699 (VideoRoute). The 181 out-patients was the number seen through telehealth during 1999. The figures of 272 and 343 were the total number of out-patients seen by telehealth plus those seen by the visiting cardiologists during 1998 and 1999, respectively. Other usage figures were assumed. As can be seen, as the patient volume increased, the total cost increased, but the average cost steadily declined.

TABLE 10. Pembroke Telehealth Program: Annual total cost and annual cost per patient.*

	Annual Total Cost		**Annual Cost per Patient**	
Number of out-patients	**Telehealth (VideoRoute)**	**Telehealth (ATM)**	**Telehealth (VideoRoute)**	**Telehealth (ATM)**
57	$ 267,834	$ 359,175	$ 4,699	$ 6,301
181	$ 272,174	$ 363,515	$ 1,504	$ 2,008
272	$ 275,359	$ 366,700	$ 1,012	$ 1,348
343	$ 277,844	$ 369,185	$ 810	$ 1,076
500	$ 283,339	$ 374,680	$ 567	$ 749
1000	$ 300,839	$ 392,180	$ 301	$ 392
2000	$ 335,839	$ 427,180	$ 168	$ 214
3000	$ 370,839	$ 462,180	$ 124	$ 154
4000	$ 405,839	$ 497,180	$ 101	$ 124

* Patient travel cost (saving) was not included.

In Table 11, we display the behaviour of Visiting Cardiologist Program costs as the hypothetical patient load increases up to full capacity. Total costs go up as they did for the Telehealth Program, but the rate of increase was more or less in tandem with the rise in volume. Hence, beyond the initial point, average costs were stable around $146. Note that, at full capacity (4000 out-patients) the difference in cost between the visiting specialist clinic and telehealth was $45 (VideoRoute) or $22 (ATM) per patient, in favour of telehealth.

TABLE 11. Pembroke Visiting Cardiologist Program: Annual total cost and annual cost per patient. *

Number of out-patients	Number of Clinics **	Annual Total Cost	Annual Cost per Patient
57	4	$ 9,221	$ 162
181	12	$ 28,013	$ 155
272	17	$ 40,231	$ 148
343	21	$ 49,942	$ 146
500	31	$ 73,502	$ 147
1000	62	$ 147,003	$ 147
2000	123	$ 292,200	$ 146
3000	184	$ 437,396	$ 146
4000	245 ***	$ 582,593	$ 146

* Patient travel cost (saving) was not included.
** Number of clinics estimated as one clinic per 16 out-patients, rounded up to the nearest integer.
*** Equivalent to 49 weeks, with clinics 5-days each week and specialists travelling between Ottawa and Pembroke each day.

These tables show that as the patient volume increased, total costs for both the Telehealth and Visiting Cardiologist Program increased. In this analysis, the key cost factor for telehealth was the cost of communication. If this system can be replaced by a pay-per-use system or less-expensive communication link without affecting the quality of service, then it will become part of the variable costs and the economic viability should improve.

A breakeven point, defined under the original set of assumptions and cost estimates, was calculated when out-patients' savings from Table 9 were included. The breakeven point for the Telehealth Program occurred when more than 497 out-patients (VideoRoute) or 668 out-patients (ATM) have been seen (Table 12). Note that the Visiting Cardiologist Program was always cost-effective. The Telehealth Programs become less costly than the visiting specialist clinic at about 2400 out-patients per year for VideoRoute or 3200 out-patients per year for ATM. These annual rates work out to approximately 24 (VideoRoute) and 32 (ATM) telehealth hours per week for 50 weeks.

Note that the behaviour of the system at full capacity is a useful, albeit unrealistic modelling exercise. For instance, at 4000 out-patients per year the telehealth system would be in constant use, 8 AM to 4 PM, Monday to Friday for 50 weeks a year. In comparison the Visiting Specialist Program would have to offer a clinic every week day for 49 weeks per year. It should be noted that a third option might be more economical as patient loads approach the maximum. The third option would be to hire one or more cardiologists to work at PGH on a full-time or rotating basis. This alternative was not analyzed but is mentioned to indicate one limitation of the modelling exercise.

TABLE 12. Pembroke net Telehealth Program costs (savings) and net Visiting Cardiologist Program costs (savings).*

	Net Total Cost (saving)			Net Cost (saving) per Patient		
Number of out-patients	Telehealth VideoRoute	Telehealth ATM	Visiting Cardiologist	Telehealth VideoRoute	Telehealth ATM	Visiting Cardiologist
57	$ 235,351	$ 326,692	$ (23,262)	$ 4,129	$ 5,731	$ (408)
181	$ 169,026	$ 260,367	$ (75,135)	$ 934	$ 1,438	$ (415)
205	$ 156,189	$ 247,530	$ (86,166)	$ 762	$ 1,207	$ (420)
272	$ 120,352	$ 211,693	$ (114,777)	$ 442	$ 778	$ (422)
343	$ 82,375	$ 173,717	$ (145,527)	$ 240	$ 506	$ (424)
500	$ (1,601)	$ 89,740	$ (211,439)	$ (3)	$ 179	$ (423)
1000	$ (269,041)	$ (177,700)	$ (422,877)	$ (269)	$ (178)	$ (423)
2000	$ (803,921)	$ (712,580)	$ (847,561)	$ (402)	$ (356)	$ (424)
3000	$ (1,338,801)	$ (1,247,460)	$ (1,272,244)	$ (446)	$ (416)	$ (424)
4000	$ (1,873,681)	$ (1,782,340)	$ (1,696,928)	$ (468)	$ (446)	$ (424)

* Values calculated as program cost minus patient travel cost (saving). Values in parentheses are savings.

Discussion

In this analysis, we compared tele-cardiology consultation with the alternative of Visiting Cardiologist Program between UOHI and PGH. The results show that the tele-cardiology consultation was relatively expensive. It must be kept in mind, however, that this result was based on the assumptions made and the initial year's cost structure of this pilot project. No final inferences about the economic viability of the telehealth consultation option can be made with these preliminary results. It is noteworthy, however, that most telehealth projects currently operating in the United States also report low volume of usage and hence high costs per patient (e.g., Office of Rural Health Policy 1997).

This analysis made several assumptions about the alternative options of providing cardiac consultations to the Pembroke-area out-patients. The cost figures used in this analysis were based on circumstances surrounding this service provision. For example, Pembroke is located relatively close to Ottawa. Hence, the patient travel cost savings and the fixed costs of providing the Visiting Cardiologist Program were relatively low. These conditions will not apply to a more geographically remote community. Thus, generalizing from this analysis of data of the first two years of this pilot project to the over-all viability of the telehealth system requires caution.

The cost of equipment is changing. Due to technological developments and market competition, the prices keep dropping, while the quality keeps improving. Hence, any economic analysis quickly becomes outdated. The assumptions used in this analysis may not apply to subsequent years of this project.

The UOHI-Red Lake Link

A similar analysis of the UOHI and Red Lake link was undertaken, based on a CDC platform with a satellite communication link. The satellite communications link was either a pay-per-use or a flat monthly rate. The total annual cost for tele-cardiology consultation between UOHI and Red Lake for 1999 was $112,220 for pay-per-use or $341,203 for flat monthly rate for satellite communication costs for 18 out-patients (Table 13). Of this, over 98% can be attributed to fixed costs and the rest to variable costs (for either communication cost model).

TABLE 13. Costs of tele-cardiology consultation between UOHI and Red Lake for 18 out-patients in 1999 using a CDC platform and a satellite communications link. *

Cost Item	Unit Price	Quantity	Satellite – pay-per-use	Satellite – monthly rate
Telehealth Platform (CDC)	$ 48,800	2 sites	$ 97,600	$ 97,600
Electronic stethoscope	$ 3,200	2 sites	$ 6,400	$ 6,400
Patient camera	$ 7,300	2 sites	$ 14,600	$ 14,600
Flatbed document scanner	$ 1,100	2 sites	$ 2,200	$ 2,200
SVGA to NTSC converter	$ 3,500	2 sites	$ 7,000	$ 7,000
Computers, printer and software (25%)	$ 1,500	1 site	$ 1,500	$ 1,500
Renovations and lighting	$ 3,000	2 sites	$ 6,000	$ 6,000
System installation	$ 5,850	2 sites	$ 11,700	$ 11,700
Shipping and Handling	$ 2,400	2 sites	$ 4,800	$ 4,800
Satellite earth station (UOHI)	$ 75,000	1 site	$ 75,000	$ 75,000
Satellite earth station (Red Lake)	$ 75,000	1 site	$ 75,000	$ 75,000
Subtotal, equipment costs			*$ 301,800*	*$ 301,800*
Tax (GST & PST)	15%		*$ 45,270*	*$ 45,270*
Interest rate	0.05			
Years of useful life	5			
Annuitizing factor	0.2309748			
Annuitised equipment costs (includes tax)			**$ 80,164**	**$ 80,164**
Warranty/maintenance (10% of pre-tax equipment costs)	$ 27,930	2 sites	$ 27,930	$ 27,930
Satellite communication costs/month plus GST	$ 17,954**	12 months	$	$ 215,442
Subtotal, other fixed costs			$ 27,930	$ 243,372
Tax (GST)	7%		$ 1,955	$ 17,036
Total, fixed costs			$ 110,050	$ 340,573
Satellite communication costs/hour plus GST	$ 171***	9 hours	$ 1,541	$
Telehealth nurse	$ 35	9 hours	$ 315	$ 315
Telehealth co-ordinator	$ 35	9 hours	$ 315	$ 315
Total, variable costs			$ 2,171	$ 630
TOTAL COSTS			**$ 112,220**	**$ 341,203**

* Cost differences between the two payment options for satellite communication are highlighted.
** Does not include the 50% rebate from Telsat given during the pilot phase
*** Personal communication: Roy Marsh, P. Eng., Telehealth Project Manager

Red Lake Patient Travel Cost Savings

A survey of 21 out-patients from Red Lake found that 95% would have made the trip to Winnipeg and back in two days.[4] The remaining 5% would have returned the same day. On average, one family member or friend would accompany each patient. Lost wage was calculated as for Pembroke-Ottawa out-patients. Our estimate of lost wages of $120/day was somewhat lower than the $130/day and $150/day estimated for 1 patient and 1 accompanying person, respectively. An estimated 67% of out-patients and 52% of accompanying persons were retired or not working.

Approximately 76% of the out-patients would have travelled by private car. Average air fare (Bearskin Airlines) for May 1999 was $390 (excluding taxes, taxi fare) which was close to the cost estimated for travel by car ($394.25). Thus, for ease of calculation, we assume that all out-patients travelled by car. Meal charges, number of days and incidentals were calculated as per Pembroke-Ottawa. Approximately 76% of out-patients would stay over one night in a hotel and 19% would stay with friends or family. Accommodation charge was the average price for a Winnipeg hotel in 1997 (Pannell Kerr Forster Consulting Inc., *Globe and Mail*, April 01, 1998). The total cost of patient travel was estimated as $1,119.67 per patient. Total cost was $651.67 when lost wage/leisure time was excluded. Most out-patients would be eligible for partial reimbursement of travel expenses through the Northern Health Travel Grant (NHTG) Program.[5] The NHTG Program reimbursement is calculated at $0.305 /km for one-way travel only. The estimated reimbursement would be $144.88, which compares favourably with the average reimbursement of $136.50 reported by five Red Lake out-patients.

Total savings for the 18 out-patients from not having to travel to Winnipeg to consult the cardiologists amount to $20,154 (Table 14). This value includes $2,608 that would be reimbursed to the patient by the NHTG Program. These averted travel costs make the net cost of Telehealth Program to be $92,066 for pay-per-use and $321,049 for the flat monthly rate. The estimated cost savings do not include many of the intangible benefits as noted earlier.

TABLE 14. Estimated cost savings for 18 out-patients and accompanying persons travelling between Red Lake and Winnipeg.

Variable Costs (per patient)	Unit Price	Quantity	Cost
Wages foregone ($/hour)	$ 15	15.6 hours *	$ 234.00
Accompanying person wages foregone	$ 15	15.6 hours	$ 234.00
Travel cost (roundtrip at CAA rate per km)	$ 0.415	950 km	$ 394.25
Food (per day)	$ 41	3.9 days *	$ 159.90
Incidentals (per day)	$ 10	3.9 days	$ 39.00
Accommodation (per day)	$ 77	0.76	$ 58.52
Total (per patient, per trip)			**$ 1,119.67**
Northern Health Travel Grant reimbursement **	$ 0.305	475 km	**$ (144.88)**
Net cost to patient			**$ 974.80**
Total cost savings (for 18 out-patients)			**$ 20,154**
Total Northern Health Travel Grant			**$ (2,608)**
Total Net cost to out-patients			**$ 17,546**

* See Table 9 for explanation of how hours and days were calculated.
* NHTG reimbursement is for one-way travel only. Average reported reimbursement was $136.50, n=5.

[4] Winnipeg is the usual referral centre for tertiary or quaternary care for many patients in northwestern Ontario.
[5] Pembroke and area residents are not eligible for NHTG.

Sensitivity Analysis

In Table 15, we display the behaviour of telehealth costs as the hypothetical patient load increases up to the full capacity level. In this table, the starting point of 18 out-patients was the actual number of out-patients seen through telehealth during 1999 as part of the pilot project. Other figures on usage were assumed. Annual cost per patient was $6,234 for pay-per-use satellite communication link for 18 out-patients. Annual cost per patient was about three times higher if the flat monthly rate was applied. The magnitude of this difference decreases with increases in the number of out-patients. As the patient volume increases, the total cost increases, whereas the average cost steadily declines for both pay-per-use and flat monthly rate. The pay-per-use satellite link was less costly than the flat monthly rate for 2700 or fewer out-patients per year.

TABLE 15. Red Lake Telehealth Program: Annual total cost and annual cost per patient. *

Number of Patients	Annual Total Cost		Annual Cost per Patient	
	Pay-per-use	**Monthly Rate**	**Pay-per-use**	**Monthly Rate**
18	$ 112,220	$ 341,203	$ 6,234	$ 18,956
25	$ 113,065	$ 341,448	$ 4,523	$ 13,658
50	$ 116,080	$ 342,323	$ 2,322	$ 6,846
100	$ 122,110	$ 344,073	$ 1,221	$ 3,441
200	$ 134,170	$ 347,573	$ 671	$ 1,738
300	$ 146,230	$ 351,073	$ 487	$ 1,170
400	$ 158,290	$ 354,573	$ 396	$ 886
500	$ 170,350	$ 358,073	$ 341	$ 716
1000	$ 230,650	$ 375,573	$ 231	$ 376
2000	$ 351,250	$ 410,573	$ 176	$ 205
3000	$ 471,850	$ 445,573	$ 157	$ 149
4000	$ 592,450	$ 480,573	$ 148	$ 120

* Patient travel cost (saving) was not included.

When the potential savings to the out-patients are included, the breakeven point occurs at about 110 out-patients per year for the telehealth service with pay-per-use satellite cost and at about 314 out-patients per year for the flat monthly rate satellite cost (Table 16).

For Red Lake out-patients, the NHTG Program reimbursement represents about 13% of the estimated travel expense or about 22% if wage/leisure time is excluded. The Red Lake Telehealth Program would have to operate at the maximum capacity of 4000 out-patients per year before the average cost per patient (Table 15) would approach that of the potential savings that could be recouped by the Ontario Ministry of Health's NHTG Program ($145 per patient) (Table 14).

TABLE 16. Red Lake net Telehealth Program cost (saving). *

Number of Patients	Net Total Cost (saving)		Net Cost (saving) per Patient	
	Pay-per-use	Flat	Pay-per-use	Flat
18	$ 92,066	$ 321,049	$ 5,115	$ 17,836
25	$ 85,073	$ 313,456	$ 3,403	$ 12,538
50	$ 60,096	$ 286,339	$ 1,202	$ 5,727
100	$ 10,143	$ 232,106	$ 101	$ 2,321
200	$ (89,764)	$ 123,639	$ (449)	$ 618
300	$ (189,671)	$ 15,172	$ (632)	$ 51
400	$ (289,578)	$ (93,295)	$ (724)	$ (233)
500	$ (389,485)	$ (201,762)	$ (779)	$ (404)
1000	$ (889,020)	$ (744,097)	$ (889)	$ (744)
2000	$(1,888,090)	$(1,828,767)	$ (944)	$ (914)
3000	$(2,887,160)	$(2,913,437)	$ (962)	$ (971)
4000	$(3,886,230)	$(3,998,107)	$ (972)	$ (1,000)

* Values calculated as program cost minus patient travel cost (saving).
** Using pay-per-use or flat monthly rate for satellite communications link.

The Chapleau/Sudbury Link

An analysis of the Sudbury and Chapleau link was undertaken using the methods described previously. The economic evaluation was completed for a CDC platform with an ISDN communication link (a combined fixed and a pay-per-use fee). We modelled the Sudbury to Chapleau route, which is the normal referral route, rather than the Chapleau to Ottawa referral route. Data on telehealth usage and travel cost were not available because the Chapleau/Sudbury link was just starting. We used patient numbers, telehealth costs and travel savings from Red Lake, which is a reasonable assumption given the similar population size and distance to tertiary/quaternary care. Travel distances, hotel rates, etc., were adjusted to reflect the Chapleau-Sudbury route. We used simulation modelling to analyze the costs and savings of the link.

The total annual cost for tele-cardiology consultation between Sudbury and Chapleau for 1999 was estimated as $64,464 for 18 out-patients (Table 17). Of this, approximately 98% can be attributed to fixed and the rest to variable costs.

TABLE 17. Costs of tele-cardiology consultation between Chapleau and Sudbury for 18 out-patients in 1999 using a CDC Platform and ISDN link.

Cost Item	Unit Price	Quantity	Cost
Telehealth Platform (CDC)	$ 48,800	2 sites	$ 97,600
Electronic stethoscope	$ 3,200	2 sites	$ 6,400
Patient camera	$ 7,300	2 sites	$ 14,600
Flatbed document scanner	$ 1,100	2 sites	$ 2,200
SVGA to NTSC converter	$ 3,500	2 sites	$ 7,000
Computers, printer and software (25%)	$ 1,500	1 site	$ 1,500
Renovations and lighting	$ 3,000	2 sites	$ 6,000
System installation	$ 5,850	2 sites	$ 11,700
Shipping and Handling	$ 2,400	2 sites	$ 4,800
ISDN installation	$ 730	2 sites	$ 1,460
Subtotal, equipment costs			*$ 153,260*
Tax (GST & PST)	15%		*$ 22,989*
Interest rate	0.05		
Years of useful life	5		
Annuitizing factor	0.2309748		
Annuitised equipment costs (includes tax)			**$ 40,709**
Warranty/maintenance (10% of pre-tax equipment costs)	$ 12,930	2 sites	$ 12,930
ISDN annual rental ($355.45/month for 4 lines per site)	$ 4,265	2 sites	$ 8,531
Subtotal, other fixed costs			*$ 21,461*
Tax (GST)	7%		*$ 1,502*
Total, fixed costs (includes tax)			**$ 63,672**
ISDN Communication costs /hour (plus GST) **	$ 18	9 hours	$ 162
Telehealth nurse (at remote site)	$ 35	9 hours	$ 315
Telehealth co-ordinator (at hub site)	$ 35	9 hours	$ 315
Total, variable costs			**$ 792**
TOTAL COSTS			**$ 64,464**

* All equipment costs and ISDN costs obtained from Mr. Roy Marsh, Telehealth Project Manager.
** Calculated as $0.35/10 minutes x 60 minutes/hour x 4 lines x 2 channels per line=$17.98/hour.

Chapleau Patient Travel Cost Savings

We used results from the survey of Red Lake out-patients and adjusted distance to reflect travel between Chapleau and Sudbury. Accommodation charge was the average price for a Sudbury hotel in 1997 (Pannell Kerr Forster Consulting Inc., *Globe and Mail*, April 01, 1998). The total cost of patient travel was estimated as $1,055.08 per patient or $587.08 per patient if lost wage/leisure time was excluded. Data from Red Lake suggest that 67% of the Chapleau out-patients and 52% of accompanying persons were retired or not working. The first five out-patients from Chapleau were seen by telehealth on September 24, 1999. We assumed 18 out-patients as a starting point for the Chapleau model, based on patient loads at Red Lake.

An estimated saving for the 18 out-patients to avoid travel to Sudbury to consult cardiologists totalled $18,991 (Table 18). This value includes $2,251 that would be reimbursed to the patient by the NHTG Program. These averted travel costs make the net cost of Telehealth Program to be $45,473. The estimated cost savings do not include the intangible benefits as noted earlier.

TABLE 18. Estimated cost savings for 18 out-patients and accompanying persons travelling between Chapleau and Sudbury. *

Variable Costs:	Unit Price	Quantity	Cost
Wages foregone ($/hour)	$ 15	15.6 hours**	$ 234.00
Accompanying person wages foregone	$ 15	15.6 hours	$ 234.00
Travel cost (roundtrip at CAA rate per km)	$ 0.415	820 km	$ 340.30
Food (per day)	$ 41	3.9 days **	$ 159.90
Incidentals (per day)	$ 10	3.9 days	$ 39.00
Accommodation (per day)	$ 63	0.76	$ 47.88
Total (per patient, per trip)			**$ 1,055.08**
Northern Health Travel Grant reimbursement * **	$ 0.305	410 km	**$ (125.05)**
Net cost to patient			**$ 930.03**
Total cost savings (for 18 out-patients)			**$ 18,991**
Total Northern Health Travel Grant			**$ (2,251)**
Total Net cost to out-patients			**$ 17,741**

* Number of out-patients as well as travel costs were based on survey of Red Lake out-patients, adjusted for travel distance and hotel rates in Sudbury.

** See Table 9 for explanation of how hours and days were calculated.

*** One Chapleau patient reported a NHTG reimbursement of $66 (~216 km).

Sensitivity Analysis

In Table 19, we display the behaviour of telehealth costs as the hypothetical patient load increases up to the full capacity level. All usage figures were assumed. At 18 out-patients per year the cost per patient was $3,581. As can be seen, as the patient volume increases, the total cost increases, but the average cost steadily declines.

When patient savings due to reduced travel are included, the breakeven point occurs at about 63 out-patients (Table 19). As mentioned earlier, the NHTG Program provides for partial reimbursement of patient travel expenses. For Chapleau out-patients the NHTG reimbursement represents about 12% of the estimated travel expense, or about 21% if wage/leisure time is excluded. At about 785 out-patients or more per year, the Chapleau telehealth service (Table 19) becomes less costly than the average reimbursement from the Ontario Ministry of Health's NHTG Program (~$125 per patient) (Table 18).

TABLE 19. Chapleau Telehealth Program: Annual total cost, annual cost per patient, net program cost and net program cost per patient.

Number of Patients	Telehealth Program Cost		Telehealth Cost minus Patient Cost	
	Annual Total Cost	Annual Cost per Patient	Net Total Cost (saving)	Net Cost (saving) per Patient
18	$ 64,464	$ 3,581	$ 45,472	$ 2,526
25	$ 64,772	$ 2,591	$ 38,395	$ 1,536
50	$ 65,872	$ 1,317	$ 13,118	$ 262
100	$ 68,071	$ 681	$ (37,437)	$ (374)
200	$ 72,470	$ 362	$ (138,546)	$ (693)
300	$ 76,869	$ 256	$ (239,655)	$ (799)
400	$ 81,267	$ 203	$ (340,765)	$ (852)
500	$ 85,666	$ 171	$ (441,874)	$ (884)
1000	$ 107,660	$ 108	$ (947,420)	$ (947)
2000	$ 151,648	$ 76	$ (1,958,512)	$ (979)
3000	$ 195,636	$ 65	$ (2,969,604)	$ (990)
4000	$ 239,624	$ 60	$ (3,980,696)	$ (995)

Analysis of In-Patient Telehealth Clinical Consultation Data

The UOHI-PGH Link

In this section, we report results from an analysis of the data collected on the in-patient cardiac consultations. Although the link between UOHI and PGH was established in the spring of 1997, the in-patient consultation did not begin until May 1988. From the time of its inception to the cut-off period of this report (end of September 1999), a total of 64 in-patients were seen through telehealth.

Analysts have noted that telehealth consultations will impact the quality of care, accessibility and cost (Bashshur and Grigsby 1995). As Lobley (1997) pointed out, the quality improvement in patient care takes place in the form of "Improved treatment, faster and more accurate diagnosis, reduced need for patient referral due to remote consultation…, reduced disruption to patients through reduced travel…." These improvements are qualitative in nature and not easily captured through monetary measures.

In terms of accessibility, telehealth makes available highly specialized care to rural and remote area residents who do not have to leave their community to seek care. From the point of view of the clinicians, telehealth makes it possible for them to deal with "more interesting and high-quality referrals for specialist consultations, leading to greater opportunities to undertake research" (Lobley 1997). Thus, the benefits of accessibility are felt both by the patients and the clinicians. In the short run, improved accessibility confers immediate benefit to the patients. In the long run, the interaction between the rural and remote patients and their research-minded clinicians can lead to improvements in treatment modalities which, in turn, will benefit patients in the future.

In addition to the above-noted qualitative benefits, there are quantifiable cost savings that result from the use of telehealth technology. Analysts have noted that these savings are due to reductions in patient movement, reductions in tests and procedures due to telehealth consultations, reductions in LOS due to timely and effective treatments, and more appropriate use of facilities (Lobley 1997; McIntosh and Cairns 1997). In the HEARRT Demonstration Project, an attempt was made to measure and capture some of these benefits.

Methodology

One of the ways to demonstrate cost savings due to the use of telehealth technology is to find out whether there was a reduction in the LOS. An attempt was made to verify whether there was a significant difference in LOS between telehealth in-patients and non-telehealth in-patients matched by age, sex and most responsible diagnosis. Upon examination of the data, there were no significant differences in LOS between telehealth and non-telehealth in-patients between UOHI and PGH (personal communication: Kirsten Wooden, UOHI, August 1999). Hence, an alternative research methodology was chosen.

This alternative methodology is the retrospective chart review of a sample of telehealth cases by the referring physician. The chart review provided a qualitative assessment by the referring physician of the various aspects of the telehealth consultation process.

Sample Selection Procedure

In view of the time constraint faced by the clinician, it was decided to review the charts of 15 in-patients to look for differences in disposition and treatment directly attributable to the telehealth consultation process. Patients were placed in chronological order and then every third patient was selected until a sample size of 15 was reached. The referring physician, who is an internist at PGH, was provided with a checklist to conduct the chart review (Appendix 4).[6] Thus, the chart reviews were not independent. However, the reviewer was intimately familiar with the referred cases and, therefore, can be considered knowledgeable with respect to the in-patients' conditions and the telehealth consultation process.

Components of the checklist

Chart review was used to describe why the telehealth session was initiated, and what would have been done in the absence of telehealth. The checklist included estimates of the relative change in the speed of diagnosis and treatment, as well as estimated change in length-of-stay (LOS). In addition, the checklist included estimates of the relative change in the number of procedures and tests.

Difference in urgency of transfer was also determined by the chart review. Urgency of transfer was recorded as either (1) no need for transfer, (2) non-urgent or (3) urgent need for transfer assessed before and after the telehealth session.

The checklist concluded by asking why this particular patient was selected and whether or not the internist would consider using telehealth again for the type of medical case or for the individual patient.

[6] We thank Dr. Kong C. Li, an internist at Pembroke General Hospital, for completing the in-patient review. Dr. Li was the internist who referred the majority of telehealth patients. Dr. Ben Mgbemena also saw and referred in-patients to telehealth.

In-Patient Demographics

About 68% of all in-patients were male (Table 20). The mean age was 63 years and the median age was 65 for all in-patients. In general, most in-patients were in the 70-79 age category. It is important to note that the mean or median age and overall percentage of males and females of the in-patients selected for chart review were similar to that of the in-patients who were not selected for chart review.

TABLE 20. Count of female and male in-patients at Pembroke seen via telehealth.

	All In-patients			**In-patients chosen for Chart Review**		
Age Group	**Female**	**Male**	**Total**	**Female**	**Male**	**Total**
<30	1	0	**1**	0	0	**0**
30-39	1	1	**2**	1	1	**2**
40-49	2	5	**7**	0	1	**1**
50-59	2	11	**13**	1	3	**4**
60-69	5	8	**13***	0	1	**1**
70-79	6	10	**16**	3	1	**4**
>=80	1	4	**5**	0	3	**3**
Total	**18**	**39**	**57**	**5**	**10**	**15**
	32%	*68%*	*100%*	*33%*	*67%*	*100%*

* Sex was not known for one 66 year old patient who was not selected for chart review.

In-Patient Diagnosis, LOS and Transfers to UOHI

The referring diagnosis for 41% of the telehealth in-patients was chest pain (Table 21).[7] The diagnosis of chest pain includes all chest pain syndromes such as angina, unstable angina, jaw pain, post myocardial infarct angina and chest pain not yet diagnosed. About 26% of the in-patients had a referring diagnosis of recent acute myocardial infarct and 19% had arrhythmia. Other referring diagnoses occurred in 5% or less of the telehealth in-patients.

TABLE 21. Referring diagnoses for Pembroke in-patients seen by Telehealth. *

Referring Diagnosis	**Percentage of In-patients**
Chest pain	41%
Myocardial infarct	26%
Arrhythmia	19%
Valve disease	5%
Congestive heart failure	2%
Endocarditis	2%
Connective tissue disease	2%
Hypertension	2%

* n=58, with referring diagnosis missing for one telehealth in-patient.

[7] The table and description of referring diagnoses were prepared by Sharon Ann Kearns, Telehealth Nurse, UOHI.

Admitting and discharge diagnoses for telehealth in-patients selected and not selected for chart review showed considerable overlap (see Appendices 6 & 7 for details). This suggests that telehealth in-patients selected for chart review were similar to in-patients who were not selected for chart review. Whether or not the in-patients seen via telehealth were representative of all cardiology in-patients at PGH or at UOHI was not evaluated.

The median length-of-stay (LOS) for a typical Pembroke in-patient seen by telehealth was 6.0 days (Table 22, details in Appendix 8).[8] The 20 telehealth in-patients who were subsequently transferred from PGH to UOHI had significantly longer LOS at PGH than did the in-patients that were not transferred (Mann-Whitney *U*-test, $p<0.03$).[9] The reason for this difference as not explored but could be due to the wait for beds at UOHI, more complicated or more acute illnesses, etc. It is also not clear how many of the days spent at PGH would have been spent at UOHI in the absence of telehealth. This issue of potential savings is addressed in later sections of this report.

For those telehealth in-patients eventually transferred to UOHI, the median LOS at Ottawa was 7.5 days. The median <u>total</u> LOS was 20 days for in-patients who stayed first at PGH and then at UOHI. There were no significant differences between the in-patients selected for review and the remaining in-patients for any of the three groups of LOS (e.g., at PGH, at UOHI, at PGH plus UOHI) (Mann-Whitney *U*-tests, $p>0.27$). About one-third of telehealth in-patients (selected or not selected for chart review) were transferred to UOHI.

Overall, the Pembroke telehealth in-patients selected for chart review had demographic characteristics, diagnoses, LOS and rate of transfer to UOHI similar to that of the in-patients who were not selected for chart review.

TABLE 22. Length-of-Stay (LOS), in days, for telehealth in-patients at PGH and at UOHI.

Statistic	PGH LOS			UOHI LOS*	Total LOS
	All PGH In-patients	Not Transferred	Transferred to UOHI		(PGH plus UOHI)
Mean	7.0	6.0	8.8	12.6	21.4
Standard Deviation	4.8	4.2	5.3	15.3	15.5
Trimmed Mean**	6.6	5.5	8.6	10.4	19.6
Median	6.0	5.0	7.5	7.5	20
Minimum	1	1	1	1	4
Maximum	22	22	20	63	70
n	57	37	20	20	20

* LOS at Ottawa for Pembroke in-patients who were eventually transferred to UOHI.
** Upper and lower 5% of values were trimmed and a new mean was calculated. Sample size for each trimmed mean was 90% of original sample size.

[8] Mean LOS were skewed by a few extreme values, thus median values were chosen to represent the typical in-patient, as opposed to the average in-patient.
[9] The non-parametric Mann-Whitney *U*-test was used because the assumptions of parametric tests were problematic.

Retrospective Chart Review

The retrospective chart review started by asking the clinician to indicate the major reason(s) for the telehealth consultation. The major reason for the telehealth session was almost equally divided between “Establish diagnosis” and “Seek a second opinion” (7 of 15, 47%), were always chosen together, or “Deal with the management of a known condition” (53%). Thus, the clinician at the spoke site (Pembroke) was referring roughly half of the sample in-patients to UOHI through telehealth in order to confirm a diagnosis. The other half of this sample of in-patients already had a confirmed diagnosis. Other major reasons that were listed but not chosen included: "Deal with service delivery to patient", "Prescription medication consultation/renewal", "Pre-admission screening", "Post-discharge follow-up" and "Other, please specify".

We asked the clinician to indicate the reason for choosing these in-patients for telehealth consultation. In 3 cases, the clinician indicated that the “Patient’s need for referral was borderline”. For two additional cases, “Patient needed urgent referral but Telehealth session was convenient.”

The next question asked: "If telehealth had not been available, what would you have done for this patient?" In all 15 cases the clinician indicated that he would have "Referred patient to an out-of-community specialist (e.g., cardiologist at UOHI)." Other items that were listed but not chosen included: "Prescribed treatment at Pembroke General Hospital", "Discharged patient" and "Other, please specify". This finding has cost implications for the health care system of Ontario. Thus, by avoiding routine transfers, cost savings in the form of transportation costs of transferring in-patients are being realized.

As noted above, the presence of telehealth allowed the clinician to refer PGH in-patients to UOHI cardiologists. It will be useful to know whether telehealth referral made any difference in terms of speed of diagnosis, speed of treatment and LOS. The clinician doing the chart review was asked to review these dimensions.

The clinician was unable to provide information on the number of days by which diagnosis or treatment was delayed nor on the number of days that LOS was increased or decreased. However, the clinician was able to offer the judgement that, in general, telehealth made for speedier diagnosis (87% of cases), speedier treatment(93% of cases) and decreased LOS (60% of cases) (Table 23). Note, however, that LOS was increased in 27% of the cases.

TABLE 23. The effect of telehealth consultation on (a) diagnosis or treatment, and (b) length-of-stay (LOS) for in-patients at Pembroke General Hospital. *

(a) Effect on Diagnosis or Treatment	**Diagnosis ****	**Treatment**
Speed up	87%	93%
Delay	0%	0%
Change type	0%	7%
No change in speed ***	13%	0%

(b) Effect on LOS	**LOS**
Increase	27%
Decrease	60%
No change	13%

* Based on 15 chart reviews by an internist at PGH.
** Multiple responses were permitted for diagnosis and treatment (but not for LOS).
*** Inferred for diagnosis and treatment (but not for LOS).

Cross-tabulation showed that telehealth sped both diagnosis and treatment in 80% of the cases, with LOS decreased in 7 of these 12 cases, increased in 4 cases and unchanged in 1 case. There was, however, no consistent relationship between the change in LOS and the rapidity of either diagnosis or treatment. While it was true that the telehealth sessions that resulted in decreased LOS had either speedier diagnosis or speedier treatment (or both) it was also true of the telehealth sessions that resulted in increased LOS or resulted in no change in LOS. Thus in the opinion of the clinician, speedier diagnosis and speedier treatment had no consistent effect on LOS.

Overall, telehealth allowed for speedier diagnosis and treatment. While there was evidence that LOS decreased as well, the chart review did not permit the determination of the number of days by which LOS declined. Telehealth may have caused a net decrease of 33% in LOS (60% - 27%) but it was not clear how this would translate into number of days. This issue needs further research and exploration.

Another frequently cited benefit of telehealth consultation is that it will allow for the possibility of minimizing unnecessary diagnostic tests and procedures. In order to determine whether this was the case for this sample, the clinician was asked to consider the following question while performing the chart review: "What was the effect of telehealth on prescribed treatment?"

TABLE 24. Effect of telehealth on the percentage of prescribed procedures or diagnostic tests for PGH in-patients.

Procedures or diagnostic tests	Percentage of Cases (n=15)
Fewer were prescribed	7%
More were prescribed	60%
No change in number prescribed	33%

Telehealth generally increased the number of procedures and diagnostic tests prescribed by the physician at PGH (Table 24). For each case, the number of procedures or number of diagnostic tests prescribed both changed in the same way (i.e., both increased, both decreased or both stayed the same). It was possible that the reported increase in number of tests and procedures represents a transfer of care from UOHI to PGH, enabling the local clinician and local hospital to provide appropriate treatment.

There were no consistent relationships among responses to this question on the number of procedures and tests and the previous question on the speed of diagnosis and treatment or change in LOS. There was insufficient information, due in part to small sample size, to determine if these variables were independent of one another. Overall the results suggest that telehealth consultations lead to more rapid diagnosis and treatment, and, to a lesser extent, to a decrease in LOS, albeit at the cost of additional tests and procedures.

One of the benefits of telehealth consultation is immediate determination of the need for transfer of a given patient. In the absence of telehealth, when a patient is suspected of cardiac problems at PGH, it is almost certain that the patient will be transferred to UOHI. On the other hand, with telehealth consultation, it is possible to go through an intermediate step of determining the need for transfer and thus avoid those transfers that were unneeded. The clinician was asked to review the charts to determine the effect of telehealth on the need for transfer.

The results reported in Table 25 suggest that telehealth did not change the level of urgency of the need to transfer the patient in 73% (20% + 53%) of cases and down-graded the urgency in 26% of cases. It is worth noting that all two borderline cases (non-urgent) were down-graded to "no need for transfer". Also it is worthwhile to note that the "need for transfer" was not up-graded in any of the 15 cases in our sample.

TABLE 25. Effect of telehealth on the need for transfer of PGH in-patients.

***Before* the telehealth session**	***After* the telehealth session**			
Need for Transfer	*No need*	*Non-urgent*	*Urgent*	***Total (before)***
No need	20% *	0	0	20%
Non-urgent	13%	0	0	13%
Urgent	13%	0	53%	67%
Total (after)	47%	0	53%	100% (n=15)

* Underlined numbers represent no change in need for transfer.

Finally, we asked whether the clinician would use telehealth again for this type of case and for this type of patient. The response was unanimous. For every case and for every individual in this sample, the clinician indicated that telehealth consultation would be used again. Thus, the response was resoundingly in favour of using telehealth for the type of case and for the individual in-patients in this sample.

In-Patients: Economic Implications

Our analysis of the in-patient data showed that in all cases in the sample, telehealth averted routine transfers to UOHI. In addition, telehealth consultation also downgraded the urgency of transfer for 27% of the cases. There is evidence showing that telehealth sped up diagnosis and treatment Telehealth did, however, increase the number of procedures or diagnostic tests prescribed at PGH. The referring physician at PGH indicated that telehealth would be used again for the type of cases and for the type of in-patients in the sample. Although these results were based on a small sample size and lack independent verification, the findings suggest a resounding endorsement of telehealth technology for remote consultation through the HEARRT Demonstration Project.

Impact on Length-of-Stay (LOS): In evaluating telehealth, LOS is one of the outcome measures that analysts tend to study. It is expected that telehealth will reduce LOS. We made an attempt to gather and analyze the data on LOS as part of this study. Comparing the telehealth group with a matched non-telehealth group of in-patients did not show significant difference in LOS at the aggregate level (personal communication: K. Woodend, UOHI, August 1999). We also analyzed the data from the Canadian Institute of Health Information Discharge Abstract Database (provided by PGH) and from the Ontario Case Costing Program/Joint Policy and Planning Committee. We compared the expected LOS (ELOS) to the actual LOS for the group of Pembroke telehealth in-patients and did not find a significant reduction (n=58). In fact, average LOS for the 58 in-patients was 1.6 days higher than ELOS. This difference was reduced after removing outliers and after adjustment for scheduling of telehealth sessions. For example, subtracting the amount of time from the date of the request to the telehealth session brought the average difference to less than 0.5 day per patient. It is possible that there are too many variables affecting the LOS of these in-patients at the aggregate level. Thus, it is difficult to isolate the impact of telehealth on LOS and with a small number of cases, it is likely that reductions in LOS, if present, are not registering.

Given these results, we undertook to study the impact of telehealth on LOS on a case-by-case basis. At PGH, telehealth "urgent" consults with an UOHI cardiologist took place on Mondays, Wednesdays and Fridays. For the sample that went through retrospective chart review by the attending physician in Pembroke, we found the impact on LOS somewhat ambiguous. LOS was increased in 27%, decreased in 60% and remained unchanged in 13% of the cases. Overall, there could be a net decrease in LOS in 33% of the cases. As part of the retrospective chart review, we asked the physician to indicate an estimate of the number of days of reduction in LOS. Given the information in the hands of the physician, such a quantitative estimation was not possible.

In addition to the retrospective chart review, the telehealth nurse/co-ordinator, who kept a close watch on all consultations, undertook a detailed chart review of all the 58 in-patients included in this evaluation. This review indicated that about 64% of the in-patients had either altered or reduced their hospital stay. Telehealth consultation resulted in changes in the referring diagnosis in the about 12% of the cases. There were cases where telehealth consultation was able to establish accurate diagnosis, enabling LOS to be reduced. One patient was diagnosed as having suffered a CVA and was referred on for further investigations by other specialists.[10]

The telehealth nurse's review also revealed that 35% of the in-patients were recommended for transfer to UOHI following the telehealth consultation. Upon the advice of the UOHI cardiologists, these in-patients were able to stay in PGH while awaiting transfer. About 12% of the in-patients had shorter LOS due to their diagnosis through telehealth consultation. These in-patients were discharged to their home to await further diagnostic procedures. In another 12% of the cases, the

[10] Adapted from a summary of LOS for telehealth in-patients, prepared by Sharon Ann Kearns, Telehealth Nurse, UOHI.

telehealth nurse determined that LOS was lengthened because the in-patients were admitted on a Friday and had to wait for a telehealth consultation in the next week.

Thus, a case-by-case review indicates that telehealth resulted in beneficial effects in many instances, with important financial implications for the health care system. Although the aggregate level reduction in LOS could not be determined because of small sample size, on a case-by-case basis, there is a suggestion of a reduction in LOS. This mixed result is not surprising as other telehealth programs have reported similar results. For example, Rendina et al. (1998) reported that in a program of telehealth rapid interpretation of neonatal echocardiograms for a neonatal intensive care unit in North Carolina, a reduction of LOS of 5.4 days was found, but was statistically non-significant. Rendina's sample size of 87, however, was considered to be too small to make any generalizations. When sample size was increased, the results were also dramatically different. In another study of the impact of telehealth on neonatal intensive care LOS, Rendina (1998) reported that with a larger sample and controlling for risk factors, telehealth contributed to a 17% reduction in LOS. This reduction was found to be statistically significant (Rendina 1998). Similarly, when the UOHI telehealth system becomes fully operational, it is possible that significant and measurable changes in LOS will be observed.

UOHI Telehealth Operational System: A Simulation Model of Cost Savings

In this section, we report the results of a simulation model undertaken to study the impact of an operational telehealth system. This model is based on the currently existing network of one hub (UOHI) and three spoke sites (Pembroke, Red Lake and Chapleau/Sudbury). An Excel spreadsheet was developed to perform the calculations involved in the simulation model.

Equipment and Communication Links

This analysis takes into account only the equipment and communications link that are likely to be used in an operational system. For the purposes of this analysis, we have included fixed expenses because they are known with some certainty, and have estimated variable expenses based on the assumption of two telehealth patients per hour. First year start-up costs, such as shipping and handling, installation and renovation were not included.

We have assumed that a CDC platform and related peripherals will be used at all sites. Satellite communication is assumed for remote sites. Capital equipment is amortised over five years and annuitised values are reported per year, discounted at 5%. Warranty cost is assumed to be 10% of the cost of equipment. See Table 26 for costs associated with a simulated operational system of one hub and three spoke sites.

Model Assumptions

The simulation model is based on the experience and assumptions associated with the UOHI-PGH link. The parameters and weights are adopted for the other links, on the assumption that the experiences in the other sites are similar.

Catchment area population estimates: We estimate the catchment area population at 70,000 for Pembroke, 5,000 for Red Lake, and 4,000 for Chapleau, based on 1996 population figures from Statistics Canada and discussion with UOHI personnel (UOHI 1998, HEARRT Business and Marketing Plan).

Annual number of cardiac in-patients: This is based on a case-mix summary of PGH in-patients available through the CIHI database. Based on the case-mix summary data for 1997-1998, it is estimated that 1% of the catchment area population is likely to suffer cardiac symptoms requiring in-patient care (UOHI 1998, HEARRT Business and Marketing Plan).

Annual number estimated to receive telehealth: In a site such as Pembroke, which is close to an urban centre, it is assumed that this percentage of cardiac in-patients who would receive telehealth will be about 70%. In a more remote location, without specialist support, it is assumed to be 90%. Changes in these percentages and other assumptions were explored through sensitivity analyses.

Hospital bed charges: It is assumed that the *per diem* bed charge at PGH and other spoke sites is $400 and $800 at the UOHI hub site (Cheung *et al*. 1998). Thus potential savings to the health care system would accrue on the order of $400/day if in-patients could stay at spoke sites rather than at UOHI.

Proportion staying locally awaiting transfer: One potential cost savings is for some of the telehealth in-patients to stay at the local hospital while awaiting transfer. Based on the results of the case-by-case chart review, where 20 of 58 in-patients were transferred, we assume that this proportion is 33%. The assumption was, that prior to telehealth, the majority of these in-patients would have been transferred to UOHI within a few days.

TABLE 26. Major equipment and communication costs for the UOHI Telehealth Network.

Cost Item by Site	Capital Cost	Annualized Charge
UOHI		
Platform and Peripherals (includes ¼ of a computer)	$ 65,400	$ 15,106
Satellite Earth Station	$ 75,000	$ 17,323
tax (GST & PST)	*$ 21,060*	*$ 4,864*
Sub total (equipment cost)	**$161,460**	**$ 37,293**
Warranty/Support@10%		$ 14,040
Communication costs (included with spoke sites)		
tax (GST)		*$ 983*
Total UOHI		**$ 52,316**
Pembroke		
Platform and Peripherals	$ 63,900	$ 14,759
tax (GST & PST)	*$ 9,585*	*$ 2,214*
Sub total (equipment cost)	**$ 73,485**	**$ 16,973**
Warranty/Support@10%		$ 6,390
Communications - ATM line rental	$23,600/month	$283,200
tax (GST)		*$ 20,271*
Total Pembroke		**$326,834**
Red Lake		
Platform and Peripherals	$ 63,900	$ 14,759
Satellite Earth Station	$ 75,000	$ 17,323
tax (GST & PST)	*$ 20,835*	*$ 4,812*
Sub total (equipment cost)	**$159,735**	**$ 36,895**
Warranty/Support@10%		$ 13,890
tax (GST)		*$ 972*
Communications - Pay-per-use (+GST)	$171/hour	
Total Red Lake		**$ 51,757**
Chapleau/Sudbury		
Platform and Peripherals(2 sites)	$129,300	$ 29,865
tax (GST & PST)	*$ 19,395*	*$ 4,480*
Sub total (equipment cost)	**$148,695**	**$ 34,345**
Warranty/Support@10%		$ 12,930
Communications - ISDN Line rental	$4,265/site/year	$ 8,530
tax (GST)		*$ 1,502*
Communications - Pay-per-use (+GST)	$17.98/hour	
Total Chapleau/Sudbury		**$ 57,307**

Median LOS: Median LOS at PGH was 7.5 days for in-patients that were eventually transferred to UOHI and 5.0 days for in-patients that stayed the entire time at PGH (see Table 22). We assumed, that prior to telehealth it was likely that most of the in-patients would have stayed 2 days at PGH while awaiting transfer. Thus in the simulation model, we assume that the number of days at PGH that were previously spent at UOHI are 7.5-2=5.5 days for in-patients that were eventually transferred to UOHI and 5-2=3 days for in-patients that stayed the entire time at PGH. Sensitivity analyses were used to explore variations in LOS.

Number of transfers prevented: Based on the chart review of 15 in-patients, the need for transfer and the mode of transfer was unaffected by telehealth for about 75% of the in-patients (see Table 25). There is some conflicting evidence in that the same reviewer indicated that 100% of the 15 in-patients would have been transferred to UOHI in the absence of telehealth. We chose to be conservative in this default assumption and to explore variation in the number of transfers prevented through sensitivity analyses. Subsequent assumptions are that air ambulance transfer will be averted for 2% of the telehealth in-patients and ground ambulance transfer will be averted for 23%. These percentages were applied to all telehealth in-patients. Data for 1998 suggest that there would be about 11 medical evacuations for Red Lake and about 4 for Chapleau for cardiac cases (personal communication: SA Kearns, December 1998). Our assumptions would have at least one of these transfers averted at each remote location.

Air and Ground ambulance charges: Air ambulance costs based on an average for helicopter, Citation jet and turbo prop aeroplane for one-way distance for all locations. Ground ambulance charges are a flat rate of $350.[11]

Telehealth co-ordinator: We assume that a telehealth co-ordinator will be hired at $35 per hour. The cost is directly proportional to the number of patients. In the simulation model, it is easier to show this cost as a function of telehealth patients seen at each spoke site.

Telehealth expenses: These are derived from the equipment and communication charges.

The spreadsheet model that was used to estimate the cost (saving) and the default assumptions of the model are presented in Table 27. Breakeven points were not estimated because some assumptions had sketchy empirical support and thus it was not clear which of the assumed values should be fixed and which should be varied during the breakeven analysis. Instead, changes in model results caused by changes in the assumed values were explored through sensitivity analyses.

The first group of sensitivity analyses explored the result when <u>all</u> assumptions were either set to their minimum or maximum value. The second group of sensitivity analyses explored the result when each assumption was set to its minimum value or its maximum value while all other assumptions were held at their default value. Results of the sensitivity analyses are presented in Table 28 and all model results are described in the following section.

[11] Ambulance costs were obtained from R. Blake Forsyth, Regional Manager, Eastern Ontario, Emergency Health Services Branch, Ontario Ministry of Health, October 1998.

Results

This simulation model shows that, given the assumptions, the net saving for the health care system from the operation of this one hub and three spoke network is likely to be about $422,000 per year (Table 27). About 95% of the estimated savings accrued when the in-patient stayed at the local hospital rather than at UOHI, because of the estimated difference in bed charges.

TABLE 27. Potential annual health system costs (savings) for the UOHI Telehealth Network.* **

Item	UOHI	Pembroke	Red Lake	Chapleau/ Sudbury	Total
Catchment area population		70,000	5,000	4,000	**79,000**
Annual number of cardiac in-patients		700	50	40	**790**
Annual number estimated to receive telehealth		490	45	36	**571**
Bed charges					
Proportion staying locally awaiting transfer		0.33	0.33	0.33	
Number staying locally awaiting transfer		162	15	12	**189**
Average length of stay (days) at local hospital awaiting transfer		5.5	5.5	5.5	
Number always staying locally		328	30	24	**382**
Average length of stay (days) at local hospital		3.0	3.0	3.0	
Difference in bed charges (per diem)		$400	$400	$400	
Total savings due to transferred in-patients staying locally		**($750,000)**	**($69,000)**	**($55,200)**	**($874,200)**
Ambulance					
Proportion of in-patients at local hospital that did not have any change in need or mode of transfer		0.75	0.75	0.75	
Proportion of in-patients at local hospital who had air ambulance transfers prevented		0.02	0.02	0.02	
Number of air ambulance transfers prevented		10	1	1	**12**
Air ambulance charges		$1,200	$3,800	$3,300	
Air ambulance charge savings		**($12,000)**	**($3,800)**	**($3,300)**	**($19,100)**
Proportion of in-patients at local hospital who had ground ambulance transfers prevented		0.23	0.23	0.23	
Ground ambulance transfers prevented		76	7	6	**89**
Ground ambulance charges		$350	$350	$350	
Ground ambulance charges saved		**($26,600)**	**($2,450)**	**($2,100)**	**($31,150)**
Total savings to health care system		**($788,600)**	**($75,250)**	**($60,600)**	**($924,450)**
Annualized costs					
Capital equipment	$32,429	$14,759	$32,082	$29,865	**$109,136**
Equipment taxes (GST & PST)	$4,864	$2,214	$4,812	$4,480	**$16,370**
Warranty	$14,040	$6,390	$13,890	$12,930	**$47,250**
Annual communications charges		$283,200		$8,530	**$291,730**
Warranty/communication taxes (GST)	$983	$20,271	$972	$1,502	**$23,729**
Variable costs					
Pay-per-use communication charges			$3,848	$324	**$4,171**
Telehealth co-ordinator/nurse		$8,575	$788	$630	**$9,993**
Total costs	**$52,316**	**$335,409**	**$56,392**	**$58,261**	**$502,378**
Net cost (saving) to health care system	**$52,316**	**($453,191)**	**($18,858)**	**($2,339)**	**($422,072)**

* Savings to the system are in parentheses.

** Cost (saving), displayed by site for ease of calculation, are assignable to the whole network and not to individual sites.

Model results were sensitive to the assumed values. Net cost (saving) to the system were estimated to be $383,827 per year (a net cost) when all model assumptions were at their minimum values and ($4,508,658) per year (a net saving) when all assumptions were at their maximum values (Table 28a).

Assumptions related to the savings when the in-patients stay at the local hospitals rather than at UOHI had a greater impact on the net cost (saving) than did assumptions related to ambulance transfer. When assumptions were modified one at a time, it was found that changes to the proportion of cardiac in-patients in the catchment basin and changes to the difference in bed cost had the largest effects on the net cost (saving) (Table 28b). For example, when the proportion of cardiac in-patients was halved, then the estimated net cost (saving) decreased by about $450,000 to $28,298 and net cost (saving) increased by about $900,000 to ($1,332,008) when the rate was doubled. Similarly, the estimated net cost (saving) decreased by about $437,000 to yield a net cost of $20,300 when the difference in bed charges was halved to $200/per day. Due to the nature of the evidence for some assumptions, all results must be considered preliminary and subject to independent verification.

TABLE 28. Sensitivity of annual net cost (saving) of the UOHI Telehealth Network to (a) simultaneous changes, and (b) single changes to model assumptions.

(a) Simultaneous changes to all assumed proportions and costs.

All assumptions set to:	Net Cost (saving)
Default Value	($422,072)
Minimum Value	$383,827
Maximum Value	($4,508,658)

(b) Single changes to assumed proportions and costs, all other assumptions held at default value.

Model Assumption	Default Value	Minimum Value	Maximum Value	Cost (saving) for Minimum Value	Cost (saving) for Maximum Value
Proportion of cardiac in-patients	0.01	0.005	0.020	$28,298	($1,332,008)
Proportion to receive telehealth	0.70	0.70	0.90	($396,014)	($644,922)
Proportion staying locally awaiting transfer	0.33	0.10	0.50	($301,922)	($511,722)
Average LOS (days) at local hospital awaiting transfer	5.5	3.0	11.0	($233,072)	($837,872)
Average LOS at local hospital	3.0	1.5	6.0	($192,872)	($880,472)
Difference in hospital bed charges	$400	$200	$400	$15,028	($422,072)
Proportion of in-patients at local hospital that did not change mode of transfer *	0.75	0.60	0.90	($442,372)	($402,122)
Proportion of in-patients at local hospital who averted air ambulance transfers **	0.02	0.01	0.05	($417,472)	($446,772)
Proportion of in-patients at local hospital who averted ground ambulance transfers ***	0.23	0.2	0.24	Varies inversely with the proportion who had averted air transfers.	

* Minimizing this proportion will increase benefits.

** Proportion of averted air transfers is fixed when the proportion of no change is altered and thus the proportion of averted ground transfers is adjusted so that all three proportions sum to 1.

*** Proportion of no change is fixed when the proportion of averted air transfers is changed and thus the proportion of averted ground transfers is adjusted so that all three proportions sum to 1.

Discussion

At the assumed volume of use, the network shows a net saving. This finding, however, must be viewed in light of model assumptions, including population size, LOS, percentage of transfers and the remoteness of the sites. Results are particularly sensitive to the assumptions about anticipated savings due to in-patients staying at the local hospital rather than at UOHI. Furthermore, these results are based on autumn 1999 prices for equipment and communication charges. As these costs come down, the financial viability of the system is likely to change as well. For example, a 10% reduction of all equipment and communication costs would cause a $50,000 per year decrease in costs.

In addition, it should be emphasized that this model captures only the savings to the health care system and does not capture the sizeable benefits accruing to the in-patients and their families. For example, if the telehealth session allowed 50% of the projected 571 in-patients to avoid one trip to the cardiologist by private means, this would result in an estimated net savings of around $85,000 per year and, if lost wage/leisure time was included, this would total about $178,000. The estimated saving to the Northern Health Travel Grant Program is approximately $5,500 per year.

This simulation was based on cardiac consultations only. As other specialties are introduced and as other uses, such as continuing education and administrative meetings, are included, the benefit of the system will be of much higher magnitude. Thus, this result must be considered as only a starting point estimate.

The results reported here consider only a four site model. The UOHI telehealth system has the potential to become part of a larger network linking most health care institutions in northeastern Ontario. In the context of such a scenario, this model is again only a starting point.

Potential Benefits of CME through a Telehealth Platform: Results from the UOHI Pilot Project Physician Survey

In addition to clinical consultations, the telehealth platform can be used for staff training, administrative meetings, conducting conferences and educational sessions such as continuing medical education (CME).

The ability to provide CME sessions is particularly important in the environment within which physicians in rural and remote area practise medicine. These physicians do not have access to nearby medical schools. They have very busy practices, allowing them very little time to go out-of-town to attend sessions. Even if they want to go out-of-town, geographic distances can be a major hurdle for them. Another problem is the difficulty in arranging for *locum tenens* coverage while they are away. Such obstacles may discourage the rural and remote area physicians from making out-of-town trips for CME sessions.

While the obstacles are many, the need for CME cannot be greater. The medical field is constantly undergoing rapid changes and technological advances. In addition, due to lack of specialist care in rural and remote areas, FP/GPs have to develop a wide variety of skills in order to deal with the problems that they encounter in their practices.

It is in this context that CME, offered through a telehealth platform, assumes its special significance. By connecting rural and remote area physicians to medical schools and specialists, the benefits of CME can be made available to them. With access to such programs, the rural and remote area physicians might be able to provide additional medical care to their patients.

From the point of view of the physicians, they can participate in CME sessions without having to travel to central locations, thereby realizing monetary as well as non-monetary benefits. These are the direct out-of-pocket cost savings. In addition, they do not have to leave their own families to attend the sessions in distant cities. Their patients do not have to go without their care for extended periods of time while they are away to attend CME sessions out-of-town.

As part of this evaluation project, an attempt was made to capture some of these benefits. The results reported here were based on a survey of physicians conducted in the spring of 1998. The physicians were located in the Pembroke and Almonte area. Both communities are connected to UOHI through a telehealth platform. Physicians were asked if they would be interested in participating in telehealth CME sessions and the subject areas of interest. In addition, the questionnaire asked physicians to estimate the costs to attend local and out-of-town CME sessions. The difference in cost between local and out-of-town CME was used as an estimate of the potential savings to be realized in offering CME by telehealth.

Potential Savings to the Physician

A total of 46 survey questionnaires were sent out to Pembroke and Almonte area physicians in the spring of 1998. Out of these, 14 completed questionnaires were returned, giving a response rate of approximately 30 percent. Given the busy practice patterns of these physicians, this response rate can be considered satisfactory. This section is based on these 14 responses.

All the respondents were in family practice. Two respondents indicated additional specialization in emergency medicine. Another two respondents reported additional specialization in emergency medicine and anesthesia.

In terms of attendance at CME sessions, all but one indicated that they were regularly attending. The single non-attending physician reported that, even though the CME sessions were relevant to the practice, there was no time to attend CME sessions held out-of-town.

As the estimates in Table 29 indicate, the most important cost of attending local CME sessions was the opportunity cost in terms of lost income. The reported estimates ranged widely, from no lost income to $5,000. It was possible that those who reported no lost income chose to attend sessions held outside their office hours or practice time. Even such physicians, however, have opportunity cost in terms of loss of leisure time, time with families and so on. It was clear, however, that the physicians in the Pembroke and Almonte areas report considerable loss of income from attending CME sessions, even if the sessions are held locally.

TABLE 29. Estimated annual costs of attending local and out-of-town CME sessions

CME Expense	Local CME Average Estimates (n=13)	Out-Of-Town CME Average Estimates (n as given)	Cost Difference ***
Registration Fees	$ 138	$ 1,013 (12)	$ 875
Incidentals*	$ 8	$ 38 (12)	$ 30
Lost Income	$ 1,385	$ 3,667 (12)	$ 2,282
Hotel**		$ 700 (10)	$ 700
Meals**		$ 218 (10)	$ 218
Travel**		$ 417 (11)	$ 417
Hotel, Meals & Travel		$ 1,480 (12)	$ 1,480
Total Costs	**$ 1,530**	**$ 5,874 (13)**	**$ 4,344 ******

* Only one respondent gave a cost estimate for incidentals ($100)
** One respondent gave combined cost for hotel and meals while a second gave combined total for hotel, meals and travel. These cost estimates were not included in the averages for the separate categories of hotel, meals or travel.
*** Based on the difference between average costs.
**** Cost differences do not sum exactly to total cost difference because some respondents gave totals only.

Expenses in all categories were higher for out-of-town sessions. The estimated registration fees and lost income stand out as the most significant items of costs of attending out-of-town CME sessions. Travel, meals and hotel costs were also important cost items. Here also, the range of estimated lost income was wide, from nothing to $10,000. The two physicians who reported no loss of income may have combined CME sessions with their holiday plans. If so, there was still a non-monetary opportunity cost in terms of foregone leisure time.

The cost difference was calculated as the difference between the local and out-of-town average estimated costs. If telehealth sessions are provided so that the physicians do not have to leave the community, it is this cost difference that would be saved from the point of view of the physicians. Thus, the estimated costs reported by the physicians in this sample indicated that a potential average saving to the physician of $4,344 per year can be realized by offering CME by telehealth.

The Cost of CME via Telehealth

Modelling the cost of using telehealth to provide CME requires a number of assumptions that have varying amounts of empirical evidence. Fixed cost was based on the estimate for clinical use for the PGH-UOHI link and only includes the equipment costs and communication charges. Variable costs, in the form of personnel costs for cardiologist and nurse, were excluded. We reasoned that the personnel costs associated with providing CME by telehealth would be the same if the CME were provided locally. This assumption permits the use of the difference between local and out-of-town costs as an estimate of potential savings. The effect of the magnitude of the potential savings on the evaluation result was explored through sensitivity analyses.

The cost to provide CME via telehealth, the cost of the equipment and communication link, was estimated as $265,839 per year for VideoRoute link and $357,180 per year for ATM communications link. Based on the number of physicians who returned the questionnaire, we assume that at least 15 physicians will use the telehealth system instead of travelling out-of-town for CME. The potential savings realized by these 15 physicians was estimated as 15 x $4,344=$65,160.

This magnitude of use, however, was not sufficient to balance the potential savings to the physician against the cost of the telehealth system. In the sensitivity analysis we varied the number of physicians using the telehealth system for CME instead of travelling out-of-town. As expected, the average cost per physician decreased with increased number of physicians (Table 30). Net total cost (saving), calculated as telehealth costs minus physician savings, changed from a cost to a saving with increased use. The breakeven point occurred at about 61 physician per year for the VideoRoute communication link (not shown) and at about 82 physicians per year for the ATM link; assuming that all potential savings to the physician were applied to the balance sheet.

TABLE 30. Annual cost of Telehealth Program (ATM line): average cost per physician, net total cost (saving) and net average cost (saving) per physician

		Telehealth Costs minus Physician Savings *	
Number of Physicians	**Average Cost per Physician**	**Net Total Cost (saving)**	**Net Average Cost (saving) per Physician**
15	$ 23,812	$ 292,016.54	$ 19,468
25	$ 14,287	$ 248,574.23	$ 9,943
50	$ 7,144	$ 139,968.46	$ 2,799
100	$ 3,572	$ (77,243.08)	$ (772)
200	$ 1,786	$(511,666.15)	$ (2,558)

* Physician savings were estimated from survey responses of 14 physicians from the Almonte and Pembroke area.

If only half of the potential savings to the physician was applied to the cost of the Telehealth Program then the breakeven point would occur at 122 and 164 physicians per year for the VideoRoute and ATM links, respectively (Table 31). If the amount of potential savings that was applied was decreased to about 25% of the estimate savings, then the breakeven point would be increased to 245 (VideoRoute) and 329 (ATM) physicians per year.

TABLE 31. Breakeven point (number of physicians per year) for providing CME by telehealth as the amount of the potential savings that was applied to the program costs was decreased.

Percent of Potential Savings	Potential Savings	Number of Physicians per year: VideoRoute	Number of Physicians per year: ATM
100	$ 4,344	61	82
50	$ 2,172	122	164
25	$ 1,086	245	329

Discussion: CME and Telehealth

Results of the economic evaluation on the feasibility of offering CME via telehealth between Pembroke and Ottawa suggest that non-clinical use may allow the program to recoup its investment in a shorter time period than if the system were used exclusively for clinical use. This conclusion relies on a number of assumptions that have varying degrees of empirical support and must therefore be considered tentative.

It is quite likely that not all of the potential savings accrued to the physician would be applied to the Telehealth Program. If, however, physicians would pay about $2000 per year for the convenience of using the telehealth system then a breakeven point would be reached for CME alone at about 150 physicians per year. This amount of $2000/physician/year would be in addition to the registration fees normally charged for local CME.

Extrapolation of evaluation results from the Pembroke-Ottawa area to other locations was not justified at this time because of the lack of independent verification of the potential savings, the relatively small sample size and the lack of data from other locations. Nonetheless, it is important to note that CME offered by telehealth may become more cost-effective for physicians in more remote or isolated communities.

It is also important to note that telehealth CME is unlikely to replace all out-of-town CME because there are other reasons to travel such as the need to get away, to see people face-to-face and to get hands-on training. Fortunately, offering CME by telehealth has the potential to make it easier for physicians to stay up-to-date by offering courses tailored to their needs and schedule. The benefits to the physician and to the health care system in general are potentially large but difficult to measure due to their intangible or long-term nature.

Economic Evaluation: Conclusions and Recommendations

An economic evaluation was undertaken of the HEARRT Demonstration Project launched by the University of Ottawa Heart Institute. As part of this evaluation, a literature review was conducted. Based on the review, many potential costs and benefits were identified. For this project, an attempt was made to capture as many of these costs and benefits as possible and thus a variety of data gathering instruments were developed. As the project proceeded, these instruments were administered, yielding data for project evaluation, including data on use, costs and some benefits.

It is important to note that the HEARRT Demonstration Project occurred during a time of major re-structuring in the Ontario health care system, including significant re-organization at Pembroke and Ottawa area hospitals. In addition, pilot projects are characterized by small numbers of participants and rapidly evolving conditions, which makes evaluate difficult. Telehealth pilot projects may be a special case in that the rapidly changing technology poses additional problems of installation, orientation and changes to standard operating procedures. It is a testament to the potential of telehealth that interest and participation continues to increase despite the problems that characterize telehealth pilot projects and the particular difficulties encountered during a time of re-structuring.

This evaluation takes the preceding problems of evolving conditions and small sample size into account through the use of simulation models and sensitivity analyses that were backed by data, when available. The simulation models were designed to mimic an operating system based on the best available data. Thus conclusions are presented within the limits of the models and available data.

Out-Patients
Our results show that provision of out-patient cardiac clinical services via telehealth between PGH and UOHI was expensive relative to the Visiting Cardiologist Program at current rates of use (60-340 out-patients per year). These findings, based on CDC platform, peripherals and either VideoRoute or ATM communications links, were largely attributable to the high initial capital costs and low volume of use. Many telehealth demonstration projects, as well as operating systems in other countries such as the United States and Australia, also report similar findings (see, for example, Office of Rural Health Policy 1997). Once the demonstration has been successfully completed and telehealth system becomes operational, then use and cost configurations are likely to be different.

In order to study the impact of different levels of usage on the cost, we conducted several sensitivity analyses. These analyses showed that as use of the system went up, the average cost per patient consultation session went down. Telehealth only becomes less costly than the Visiting Specialist Program when 2400 or 3200 or more out-patients are seen per year. At this level of use, however, both the Visiting Specialist and Telehealth Programs might be supplanted by a third option: the hiring of one or more cardiologists at Pembroke General Hospital on a full-time or rotating basis.

It is useful to explore the perspective of the out-patient in the health care system . We estimated that out-patients and their families saved considerable costs by not having to travel to UOHI for diagnosis or treatment. If patient savings due to reduced travel were included, the Telehealth Program between PGH and UOHI breaks even at 500-670 out-patients per year. The Visiting Specialist Program always generated net savings if patient savings were included.

Our analysis of the cardiology clinics held for out-patients at Red Lake suggests a breakeven point of 110 out-patients per year when patient savings due to reduced travel were included. This evaluation was based on a CDC platform with pay-per-use for satellite communication costs. It seems unlikely that this level of use would be reached for cardiological consultations alone; in the 9 months of use in the year 1999 a total of 18 out-patients were seen via telehealth at Red Lake. A breakeven point might be achieved if additional specialties and other health care services were provided. It was also noteworthy that at the current level of use and up to 2700 out-patients per year, it would be less costly if communications charges were on a pay-per-use basis.

Similarly, our analysis of Chapleau out-patients suggests a breakeven point of about 65 out-patients per year when patient savings due to reduced travel were included. This evaluation was based on a CDC platform with costs for ISDN communications link (a combined pay-per-use and monthly rate). Results for Chapleau-Sudbury were tentative because of small sample size. At the end of data collection, only five patients had been seen at Chapleau and the link was to UOHI and not to Sudbury as modelled. As with Red Lake, Chapleau's breakeven point of 65 out-patients might be achieved if other specialties were included.

We also evaluated the Red Lake and Chapleau links to determine if the Telehealth Program could be justified on the basis of potential savings to the Northern Health Travel Grant (NHTG) Program for out-patient travel. Residents of Red Lake and Chapleau and surrounding areas are eligible for partial reimbursement of travel expenses from the NHTG Program. Red Lake residents were assumed to travel to Winnipeg, Manitoba, while Chapleau residents were assumed to travel to Sudbury. Our evaluation suggests that the NHTG reimbursement provides for only 12-13% of the patient's estimated travel expense. At this rate of reimbursement, the cost of the Telehealth Program only approached the cost of the NHTG Program at close to maximum use (4000 patients per year) for residents of Red Lake. The breakeven point occurred at approximately 785 Chapleau out-patients but this annual rate is unlikely to be achieved. Thus it is difficult to justify the Telehealth Program solely on the potential savings to the NHTG Program for out-patient travel.

There were also many non-quantifiable benefits accruing to the patient (and physician) through the provision of telehealth clinics. The fact that the patient in a fragile state of health avoids travel has benefits in terms of reduced anxiety and suffering. In addition, telehealth provides high-quality cardiac services to patients in communities nearer to home. These findings suggest that it is useful to consider costs, quality of life and accessibility together in assessing the value of telehealth services.

In-Patients

Our evaluation of the in-patient telehealth consultations was based on data derived from: (1) retrospective chart review of 15 in-patients conducted by the referring physician at PGH, (2) a chart review of 58 in-patients conducted by the UOHI telehealth nurse, and (3) CIHI Discharge Abstract Data as provided by PGH.

In-patients selected for chart review by the referring physician were not notably different from other in-patients seen via telehealth: age, sex, diagnoses and percentage transferred to UOHI were similar. It was not known, however, whether telehealth in-patients differed in meaningful ways from cardiology in-patients that were not seen by telehealth.

Our analysis of the physician-reviewed data showed that in all cases in the sample, telehealth averted routine transfers to UOHI. In addition, telehealth consultation also downgraded the urgency of transfer for about 1/4 of the cases. There was evidence showing that telehealth sped up diagnosis and treatment. Telehealth, however, increased the number of procedures or diagnostic tests prescribed at PGH, which suggests a transfer of care from UOHI to PGH.

The referring physician at PGH indicated that telehealth would be used again for the type of case and for the type of in-patients in the sample. Although these results were based on a small sample, the findings suggest a resounding endorsement of telehealth technology for remote consultation.

The impact of telehealth on LOS was mixed. Overall, there could be a net decrease in LOS in 1/3 of the cases but there was no measure of the magnitude of this decrease. Analyses conducted by researchers at UOHI on telehealth in-patients matched to non-telehealth in-patients by age, sex and Most Responsible Diagnosis did not find significant differences in LOS (personal communication: K. Woodend, August 1999). A comparison of expected LOS[12] and the actual LOS did not demonstrate a difference for 58 telehealth in-patients even after adjusting for outliers or for time spent waiting for a telehealth session. The sample size may be too small to demonstrate a significant difference (e.g., Rendina *et al.* 1998).

It is important to note that the real savings may come from the location of hospitalization and not the number of days *per se*. For example, *per diem* bed costs at PGH are about $400 while at UOHI costs are about $800. Thus an in-patient that can be treated at PGH can potentially save the provincial health care system $400 per day. Additional cost savings may accrue due to reductions in the number and urgency of ambulance transfers.

A preliminary model, based on UOHI-Pembroke-Red Lake-Chapleau-Sudbury, suggests that such a telehealth network may generate savings for the provincial health care system when in-patients stay at their local hospital for part or all of their hospital stay. In the preliminary model, the net saving was estimated to be about $422,000 per year. About 95% of the estimated savings accrued when the patient stayed at the local hospital rather than at UOHI.

Models results were, not surprisingly, sensitive to assumptions of how many in-patients stayed at local hospitals, how long they stayed at local hospitals and the cost difference between local (remote) hospitals and UOHI. For example, the proportion of cardiac in-patients in the catchment basin and the difference in bed costs had the largest effect on net cost (saving). Model results were less sensitive to the number and mode of averted ambulance transfers.

On a broader societal basis, savings would be increased if some of the costs of patient travel were incorporated into the model. For instance, if the telehealth session allowed 50% of the in-patients to avoid one trip to the cardiologist by private means, this would result in an estimated net savings of around $85,000 per year and, if lost wage/leisure time was included, the savings would double.

Education

During the HEARRT Demonstration Project, it was shown that it was feasible to provide health care practitioner and patient education courses through telehealth technology. Our survey of Almonte and Pembroke area physicians suggested that telehealth delivery mode for CME would lead to considerable cost savings for rural and remote physicians (~$4,340 per physician per year). The major component of these cost savings was the avoidance of lost earnings, which represents the loss of practice time used instead for travel and attendance. For practitioners with heavy patient loads and on-call obligations in rural and remote areas, these savings may represent more than just monetary savings. Assuming that CME by telehealth would replace all of out-of-town CME for

[12] Obtained from the Ontario Case Costing Program/Joint Planning and Policy Committee courtesy of PGH

the year, the estimated breakeven point, if all the potential savings would be applied to the Telehealth Program was 60-80 physicians per year. If only 50% of the potential savings would be applied then the breakeven point would be 120-165 physicians per year. Extrapolation to other locations was not justified given the nature of the data.

Recommendations

The following recommendations are made based on the results of the economic evaluation of the HEARRT Demonstration project and supported by a number of published studies.

Reduce equipment and communication costs. The experience in Newfoundland (Elford 1998) and other locations was that clinical need should drive the technology and that the system should be set-up using the least expensive equipment and cheapest communication links that will do the job. In order to reduce the cost of communication, consider arranging for pay-per-use fees rather than monthly fees. Alternatively, different users with different telehealth platforms may be able to use the same communication lines if arrangements are made to prioritize use.

Increase use of the system. Currently, cardiology is the predominant specialty provided through the hub site at UOHI. The level of use of the system will go up, if other specialties are brought on board. A good start has been made with the addition of rheumatology clinics between UOHI and PGH. Another line of activity worth exploring is the addition of more spoke sites. The system can also be used for non-clinical applications. In order to promote full use of the system, consideration should also be given to renting out facilities to users outside the health care system. We have demonstrated that moving towards full use brings down the average cost. Exploiting this finding will be critical in sustaining this technology over the long run.

Take a broad perspective in the economic evaluation. Taking a broader societal viewpoint in economic evaluation, as was attempted in this analysis, implies the inclusion of all the monetary, social and psychological costs and benefits of telehealth versus non-telehealth delivery of health care, education and other non-clinical use. These costs and benefits would include, for example, the potential savings realized by reduced waiting times, reduced need for transfer, more appropriate use of services, etc. In this evaluation, the potential savings realized by patients and health care providers through reduced travel, less time off work, etc., went a long way towards balancing the cost of the Telehealth Program.

In conclusion, the HEARRT Demonstration Project launched by the University of Ottawa Heart Institute has the potential to be operated in a breakeven manner. We understand that UOHI is already moving in this direction. UOHI is planning to increase the number of remote sites and increase the number of specialties offered by telehealth. As well, UOHI plans to reduce costs by using the most appropriate platform and pay-per-use communication links where and when available. All of this suggests that in an operational mode, the UOHI telehealth network can be economically viable. The long-term costs and benefits of telehealth projects in the health care system are uncertain but the weight of opinion is still in favour of telehealth, albeit with the need for continuing evaluation and assessment.

References

Bartolozzi, C., Caramella, D., Lencioni, R., Bassi, A. M., Moretti, M., Armillotta, N., and del Sarto, M. (1996). "Cost-effectiveness of intrainstitutional information exchange in the diagnostic and therapeutic management of hepatocellular carcinoma." *Academic Radiology* 3 Supplement 1:S77-S79

Bashshur, R. L., (1997). "Critical issues in Telemedicine", *Telemedicine Journal*, 3(2): 113-126

Bashshur, R. L. (1998). "Rethinking the Evaluation and Priorities in Telemedicine." *Telemedicine Journal* 4(1):1-4, 1998.

Bashshur, R. L. and J. Grigsby, (1995). "Position paper: Telemedicine effects: Cost, quality and access", *Journal of Medical Systems*, 19(2): 79-91.

Bashshur, R. L., Sanders, J. H. and Shannon, G. W. (eds.), (1997). Telemedicine: Theory and Practice. Springfield, IL: Charles E. Thomas Publishers

Brecht, R. M. et al., (1996). "The University of Texas Medical Branch - Texas Department of Criminal Justice telemedicine project: Findings from the first year of operation", *Telemedicine Journal*, 2(1): 25-35.

Cheung, S. –T., Davies, R. F., Smith, K., Marsh, R., Sherrard, H. and Keon, W. J., (1998). "The Ottawa telehealth project", *Telemedicine Journal*, 4(3): 259-266.

Drummond, M. F., O'Brien, B. O., Stoddart, G. L., and Torrance, G. W. (1997). *Methods for the Economic Evaluation of Health Care Programs*. Second edition. Oxford: Oxford University Press. Ch. 4.

Elford, R. (1998). "Telemedicine activities at Memorial University of Newfoundland: a historical review, 1975-1997." *Telemedicine Journal*, *4,* 207-224.

Grigsby, J., Kaehny, M. M., Sandberg, E. J., Schlenker, R. E., and Shaughnessy, P. W, 1995. "Effects and effectiveness of telemedicine", *Health Care Financing Review*, 17(1): 115- 131.

Grigsby, J. and Sanders, J. H., (1998). "Telemedicine: Where is it and where it's going", *Annals of Internal Medicine*, 129(2): 123-127.

Hassol, A., Irvin, C. Gaumer, G. Puskin, D., Mintzer, C. and Grigsby, J., (1997). "Rural applications of telemedicine", *Telemedicine Journal*, 3(3): 215-225.

Julsrud, P. R., Breen, J. F., Jedeiken, R., Peoples, W. Wondrow, M. and Bailey, K. R., (1999). "Telemedicine consultations in congenital heart disease: Assessment of advanced technical capabilities", *Mayo Clinic Proceedings*, 74: 758-763

Lobley, D., (1997). "The economics of telemedicine", *Journal of Telemedicine and Telecare*, 3: 117-125.

McCue, M. J., Mazimanian, P. E., Hampton, C., Marks, T. K., Fisher, E., Parpart, F., and Krick, R. S., (1997). "The case of Powhatan Correctional Center/Virginia Department of Corrections and Virginia Commonwealth University/Medical College of Virginia", *Telemedicine Journal*, 3(1): 11-17.

McIntosh, E. and Cairns, J., (1997). "A framework for the economic evaluation of telemedicine", *Journal of Telemedicine and Telecare*, 3: 132-139.

Office of Rural Health Policy. (1997). *Exploratory Evaluation of Rural Applications of Telemedicine*. Final Report. U.S. Department of Health and Human Services, Rockville, MD..

Phillips, C. M., Burke, W. A. Allen, M. H. Stone, D. and Wilson, J. L., (1998). "Reliability of telemedicine in evaluating skin tumors", *Telemedicine Journal*, 4(1): 5-9.

Preston, J., (1995). "Texas telemedicine project: A viability study", *Telemedicine Journal*, 1(2): 125-135.

Project Steering Committee, *Northwest Teleradiology Project: Evaluation Report*. 1998

Rendina, M., (1998). “The effect of telemedicine on neonatal intensive care unit length of stay in very birth weight infants”, *Proceedings of the 1998 American Medical Informatics Association Fall Symposium*, pp. 1-5

Rendina, M. C., Downs, S. M., Carasco, N., Loonsk, J. And Bose, C. L., (1998). “Effect of telemedicine on health outcomes in 87 infants requiring neonatal intensive care”, *Telemedicine Journal*, 4(4): 345-351.

University of Ottawa Heart Institute. (1998). “Healthcare and education access for remote residents by telecommunications (HEARRT): Business and Marketing Plan. UOHI, Ottawa, October 1998.

Watanabe, M., (1998). "Editorial: Telehealth in Canada", *Telemedicine Journal,* 4(3): 197-198*.*

Wright, D. R. (1998). “Telemedicine and developing countries: a report of Study Group 2 of the ITU Development Sector”. *Journal of Telemedicine and Telecare*, 4(supplement 2): 1-88.