ISSUES AND PROSPECTS IN TELEMEDICINE:

A Literature Review

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The views and opinions expressed in this document reflect those of the author, and do not necessarily represent the views and direction of the Department of Communications.

PREFACE

The general purpose of this document is to establish the salient features and characteristics of operational telemedicine systems, and incorporate these into a guide for the development of a Canadian telemedicine policy framework. It will serve to clarify what has been achieved in the field of telemedicine, by whom, how, and with what effects on the delivery of health care.

To the best of the author's knowledge, there is no single Canadian document to date containing the evolution, thrust, and impact of telemedicine systems as a whole, although many single experiments, projects, etc. have been reported. Canada is in the fortunate position of being able to learn from the American experiences in the field, and a concise summary of major events in telemedicine could enhance or at least facilitate this learning position. In this light, the document will concentrate on projects reported in the U.S., and their applicability to the development of telemedicine in Canada.

The Department of Communications is responsible for the development and implementation of national telecommunications policy. In so doing, it has the responsibility of assisting other departments and agencies, as well as other users, in utilizing telecommunications to achieve their respective aims. Policy development therefore encompasses the practical applications of telecommunications technology, systems configurations, and user needs. In the area of social policy, for example, the Department of Communications has the responsibility of developing policy that is responsive to social needs, within the confines of telecommunications applications. In the field of telemedicine, policy development should thus be geared to applications of technology in assisting service delivery agencies. The testing of technologies and systems configurations for the delivery of service are major functions in the development of social policies for telecommunications in Canada. Telemedicine is but one area that social policies must address; however, it is an area where the need is immediate.

TABLE OF CONTENTS

I INTRODUCTION

In recent years, the practice of telemedicine has become better known to policy planners and program managers. In its relatively short evolution it has been used for different purposes and has also often assumed varying definitions. Some define it as the use of two-way or interactive television to conduct transactions in the field of health care (Park - 1974), while others simply define it as the use of a communications medium (i.e., telephone) to assist health care delivery.

A) Telemedicine: A Definition for Canada

Interactive television for the delivery of health care does not exist in Canada, on a permanent basis, in an operational setting. Defining telemedicine in that context would therefore not be appropriate for this country. The most widely used communications medium for medical care delivery in Canada is the telephone. Particularly in remote areas, where physicians are often inaccessible and hospitals are as far from communities as 900 air miles, communications systems become a crucial and indispensible agent of service delivery. Also, due to the extreme distance between centers, interactive television requires satellite technology which is available but at extremely high costs. The telephone, therefore, is the basis for communications. However, it too is often dependent on satellite technology, again due to distance, climate, and terrain but at less cost than interactive television. The communities without telephone service by satellite are using HF radio which has long been found unreliable, of poor quality, and generally unsatisfactory, particularly for medical purposes.

One of the policy aims, therefore, is to provide reliable telephone communications to communities lacking this level of service, rather than provide interactive television to communities or hospitals who are already equipped with reliable telephone. To speak of operational interactive television for medical use in Canada, and particularly in remote areas, is to speak of futures research. The present aim is to formulate policy for short-term implementation. Though interactive television is definitely included in the practice of telemedicine, this author believes that it need not be a criterion for defining telemedicine.

For the purposes of this document, and as the document itself contends, telemedicine, as it applies to Canada, should be defined as follows:

> "Telemedicine is the use of any communications system to link two or more geographically separate points for the purpose of accomplishing medical tasks." (Foote, Parker, Hudson - 1976)

This type of practice (as described in the definition) is certainly not new. Physicians and other health care providers have been making use of communications systems for many years. What is new, however, is that telecommunications are beginning to be considered systematically; that is, as an integral part of the health care delivery system. New technologies are being explored for medical use, and perhaps most important, health care professionals are beginning to consider telecommunications as one of their tools to deliver service, and are amenable to exploring the potential of using telecommunications more extensively in their professional practice. This is true of most urban and

...3

rural areas, but nowhere is it more true than in remote areas of Canada where an effective communications system can replace extensive patient or physician travel and in fact save lives.

The above definition is sufficiently broad to satisfy other requirements that are applicable to the Canadian context. As basic as it is, it also allows for exploration and innovation in the field, since it contains three fundamental components that can range from very basic to quite elaborate. These are:

(1) communications systems
(2) geographical separation
(3) medical tasks

Communications systems in telemedicine can include HF radio, telephone (both audio and digital), picturephone, television (both one-way and interactive), as well as computers and other supporting equipment for transmission of medical data, such as telex, facsimile, slow-scan, etc.

Geographic separation can vary from an urban health clinic linked with a neighbouring hospital, to a remote nursing station linked with a hospital or health clinic as distant as one thousand air miles.

Medical tasks can also vary considerably. They can firstly include any level of medical service: primary, secondary, or tertiary. Medical services can include treatment, diagnosis, consultation, care management, patient management, supervision, monitoring, administration, training and development, preventive

...4

care, public health, and transmission of medical data. Medical services envisaged in telemedicine are not limited to the above practices, but these are the most common. Amongst the less common practices are ambulatory service using telecommunications, speech therapy, and dental care.

Clearly, the definition is flexible: from basic communications practices in the Canadian North to more sophisticated systems such as used in many of the American projects that will be reviewed in this document. It thus allows telemedicine policy and research to consider the basic needs of simple communications for medical purposes, as well as plan and explore the potential of more innovative and sophisticated communications techniques in health care delivery. Policies and programs can attempt to fill a basic immediate need and also contribute to long-range planning.

B) Goals and Objectives

Generally speaking, the varied telemedicine systems have similar goals and objectives. They usually fall within three broad aims:

(1) To render health care services more accessible to areas that are underserviced (in terms of both quality and quantity);

(2) To facilitate the task of medical care practitioners, by being able to handle a larger volume of cases without hindering the quality of service;

(3) To explore the potential of telecommunications technology as an additional available instrument for service delivery.

These widely encompassing goals remain to be thoroughly tested, particularly the effects and impact of telemedicine systems on the health care delivery system as a whole. In general, most telemedicine projects have been deemed as at least partially successful in achieving the goals and objectives cited above. Though the vast potential of telemedicine has been hypothesized and analyzed, strict criteria evaluation relating to health care systems in the aggregate has been somewhat lacking. Independent projects have been tested and evaluated, but a more comprehensive approach would enhance policy development and planning in the field. Program implementation could consequently proceed in a more widely applicable context. These observations are particularly true of Canada, though also valid with respect to the United States. The American experience in telemedicine has been much broader than in this country, and the field has had a stronger and longer evolution. Consequently, a comprehensive telemedicine policy, guiding the utilization of telecommunications in health care delivery, may be closer at hand in the United States than in Canada.

Nevertheless, Canadian goals in regard to telecommunications and health care delivery fall within the confines of those outlined above. Further, more emphasis is placed on service delivery to unserviced areas since Canada is much more sparsely populated than the United States, and therefore contains a greater number of remote communities with very limited medical facilities and service.

It should be stressed, however, that there are numerous isolated and unserviced communities in Canada that are not located in the far North, and in some cases are in greater need of amelioration of service than communities in the North. These communities require equal attention in developmental planning.

II HISTORY OF TELEMEDICINE

It is difficult to trace the early beginnings of telemedicine in the literature since historical accounts vary considerably depending on which definition of telemedicine is adhered to. For instance, some authors do not acknowledge telemedicine as such prior to 1959 when the first interactive television link was utilized in Omaha (Park - 1974). This link connected two institutions across the street from each other, and was used "to confirm and utilize the mutuality of their missions in teaching and therapy, as well as to promote discourse between psychiatry and other medical school disciplines". This link was between the Nebraska Psychiatric Institute (Department of Psychiatry) and the Department of Anatomy at the University of Nebraska College of Medicine.

It is accepted, however, that communications systems were used in medical practice prior to this date. Dr. Cecil Wittson, who was the initiator of the above mentioned link (1959) also had some experience in the early fifties with long distance telephone consultations and conferences involving health professionals throughout Nebraska, as well as inter-state. In short, the telephone has served medical practitioners in some capacity almost since its early years of existence.

Some authors (e.g., Bashur & Armstrong - 1975) choose to divide the development of telemedicine into three evolutionary stages:

1) The first phase was comprised of experimentation in the clinical applications of telecommunications. These varied experiments demonstrated that

...7

a wide scope of medical and clinical tasks could be successfully performed using telecommunications. This experimentation stage is generally understood as prior to 1969.

2) As a result of these successful technological demonstrations, more thought and effort began to be concentrated on the administration and organization of telemedicine systems. Other operational issues, such as manpower requirements, the varying roles of different manpower levels (e.g., non-MD's) also surfaced during this phase. This orientation molded the second developmental stage, 1969 - 1973. This phase also featured a number of widely encompassing research projects, aiming at testing operational systems as well as exchanging experiences and knowledge amongst participants. Thus, this stage was marked by a sense of cohesiveness amongst the telemedicine projects and their participants. Many research and demonstration projects in this phase were made available through government support and sponsorship. The Health Care Technology Division in the Department of Health, Education and Welfare, for example, funded seven distinct telemedicine research projects in 1972 (Bashur - 1975).

3) The third stage is said to have started in 1973. It is characterized by the belief that telemedicine is an innovative mode of medical care delivery, and is inherent in the health care delivery system. A major shift in operationalization methods is featured in this stage, characterized by two goals becoming paramount:

(1) That telemedicine systems become self-supporting or at least economically viable on their own;

(2) If the above can be achieved, then the permanent operationalization of systems can be greatly facilitated and telemedicine can become truly inherent in the health care delivery system.

These goals are largely dependent on rigorous evaluation of telemedicine projects, and the third stage has shifted towards this. It is generally believed that evaluation of telemedicine must follow the concepts and methods of evaluation in the medical care field (Bushur & Armstrong).

Perhaps the most important notion in this third stage, as outlined by various authors, is the look into the future. A first observation points to the fact that telecommunications are gaining much acceptance in the medical field as an instrument of service delivery, and telemedicine, as an aggregate system, may soon be seen as an inherent necessity within the health care system. A second observation reinforces the belief that telemedicine systems must become self-sufficient. According to some, new trends in telemedicine can mold a system that will generate revenue and make this mode of delivery viable for the future (Bushur & Armstrong - 1975).

In the United States, the three pioneer telemedicine locations were the <u>University of Nebraska</u> (mentioned earlier), <u>Massachusetts General Hospital</u>, and <u>Dartmouth Medical Center</u>. The Massachusetts General Hospital (MGH) initiated a link with the Logan Airport in 1962, due in large part to an airplane accident causing several deaths and injuries, due to the lack of emergency medical services at the airport. This sparked Dr. Kenneth Bird of the MGH to initiate emergency medical facilities at the Logan Airport and link it with the MGH. From 1962 - 67 the mode of communication between the two sites was the telephone and two-way radio. In 1967 an interactive television system was installed, via microwave, for the purposes of consultation and diagnosis. The MGH/Logan Airport link is one of the most important early programs in telemedicine because it was the first program to use telemedicine in physical diagnosis and patient care. Its effects were therefore extremely instrumental for the development of telemedicine. The MGH/Logan Airport link remains operational as of this day.

At Dartmouth Medical Center a telemedicine link (ITV) between the Center's Hitchcock Hospital and Claremont General Hospital, 25 miles to the south, was initiated in 1968. The project was originally funded by the National Institute of Mental Health, and had two main objectives:

(1) To evaluate the utilization of television in psychiatric interviewing and consultation;

(2) To evaluate the effectiveness of readily available psychiatric consultation as an educational program for physicians in the community (Park - 1975).

These three pioneer projects were to spark several telemedicine projects in the years to come, including the expansion of their own telemedicine networks. In December, 1969 three Veterans Administration Hospitals in Nebraska entered the network at the University of Nebraska Medical Center. VA hospitals in Grand Island, Omaha, and Lincoln were linked together as well as with the Medical Center and Psychiatric Institute which had begun their telemedicine link in 1959. In March, 1970 the Massachusetts General Hospital expanded its original

...10

telemedicine link with Logan Airport to include the Bedford Veterans Administration Hospital. The objective was to study and demonstrate the feasibility of specialized tele-consultation as well as continuing the objective of the original network: delivering patient care service. The network thus connected all three locations via interactive television and remains active and in constant use.

The Dartmouth Medical Center also expanded its telemedicine network. In June, 1971 the University of Vermont Medical Center at Burlington and the Central Vermont Medical Center at Berlin were included in the network. Thus, with the existent link between Dartmouth and Claremont, New Hampshire, the expansion represented the first inter-state telemedicine network.

In 1972, ten of eleven new projects were funded by the American Federal Government, and seven of these were funded by the Health Care Technology Division (HCTD) of HEW. The National Science Foundation funded a telemedicine project to provide health care delivery to correctional institutions in Miami, Florida (1974). NASA prepared plans for satellite telemedicine systems in Alaska, the Northwest and the Southwest. The Veterans Administration planned for various new telemedicine links amongst its hospitals. In short, widespread interest in telemedicine and its potential began to flourish, and agencies of various sorts began funding projects. The HCTD was probably the "leader" of funding agencies at that time, since it directly funded seven distinct projects. This funding effort as well as HCTD's overall program in communications for health care delivery systems was labeled the Logistics Program. The program was divided into three phases which closely correspond to the historical outline above. These were:

Phase I

Exploratory phase to hopefully fund useful applications of Communications technology in health care delivery systems.

Phase II

An operational phase which would generate data regarding technology, medical service, acceptance, alternate technologies, etc.

Phase III

This phase represented the ultimate objective of the program - "to analyze and create cost-effective communication and transportation networks for a number of different health care delivery system modes." (Park - 1974)

The present state of the art in telemedicine is congruent to Phase III in HCTD's Logistics Program.

TELEMEDICINE DEVELOPMENT IN CANADA:

In Canada, telemedicine programs have not been as numerous as in the U.S., and video projects remain wholly experimental. The above outline is applicable, nevertheless, since Canada must also look into the future at ways and means by which to render telemedicine economically feasible and self-sufficient. Though the technologies may differ at present (e.g., audio vs. two-way video), developments should aim at the same goal: integration into the health care delivery system. There are many advantages to achieving this goal, as outlined earlier, but perhaps the salient one in Canada is to make medical care more accessible to areas that are unserved or ill-served.

Reliable communications systems have been a major goal for Northern and remote health care providers for several years. Prior to satellite communications in Canada's north, all voice communications were dependent on HF radio telephone, with the exception of a few locations using tropospheric scatter systems. With the advent of Telesat Canada's Anik I satellite launched in 1972, telephone service by satellite reached the far north by February 1973. Today there are approximately 30 isolated communities in the north serviced with reliable telephone communications via satellite. In addition, the Federal Cabinet recently approved the Northern Communications Assistance Plan (NCAP), which will provide basic telephone service to some 28 communities in the NWT over the next five years. This type of progress in communications development can bear great impact on the health care delivery system in Canada's North.

The CTS (Hermes) Telemedicine Experiments:

In January 1976, the Communications Technology Satellite (CTS) was successfully launched. This more powerful satellite has the capacity to transmit two-way television signals from small ground stations, which has obvious implications for telemedicine.

As a result of the DOC extending invitations to a wide variety of potential users to experiment with the CTS during its two-year life span, several experiments exploring the social applications of the satellite have developed. Of these, three distinct experiments are specifically concerned with telemedicine.

1) The first is being conducted by the University of Western Ontario in London, and features a telemedicine network linking the U.W.O. Hospital with

...13

a small base hospital in Moose Factory, and a nursing station in Kashechewan. Moose Factory and Kashechewan are small communities in northern Ontario situated just south of James Bay. The link firstly consists of a telephone system, with conferencing capability, linking all three sites. This system also features speaker-phones, telecopiers for document transmission and EKG telephone telemetry units. Secondly, there is a one-way video and two-way audio link from Moose Factory to London. The video link is at the option of the medical staff in London, and they are able to remotely control and switch two cameras in Moose Factory. This system is used for a variety of experiments including transmission of x-rays, ultra sound images and microscopic slides, and remote supervision of anesthesia and psychiatric counselling. One of the audio channels is also used for the direct transmission of signals from an electronic stethoscope. This experiment is scheduled to terminate at the end of February '77.

2) The second CTS telemedicine experiment will be conducted by Memorial University in St. John's, Newfoundland, and will feature a one-way video, two-way audio link between the University Health Center and six remotely located communities in Newfoundland and Labrador. The crux of the experiment will be in the area of continuing medical education for physicians and other health professionals practicing in remote areas. The objective is to test the feasibility of this type of system as an alternative to the traditional methods which involve either the teaching doctors travelling to the remote areas or the remote area physicians travelling to St. John's. This type of arrangement is both costly and time consuming. The second segment of the experiment will concentrate on medical data transmission and consultation. Electro-cardiograms, x-rays and vital signs will be transmitted. The objective here is to determine

whether first line medical care can be significantly quickened and improved, again at savings in time and money. Aside from the CTS experiment, the Memorial Health Center is also making use of a two-way audio/video microwave system linking the Health Center with St. John's General Hospital. Various forms of tele-consultation and tele-diagnosis have been conducted via this system, as well as transmission of x-rays and some continuing education programs for nurses. This system is presently on-going and is due to remain operational following the CTS experiment, scheduled to begin in March '77.

3) The first of two phases in the third CTS telemedicine experiment has been conducted by the Ministry of Health in collaboration with the Ministry of Communications, Government of Ontario. The system consisted of an audio conferencing link between Toronto, Dryden and Sioux Lookout hospitals. Conferences concerning radiology, orthopedics and cardiology were successfully held involving all three sites. In addition, a simulated emergency evacuation from Pickle Lake, Ontario to Sioux Lookout Hospital was conducted, during which the patient's vital signs were monitored in Sioux Lookout and Toronto.

The CTS is somewhat of a catalyst in the practice of telemedicine in Canada, firstly because the Telemedicine Experiments form the first thrust of sizeable proportions to look at telemedicine systems and their applications in an operational setting. Secondly, these experiments are testing the technical, medical and social feasibility of various medical applications of telecommunications systems, which will be extremely useful for future developments in telemedicine. Hence the evaluation of these experiments is extremely important for the success of telemedicine experimentation in Canada.

...15

Other Canadian telemedicine endeavours exist at the University of Waterloo under the auspices of Drs. David Conrath and Earl Dunn (testing alternate communication modes for remote diagnosis), and at l'Hôpital Sacré-Coeur of Montréal under the directorship of Dr. F. Roberge.

...16

III TELEMEDICINE FEATURES & APPLICATIONS

In order to understand telemedicine and its various features, it is imperative to understand the overall health care system in which it functions.

Generally speaking, health care systems are comprised of three levels of care: primary, secondary and tertiary. The primary care level consists of care being administered by individual nurses, nurses' aides, individual physicians, etc.. The secondary level caters to the administration of care through small base hospitals, clinics, group practices, etc.. The tertiary level of care represents large, highly specialized hospitals, university medical research hospitals and institutions. In this manner of organization, the system is centralized at the level of highly skilled and specialized resources, and decentralized at the primary care level to provide the greatest possible public access. As a result, the vast majority of cases enter the system at the primary level and depending on the seriousness of the situation are either treated at that level or referred to the next level. Both treatment and referrals are largely dependent on communication and consultation between the levels. Communication links thus become vital for the operation of the entire system. This is the area in which telemedicine has direct applications.

In urban areas, telecommunications can save valuable time for both consultative treatment and referrals, as well as ease and facilitate various administrative duties.

...17

The need for telecommunications is amplified in rural and remote areas for reasons of distance, difficult transportation, climate, and low physician-population ratio. Further, it is imperative that communications systems be reliable and of high quality in these regions, since these are often the only means available for interaction amongst the levels of care. Unfortunately, similar factors to those making effective telecommunications paramount, also render their development and implementation difficult and costly.

It is thus within the above "systems" context that telemedicine systems operate. They can be effectively applied for treatment, consultation, diagnosis, information and data transmission, administrative matters, and countless other purposes inherent in health care service delivery.

A) Tele-consultation:

Consultation is one of the most prevalent activities in almost all aspects of medicine, be it concerning treatment, diagnosis, referrals, research or matters of administration. It occurs within and amongst all levels of the medical service system, as well as amongst all levels of health care providers. Consultation is undoubtedly an integral part of providing medical and health services.

When distance, time and other constraints dictate that face to face consultation is unavailable, often the best alternative is to consult via a telecommunications system. Various systems have been used for this purpose, ranging from two-way radio to interactive television.

Teleconsultations can be held in a number of medical settings. The traditional physician-to-physician consultation is of course extensive, as well as nurse-physician, nurse-nurse, and other health care providers. In remote areas, for instance, the occurence of nurse-physician consultations is necessarily more frequent since nurses are the principle health care providers in small isolated communities and settlements. The great benefit of these types of consultations is the widening of access to professional and specialized physician care.

One of the ways of measuring the success or adequacy of teleconsultation systems has been to compare its effectiveness to face to face interaction. Advantages and constraints are then identified according to the comparison. This method of evaluation, however, has proved somewhat inadequate for several reasons. Firstly, teleconsultation is an alternative to face to face interaction and should therefore not be compared to the "ideal" condition. Secondly, it is clear that teleconsultation does contain some constraints, particularly for diagnosis, since there are only one or two human senses operating: sight and/or hearing. This type of consultation cannot be compared to the situation where all of both consultants' senses are active in the consultation. Thirdly, the success or failure of teleconsultations depend largely on a wide variety of "exterior" factors, such as necessary preparation by both consultants, familiarization with the equipment, administrative and organizational arrangements, previous exposure to this type of consultation, and patient as well as professional attitudes towards it. Finally, teleconsultations should be measured in terms of their benefits and constraints in relation to the health care system as a whole and ultimately to the delivery of services. Benefits of teleconsultations only make themselves felt when face to face interaction is unavailable or difficult to achieve.

In this context, the benefits center around reduction of patient and physician travel, greater accessibility to professional care, faster second medical opinion in the event of emergencies, greater professional support and backup, less professional isolation, quicker transmission of routine medical and/or administrative matters, and in short a possible reduction in time and costs involved in health care delivery.

Constraints facing teleconsultation can be aggregated into four major categories of causes:

(1) the technology

(2) the content of the consultation (e.g., particular cases or tasks may not be conducive to telecommunications interaction)

(3) the people (i.e., physicians', nurses', other professionals', and Patients' attitudes, perception, and ability with the system)

(4) administrative and organizational arrangements

Within the telemedicine experiments funded by DHEW mentioned earlier, results showed that teleconsultation was generally desirable. (O'Neill, Nocerini, Walcoff, 1975).

1) The Cambridge Hospital Project, involving three neighborhood health stations linked via IATV with the hospital, demonstrated that teleconsultations increased the accessibility of professional attention, increased the amount of information available for medical decision-making, provided re-assurance and support to the providers in the health stations, therefore decreasing the sense

...20

of isolation. Other benefits included the reduction of immediate physician referrals, a more organized approach to patient care management, and a shorter appointment waiting time.

Some of the problems encountered were minimal system training, poorly located equipment, excessive wait time from consult initiation to consult commencement, distance to studio in hospital basement burdensome; in sum, poor organizational and administrative arrangements and preparations. In general, it was found that these problems became minimal once the system was operational.

2) The Case Western Reserve University Telemedicine in Anesthesia Project, also found various advantages and problems. This is an interesting project to review since it was concerned with the applications of teleconsultation for treatment. It consisted principally of a single anesthesiologist located at the Care Western Reserve University Lakeside Hospital supervising the procedures of a nurse anesthetist in a surgical room at the Veterans Administration Hospital, via a two-way laser-beamed television link. The major benefits found were that it gave access to medical consultation where it was not previously available, freed the nurse anesthetist from medical decision-making, generally improved the quality of care particularly in emergency situations, improved training environment for nurse anesthetist, and generated closer teamwork between health care providers. This last point is a very important one as it relates to the distribution and deployment of medical staff, which is a major factor in the accessibility of care issue.

Problems encountered in this project centered around problems of technology and administration. It was found that the reliability of the system was unsatisfactory, that conventional TV resolution was not adequate for reading anesthesia records, and that remote stethoscope signals were unsatisfactory. Concerning administrative matters, it was concluded that the paging system used to locate physician consultants was not acceptable, scheduling of patients to operating room proved to be a difficulty for the co-ordination with the teleconsultation. Other unresolved problems were found to be of a financial and legal nature. These will be addressed in a later section of this document.

3) Another project of significance in teleconsultation is the INTERACT project - New Hampshire/Vermont Interactive Medical Television Network. Interact links seven institutions in New England by way of a two-way microwave television and telemetry. The project was concerned with two areas of consultation: speech therapy and dermatology. The results of this experimentation clearly showed a wide acceptance of the telecommunications system, and in the speech therapy segment it was expressed that the teleconsultation mechanism was as successful as face to face interaction. The consultant therapist did not feel that the television link impinged upon the rapport with the children being treated, nor did the speech consultation require an unacceptable commitment of professional time. (O'Neill, Nocerino, Walcoff, 1975). In the dermatology segment of experimentation, the consulting dermatologist concluded that: (O'Neill, Nocerino, Walcoff, 1975).

(1) In every case (131), she felt that she was in control of the consultation.

(2) Supervision was adequate although in some cases it was frustrating to direct verbally rather than the "hands on" situation.

...22

(3) Inactivity (remaining in the same sitting position during the consultation) was the most serious limit to the television clinic.

(4) Remote consultations required no additional time, but the availability of only one examining room caused delays.

(5) All lesions were discernable and color transmission was helpful.

4) An evaluation study of the Logan Airport - Massachusetts General Hospital project revealed that of the first 200 patients to be seen on the video teleconsultation, 96% had been diagnosed correctly and only 1% of the cases produced diagnoses that were deemed "not satisfactory". (Foote, Parker, Hudson, 1976). Though this is more relevant to a purely diagnostic environment, it nevertheless demonstrates the successful applications that teleconsultation can have.

The above projects all had at least one characteristic in common: they all contained at least one interactive television link. It has been demonstrated elsewhere, however, that voice only teleconsultations can also be very effective with a high rate of success. The ATS-1 Alaska Satellite Experiments, for example, clearly demonstrated that voice links can provide physicians and other professionals with much needed consultation at a high level of acceptance, effectiveness and efficiency. However, the voice link must be of high quality and reliability for the consultation to be useful. In a "before-after" satellite radio installation comparison, the ATS-1 experimenters found that in some satellite villages the number of cases managed by satellite radio showed almost a 300% increase over the previous year when only HF contact was available. (Kreimer, 1974). Thus, it is imperative that voice only consulta-

...23

tions be of high quality and reliability. This has direct implications for the present communications uses for medical care in Canada's remote areas.

Other projects related to the extension of medical services to remote areas are the ATS-6 experiments; notably the Veteran's Administration Appalachian Experiment, and the Alaska ATS-6 Biomedical Demonstration. It is of some importance that emergency cases were more prevalent (proportionally) in these experiments than in other less remote experiments, although the frequency of emergency situations was still low. This factor may bear meaning on the value of second medical opinion for isolated health care providers in comparison to the more centrally located personnel.

The ATS-6 Biomedical Demonstration Experiment recorded over 300 medical consultations during the period of 104 scheduled transmission days. (Foote, Parker, Hudson, 1976). The average duration of these was approximately 12 minutes. By comparison, radio consultations last about 3 minutes with health aides and 6 minutes with physicians. (Foote, Parker, Hudson, 1976). It was also calculated that 43% of consultations were concerning acute problems, 44% were follow-up of acute problems, and 13% were concerning chronic ailments.

In sum, teleconsultation encompasses a wide variety of medical tasks and purposes and is to a large extent dependent upon factors of technology, user needs and attitudes, administrative arrangements, and of course, the content of the consultation.

...24

Perhaps the most appropriate summary of teleconsultation has been put forth by Maxine Rockoff (1975). She outlines some of its major functions as follows;

(1) reduces health care provider uncertainty, as when the consultant affirms the provider's diagnosis or treatment plan.

(2) saves patient travel to another health care site, or otherwise improves his "trajectory" as he moves through health care system during an episode of illness (e.g., primary level to tertiary level).

(3) induces patient compliance.

(4) increases quality of care by bringing additional expertise to a provider/patient encounter.

(5) increases continuity of health care as a patient moves between health care delivery sites or levels.

(6) improves distribution of physicians and specialists.

(7) allows for remote supervision which permits a lesser-skilled health worker to substitute for a higher-skilled one, again improving the distribution and deployment of staff.

B) Telediagnosis

Diagnosis is perhaps the most widespread use of teleconsultation. Telediagnosis can take place between two physicians, a physician and a non-physician health care provider, between a nurse and another nurse, or an aide, etc.. It has also been demonstrated that telediagnosis can be performed as a teleconference. Whether only two persons or more are included in the diagnosis, the basic goal is the same: to diagnose a patient from a distance. The patient may or may not be present. Telediagnosis is thus that type of teleconsultation that concentrates specifically on the diagnosis of a patient.

Several kinds of medical conditions can be diagnosed through a telecommunications system. Various technologies, including support equipment, have also been deemed feasible for diagnosis. One of the most renowned institutions for the practice of telediagnosis is the Massachusetts General Hospital. Some of the procedures that have proved feasible via their interactive television system are:

(1) tele-radiology, (2) tele-dermatology, (3) tele-auscultation, (4) telepsychiatry, (5) speech therapy. (Bashur, Armstrong, Youseff, 1975).

(1) Tele-radiology, or transmission of x-rays, has been widely experimented with. Its success has been reported to depend on two primary factors: the technology used and the radiologist's attitude or adaptability to the process. Even though in some instances the technology may be deemed adequate, teleradiology is one area where physician acceptance has been mixed. Some physicians insist that the quality of transmission is not sufficient to allow exact reading and interpretation of the x-ray while others maintain that practically all types of x-rays can be accurately read, therefore enhancing rather than hampering diagnosis. The acceptance or rejection of x-ray transmissions is greatly dependent on the technology employed. In addition, it was shown in studies (Andrus, Bird) that physicians are sometimes forced to change the way in which they read x-ray images. They must adopt a 'systematic scan pattern' and make extensive use of the camera's zoom lens. The problem is essentially one of limited resolution, and the zoom lens maximizes the resolution.

...26

One project at the University of Nebraska transmitted still pictures of x-rays by slow scan via telephone lines. The ATS-6 Veterans Administration Experiment also successfully transmitted x-ray images via slow-scan. Reports have shown that although the system can be adequate for many diagnostic purposes, the image is sometimes lacking in clarity and precision. The great benefit of using slow-scan for x-ray transmission is its relatively low cost. The cost of using telephone lines is obviously much less than that of transmitting at full video bandwidth. In Canada, x-ray transmissions have been very successful in the University of Western Ontario - Moose Factory CTS Experiment.

(2) One of the areas which has been demonstrated as one of the most successful applications of tele-diagnosis is dermatology. Several experiments and studies have found that tele-dermatology was entirely feasible. (e.g., MGH-Logan Airport, Interact, Murphy and Bird, 1974, Zinser, 1975). The key feature of dermatological diagnosis is inspection. These and other experiments have concluded that accurate inspection is indeed possible via television. Although the black and white vs. color television dichotomy has been an issue, it was also shown that in most cases black and white TV is sufficient for accurate inspection and diagnosis.

(3) Another area of proven feasibility is auscultation. Tele-auscultation is performed with the use of an electronic stethoscope and transmits heart and chest sounds. Generally speaking, most experiments in tele-auscultation are deemed useful and successful, but there are inherent constraints. By virtue of the fact that the faintest murmurs should be heard for an accurate diagnosis, this may pose technical problems. For example, the Lakeview Clinic Project

...27

reported difficulties in tele-auscultation mostly due to slight distortion of sounds and/or "extra" sounds heard by the physician and therefore hampering his diagnosis.

(4) Psychiatric diagnosis has been undertaken and tested in a wide variety of projects, and the results show that it is one of the most successful applications of tele-diagnosis. Amongst the most notable tele-psychiatry projects were: Massachusetts General Hospital - Bedford Veterans Administration Hospital Project, New Hampshire/Vermont "Interact" Project, Illinois Mental Health Institute Picturephone Project, and the Nebraska Psychiatric Institute - University of Nebraska College of Medicine link mentioned earlier. The results of these and other projects are unanimously in support of tele-medicine in the field of psychiatry (both for diagnostic and treatment purposes). All experimenters concluded that no significant differences between tele-psychiatry and face to face psychiatric diagnosis and treatment were discernable. As one author expressed: "Television has presented almost no difficulties as a medium for psychiatric consultation. It has not proved to be a significant barrier in establishing rapport with the patient or in perceiving emotional nuances". (Claremont Hospital, "Interact" Project).

(5) A less widespread but nonetheless successful practice of tele-diagnosis is in the area of speech therapy. The most renowned telemedicine project in speech therapy is the MGH - Bedford VAH Project. After dealing with over 30 patients, the speech pathologist concluded that "the intimately personal nature of therapy is not reduced and in fact may be enhanced by interactive television.........IATV may even enhance face to face communications. Non-verbal

...28

communication is not only clearly seen and appreciated, but may also be augmented". The New Hampshire/Vermont "Interact" Project which incorporated speech therapy experiments also responded very favourably to this type of practice.

The above-mentioned applications of tele-diagnosis are those that have been tested in an operational setting. The practice of tele-diagnosis encompasses far more uses and applications, however. In fact, a fairly complete physical examination can be performed via interactive television. Those aspects of an examination that are dependent on inspection and motion of a part of the body are reported as easily conducted in tele-diagnosis. (Park, 1974). Diagnosis of surface anatomy has also been marked with success. The greatest area of difficulty is the type of diagnosis that involves percussion and palpation. As mentioned earlier, these diagnoses have been performed, but they have generally been less accurate than other types. The help of diagnostic support equipment has rendered the practice more feasible, however.

The nurse clinician at the remote site also plays an indispensable role in the practice of tele-diagnosis and subsequent delivery of treatment. The remotely situated nurse usually conducts a preliminary examination and diagnosis and can therefore quicken the process considerably upon consultation with a physician. The nurse can direct the physician directly to the problem without need for preliminary examination. In addition, if the case involves a returning patient, she can review the patient history and quickly relay the appropriate facts to the consulting physician without any unnecessary delay. It is also in this domain that administrative arrangements become crucial and can save valuable time. The remote nurse clinician occupies a very active

...29

position in the diagnosis during the consultation. She can help to position the patient at the physician's request, as well as provide substantial reinforcement for the physician in visual and/or hearing matters. In auscultatory cases, for example, she can assist the physician by placing the stethoscope in the desired position, as well as listen to the palpations and murmurs along with the physician. She can then reinforce the physician's diagnosis, and negate "foreign" sounds that the physician could hear on his distant stethoscope, as was reported in some tele-auscultation projects. In numerous applications, tele-diagnosis would not be possible without the remote nurse clinician's active participation in the diagnosis itself as well as its preparation.

Another often indispensable condition for accurate tele-diagnosis is the use of diagnostic support equipment and data transmission.

C) Data Transmission:

The transmission of medical data is one of the features of tele-medicine that is sometimes undermined, although its effects are noticeable in almost every aspect of telemedicine. These can range from routine administrative matters such as the transfer of patient records to the transmission of diagnostic data using diagnostic support equipment.

1) Diagnostic Support Equipment:

Diagnostic aides are used routinely in face to face diagnoses, and if telemedicine is to provide a reasonable alternative to direct diagnosis and

...30

care, it must incorporate these aides into the system. Amongst the most widely used diagnostic aides are electrocardiograms, x-rays and stethoscopes.

a) Electrocardiograms:

Of the three mentioned, the transmission of electrocardiograms has had the most success. Several projects transmitted electrocardiograms, and all reported the practice to be feasible and useful. Electrocardiographic transmissions from one project were reported as having less than a 2% variation in magnitude of the recorded wave form. (Murphy and Bird, 1974). This transmission was performed via microwave, but other ECG transmissions have been successfully performed via telephone lines. (Holsinger and Kempner, 1972). Transmission of ECG's were also found successful and widely accepted in the ATS-6 Satellite Biomedical Demonstration in Alaska. (Foote, Parker, Hudson, 1976).

b) Electronic Stethoscopes:

The use of electronic stethoscopes has not had the same degree of success. In most projects reported, physicians identified several constraints inherent in using this device. Most of the difficulties centred around the quality of the transmission. Physicians frequently complained of hearing "foreign" sounds, or of momentarily losing palpation sounds, or of static interference. In the ATS-6 project, for example, the electronic stethophone was deemed as completely unsatisfactory. Other more successful attempts at using an electronic stethoscope have been reported, however. The Massachusetts General Hospital Telemedicine Network, for instance, reported that although

...31

some constraints were found, the practice was generally feasible. In testing the practice, the experimenters compared the results of in-person and tele-auscultation of heart murmurs. They found that all murmurs of grade 2/6 or higher were heard satisfactorily through the electronic stethoscope, but two grade 1/6 murmurs were detected in the in-person mode and missed in the tele-auscultation method. Another study (Hastings and Dick, 1975) concluded that a telephone line link could not transmit sounds in the frequency range of 150 to 50 cycles per second, which are the frequencies at which initial murmurs and extra heart sounds are heard. Similarly, the ATS-6 project concluded that a very high quality channel would be required for effective use of an electronic stethophone. (Foote, Parker, Hudson, 1976).

c) X-rays:

The third diagnostic aide mentioned, x-rays, has had the most wide-spread experimentation in telemedicine systems. As mentioned earlier, x-ray transmissions are extremely vulnerable to the type of technology utilized. The Massachusetts General Hospital deemed tele-radiology entirely feasible after conducting four separate tests of their microwave link. Slow-scan transmissions have also been found successful in a number of projects, notably the ATS-6 Veterans Administration Experiment and the University of Nebraska. Although there are certain inherent constraints in x-ray transmissions, such as those outlined earlier, most experimenters have responded favourably to this practice. As a result, it has gained considerable support for experimentation. The Canadian CTS experiment at the University of Western Ontario, for example, is testing the feasibility of x-ray transmissions through a one-way video link.

A number of other supplementary diagnostic aides have been used in telemedicine systems, though not as frequently as the three outlined here. These include the transmission of electroncephalograms, gamma scintigram pictures, microscopic slides, and ultra-sound images.

2) Other Medical Data:

Aside from diagnostic support equipment there is a considerable amount of other medical data that can be transmitted via a telemedicine link, and which often enhances the functioning, efficiency and effectiveness of the entire system. Amongst the most widely used data transmissions are transmission of patient records, document transmission, results of laboratory tests, physical examination results and a variety of administrative data such as the ordering of supplies, financial data, personnel data, and so on.

Perhaps the most beneficial aspect of data transmission is the rapid and easy access to necessary information within the telemedicine sites. Data can be stored and later retreived for immediate use. In essence, data transmission provides an information system that can be utilized for patient management decisions, information-sharing, as well as the administration of the delivery of service. Though medical data transmission between two sites is useful, it is especially beneficial if the link is between all sites involved in the telemedicine network. In such cases, a data bank is built, from which information and data can be retreived and transmitted to any of the network sites. The result is an information system for the entire telemedicine network.

Technologies vary in the transmission of data but most document-type data as well as administrative data can be easily transmitted via a narrow bandwidth. Facsimile, telecopies, telemetry and slow-scan are examples of narrow-band technologies that have been used.

A substantive amount of conclusive results have been derived from various projects involved in medical data transmission. The Bethany Brethren/Garfield Park Community Hospital Project in Chicago, for example, considered the transmisson of medical and financial data as one of its foremost objectives. The technology used in this experiment was Picturephone with a video bandwidth considerably reduced from that of standard television. This was found suitable for most types of data transmission, with the exception of x-rays and medical documents. The resolution was found unacceptable for satisfactory x-ray transmission, and the small image size on the Picturephone (5" x 5½") proved to be unsatisfactory. On the other hand, microscopic image transmissions were found to be highly accurate, as well as sophisticated laboratory results.

The ATS-6 Biomedical Demonstration project in Alaska featured a Health Information System (HIS) which was used by health care providers. HIS was essentially a medical problem oriented record keeping system for the entire community being served. All entries were computerized and stored on disc and tape in Tucson, Arizona. Patient record summaries were then made available on microfiche at each site of the project. (Foote, Parker, Hudson, 1976)

Most benefits of data transmission in telemedicine systems can be grouped into two categories: <u>medical</u> and <u>organizational</u>. The rapid access

...34

to patient records, laboratory results, etc. greatly enhance the quality of service delivered via telecommunications network. Within the organizational sphere, data transmission can facilitate and quicken referrals, admissions, and financial data processing to the business office. One benefit which was reported by the Bethany/Garfield Project staff was that quick data transmission enables emergency room personnel to admit patients into the hospital while continuing patient care.

One area of organizational and administrative benefits of data transmission systems that is directly applicable to delivering health care to remote areas of Canada is the ease and rapidity with which travel and evacuation arrangements can be made.

D) Education:

Medical education via a telecommunications system is a facet of telemedicine that can have far-reaching implications. Educational applications can range from continuing professional education for medical practitioners of all levels to programs in public health education and preventive care.

Accessibility to continuing education is greatly enhanced by telecommunications for health care providers situated in remote or rural areas. Aside from the benefits of upgrading professional skills, continuing education contributes toward combatting professional isolation. Better accessibility to medical education can also influence the maldistribution of physicians across rural and remote areas. Extension of continuing education to physicians practicing in remote and rural areas can also greatly reduce travelling (by either the student physician or the teaching physician), and therefore provide considerable cost as well as time savings.

One of the very potent effects on the extension of medical education via telecommunications has been the training of non-physician medical care providers. Not only does this result in a greater influx of trained non-physician providers, but it also improves the quality and expertise demonstrated in their work. This is of great importance for health care delivery in remote areas since these are mostly staffed with non-physician personnel. Nurses, for example, are the principal health care providers in the Canadian north, and they must therefore perform numerous tasks and assume responsibilities that would normally be delegated to physicians. Continuing education for nurses can occupy a potent role to sustain and often enhance the nurses' expertise as well as the necessary confidence in performing the work.

By virtue of the fact that tele-education in medicine greatly increases access to medical training, it can also act as a potent decentralizing force. That is to say, with the advent of extension of medical education to previously unserved regions, it is conceivable that more local or regional people can be trained in all levels of medical practice and thus possibly enhance medical service delivery in their respective region. In addition, greater emphasis is now being placed on preventive care, and the extension of public health education programs are forming the core of an effective preventive care effort.

Although there are several telemedicine projects that have either partially or totally dedicated themselves to some form of medical education, amongst the most noteworthy is the ATS-6 WAMI Project. The name is derived from the fact that the interactive telecommunication system used in the project provided medical education and linked a region that is comprised of four states: Washington, Alaska, Montana and Idaho. The project consisted of two phases: the university phase, and the clinical phase. The university phase was designed to provide the basic science courses of a medical program to first-year medical students whose universities did not have medical schools. The extension of courses was mainly directed at rural communities in the WAMI region. The clinical phase allowed the third or fourth year student to return to his/her rural community and undergo clinical training from selected clinical teaching sites. The WAMI satellite projected involved three principal teaching sites: the University of Washington at Seattle, the University of Alaska at Fairbanks, and the Family Medical Centre and Mid Valley Hospital at Omak, Washington. The communication modes used were 2-way audio-visual in color between Seattle and Fairbanks, 2-way audio and one-way video with color from Seattle to Omak, and the same mode but black and white video from Omak to Seattle. The technology was found to be highly satisfactory, and acceptance from both students and teachers was extremely high.

Another project concentrating on medical education is the Peacesat Project. The acronym Peacesat stems from Pan Pacific Education and Communication Experiments by Satellite. Essentially, it is an international experiment involving institutions in twelve countries of the Pacific Basin. The Project has approximately ten networks, including a medical and an educational network, which forms an information-sharing medium between the participants. Within the medical network, one experiment was concerned with continuing education for

...37

nurses. The Peacesat communication system is two-way audio only, but the nurse education link was supplemented by a previously mailed videotape. The experiment was seen as successful, and the participants offered three conclusive statements:

(1) joint conferences on nursing education via Peacesat are desirable.

(2) the Peacesat system was effective as an instruction medium.

(3) two-way audio communication is useful when used in support of videotaped instruction.

As described previously, the <u>Memorial University CTS Experiment</u> will be mainly concerned with providing continuing medical education to remotely situated physicians and nurses. The satellite will enable an interactive audio link and a one-way video capability.

Although various technologies have been used in medical tele-education programs, there is one element that is seen as indispensable in most if not all tele-education ventures. That is the interactive audio capability between the student and teacher. Though a full duplex (2-way voice and video) has generally been found as superior, the link must have a minimum capability of audio interaction in order to simulate as closely as possible the face to face or in person teaching method, in which the student can ask questions and voice concerns.

...38

IV TECHNOLOGIES

At the outset of this document the parameters of telemedicine were discussed. One of these parameters is the necessary telecommunications system linking the sites involved.

There are technical aspects inherent in almost all facets of telemedicine, since it depends largely on technical capability and efficiency in its delivery of care. The effects of telemedicine on health care systems in general, the wide variety of features and applications, user acceptance, etc., are all influenced to some degree by the technology being utilized. Since a wide variety of technologies and technical equipment have been experimented with and often tested at length, there is considerable debate as to what types are most appropriate for maximum efficiency of service delivery.

There is a vast array of factors involved in technological evaluation, a few of which are the services rendered by the technology, its cost, its availability, its maintenance and operation requirements, and also its adaptability (as well as capability) to the practice of telemedicine.

Space and Terrestrial:

The first technological dichotomy that can be drawn is between terrestrial and space systems. When distance and terrain prohibits terrestrial technology, the best alternative is often the utilization of satellite communications. With the advent of satellite technology, communications services can now be extended to areas at a great distance and over rugged mountainous or arctic terrain, where the only previous mode of communication was often HF radio. When medical applications are conceived in this satellite technology, many of the benefits centre around the possibility of extending medical services to remote and isolated areas that were previously ill-served or not at all. Satellite telemedicine networks thus hold the extension of services to remote regions and communities as a foremost goal.

Amongst satellite telemedicine projects were the ATS-1 and ATS-6 Experiments in Alaska, the WAMI Project described earlier, the Veterans Administration Telemedicine Experiment with the ATS-6, the Peacesat medical network, and the Starpahc project - Space Technology Applied to Rural Papage Advanced Health Care. In Canada, of course, the CTS telemedicine experiments are performed via satellite.

Bandwidth:

More pertinent to the direct applications and features of telemedicine is the bandwidth of the system at use. Bandwidths usually are considered as broadband and narrow-band. Each has different capabilities and therefore different applications and usage. Generally speaking, broadband allows for full interactive video, while narrow band enables interactive audio and some data transmission. In telemedicine applications, the media associated with bandwidth are: color and black and white one-way and two-way television are broadband; and telephones (with conferencing capability), slow-scan television, picture phones, and facsimile transmissions are narrow-band.

...40

The principle dichotomy in terms of telemedicine system bandwidths is between voice and video. Several experiments set out to determine the capabilities of each and attempt to arrive at a utility comparison. One experiment compared the use of black and white television, color television, hands-free telephone and in-person examination for diagnostic accurateness (Conrath, 1975). It was found that in-person diagnoses were superior, particularly in identifying other supplementary ailments. Within the telecommunication modes, no significant differences in diagnosis were found. In terms of physician preference, however, a clear hierarchy was identified. First was in-person diagnosis, followed by color television, black and white television, and finally hands-free telephone. The participating physicians expressed the value of video in diagnoses. Another study compared black and white television with telephone consultations between physicians and remote nurse practitioners. (Moore, 1975). Results showed firstly that the distribution of problems which were consulted on were very similar between the two modes. Television consultations were found to be slightly longer than telephone consultations, although equal proportions of each resulted in referrals to hospital doctors (30%). Television consultations, however, were found to result in a decreased number of <u>immediate</u> referrals to physicians, which suggests that physicians more easily defer or delay referrals once the patient has been seen. Yet another study compared the use of telephone, slow-scan, and both color and black and white television for general consultation purposes. Participants reported that television was slightly more useful than telephone, but that color made very little difference. It was also reported that slow-scan television was no more useful than telephone.

...41

One of the important variables in assessing video vs. audio modes of communications is the patient and/or remote practitioners participation and reaction. Firstly, the remote non-physician practitioner must assume a much more active role in audio consultations, since he/she must present the case to the physician. Secondly, patient reaction may be such that dealing directly with the physician rather than "through" a paramedical is seen as favourable.

In sum, it seems that broadband systems can have some practical advantages over narrow-band systems, but when the ever-important cost factor is incorporated into the assessment the scale is balanced considerably. One author roughly estimates relative costs of different bandwidths as follows: "Facsimile techniques cost about ten times as much as telephone, and two-way TV costs about ten times as much as facsimile". (Willemain, 1975). This means that a full duplex television consultation can cost up to 100 times more than a telephone consultation. In this context, the video advantages quickly take on a different light. However, these estimates are influenced by such factors as the equipment required, the number of sites to be linked, and the distance involved in the link, and an accurate cost-benefit analysis would take all of these factors into consideration. Of particular importance is the distance the signal must be sent and the initial technology utilized. For instance, transmitting video signals at a distance via satellite is far more costly than via terrestrial means. Foote, Parker and Hudson, for example, estimate that a broadband video channel leased from presently available commercial satellites would cost approximately $1,000,000 per year. Furthermore, this can be seen as a conservative estimate in Canadian terms, since present leasing costs per television channel for Anik are higher than this.

...42

Networks:

According to one source, telemedicine systems can be conducted over either of three types of networks: (Vivian, W. in Bashur, Armstrong, Youssef, 1975)

(1) Private dedicated links and networks

(2) Public contract links and networks

(3) Public utility networks

1) The first of these refers to facilities that are implemented to serve a specific user and are usually under ownership or control of the user. The most common private dedicated link is microwave, which can carry a number of channels. These links can usually transmit from ten to twenty miles. Many of the video medical telecommunications systems that have been mentioned thus far fall into this category of networks. The Massachusetts General Hospital - Logan Airport system is an example of a private dedicated link.

2) The second type of network refers to facilities that are made available to users dependent upon contractual arrangements. Usage time periods are usually specified and limited. The link usually consists of long distances, sometimes featuring inter-continental links. Satellite systems comprise a large portion of this type of network, and full interactive video is only rarely featured largely due to the extremely high leasing costs involved. However, there is increasing support and demand for this type of network as a result of the desire to extend services to remote isolated areas as well as to sometimes

....43

form a large regional network. Due to the high costs involved, most projects operating within this type of network are not self-funded and therefore do not control the network. Channel leasing time on the Canadian Anik satellite is an example of a public contract network.

3) The third type of network is the public utility network which is characterized by the telephone network. Telephone bandwidths can also produce video capabilities, such as through the Bell Telephone Corp. picturephone system and still image transmission, as previously described. Examples of projects utilizing this type of network are the Bethany/Garfield Park Hospital Community Health Network, the Cook County Hospital, and the Illinois Institute of Mental Health. The cost of operating such a network is relatively minimal, although the modifications necessary to permit image transmission, ECG's and picturephones can be significant.

Of the three types of networks mentioned, only the second is technically feasible for delivering medical service to remote areas of the Canadian north. This explains, in part, the extremely high costs of telecommunications in that region of the country.

Operational Performance:

The best method of testing the various technologies and their accompanying equipment is through an operational performance measure. However, this is not easily or rapidly done, since the benefits and problems of each technology can vary depending on its specific usage within the telemedicine system. For example, telephone consultations have been found adequate for a number of applications, but for dermatological diagnosis, for instance, the interactive television mode is far superior. On the other hand, broadband transmission is not necessarily needed for transmitting medical data and documents. In addition, the role of the remotely located paramedic can have great effects on the adequacy of the system.

Some of the benefits and problems of different modes of communication have already been reviewed. It was said that picturephones were found to be often inadequate for document transmission due to small screen size, as well as for x-ray transmissions due to poor resolution. The greatest benefit of picturephones is that it allows video transmission at relatively low cost since its bandwidth is narrow. With the video capacity, picturephones have been found superior to telephones for consultations.

Concerning benefits and problems of television, it was generally found that it can be successfully utilized in almost all telemedicine applications but that cost sometimes proved constraining, as discussed above. Other constraints such as resolution problems in viewing x-rays, and lack of mobility and flexibility were eased considerably in several projects through the use of additional features such as self-viewing monitors, zoom lenses, and remote controls. Self-viewing monitors were used quite extensively in the DHEW projects and were found to yield three primary beneficial results:

(1) they ensured that the best possible picture was being transmitted,

(2) they ensured that the sender's image remained within the field of view,

(3) they ensured that the subject matter being transmitted (e.g., a close-up of skin lesion) was being presented from the proper perspective and in response to the verbal directions of the consultant.
(O'Neill, Nocerino, Walcoff, 1975)

Remote controlling of the camera, particularly of zoom lenses, can have beneficial results in the reading and precision of x-rays. Other remote controls such as pan, tilt, focus, and iris aperture were also helpful to combat problems of patient mobility and image flexibility. The fact that this freed the non-physician from alternating between camera controls and the patient while listening to consultant directions was also seen as an advantage. In the Case Western Reserve project, remote controls were used by the physician anesthesiologist, and these were seen as desirable. Another positive extra feature was videotapes. Taping some of the sessions was found valuable both for educational and training purposes as well as for self-evaluation.

The role of color in television remains questionable. Although some authors outline certain advantages of color over b&w, such as for dermatological diagnosis, its maintenance and operation expenses are far greater than black and white television, which can offset the slight advantages that color might yield in some cases. A conference capability involving a link of two or more sites was seen as highly desirable with potential positive results. (Hudson and Parker, 1973). Conferencing can also be a valuable feature to audio systems.

The most serious difficulties concerning interactive television revolve around issues of maintenance and operations. Several ITV projects found reliability to be poor in addition to the system's complexity. Breakdowns were

...46

reported in a few of the DHEW projects, for instance, therefore halting or at least hampering the link. Most technical problems were not of a serious nature, but their occurence was found to be most disruptive. Television systems are usually complex, so that when breakdowns or poor quality occur most medical staff do not have the necessary expertise to identify or confront the problem. It is favourable, therefore, to have technically qualified support staff present in at least one of the locations in the link. This requirement was seen as a disadvantage. In addition, the fairly frequent mishaps or reduction in transmission quality sometimes reinforced some medical staff apprehension toward the seemingly complex technology. Complexity of the systems also partly accounted for the lengthy set up time involved.

Other television constraints have sometimes been reported. The sheer size of the equipment was often reported as extremely cumbersome and awkward, as well as making its often necessary movement difficult. The culmination of all these interactive television deficiencies or incapabilities makes the availability of ITV somewhat lacking. For example, present ITV systems do not allow for a caller to direct his call to any one of many distant sites, such as the telephone is capable of. The inferior availability of interactive television was widely acknowledged throughout most ITV projects undertaken. In fact DHEW researchers reported that within their seven interactive television projects the general availability of the telephone as opposed to ITV proved to be a continuing point of reference for all ITV system users.

In sum, the ideal technology for telemedicine systems would be a "mix" between present telephone and television systems. It would incorporate the narrowband, low cost, high reliability, and high availability aspects of the telephone with the most highly positive feature of television, interactive video.

The closest technology to the above "ideal" at present is the picture-phone, and as was seen, it bears both benefits and problems. Nevertheless, it is through testing and experimentation that various benefits and constraints of different telemedicine technologies have come to be known, and it is thus through continual experimentation in telemedicine that more appropriate and beneficial technologies will emerge.

...48

V ATTITUDES & ACCEPTANCE OF TELEMEDICINE

An extrememly important element of telemedicine is the people that are involved, both users and consumers of the system. Their basic attitudes and acceptance or rejection of a telemedicine system are sufficiently potent to mold its success, mediocrity, or outright failure.

By and large, telemedicine has earned acceptance from both medical staff and patients. The positive attitudes undoubtedly outweigh the negative attitudes, but the acceptance verdict is by no means unanimous. Skepticism does exist amongst providers and patients alike. Throughout telemedicine's short history, however, providers have tended to be more skeptical than patients, for a variety of reasons. The most blatant of these is that providers are those who generally bear the operational inadequacies and difficulties inherent in delivering medical care by means of telecommunications.

There also seems to be some variance in attitudes amongst the different types of personnel involved in providing medical care. Amongst those who harbour negative attitudes toward telemedicine, physicians have been known to be the most frequent. It is true, though, that should fault or trauma occur in a telemedicine interaction, they are the most vulnerable since they are basically the main actors within the system.

A) Attitudes of Health Care Personnel:

Almost all projects that were received conclude that the majority of medical staff respond favourably to the practice of telemedicine. Ben Park

...49

(1974) suggests two warnings in the interpretation of these widespread results. Firstly, he argues, most medical personnel involved in telemedicine are pioneers in the field, and thus may react over-enthusiastically. Secondly, Park maintains that there is a distinct group of medical practitioners who are the leaders in the field and who are responsible for the bulk of interactions. This may also be a cause of enthusiasm as well as promotion. Another possible bias that may exist is that most medical personnel agree with the broad goals of telemedicine (i.e. greater accessibility to health care, remote service, etc.), and this causes reluctance to evaluate it negatively.

Perhaps as a result of the latter point, most of the negative attitudes that do exist focus on operational techniques, methods, equipment, etc. rather than on the fundamental concepts of telemedicine. Nevertheless, there are some who are opposed to telemedicine as a matter of principle. A common reason attributed to these kinds of objections is that the physician practicing in a telemedicine system can be subject to constant review by his/her peers and colleagues. Attitudes of practitioners about this range from uncomfortable feelings to demeaning threats. This can be true of both physician and nurse practitioners.

Although most studies show that physicians are usually the most frequently reluctant group probably due to their vulnerability, one survey of providers who had used the Miami-Dade County system concluded that nurses were less favourable to the system than doctors. (Hastings & Dick, 1975). Most of the negative attitudes stemmed from technical constraints and difficulties, such

...50

as those outlined in the previous section. Some of the problems encountered in the Miami-Dade County system were: TV maintenance problems, ineffective stethoscope, lengthy TV set-up time, and a lack of familiarity with the mechanics of TV.

A "before and after" survey of physicians involved in the Lakeview Clinic project (Wempner, 1974) showed that certainly not all their expectations had been met. On the negative side, they felt that the quality of care had not increased, health worker involvement had not increased, costs had not been reduced, consultations had not been encouraged, lab reports were not more readily available, and patient waiting time had not been reduced. (Foote, Parker, Hudson, 1976). It is clear that many of these defects that were reported are directly contrary to many other documented studies and projects, demonstrating the often wide variance between projects. On the positive side, which is in accordance with most other projects, physicians at Lakeview felt that travel was saved, patients were reassured, patient-physician relations were enhanced, and it was easier to obtain specialist consultations. (Foote, Parker, Hudson, 1976).

B) Patient Attitudes:

The attitudes of patients, as a group, is much less divided than amongst medical personnel. This type of homogeneity was found throughout most projects. Contrary to what many had expected, patients were extremely receptive to telemedicine in all experiments that have been reported. What was an inherent fear by providers (that patients would be apprehensive to being diagnosed,

...51

treated, etc. via television) turned out to be completely unfounded. In fact, patient attitudes were often more enthusiastic than those of health care providers.

Studies of patient attitudes and acceptance have all shown that positive attitudes prevail. One study (Rule, 1975) which looked at patient reaction to telediagnosis at the Massachusetts General Hospital, found that only about 15% of patients were at all critical of telediagnosis. These were also thought to be closer to reservations than criticisms. In the evaluation of the seven DHEW telemedicine experiments, O'Neill (1975) states that "no appreciable patient dissatisfaction with telemedicine care was detected or registered." Cases have also been reported where patients actually preferred the telecommunications interaction than the usual face to face type. This was particularly true in psychiatric counselling.

Amongst the more frequently perceived benefits of telemedicine by patients were: new services provided that were not previously available, accessibility to specialized care, sooner emergency treatment, less waiting time, reduced admission procedures, etc. (O'Neill, Nocerino, Walcoff, 1975).

Perhaps the only drawback associated with patient attitudes and acceptance is the lack of knowledge as to how the system was operating. In the Mount Sinai project for example, patients demonstrated a lack of knowledge about who was involved in the consultation and where the remote consultant was located (O'Neill, Nocerino, Walcoff, 1975). Very few cases were reported where patients felt somewhat inhibited about the feeling of having their problems, ailments, etc. seemingly "broadcasted". There were also a few reported feelings

...52

of the care provided being impersonal since it was "coming out of a television set". These reports were purely anecdotal, however, and in the aggregate patient attitudes were overwhelmingly positive.

Another aspect of attitudes toward telemedicine that is not widely documented but nonetheless deserving of attention is the attitudes harboured by people in the community. Telemedicine is not a widely known field, and its eventual acceptance will not only depend on user acceptance but also on the perceptions of the community at large. In a small study of a rural community involved in a telemedicine link (Rural Health Associates Project) Rashid Bashur showed that 40% of the citizen sample had no knowledge of telemedicine. He also found a fairly high rate of apprehension toward telemedicine within the community. However, this varied greatly according to the amount of knowledge and exposure that respondents had had to telemedicine. For example, most respondents held that they would prefer in person contact with a physician, but over 40% expressed that they would accept telemedicine in the event of emergency cases. In his concluding remarks, Bashur states that the majority would vouch acceptance to the use of telemedicine if no other options were available. Nevertheless, if telemedicine is to ever become widely practiced, recognized and accepted as a means of delivering health care, it will have to emerge from the closely knit professional circles that Park (1974) describes, and enter the community.

VI ADMINISTRATIVE & ORGANIZATIONAL ARRANGEMENTS:

Administrative and organizational arrangements are a crucial element of telemedicine practice. Most of them have been anecdotally outlined throughout this document, but it is worthwhile to briefly summarize them here.

Firstly, administrative matters comprise a much larger portion of telemedicine than many experimenters had previously anticipated. Experimentation has also revealed that the handling of administrative and organizational matters via telecommunications has further potential than has been exploited thus far. In a study reported by Bashur, Armstrong and Youseff (1975), it was found that some telemedicine projects devoted approximately 40% of communications to administrative matters. Another project which demonstrated widespread administrative and organizational matters in telemedicine is the ATS-1 system in Alaska. Researchers report that over the course of a year, a community health aide in an Alaskan village made use of the system for 230 patient consultations and 280 administrative items (Foote, Parker, Hudson, 1976).

Administrative and organizational arrangements in telemedicine can basically be divided into two groups:

- administrative matters that can be performed by using the system,

- preparatory organizational arrangement required.

(1) Data transmission is the prime means of conducting administrative matters via telecommunications. The Bethany/Garfield Project in Chicago con-

...54

centrated on the transmission of data. Some of the administrative activities that were reported enhanced or made possible were:

- emergency room personnel were able to obtain quick and accurate lab results.
- transfer of sophisticated lab results between facilities was facilitated.
- admission of patients was facilitated, and emergency room personnel could admit patients into hospital while continuing patient care.
- by the same token, referrals from one facility to another was facilitated and quickened.
- inter-facility travel costs, time and inconvenience were reduced.
- from a staff administration point of view, medical staff conferences were made possible, supervision and consultation with staff was facilitated, and in-service training was both enhanced and more accessible.
- general administrative data, such as financial data, staff data, patient data were more easily collected and processed.

Another telemedicine project which placed considerable attention (20% of use) on administrative matters was the Cook County Hospital Project. One of the fundamental objectives of the project was to improve administrative control. The Chairman of the Department reported that his time was much more efficiently deployed as a result of the link, and that he had a constant and current impression of the matters of concern to the Department. (Park, 1974).

...55

The Rural Health Associates project in Farmington, Maine also devoted much time to administration (40%). Experimenters reported most of the factors listed above, and in addition mentioned that the processing of prescriptions and the dispensation of drugs were facilitated. Ordering and checking on supplies, billings, procedures, etc. were other regular administrative activities that were reported. One of the original objectives of this project was to allow health care providers at all four sites involved in the link to communicate at will. The system was thus widely used for purposes other than medical. The result, according to the experimenters, was that it brought all levels of medical staff together from all sites and formed a tightly-knit, well-organized health care delivery system.

(2) Preparatory organizational arrangements are probably the most undermined of all facets of telemedicine. Their importance, however, is often reflected in the final results of projects. Dissatisfaction, apprehension, and sometimes sheer failure are often attributable to the lack of proper preparations. Preparations are not only necessary for matters related to equipment, technology, procedures, etc., but also to the basic concept of telemedicine. Telemedicine has often been described as an entirely new method of medical service delivery. Practitioners must therefore be familiar with all aspects of telemedicine if they are to function competently within the system. In the same manner, the entire organization using the system must be geared to this mode of service delivery.

One of the best means by which to achieve this end is to train all staff that will be involved with the system. They should be trained, or at

...56

least familiarized with the utilization of equipment, its high points and constraints, the procedures and methods involved, the assistance required, and so on. One seemingly successful method of training and familiarization is to perform various simulations of the forthcoming activities that are scheduled. In this way, physicians and other providers can gain an awareness and appreciation of how systems operate. Simulations would also equip practitioners with a general knowledge of the various difficulties that can occur under certain circumstances, and they would therefore be better prepared to cope with these difficulties when they emerged during real sessions. Reducing the element of surprise in regard to system constraints and unreliability would also decrease the frustration, dissatisfaction, and aggravation sometimes borne by practitioners. Ultimately, these kinds of training and familiarization activities would result in an improved quality of service.

At a more operational level, organizational arrangements must be made to rectify such problems as lengthy set-up times, initiating consultation between or among sites, paging physicians as well as other practitioners when they are requested for consultation, procedures for routing incoming calls (particularly emergencies), etc. These too can be confronted with better training through simulated sessions and experience, but these problems seem to be more of an administrative drawback rather than one of perception. As in many other service administration areas, perhaps what is needed in telemedicine to overcome these difficulties is an administrative and managerial body to direct and control the program. For example, a chief manager could be appointed, followed by a director for each area of application, and so on. In short, telemedicine systems are in need (or seem to be) of ameliorated management techniques. If this need were to be satisfied, administrative and organizational arrangements would be more efficiently and easily implemented.

VII UNRESOLVED ISSUES & AREAS FOR FURTHER RESEARCH:

Although telemedicine has had widespread acceptance by its users, and its utilization and applications are generally successful, it is far from being a panacea. There are many uncontrollable difficulties inherent in the practice of telemedicine, due to its very nature. Delivering health and medical care by means of telecommunications is a difficult task. A number of questions remain unanswered and issues unresolved. The need for further research in telemedicine remains paramount.

This final section of the document will address itself to some of these unresolved issues and areas in need of further research. Though the list is long, varied and encompassing, the aim here is to concisely summarize some of the salient issues. For the sake of presentation, four categories of issues are addressed: technical, medical, legal, and financial. By no means do these exhaust the list of unresolved issues, but they do provide a point of departure for further research.

Technical:

Technical issues have been studied in almost all telemedicine projects that have been undertaken. Indeed, technical considerations together with medical applications form the core of telemedicine. Most technical parameters have been defined and their applications tested, but a few problem areas remain, nevertheless.

First in priorities of further technical research in telemedicine should be the issue of finding the most and best applicable technology for medical service. It has been shown, for example, that interactive television contains some desirable features, but it also has drawbacks. By the same token, narrowband audio systems have some definite advantages over broadband in terms of cost, availability, reliability, and so forth. Research should concern itself with the possible "mix" of these two basic technologies, in order to arrive at a feasible yet highly medically applicable and valuable technology. Technical routes such as the picturephone, facsimile, etc. need to be further explored and consequently tested operationally.

Secondly, essentially untapped technical capabilities must be given a harder look for use in telemedicine. Such things as portable slow-scan television extensions via telephone lines need to be explored further, and their medical applications tested.

Another example of making use of existing capabilities is the use of CATV in telemedicine. This would only be applicable to urban and surrounding areas at present, but it could have far-reaching implications. CATV networks now permeate most cities across Canada. Furthermore, some CATV networks already have an interactive capability. In the cities that are "wired" with cable, video medical communication could be accomplished not only between the various medical centers but also between these centers and virtually every school and home in the service area. (W. Vivian, in Bashur, Armstrong, Youssef, 1975). CATV costs would also be minimal as compared to present technologies utilized for medicine.

...59

In sum, future research should concern itself more with the integration of communications technology into health care delivery systems, at a more feasible cost.

Medical:

Medical research, of course, should never stop. It should always explore new ways and means of innovation. Similarly, medical research in telemedicine must constantly and continuously explore new areas of practice and application. Although many areas of feasible and possible medical applications have been demonstrated through various projects, there are many others that have yet to be explored. Research teams comprised of physicians, engineers, and communications planners should attempt to identify further areas of medicine that would be feasible for telecommunications transmission.

Other important areas of future telemedicine research center on the impact of the practice on the organization and effectiveness of health care delivery systems as a whole. Some authors argue that telemedicine can change the very nature of health care delivery systems, and therefore their subsequent organization and structure. Assessments are needed in areas such as the distribution of medical manpower, the increasing role of paramedics, the extension of services, necessary training and continuing education, in short, all aspects of organizational performance and analysis.

In addition, indicators should be derived to measure the effectiveness of telemedicine in terms of the entire health care system. Does it improve

...60

service? Is the quality of service affected? What is its impact on the organization of the service delivery system? Indicators to measure these and other factors cannot be easily designed, however, since results are by and large intangible. Nevertheless, researchers and experimenters must take it upon themselves to search out answers to these questions.

Another area which needs to be resolved is regional telemedicine service delivery. For instance, it is quite a different situation to deliver service to a distant remote area than it is to deliver telemedicine within short distances. Different technologies can be required according to distance, and technology often dictates the limits to which telemedicine can be put to use.

In brief, a great deal of planning is required for future telemedicine systems. This planning function should be within the context of telemedicine integrated into the health care delivery system in its entirety.

Legal:

There is a wide scope of potential legal issues involved in telemedicine. A few have been recognized, but virtually none have been resolved. The various legalities inherent in telemedicine fall into three main groups.

1) The first group refers to issues of privacy and confidentiality. It has yet to be resolved whether such telemedicine activities as video and audio conferencing, video-taping, processing of patient records, etc. constitute a breach of the privacy and confidentiality laws. Lawyers have warned that these types of activities may be in danger of being contrary to individual privacy

and personal confidentiality laws. There are also laws restricting physicians and other practitioners to reveal personal patient information. Whether or not telecommunications transmission is actually revealing information has yet to be determined. These and other issues need to be ironed out decisively before telemedicine can proceed on a larger scale.

2) The second group consists of a wide variety of laws and regulations concerning the administration of patient care and treatment. Patient admission and registration, patient referral, prescription and dispensation of drugs, treatment given by non-physicians, for example, are all subject to procedural regulations. Patient admissions, referrals and discharges all require a signature authority. Whether a remotely transmitted signature (in real-time using electrowriters, etc.) constitutes an authorization has not been legally determined. Assuming that it is legal, problems still exist - once a signature exists as an electrical signal it can be recorded and reproduced, which is clearly unacceptable. (O'Neill, 1975). Other procedural regulations pertinent to physician - assistant supervision also exist in some areas, notably the state of Illinois in the U.S. The regulations state that supervision must be on a one-to-one basis for reasons of medical treatment quality and control. Clearly, this would be unacceptable for such practices as those in the Bethany/Garfield and Lakeview Clinic projects, where remote supervision of several practitioners was a prime objective.

3) The third group of legal issues is basically the culminant of all of the above. It pertains to medical malpractice suits. In the Case Western Reserve project, for instance, physicians were warned by malpractice lawyers of the advantages telemedicine systems would provide to a plaintiff's lawyer.

(O'Neill, 1975) When is a physician guilty of malpractice during telemedicine treatment? Does a breakdown in equipment therefore hampering treatment constitute a charge of malpractice? Can malpractice be charged in the event of inaccurate reading of patient data, due to poor quality of transmission? What defences can physicians turn to for protection, or are they vulnerable to malpractice lawyers as well as technology and equipment?

Legal issues in telemedicine have seldom been addressed directly, yet their impact can bear grave consequences.

Financial:

Financial issues permeate all of telemedicine applications. They can be briefly described in two areas: cost-benefit analysis of service, and issues of payment to practitioners and hospitals.

One of the fundamental goals of telemedicine is to reduce costs of delivering service, particularly to areas that are ill-served. An evaluation of this goal must include the following factors: cost of technology and equipment, cost of staff services, cost of transmission time, etc. and the trade-off of these with cost-savings in time, travel, the number of sites linked, etc. Quality of service is of course difficult to measure, but quantity is certainly measurable in tangible terms. An accurate cost-benefit analysis would incorporate these factors and assess the true cost of delivering care. More than likely, however, the costs will be extremely high. Telemedicine projects are generally very costly, mostly due to the high cost of technology. A revealing sign of this is that of all but two projects reviewed were dependent upon public or other funds for operation. The Cook County Hospital project and the Massachusetts General Hospital - Logan airport project were reported as self-funding. Both, however, transmitted only a short distance and used narrowband technology. How can telemedicine programs become self-funding? This is a perplexing question, but it must be answered if telemedicine is to become widespread. Is self-funding necessary? Yes, unless governments are prepared to fund telemedicine programs from the public purse. This, of course, has largely been the case thus far, but unless self-funding mechanisms are designed, telemedicine will almost surely remain at the experimental level.

One possible mechanism involves payments to practicing telemedicine physicians and hospitals. This avenue has not been explored in depth. To date, health insurance organizations such as Blue Cross and government health insurance programs have not been responsive to payments for telemedicine treatment. However, it is indeed conceivable that they would become amenable to payment arrangements since telemedicine is in effect a form of medical treatment.

Not only are funding mechanisms essential for telemedicine to fulfill one of its fundamental goals (i.e. reduce health costs), but they are necessary for its existence. It is unlikely that physicians will continue to practice telemedicine for promotion or experimental purposes at no charge, and some form of fee-for-service device will have to be designed. Similarly, patients are not likely to pay for telemedicine themselves. Hence, appropriate funding mechanisms are mandatory.

The above unresolved issues are probably the most challenging task facing telemedicine planners, but they are at the apex of priorities for the future of telemedicine. Solutions can only emerge through experimentation and evaluation, which is the prime means by which to bridge the gap between experimental and operational telemedicine systems, both in Canada and elsewhere.

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