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Preface

Since those days when care was provided to those families that lived and worked on their remote farms located in the “outback” of Western Australia by those famous ‘flying doctors’, information technology has come a very long distance. Every farm had a well-laid and well-maintained airstrip. Whenever any person on the farm had a health-related problem, they could call up their doctor on the wireless radio. They would explain their condition and the illiterate amongst them had a picture of a man and a woman with numbers pointing to the various parts of the body which they could use to point out to their doctors as to where exactly their problem lay. The doctor would communicate via the same wireless as to how relief may be sought. Each farm had a well-stacked medicine chest with numbers identifying each medicine. A concurrent list was also maintained by the doctor. The doctor could then inform the particular medicine number and advise the patient how and when to take it. If the situation so warranted, the doctor would fly out to the farm and do the needful.

Telemedicine is a serious attempt at extending the same concept on a much more wider and deeper scale. Some care provider would still need to be physically present by the customer or very near at hand to actually deliver the care (e.g., in the form of nursing, taking samples for investigation, taking the pulse rate, blood pressure, temperature, or do dressings, etc.), but the expert may be physically present at great distances away. A doctor treats his patients by seeing, hearing, reviewing, judging, and touching. Telemedicine allows all of these except touching.

Introduction

Telemedicine literally means '*distance healing*'. The Time Magazine calls it "*healing by wire*". Information Technology, through the judicious use of computers, related softwares, telephone lines, fibre-optic cables and satellite link-ups, is used to deliver quality health care to the patient at his[1] place of residence. Imagine an environment where a doctor is able to consult with another halfway across the globe at the touch of a button. Telemedicine is a technology that would make this a reality and allow the delivery of health care and management through a PC from anywhere to anywhere as long as they are linked to each other by a connection. That is the power that this technology promises to offer to the health care industry.

Telemedicine would help in providing complete and accurate diagnostic opinion by the best available specialist residing physically anywhere who would then suggest an effective management plan for the patient. Telemedicine will dramatically reduce the costs in a number of ways but principally as a result of less time and money being spent on travelling as well as through obviating the necessity of maintaining specialists whose expertise is rarely called upon. Overall expenditure control is also made possible by the judicious use of this technology.

The quick and efficient diagnosis, ability to maintain constant contact from, to and with experts in any discipline anywhere. It would also reduce referrals which could be done 'online' and increase confidence, in and in the viability of, remote and rural health care centres and in personnel manning them. Geography would be no barrier to providing quality health care and management anymore.

Current technological limitations lead to slow transmission rates while faster and more acceptable speeds is available at a price which is not yet cost justifiable. This situation is however bound to change very soon, possibly by the year 2000.

Cultural barriers might be required to be overcome in certain areas of the globe where this technology could well be viewed as "foreign". Successful implementation and wide acceptance by the users elsewhere would no doubt help in bringing down these barriers sooner rather than later.

The equipments required are costly and therefore high capital inlays are required initially along with continued maintenance costs. Furthermore, the constant presence of at least one qualified health care personnel to actually administer care is required, though further developments might see the use of personnel being progressive lessened and they would then be mostly required during emergencies.

Telemedicine would definitely help in research and development of better management protocols, efficient and detailed epidemiological studies, statistical analysis, and through well designed data warehousing techniques the eventual building of a health data mart.

It has been found that telemedicine is quite effective through the judicious use of the low-end technology available only and that one does not need to make higher capital expenditures in the high-end ones right away.

General efficiency of the health care system can be created by the use of this technology with successful computerisation yielding many tangible benefits to the health care management and relevant information diffusion accelerated so that care is improved, demands for information of various natures met and the decision-making process streamlined

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[1] **The masculine includes the feminine, the singular the plural.** *This convention has been used throughout this dissertion*

and made more viable through the active participation of the customer themselves. Telemedicine would also help in transforming the health care industry into an integrated system as a whole supporting the continuum of care.

Telemedicine would definitely reduce professional isolation and provide the ideal medium for the deliverance of CME[2] on a continuous basis with the latest information being deliverable. With CME being available at any time at anywhere, even in the comfort of one's clinic/office/workplace/home, thereby eliminating the need to travel and spend time away from work simply to re-train and hone one's professional knowledge and skills would be eliminated. The technology positively contributes towards the safety of out-of-hours care by less skilled personnel even in areas demanding high skills. There would also be increased job satisfaction amongst health care workers in the rural and remote areas as a consequence of their involvement in the ongoing care of patients in their own community. Their experience and knowledge levels would concomitantly increase too as a direct consequence. Remote access to archived electronic scans and records, and the provision of health care information (pre-operative, antenatal, support groups, etc.) direct to patient's home would also be made possible through this technology.

Emerging technology in the field of Information Systems (IS) will further enhance the quality, quantity and efficiency of telemedicine. Patient confidentiality is still an issue but no more a serious one and the acceptance by the patients generally is favourable. It is rather the acceptance of the technology by the health care professionals and the administrators the problem. They still view telemedicine as a threat to their livelihood, disruptive in their otherwise normal day-to-day functioning and the financial results not yet spectacular enough with respect to the amount invested in the acquisition of this technology. Analysis of break-even period has revealed a time period of 2.7 years and an equipment pay-back period of 3.5 years in the US (1994 figures).

Telemedicine would allow the active participation of the family in the management and care process of the patient concerned thereby increasing the effectiveness of the healing process. It would also be an additional revenue generator by way of additional patient consultations as they may now "virtually" visit the organisation from the comfort of their homes. It would also cause increased patronage by the remote and rural centres allowing the organisations possessing telemedicine technology to export their various skills to them. Since telepsychiatry has been found to be a much less threatening consultative medium than the real one, increased customer volume would doubtlessly result.

Thus we see that telemedicine appears to yield such benefits that the possession of it would prove to be a boon rather than a burden on the organisation even with the still lingering and essentially niggling downsides. This one technology truly can create an effective global health village, albeit in "virtual reality", and make health for all a real possibility.

An analysis of the SWOT as well as the competitive advantage based on Michael E. Porter's five forces model reveals that telemedicine, if successfully and carefully implemented, would prove to be a real asset to the health care industry and help in transforming it into such an industry the likes of which has never been seen before. The world would truly become a global village as far as health is concerned at least and all its inhabitants would have an equal opportunity to receive the best of medical attention and care that is available everytime he is in the need of it.

Once telemedicine as a technology does take off with the utilisation of existing technology and facilities, the industry and its customers would soon be able to demonstrate its usefulness and provide a glimpse about its immense potential. Initially, the components of

[2] **CME** Continued Medical Education

the industry and the final customer in his home may be linked up using the existing telephone lines with narrow bandwidths. ISDN lines would definitely be a boon, but even if they are not available, it would not be a total disaster. ADSL technology would do just as fine, thank you very much.

The PCs or workstations could upload and download files and communicate using e-mail and Internet phone as well as send digitised scans and pictures and picto-micrographs of pathological specimens. Videos may be captured and send as files by FTP[3] and then viewed as necessary. Videoconferencing would not currently be possible except on a very limited scale when too the pictures would be jerky. It must be stressed that the quality of pictures would not be poor though.

As with any technology, telemedicine too should be gradually be 'phased-in' as the older system is 'phased-out'. As the infrastructure is in place and the usefulness of telemedicine appreciated, the demand for newer and better techniques would automatically grow. As the ancillary technology grows and becomes better and more cost-effective, the telemedicine product mix on offer can change accordingly and newer and hopefully better facilities may then be provided.

[3] **FTP** File Transfer Protocol

Virtual Scenarios

Scenario 1

It is 10:00 p.m. on a Saturday evening a physician receives a phone call from a patient hitherto unknown to him. The man says he has a painful blister on his right toe. It has been there for a couple of days but has aggravated since that very afternoon. He cannot move his foot and the toe is throbbing. He mentions that he has had some trouble in the past for which several blood tests have been carried out. These tests are repeated regularly every month and it has been just a few days ago that the last battery of tests was carried out. He cannot specifically say what the tests were for and the blood samples were taken at random without bearing any specific relationship to anything like food, etc. He also is unable to give a definitive 'yes or no' answer to the question as to whether any of his immediate blood relatives ever suffered from diabetes.

The physician decides that he must take a look at the toe and investigate before he is able to do anything further about it. The patient is not keen to travel and asks whether or not there was something the doctor could advise for the night and then the patient could attend his clinic or any emergency room in the morning for further management. The doctor firms dissents and asks the patient to come to surgery immediately.

Had there been any way the doctor could have found out about this person's past history which must exist somewhere in some form, there was a definite possibility that he could have decided otherwise. In the emergency room too he would not have had to carry out at least those tests which may have been carried out recently enough not to warrant a repeat at that time.

Scenario 2

A 30 year old man has been brought into the Emergency Room at around midnight. He has multiple injuries to the chest and head. His right pupil is dilated and only mildly reacting to light. His pulse rate is around 60 min^{-1}, Babinski's sign is positive on the right side and he is also semi-conscious. He has just his driving license on him and there is no possibility of finding any of his relatives that night.

A baseline array of tests would have to be carried out and the patient immediately shifted to the operation theatre for the management of his chest injuries apart from the cleaning and dressing of his wounds. An emergency CT scan of the head would have to be carried out too and further management depending upon the findings thereof.

If the ER doctors had access to a system which would have allowed them to retrieve all the relevant past informations relating to the vital statistics and health of the man, they would have certainly been in a much better position to manage this case.

Scenario 3

A patient has been referred for expert consultation. The patient lives at a considerable distance away and has to spend the better part of an hour on the road before he is able to present himself at the physician's office. His general condition is not too good and neither is the road that he has to take. The expert asks him to go over his complaints from the very beginning. Then he asks to see all the past papers related to his condition. The patient has been suffering for quite sometime now and the passage of time has resulted in him misplacing some papers. The consultant asks the patient to undergo a few tests. Only after three further painful and distressing journeys to the doctor's chamber later and undergoing several tests is the doctor able to come to a definitive diagnosis and the actual management begins.

Had the physician been able to retrieve and view all the previous records of the patient as well as the test results that were carried out after the first visit, perhaps the diagnosis could have been made on the very first day or at the end of the second visit. Furthermore, had the patient and his consultant been able to somehow communicate face-to-face long-distance, the patient might have been able to eliminate the travel part and save himself from a lot of botheration, frustration, expense, and the inevitable loss of time and the consultant could still have charged him according to the billable hours and gotten his fee.

Scenario 4

"Doctor, I would like to get a second opinion."

"Very well. Whom would you like to consult?"

"Dr. A. B. Cee."

"But he is half-way across the globe and he cannot come and you are in no position to go, financially or physically. It's impossible!"

"Then doctor, what am I to do?"

"I am very sorry to have to tell you - pray and then pray harder."

Real Case Studies

Case Study 1[4]

In a Middle East hospital, a patient with a suspected pancreatic carcinoma has a CT scan. Ten minutes later, specialists at the world renowned Massachusetts General Hospital in Boston, USA are able to view the scans, confirm the diagnosis and suggest a course of action to the attending physicians in the hospital in Middle East.

WellCare's global TeleMedicine service was launched at the beginning of 1994. It enables clinicians in any country to send a patient's x-rays, CT or MRI scans and images of pathological studies directly to the world's major medical centres of excellence. The specialists who then view them are able to render a completely accurate diagnostic opinion and suggest a management plan for the patient.

It is expected, for justifiable reasons, that this technology will dramatically reduce the costs of delivering sophisticated health care to patients anywhere in the world. Within the next few years medical personnel will be linked with the major specialists, no matter where they are anywhere in the world. A patient's physician may therefore be able to maintain constant contact with specialists of any discipline.

TeleMedicine would also help in providing continuing medical education. It would also help in expenditure control since there would be no more need to maintain specialists whose expertise is infrequently called upon. This would inevitably lead to substantial cost savings. Patient's suffering is lessened as diagnosis is made much more efficiently and quickly.

The problem areas are as follows:

- Data compression - since pictures of various complexities and magnitude have to be transmitted over an ordinary phone line with minimal loss of quality, expensive

[4] From a commercial video distributed by WellCare, WCH International Inc., entitled TeleMedicine®

equipment and computer software is required. Though this is essentially a one-time cost, maintenance of the equipment is also not cheap, at least at this point of time.

- Speed of transmission - this is still not fast enough with routine turnaround times being between 12 to 24 hours, though it is hoped that with the introduction of fibre-optic cables and increase in transmission speeds of 36.2 Kbps[5] of today to 2 to 10 Mbps in, hopefully, very near future would go a long way in reducing this turnaround time to a more comfortable and acceptable level.
- "Foreign" technology integration - this technology will be viewed as "foreign" by many cultures and therefore a certain degree of hostility towards it could naturally be expected to exist.

Working Modalities:

The films of CT / Ultrasound / MRI scans or pathological slides is inserted into a digitising station into which the relevant patient details are fed in. This digitising station then captures the images and digitises it. The digitised image is then compressed and transmitted via an ordinary telephone line.

There are regional hubs placed in the country which are able to serve up to 30 hospitals. The routine turnaround time is 12 to 24 hours though for emergency cases this can be reduced to minutes. In 1994 it took 4 minutes to transmit 10 images via an average telephone line. This situation is bound to improve in not-too-distant future.

The concept is the same as for frozen section biopsy where the anaesthetised patient is not moved while a biopsy is analysed in the pathological laboratory by experts and the results made available within minutes and the necessary management of the patient is chalked out while the patient is still under anaesthesia.

Case Study 2

On April 10, 1995, a brave young student from Beijing University, Bei Zhicheng, and his fellows sent an SOS e-mail message through the Internet to ask for international help for a young female university student, Zhu Lingling, suffering from an unknown but severe disease.

The message was widely spread and since then Bei has received over 2,000 e-mail replies from 18 countries and regions and the Internet has played a very important but complicated role in Zhu Ling's life. It has also impacted on the lives of many of those who have tried to see just how far telemedicine by the Internet can be taken to bridge the cultural, linguistic, and even political gulfs between China and the Western world.

Physicians were at hand to provide general consultation or telemedicine researcher working on communication channels, but remember that it was those sub-special physicians who made the diagnosis and those toxicologists who gave the expertise treatment regimen. The beauty of telemedicine is that the best medical resources can be delivered to a remote site anywhere in the world through the information superhighway. As Dr. Hamilton pointed out, "It may be that Zhu Ling's illness has helped changed the way medicine will be practised - with more resources available the world over."

This documentation also reports on how technological and cultural factors influenced the acceptance and success of the telemedicine case involving physicians and telemedicine researchers in North America, Europe, and mainland China, to show the advantages of remote consultations with multiple experts, as well as the practical and cultural limitations of using such a system. The practical implementation of telemedicine is still limited by the cost,

[5] **bps** bits per second, also known as the *Baud Rate*; Kbps = Kilo bits per second; Mbps = Mega bits per second

availability, image quality, and security of proprietary telemedicine systems. Based upon our experience we conclude that a successful global or regional telemedicine system must be easily and widely accessible and integrate with existing clinical practice. We are working towards an architecture that uses public and ubiquitous networks and tools to address the issues of communications bandwidth, wide availability, image quality, and security.

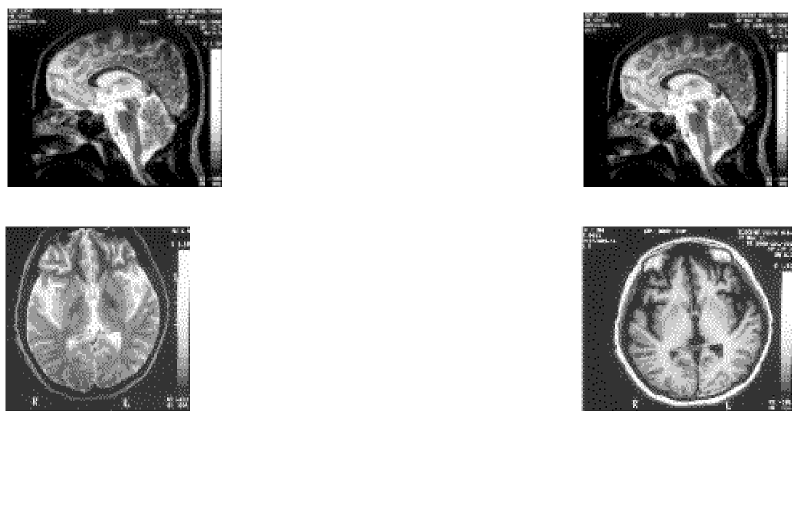
The story of Zhu Ling is far from over, but there is little question in the minds of those who have worked on the case that it has broken new ground in telemedicine. By branching off into such uncharted areas the case itself has probably raised more questions than answers. But those who have lived and worked for so many years in China and other developing countries know that the world itself was changed. *Of special note is the fact that both diagnosis and treatment was made by the experts communicating via Internet*.

The SOS message from Beijing was spread at several news groups on the Internet, such as **http://sci.med**, **http://sci.med.informatics**, and **http://sci.med.telemedicine**. They are major platforms for international medical profession to practice telemedicine and such newsgroups played an important role in distributing diagnostic and therapeutical information in Zhu Ling's case. Many clinicians who were involved in Zhu Ling's case were the newsgroups readers and initially obtained information from there.

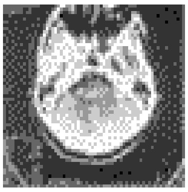
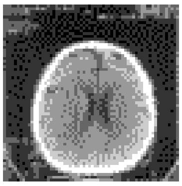
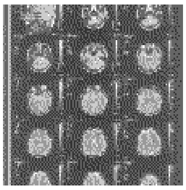
The message was also widely spread among overseas Chinese Scholars and students. For example, it was broadcasted via the list-processor of Chinese Medical Society (UK), by the list manager, Dr Xuguang Liu, to approx.150 Chinese-speaking medical staffs in the UK.

Some scans that were concerned with this case and subsequently retrieved over the Internet:

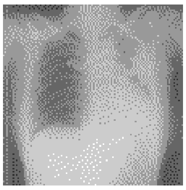
<u>Magnetic Resonance Imaging</u>



Computerised Tomography

X-Ray



Report of the above scans received and delivered over the Internet:

Name: George J. SO
Title: MD
E-mail: georgeso@mail.rad.ucla.edu
Subject: radiographic findings chest exam and MRI of the head
Contents: Dear Ms. Zhu and Mr. Wu,

First, I want to thank you for letting us to review Ling's radiographic studies. I am also happy to hear that Ling is making recovery from the poisoning and hope that the process will be a speedy one. Xin and I and some other American doctors are currently working on techniques and tools using the Internet and world wide web to facilitate communication relating to diagnosis, therapy of disease as well as education between UCLA and the medical community in China. We are certain that the tools will be helpful when another case like this comes up in the future.

I have reviewed most of the plain radiographs of the chest along with Professors Steckel and Kangarloo, MD, current and past chairman of Department of Radiological Sciences, respectively. These studies are dated from March to May this year while Ling was still in coma. These examinations do not demonstrate any sign of thallium poisoning however we know that radiographic studies are very insensitive for this condition. The studies do demonstrate the development of left pneumothorax, pneumo-mediastinum, and probable left haemothorax which was then treated successfully by chest tube. There was also development of atelectasis and likely a pneumonic process in the left lower lung that has also resolved. There was no abnormality identified in the bony structures.

An MRI examination of the head dated March 16, 1995 was also reviewed with Dr. Bentson, the chief of Neuroradiology at UCLA. The examination was performed at PUMC with the following sequences : T1W axial and sagittal, as well as T2W axial and coronal slices, no contrast was given. The examination shows normal gyral and sulcal pattern with no focal signal abnormality. The ventricular size is normal with no dilatation. No mass effect or oedema is present. There is however a small arachnoid cyst located at the anterior temporal fossa which likely of no clinical significance.

Sincerely yours,
George J. So, MD, M.S.E., Department of Radiological Sciences

School of Medicine, University of California, Los Angeles (UCLA)
CC: Professor Li Shunwei and Professor Huang at PUMC

Last information suggests that Zhu Ling has responded excellently to the treatment prescribed and is well on her way to recovery. In April 1997 too this site was active on the Internet and was being frequently updated with the very latest news about her.

Telemedicine Demonstration Project, 1989-1992[6]

Project Description and Goal: Texas Tech MEDNET was a three year demonstration project, partially funded by a $1.9 million grant from the U.S. Department of Health and Human Services. The grant period was from January 1, 1989 through June 30, 1992, during which time the project demonstrated the use of telecommunications systems to link rural health care practitioners. The goal was to use technology to alleviate professional isolation, and ultimately to improve rural health care.

Methodology: Two major services were provided with two different technologies:

1. Continuing education programs, delivered from Texas Tech University Health Sciences Centre (TTUHSC) in Lubbock, via KU band satellite technology, were provided to 48 rural hospitals by the end of the grant. TTUHSC provided live programs, including telephone questions from the participants. The continuing education component included grand rounds, case conferences, seminars and workshops for physicians, nurses and other health care professionals. At least three programs each week were broadcast. The project was designed to give hospitals in rural West Texas the ability to offer up-to-date medical information and training to their staffs without the high costs of travel and temporary replacement staffing.
2. Clinical consultations using interactive digital video were provided to two rural hospitals through terrestrial T1[7] lines. With this service, the primary care physician in the rural hospital was able to communicate with specialists in larger hospitals or medical centres for consultations on diagnosis and treatment. Patients seen in the Alpine and Ft. Stockton hospitals could also be “seen” through live video at the Texas Tech Health Sciences Centre in Odessa, Lubbock, or El Paso. The consultations often allowed the patient to remain in the local community and receive medical care there. At the time of the grant, an interactive video network (TechLink) connected the four campuses of TTUHSC in Lubbock, Amarillo, El Paso and Odessa. The grant network for clinical consultations connected two rural hospitals with TechLink.

Two additional services were also provided:

1. Although static imaging of X-rays and pathology slides was also demonstrated at three rural sites, there was not a high demand for the service, and it never became routinely used. Static imaging services used telephone lines for transmission of high resolution still images. The current equipment for static imaging is more user-friendly than that available in 1989, and it is possible that new equipment might yield different results.

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[6] Hartman, J. Ted and Moore, Mary. Using Telecommunications to improve rural health care: the Texas Tech MEDNET Demonstration Project. Lubbock: Texas Tech University Health Sciences Centre, 1992.
[7] **T1** Common for links between Internet servers; roughly 1500 Kbps, or 12 times faster than ISDN.

2. Medical information and consultation was provided via telefacsimile. Hospitals had telefacsimile machines which were initially installed to receive documents quickly from the Texas Tech University Health Sciences Centre libraries. Physicians found that they could also use the machines for foetal monitoring consultations. Over 90% of those images transferred via telefacsimile revealed abnormalities that could be managed by telephone consultation. This reduced the number of patients that had to be referred to specialised care centres. Utilisation: During the period of the grant, 255 continuing education programs, 181 interactive consultations, 35 static imaging consultations, and 91 foetal monitoring telefacsimile consultations were held.

Outcomes: Rural health care practitioners who used the services reported these services were successful in reducing rural isolation and improving rural health care. In continuing education program evaluation studies, most viewers reported that they used the information presented in the programs at least once a week to treat patients. These viewers indicated that the information they received from MEDNET programs contributed to reducing risk management incidents; resulted in positive changes in quality assurance; improved the quality of rural health care; and reduced their sense of professional isolation. In addition, 81% of physicians agreed that they had handled a patient situation differently; 60% agreed that they avoided additional tests and/or procedures; and 45% agreed that they avoided patient mortality as a result of the information presented on MEDNET programs.

Physicians and Richard Arnold, the hospital administrator in Alpine stated that the interactive video consultations kept patients in the rural health care setting, increased local patient revenues, and possibly helped keep the rural hospital from closing. Additional benefits included increased confidence in the rural physician and the rural hospital by the community; enhanced patient/specialist/rural physician communication; enhanced patient compliance; physician education on how to treat similar conditions; improved quality of care; and avoidance of patient mortality.

These programs have reportedly been valuable even to non-users in the rural hospitals. Participants in the continuing education programs have reported that MEDNET topics have resulted in revised procedures manuals hospital-wide. They also reported that discussion about topics presented on programs often reached non-viewers as well, who may make behaviour changes based on the information. One rural physician who used the consultative services identified that another physician who rarely used the services often asked for advice on patient referrals. One aspect of rural isolation was not even knowing the names of specialists before MEDNET began. This same physician has stated that before MEDNET they were often unaware of the services of particular specialist physicians, and so could not use those services in the past.

Funding: The Texas Tech MEDNET Project was begun as a cost-participation grant, in which TTUHSC was legally required to fund all equipment and to annually demonstrate its cost participation. Funding for ongoing operation of MEDNET services will be provided immediately after the grant period by Texas Tech Health Sciences Centre, foundation grants, and special State of Texas funding. It is anticipated that within two years the service will be entirely funded by cost recovery. Rural hospitals participating in the continuing education services pay a minimum of USD $450 per month for receipt of at least 12 individual programs that have been tailored for rural audiences. It has been determined that this service will reach cost recovery with 80 subscribers.

Third party reimbursement will continue to be pursued for interactive video consultations. An independent study of a varied sample of consultations identified each consult saved an average of approximately USD $1000, which could have far reaching financial effects on health care.

Continuation of services, post 1992: TTUHSC developed these systems and services to fulfil its regional and rural outreach mission. Telemedicine will be continued under Texas Tech HealthNet, an organisation that will integrate rural outreach services from Texas Tech Health Sciences Centre. The continuing education project will continue to be marketed to rural and isolated hospitals, nursing homes, and clinics. The interactive consultation project will be extended to at least one additional site, and the strategies for obtaining third party reimbursement will continue to be pursued after the end of the grant. In addition, other telecommunications services to rural communities will be examined, including support and supervision of health care students and residents in isolated sites; provision of public education and continuing education; remote management of legal hearings; regional administration of public agencies; local assessment of patients requiring rehabilitation or mental health and retardation services; and prison health care consultations.

Telemedicine

Introduction

With the tremendous advance in computer technology and computing power combined with the application of computers for nearly everything, it is perhaps only to be expected that medical sciences would also not remain immune from being influenced by it. Today, computer technology is helping medical personnel in delivering more efficient health care in lesser amount of time. Existing technology is helping in faster and better diagnosis and management of a patient even if the concerned specialists are physically located several thousand kilometres away. Distance is no barrier to better diagnosis and management of a patient with this technology. It is envisaged that the consulting doctor would be physically located at great distances away from the patient and still be able to not only see, speak, diagnose and treat but also operate on the patient through telerobotics.

Definition

Telemedicine ["*Tele*" (Greek - distance) + "*mederi*" (Latin - to heal); "*healing by wire*" (Time Magazine)] is the term given to the use of modern telecommunications and information technologies for the provision of clinical care to individuals located at a distance and to the transmission of information to provide that care.

Though some refer to information technology as "futuristic" or "experimental", telemedicine actually enjoys a forty year old history, starting with pioneering projects at universities, hospitals, and a Red Indian reservation in the 1950s. Today, telemedicine systems operate in many countries as well as in many areas of the US.

Telemedicine is not one specific technology but a means for providing health services at a distance using telecommunications and medical computer science. It spans every echelon of health care, from the first responder or emergency medical systems to tertiary[8] medical speciality consultations to performing invasive and/or surgical procedures to delivering home care.

World-wide, people residing in remote and rural areas struggle to gain access to timely and quality speciality medical care. Even when the rural areas may have access to a general practitioner, the residents are forced to expend considerable resources in the form of both time and money in order to seek speciality medical care.

Telemedicine seek to reduce burdens on these very valuable resources by improving access to medical care for populations with sub-standard access to quality health care, no matter where they are physically located. In areas where quality health care is available, this technology would make it possible to allow access to even higher standards of health care.

The technology uses electronic signals to transfer medical data in real time from one from one site to another overcoming all sorts of geographical barriers. The medical data so transmitted may be in the forms of high resolution photographs, radiological images, sounds, patient records, videoconferencing, etc. This transfer of medical data may use the Internet, Intranets, PCs, satellites, videoconferencing equipment and telephones, modems, ISDN lines

[8] **Tertiary** Third level

and ordinary or fibre-optic cables. In near future, ADSL[9] technology will revolutionise this process further.

Telemedicine is utilised by health providers in a growing number of medical specialities, including, but not limited to: dermatology, oncology, radiology, surgery, cardiology, psychiatry and home health care.

A trend in the US is the use of telemedicine in correctional facilities in which time and money for inmate transportation are reduced while safety for health care personnel and the public is increased. Telemedicine is also expected to fine tune the management and allocation of remote health care emergency programs by transmitting images to medical centres for long distance evaluation by the appropriate medical personnel.

Telemedicine permits physicians doing clinical research to be linked together despite geographical separation, sharing patient records and diagnostic images as well as exchanging information on a tele/videoconferencing basis. Improvement of medical education in the form of continuing medical education (CME) is also made possible by linking several community hospitals together with the sponsoring medical institution.

In summary, telemedicine is a high-tech solution to the universal problem of access to health care. Due to this technology, geographical isolation need no longer be an insurmountable obstacle to the basic needs of timely and quality medical care.

Other Important Definitions[10]

- **Telemedicine network** is a set of functional relationships among *telemedicine facilities*. A telemedicine network usually contains a hub and at least one spoke, but may contain multiple hubs and spokes. A network can contain several different projects with distinctly separate funding sources. As a sum of all these parts, the network provides and obtains telemedicine services such as consultations.
- **Telemedicine project** is the term given to the activities of telemedicine activities of facilities and participating organisations that derive from common funding sources and objectives. A *telemedicine network* may have multiple projects.
- **Primary organisation** is the organisational entity (institution, consortium, etc.) that serves as the primary network administrator with ultimate legal and financial accountability for performing telemedicine tasks and services, regardless of the source of funds. The primary organisation provides direction for the *telemedicine project(s)* within the network and has at least one facility where telemedicine is conducted.
- **Participating organisation** is an organisation involved with a *telemedicine project(s)*, but the participating organisation does not provide patient or clinical care.
- **Funding source** is the fiscal agent that provides funding for a *telemedicine project*.
- **Telemedicine facility** is a location where telemedicine services are provided and/or received.

History of Telemedicine[11]

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[9] **ADSL** Asymmetric Digital Subscriber Line, which converts twisted-pair phone lines into digital "pipes" that allow up to 6.1 Mbps downstream to the client (90 times faster than ISDN), and up to 640 Kbps upstream from the client. This operates through a separate data network at the phone company's central office, and requires special modems (currently about $4,000/pair, with prices dropping dramatically). Price should be competitive with ISDN. PacBell and GTE have recently begun ADSL trials.

[10] JWGT - Telemedicine Inventory

While the explosion of interest in telemedicine over the past four or five years makes it appear that it's a relatively new use of telecommunications technology, the truth is that telemedicine has been in use in some form or other for over thirty years. The National Aeronautics and Space Administration (NASA) played an important part in the early development of telemedicine (Bashshur and Lovett, 1977). NASA's efforts in telemedicine began in the early 1960s when humans began flying in space. Physiological parameters were telemetered from both the spacecraft and the space suits during missions. These early efforts and the enhancement in communications satellites fostered the development of telemedicine and many of the medical devices in the delivery of health care today. NASA provided much of the technology and funding for early telemedicine demonstrations, two of which are mentioned below. A book by Rashid L. Bashshur published in 1975 (Bashshur R.L. et al. 1975) lists fifteen telemedicine projects active at the time. There were several pioneering efforts not only in the US, but all over the world.

Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC): One of the earliest endeavours in telemedicine, STARPAHC delivered medical care to the Papago Indian Reservation in Arizona. It ran from 1972-1975 and was conceived by the National Aeronautics and Space Administration (NASA), engineered by NASA and Lockheed, and implemented and evaluated by the Papago people, the Indian Health Service (US) and the Department of Health, Education and Welfare. Its goals were to provide health care to astronauts in space and to provide general medical care to the Papago Reservation. A van staffed by two Red Indian paramedics carried a variety of medical instruments including electrocardiograph and x-ray. The van was linked to the Public Health Service hospital and another hospital with specialists by a two-way microwave telemedicine and audio transmission. (Bashshur, 1980).

Nebraska Medical Centre: The Nebraska Psychiatric Institute was one of the first facilities in the country to have closed-circuit television in 1955. In 1964 a $480,000 grant from the National Institute for Mental Health allowed a two-way link between the psychiatric institute and Norfolk State Hospital, 112 miles away. The link was used for education, and for consultations between specialists and general practitioners. In 1971 the Nebraska Medical Centre was linked with the Omaha Veterans Administration Hospital and VA facilities in two other towns. The psychiatric institute also experimented with group therapy. (Benschoter, R.A. 1971).

Massachusetts General Hospital/Logan International Airport Medical Station: This station was established in 1967 to provide occupational health services to airport employees and to deliver emergency care and medical attention to travellers. Physicians at MGH provided medical care to patients at the airport using a two-way audio-visual microwave circuit. The Medical Station was staffed by nurses 24 hours/day, supplemented by in-person physician attendance during four hours of peak passenger use. Evaluation of diagnosis and treatment of the nurse-selected patients was made by participating personnel and independent physician observers. Analysis was also made of the accuracy of microwave transmission. Inspection, auscultation, and interpretation of roentgenograms and microscopic images were also performed. Necessary hands-on procedures were performed by the nurse-clinicians. (Murphy, R.L. Jr. and Bird K.T.(1974) and Murphy, R.L. Jr., et al (1972).

Alaska ATS-6 Satellite Biomedical Demonstration: In 1971, 26 sites in Alaska were chosen by the National Library of Medicine's Lister Hill National Centre for Biomedical Communication to see if reliable communication would improve village health care. It used ATS-1, the first in NASA's series of Applied Technology Satellites launched in 1966. This

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[11] Abridged from an article on the Internet

satellite was made available in 1971, and was still in use in 1975. The primary purpose was to investigate the use of satellite video consultation to improve the quality of rural health care in Alaska. Satellite ground stations permitting transmission and reception of black and white television were installed at four locations, and a receive-only television capability was installed at the Alaska Native Medical Centre in Anchorage. All five sites had two-way audio. Two of the locations had no resident physician. Simultaneous two-way video capability was not available, although the one-way video could be switched for transmission from any site except Anchorage. This was an exploratory field trial, not a rigorous experiment. Evaluation of the project was done by the Institute for Communications Research at Stanford University. It was determined that the satellite system was workable, could be used effectively by health aides at the various locations, and could be used for practically any medical problems except emergency care (emergencies could not wait for scheduled transmission times). It was also determined that the "unique capabilities of the video transmission may play a critical role in 5-10% of the cases selected for video presentation. Otherwise, there was little measurable difference between the effect of video and audio consultation." (Foote, D. et al. 1976) and (Foote, D. 1977).

Video Requirements for Remote Medical Diagnosis: In 1974 NASA contracted with SCI Systems of Houston to conduct a study to determine the minimal television system requirements for telediagnosis. The experiment was conducted with a help of a simulated telemedicine system. First, a high-quality videotape was made of actual medical exams conducted by a nurse under the direction of a physician watching on closed-circuit television. This was the baseline for the study. Next, these videotapes were electronically degraded to simulate television systems of less than broadcast quality. Finally, the baseline and degraded video recordings were shown (via a statistically randomised procedure) to a large number of physicians who attempted to reach a correct medical diagnosis and visually recognise key physical signs for each patient. Six television systems were investigated: two systems were compatible with transmission over full bandwidth television channel, while the other four allowed more detailed investigation of the frame rate and horizontal bandwidth required for each medical case. The following four results were found:

1. statistical significance between the means of the standard monochrome system and the lesser quality systems did not occur until the resolution was reduced below 200 lines or until the frame rate was reduced below 10 frames/second;
2. there was no significant difference in the overall diagnostic results as the pictorial information was altered;
3. there was no significant difference in remote treatment designations as a function of TV system type that would cause detriment to patients;
4. the supplementary study of radiographic film televised transmission (25 cases) showed that no diagnostic differences occurred between the TV evaluations and the direct film evaluations for TV resolutions above 200 lines if special optical lenses and scanning techniques were utilised. (SCI Systems, Inc. 1974).

Memorial University of Newfoundland (MUN): MUN was an early participant in the Canadian Space Program. The joint Canadian/U.S. Hermes satellite provided Canadians with an opportunity to use satellite technology in distance education and medical care. Since 1977, The Telemedicine Centre at MUN has worked toward developing interactive audio networks for educational programs and the transmission of medical data. Among the guidelines followed were: use the simplest and least expensive technology; be flexible; involve the users from the beginning of the project; seek administrative support in hospitals, clinics and other agencies; and include evaluation. The MUN Teleconferencing System, a province-wide network consisting of five dedicated circuits, began programming in 1977. There are installations in all provincial hospitals, community colleges, university campuses, high schools, town halls and education agencies. MUN has been active in international teleconferencing, and played a significant role in the School of Medicine at the Univ. of Nairobi, Kenya in the 1960-70s. In 1985 MUN became involved in the International Satellite Organisation (Intelsat), linking to Nairobi and Kampala, which later was extended to six Caribbean countries. MUN has been a model for the judicious and low-cost use of telemedicine technology. They have proven that many times there is no need for the higher-end, higher-cost videoconferencing equipment. (House and Roberts, 1977).

The North-West Telemedicine Project: This project was set up in 1984 in Australia to pilot test a government satellite communications network (the Q-Network). The project goals were to provide health care to people in five remote towns south of the Gulf of Carpentaria. Two-thirds of these people were Aborigines or Torres Strait Islanders. The Q-Network consisted of 20 two-way earth-stations and 20 one-way (television-receivers only) earth stations. The hub of the network was the Mount Isa Base Hospital. All sites were supplied with a conference telephone, fax, and freeze-frame transceivers. Evaluation for the project showed that the technology did improve the health care of these remote residents. While it was impossible to calculate the operating costs of the telemedicine network separate from the other functions of the network, some health care costs were reduced. Fewer patients and specialists flew to and from these remote areas for routine consultations, and fewer patients were evacuated for emergency reasons. (Watson, 1989).

The NASA SpaceBridge to Armenia/Ufa: In 1989 NASA conducted the first international telemedicine program, Space Bridge to Armenia/Ufa. In December of 1988 a massive earthquake hit the Soviet Republic of Armenia. An offer was extended from the United States to the Soviet Union for medical consultation from the site of the disaster in Armenia to several medical centres in the U.S. Under the auspices of the U.S./U.S.S.R Joint Working Group on Space Biology, telemedicine consultations were conducted using one-way video, voice, and facsimile between a medical Centre in Yerevan, Armenia and four medical centres in the U.S. The program was extended to Ufa, Russia to facilitate burn victims after a terrible railway accident. This project demonstrated that medical consultation could be conducted over a satellite network crossing political, cultural, social, and economic borders. (Pers. Commun. Chuck Doarn, NASA, January 1996). The last ten years have seen a steady increase in the number of telemedicine projects throughout the U.S. and internationally. As more government funding became available in the early 90s, and as technology costs continue to decrease, telemedicine is possible for a wider spectrum of users.

The Health Care Industry

Introduction

The health care industry and the providers (institutional and individuals alike) seem to forget more often than not that they deal with people, people, people, and people. It is a strange industry where the provider decides what to provide and when which the customer is constrained to receive even if he does not like it. The customer is entitled to get well and that is all. The customer make seek a second or even a third opinion, but is obliged to accept at face value all that is offered to him. The customer may seek redressal for perceived or otherwise any grievances in pecuniary or other forms through malpractice suits, but that is another matter altogether.

Components of the health care industry

The health care industry typically and broadly consists of residential and non-residential institutions providing health care. These may be hospitals, clinics, doctor's chambers, health maintenance organisations, retirement homes, home for delivering nursing care, home care organisations, medical laboratories, diagnostic centres, etc. All of them come under the broad heading of service industry.

Peculiarities of this industry

Even though they are in the service industry, they provide care to those people who have virtually no control over how and what they shall receive. The customers are essentially unwell people, who wish to get well or else get relief from their condition to the best extent possible, at the shortest interval of time, and at the cheapest costs. The industry is run by people who do not particularly care for the costs while they provide the care and see any intervention by "non-professional" persons in their work as an intolerable intrusion by meddlesome persons who are essentially too dense to understand their work or their value. The hostility thus generated as a consequence is understandably rampant in the industry. The picture has been complicated by the fact that the medical personnel, especially the doctors who are "bound" by the Hippocratic oath and largely guided by a strong sense of service for the fellow human-being, feel a sense of obligation and duty while they go about their business of providing the care. Moreover, while in other industries, the advent of newer techniques and automation has helped in reducing costs, the exact opposite has happened in the health care industry where the costs have steadily risen with the introduction of newer methods, procedures and diagnostic tests.

Past

This industry was characterised in the past by an overall charitable outlook shown by the providers towards the recipients. The recipients looked on the providers as agents of God and gave their trusts totally. The providers took their compensation in pecuniary terms or in kind or sometimes none at all. The first hospitals were set up by the monks in their monasteries and cared for the sick and the disabled as a service towards God. The physicians and surgeons treated their patients with the attitude of a carer - hence the term 'health *care*' - who saw his function as healing the sick, tending the wounded, and rehabilitating the disabled. Largely guided by the Hippocratic oath, the health carers discharged their duty with a deep sense of pride and humility to the best of their capabilities and satisfaction of their customers.

Present

With the advent of commercialisation, all the honourable notions of charity and care have been cast away by the wayside without a second thought. The health care providers perform the same functions as they did before with largely the same attitude, but for pecuniary considerations which only seems to be on the up and up. Not that the providers can be exclusively blamed for the situation having to come to such a pass. The newer drugs and technology that has helped in prolonging life and the quality thereof comes at a price which can only mildly be termed as high. As a result, the time spent on training and re-training is threatening to bring the industry to its knees.

Unfortunately, this has meant that the customers too have become demanding. They do not accept all that is offered to them. They claim the privilege to be informed of all that has happened to them and whatever that is being offered as a solution. They want value for their money.

The health care provider community jealously guard their knowledge. The reasons forwarded are many and is not moot to our present discussion. The right to claim satisfactory settlement in monetary terms has meant that they have been forced to lift their veil of absolute secrecy and suitably inform their customers in exchange. Furthermore, it was found that there are certain diseases which are best treated by undertaking a few simple steps at home while some others may be avoided by taking some precautions. Prevention being better than cure, information thus has become of great and vital importance to one and all.

The health care industry is not free from the afflictions that affect the other industries currently. It is in a state of flux with the health care providers undecided as to how to proceed effectively in the 21st century. The big debate which has the industry in its stranglehold is whether or not this industry is a 'non-profit' or a 'for-profit' industry. If it is to be one or the other, what is the best balance for being able to provide the service to the customers at a price that is satisfactory to one and all? What should the pay-off be so that the customer can be provided the very best care that the current technology allows at a price that is perceived as being 'value for money'? Should 'value pricing' be practised and, if so, then at what price? How may these figures be safely arrived at?

Future

The future is assured and that is a fact. As long as human beings continue to populate this planet and other heavenly bodies in the current form, the industry will continue to thrive and grow. The quality of its existence is something that may however be debated.

Health Care Industry - An Industry In Transition

The health care industry has been termed as being an industry in transition[12]. The industry has undergone a sea of change over the past one hundred years and continued advances in research, development and technology have produced many new methods to prevent, diagnose and treatment of disease as well as the management thereof. However, as revolutionary as these new advances have been, the most radical changes in the health care industry have revolved around the creation, dissemination and exchange of information.

As public attention has increasingly focused on the health care industry, many suggestions have been made to improve its quality and efficiency. Some have favoured

[12]Ref.: Health Village Network: delivering a new age of information to health care - Jeffrey D. miller, Segment Executive, World Wide Health Network Solutions, IBM Health Care Solutions.

managed health care, others have promoted universality of access, while others have supported the more traditional health care programs[13].

Notwithstanding these different approaches, a strong and consistent message universally has been that the health care systems' productivity must be improved, the paperwork (especially administrative) reduced, spending minimised, and yet the delivery of higher-quality care fully assured.

The answer to all this seems to be to develop online services which will allow various health care professionals, connected via the network, to share patient information, thus enabling both providers and payors to become more productive.

Traditionally health care providers have approached their work on an episodic basis, treating patients for specific medical problems as they occur. For example, an individual would go to a family practitioner for a running nose or fever, to an ophthalmologist for difficulties in eye-sight, and to the obstetrician for pregnancies.

Regrettably, those involved in providing medical care frequently do not have the means to easily access and share patient information and, very frequently, the providers are unable to share information with other important, non-medical participants in the system, such as the payors.

From the patient's perspective, the problems associated with this lack of information sharing are even more basic. They are obliged to fill out pages after pages of information of various nature or are condemned to repeating the same old tale of all their afflictions, both past and present, over and over again as they get shunted from one physician's office to another.

This situation results, in large part, from the fact that health care providers have long focused on information that relates to administrative and financial issues, such as payor transactions, that too on an episodic basis. Less attention has been paid to developing an overall electronic health planning capability that focuses on all aspects of patient's welfare and includes plans to manage patient's *care from womb to tomb*.[14]

In order to migrate to a more efficient, patient centred focus, health care providers must link together a diverse group of players, including:

- Employers who wish to provide care programs at reasonable costs, while minimising their administrative workload;
- Payors and employers who want to know the "outcome" of their employees' and members' interactions with the health care system, including cost, quality, and satisfaction;
- Insurers and other financial institutions that are structuring their offerings using new risk assumptions, i.e., determining the most cost-effective quality of care in a capitated health care environment;
- Public awareness groups, local heath departments and their affiliates that are stressing childhood immunisations, mammograms, and other preventive health care and community welfare programmes;
- Government organisations, particularly at the regional level, that are determined to ensure universality of access to health care, while reducing costs that are threatening to bankrupt their treasuries;
- Physicians, the focal point of patient treatment information, who need easy access to all types of clinical information that they can share with their colleagues for opinion/reviews, in order to continue providing quality care.

[13]Health Data Networking: transforming the health care system; Sharing information through Health Data Networks: a recipe for health care.

[14] WHO statement.

Increasingly, health care providers, payors and government officials are realising that only by working together and sharing *relevant* patient information can they create efficiencies in the health care system that lower costs and improve service, access and quality.

Therefore the need for health data networks is indispensable in the present day health care environment. With the emphasis on providing services across the continuum of care, providers must now consider not only how to treat their patients, but what caused their illness. Moreover, they want to know how well the treatments have worked, if their patients require additional treatments, and if certain treatments were indeed administered, and when administered were administered correctly and in accordance with the duly prescribed principles and norms. In short, they require information on every aspect of a person's medical history, from wellness to critical care.

In the past, the communications model for the health care system was very simple. Only the patient and his physician represented the two main participants. The patient described his symptoms and relied on the physician's knowledge and experience to recommend proper treatment.

Today's health care system is significantly affected by a complex communications model populated with many players including health care organisations, medical professionals, risk managers, agents, suppliers and other entities. Information on any one user of the health care system can reside across multiple constituents, making it difficult to locate comprehensive, accurate and timely information.

Added to this complexity is the growing need for consumers to actively participate in decisions affecting their health and well-being. As the average life span increases, the health costs continue to rise, and as more employers shift financial responsibility to their employees through higher deductibles, copayments and benefit plans, today's consumers are demanding increasing amounts of information for making informed health care choices.

An educated consumer is an informed buyer. The consumers are becoming a major force within the health care industry. Their new power derives essentially from three primary sources:

- Shifting of costs from the employers to their employees in which the employers structure the health benefits in such a manner that the employees shares the cost, at least partly, and additionally take on the responsibly of choosing their own health plan. This allows greater flexibility, a participation by the employees in the decision-making process concerning the very vital aspects of their lives.
- A large percentage of the population nearing their retirement years with anticipated longer life spans and their desire for the ageing years to be active, productive and yet affordable. Often, these persons are responsible for the caring and making decisions for their elderly parents and children, as well as themselves.
- The increasing tendency to offer patients choices about the various treatment options on offer including the costs and the quality of life benefits, thus shifting a part of the medical decision-making directly on to the consumer.

As the consumers assume greater responsibility for managing their own health care, as well as that of their families, these significant life choices demand tremendous amounts of information, presented at the consumer level and easily accessible for in depth study. These include:

- General health information;
- Summary and detailed information about specific diseases and conditions;
- The pros and cons of the various treatment option on offer for the specific conditions and diseases;

- The various preventive measures available and the effect of the choices made upon the lifestyle of the individual;
- The employer/government health benefit options, costs, coverages and medical professional participation;
- Quality information on different providers and health plans.

A major cultural change has occurred over the past fifty years. Health practitioners have realised that it is better for the consumer and more cost-effective for the society to direct their services towards keeping people well, rather than just treating them when they are not. 'Prevention is better then cure' is the origin of the Preventive and Social medical sciences.

The consumers of today recognise that they too bear the responsibility for their own well-being and are suitably modifying their lifestyles in the anticipation of longer and hopefully healthier lives. As they make a personal investment in their own well-being, they naturally seek information and services personalised to their needs and preferences.

Employers too are recognising that the continued well-being of their employees directly translates into a more productive workforce and reduced costs due to less loss of workdays resulting from injuries and illness. Consequently, the companies are investing in programmes and incentives to promote well-being, including health risk assessment, cessation of smoking at least in the place of work, and membership in the various fitness programmes.

One study indicated that for every USD $ 1.00 spent on preventive health care programmes, USD $ 6.00 were saved on insurance costs.[15] This is a significant return on investment for health care systems that promote health and address the needs of their community. Employers are also using health promotion programmes to help reduce the costs of providing health care benefits to their employees, as demonstrated by recent results shared by Lee Ahsmann, VP of human resources at Superior Coffee and Foods, at a conference sponsored by The Wellness Coalition. According to Mr. Ahsmann, wellness initiatives have cut health care costs for his company considerably. His company's annual investment of approximately USD $ 125,000 for health care programmes has yielded a 17% decrease in health care costs per employee, without any changes in the health plan. During that same 1994 to 1995 time period, hospital admissions decreased by 22%, the average length of stay was shortened by 29%, and long-term disability claims fell 40%.[16]

The health care organisations that flourished a decade ago in fee-or-service and indemnity-based delivery systems are under tremendous pressure to change as the industry shifts toward fixed systems in a managed care environment. The effects of this change are two fold. The first is the recognition that an informed consumer can drive the cost and quality of care. The second is an intense effort to control costs, with an increasing focus on managing both the demand and supply sides of the market.

Increasingly, the consumer is the primary decision maker, causing health care organisations to market quality services at competitive prices. Health care organisations now must differentiate themselves by responding to the varied needs and expectations of consumers and ensuring that costs are managed to remain competitive. Providing easy access to information distinguishes the organisation, demonstrates a commitment to community health and well-being, and can improve customer satisfaction and member retention.

[15] Fortune 96-97467 V131 N11 Jun 12, 1995

[16] "Investing in Employee Wellness"; Business insurance, March 11, 1996, Volume 30, No. 11

Providing new, quality information can also assist in the management of costs through the demand side of the economic model. Providing consumers informations on treatment options and well-being plans can potentially conserve medical resources. For example:

- General health education can improve healthy behaviour and life choices, thus promoting well-being and reducing demand for services.
- Specific information about certain risk factors, diseases, and the pros and cons of various treatment alternatives can empower consumers to make more informed choices. Given such information, many consumers select less costly, less invasive procedures.

On the supply side of the equation, health care organisations now have aggregate information on costs associated with many different treatments and diagnoses, allowing them to analyse and focus on improving internal efficiencies. Using that analysis to keep costs down and more effectively supply information and services personalised to the needs of the diverse population results in enhanced customer satisfaction and market differentiation for the health care provider.

In a health care plan's relationship with a consumer, the expense to market the plan, set up coverage for the member and document the health history is far more expensive than maintaining an existing member relationship. However, the majority of consumers select their health plans through their employers, who frequently must offer several options to meet the needs of their diverse workforce population. This often results in consumers switching plans at renewal if they are less than satisfied with the relationship established with their provider.

Health care benefits are often at the centre of labour disputes for large companies and increasingly employers are requiring quality of care and patient satisfaction information from plans in order to feel secure that they are offering their employees the best options. Therefore, finding ways to enhance consumer/member relationships has become increasingly important. Ways to accomplish member retention include:

- Providing easy access to information and services directly related to the consumer's needs and interests;
- improving delivery of services, such as easy access to enrolment, claim status, and appointment scheduling;
- Increasing communications between consumers and health professionals through electronic applications;
- Offering incentives for good health practices.

Many changes in the health care delivery require, or are facilitated by, the availability and exchange of information. Improvements in the telecommunications infrastructure offer tremendous opportunities to improve access to information related to health care and communications among different participants.

Increasingly, enhanced electronic information systems, like the Internet and other online services, are one means that will be used to exchange information. As home computer usage increases, Internet usage is expected to grow exponentially.

Health care, in other words, has entered the information age. The demand for health care information, delivered online, is growing rapidly among both health care consumers and professionals. Healthcare Managed Organisations (HMOs), employers, insurance companies and other constituents are responding rapidly to address that demand. However, ensuring the response is relevant, easily accessible and useable by the consumer is another challenge.

Competitive Analysis of the Health Care Industry

The dominant economic traits are:

1. Huge and ever increasing market size.

2. The scope of competitive rivalry is intense, especially at the local level and it progressively diminishes as the scope is progressively broadened to include regional, national, international or global regions.
3. The market growth rate differs according to geography. The industry however is in late maturity and saturation state.
4. The number of rivals and their relative sizes are as varied as can be though of. It is perhaps best to describe it as being fragmented.
5. The number of buyers is astronomical. There are those for whom cost is no object while at the other end of the scale there are those who have extreme difficulty to pay for anything and consequently are utterly dependent upon the largesse and charities of the national government or institutions which operate on a totally charitable basis. However, the major size of the buyers appear to be in between these two extreme ends. It does not matter to which geographical region one goes, one is bound to find all sorts of buyers world wide. On a local scale they may be concentrated though. They however do not have much leverage.
6. There is only some possibility of backward integration though forward integration to various degrees is possible.
7. The ease of entry is more than the ease of exit, however the barriers are not high.
8. The pace of technological change is fast.
9. The services of rival firms are either essentially identical or weakly differentiated at the most.
10. Being run by highly qualified people, the industry in general has a strong learning and experience curve such that average unit cost declines as cumulative output builds up.
11. Capital requirements are very varied and depends upon the organisation. While a single physician working out of a chamber has low capital requirements, a 1500 bed hospital has huge ones.
12. The profitability of the industry as a whole is just around par.

Analysis according to Michael E. Porter's five forces model

I. **Rivalry among competing sellers**.

The competition is intense but well hidden.

- Essentially run by professionals who "serve the humanity", they only covertly compete for customers. Being a service industry, the buyers are naturally attracted principally by the quality of the services rendered rather than anything else.
- The rivalry exists primarily because the number of competitors are steadily increasing as is the growth of the number of buyers. Moreover, competitors are tempted to use price cuts and better service mix offering to boost buyer volume. The switching costs of the customers is essentially very low and the exit barriers high.

I. **Competitive force of potential entry**

This threat is very high.

- Most of the technology and specialised know-how is in the public domain and widely available, though the quality cannot always be ensured. The costs to acquire them depend upon the service mix offering of the particular organisation. The economies of scale is therefore variable.

- The existence of learning and experience curve effects allows an organisation already in the market to establish itself strongly as a market leader which the competitors would have a tough time countering.
- The loyalty of the customer is high when he is satisfied with the quality of the service, quantity being the second most important consideration. When one's life is at stake, few would think about the costs incurred. Costs therefore comes a poor third in the list of considerations. Where no loyalty exists, the particular organisation would have to demonstrate that it can amply justify in the minds of the customers that by switching they would gain more than they could possibly lose. Thus *better quality, more quantity and lower or value priced offerings is the best way to attract them*. The capital requirements vary according to the size and service mix while low cost disadvantages independent of size exist. Access to distribution channel is easy and the regulatory policies are generally favourable to any new entrant.

I. **Competitive pressures from substitute products**

This hardly exists. Perhaps it would be safer to state that it is non-existent in the developed actions of the world. Substitute of the health care services? Perish the very thought!

II. **Power of suppliers**

This is variable and depends on the technological end of the offering.

- For the majority it is limited due to low differentiation of inputs, low switching costs, presence of substitute inputs of equally good quality, the suppliers are not concentrated and for them volume is very important so they would go to any extent to ensure the maintenance of their volumes. The percentage of costs of products bought relative to total purchases in the industry is fairly constant for every organisation.
- The suppliers of the high-end technology however have considerable leverage due to the exactly opposite reasons as mentioned above. They have huge leverage, without putting too much of a fine point upon it.

I. **The bargaining power of buyers**

This is moderate.

- Their bargaining leverage is low, buyer concentration versus firm concentration places the buyers at a slight disadvantage.
- The buyer volume is large and growing.
- The buyer switching costs are very much lower in comparison to the firm's switching costs.
- The buyer has a great deal of relevant information on the products on offer.
- They are not in a position to integrate backwards and cannot avail of substitute products.
- They are price-sensitive as long as they are unaware about the quality and quantity of services on offer. The more they are quality and quantity sensitive, the less they bother about the price and would always measure their pay-off with quality on one end along with quantity while placing price at the other. Thus it may be said that the buyers are low to moderately price-sensitive only.

SWOT Analysis of The Health Care Industry

Without Telemedicine:

1. Strengths

- Personalised and human touch in the delivery of care every time.

2. Weaknesses
   - No opportunity/limited opportunity to offer expert advice to the customers at all times.
   - High costs due to repetition of tests due to unavailability of the results of the previous tests.
   - Diminished efficiency due to limited and essentially archaic communication facilities available; also especially, in emergency, many cases are not effectively dealt with for lack of vital informations (e.g., the patient's past history, therapeutic history, etc.)
   - Obsolete facilities, at least perceived to be so by the customers.
3. Opportunities
   - Lower prices of the product line on offer as no additional costs would accrue as a result of capital expenditures and maintenance expenditures on account of telemedicine.
4. Threats
   - Organisations having telemedical facilities would be in a competitively advantageous position.
   - The customers may opt for those organisations offering IT solutions as an additional to their product mix and thereby leading to lowering of the market share.
   - The customer needs may not be fully satisfied.

With Telemedicine:

1. Strengths
   - Core competency in better product mix and increased efficiency.
   - Well-thought-of by customers as they get the best care that there is available anywhere on this planet, at least potentially.
   - Some insulation from strong competitive pressures. Other organisations may only be able to offer the same technology.
   - An acknowledged market leader in innovativeness with a strong vision for the future.
   - Improved efficiency.
   - Ahead on experience curve.
   - Undoubted technological skills of a superior nature.
2. Weaknesses
   - Sub-par profitability because of lack of proper skilled personnel to handle the technology as well as bad marketing/advertisement strategy leading to under-utilisation of the facilities on offer leading to a low return of investment.
   - Potential loss of security, particularly of sensitive information - at least perceived as such by the customers (although the telemedical directors at The Consensus Conference of the Mayo Telemedicine Symposium in 1994 did not think this was serious issue).
   - Some loss of personalised care if treated by an expert who continuously resides afar and hardly, if at all, visits the patient in person.
3. Opportunities
   - Ability to serve additional customer groups or expand into new markets or market segments.

- Ability to expand product mix to meet broader range of customer requirements.
- Acquiring special skills which may be transferred to others at a price.
- Keeping at pace with the emerging technologies.

4. Threats
    - Increased vulnerability to recession and business cycles as considerable capital and manpower expenditures are involved leading the organisation open to an exposed and weakened free cash flows.

Influence of Telemedicine on the Health Care Industry

Telemedicine would allow an organisation to position itself favourably in the market. The competitors would certainly strike back but as the entry costs are high due to the capital expenditures as well as the learning curve involved, these would prove to be a definite hindrance to the competitors. The buyers would be attracted by the quality of services which would undoubtedly go up. If the organisation can practise '*value pricing*', it would be able to create a strong customer loyalty which the competitors would find very hard to counter at least in the short-to-medium term.

Information Technology

Introduction

New clinical care systems promise big savings. Suppliers expect the IT market in health care to grow by 10% annually to the year 2000, far highest than in recent years.[17]

Over the past 25 years, spending on health care services has grown faster than the GDP, especially in the "developed" economies.[18] It has therefore become imperative for the health care providers to contain costs while at the same time responding to demands from patients for better quality services and access to the latest medical techniques.

Unfortunately, the demands for health care services would only grow, fuelled by the development of new medical technology, a growth in serious diseases, such as AIDS, and the need to look after ageing populations world-wide. With social welfare systems that fund almost 70% of heath care in Europe, one can only expect that even governments too would be more than keen to seek ways and means of reducing costs and increasing efficiency, if not increasing profitability in providing the care too.

However, the efficiency with which health care is delivered remains low. Information about patients is often incomplete, unreliable, and difficult to obtain with the result that tests and interviews are often duplicated resulting in delay in the delivery of care, decreased efficiency, and escalating expenses needlessly.

Decisions about how to treat patients are made on whatever information is available leading to wide variations in the standard and cost of care. IT systems which support hospitals and primary health care are limited. They are concerned mostly with routine administrative tasks such as allocating beds, billing or booking patients into clinics.

The level of integration between systems is also low. It is not unusual for different departments in the same hospital to have separate systems, so that details about a patient gathered in an Accident & Emergency unit, for example, can not be accessed by staff in the other parts of the hospital.

The reason for all this chaos may be found in the fact that health care is just beginning to experience the kind of cost pressures that the other industries have lived with for some time and insurance companies, governments, and employers are increasing the pressure for health care providers to do more with less.

The Revolution Called Information Technology[19]

We are on the threshold of a new revolution brought about by the advent of IT. The main components of this technology, namely computers, communications, and structured data have undergone a sea of change.

The arrival of the ubiquitous integrated circuit chip, and the rapid technological changes in the field of satellite communications, fibre optics, low-cost PCs which have more processing power and speed than a mainframe computer of late 1970s, and the modalities in which data is presented, have all led to a new technological dimension. Data has become more amenable for access, easy for presentation and understanding; computers have become more 'user friendly', reliable, and faster; and all this at a very low and affordable cost.

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[17] The quest 'to provide more with less' - by John Lamb; Health care agencies seek cost-saving IT solutions. FT, February 5, 1997

[18] Management control Systems - Anthony Dearden, Vijay Govindarajan

[19] Compiled from February 5, 1997 edition of FT and Computers in Medicine, RD Lele, JPB Publications, 1989

These changes in IT have not only had salutory effects in all fields of science, technology, and medicine, but are so all-pervading that they have penetrated our very homes. This technological impact is felt daily in our living rooms through TV, VCRs, satellite imagery, electronic mail and on the screens of the computer in a variety of formats that are elegant, easy to access, and have large memory capacities to hold a vast amount of information.

These new developments have led to the arrival of 'knowledge-based systems' for our understanding of complex processes and management of materials, manpower, industrial processes, and even hospital management has become easily possible.

The use of computers and IT may be understandable in the context of scientific and engineering pursuits, but less so in the area of medicine where it will have the largest amount of social impact. Let us take the case of computer-based instruments in medicine, such as applications of computers for post-operative care, intensive care patient monitoring and management.

The other areas would be imaging techniques which are common to MRI[20], x-ray imaging techniques like CAT[21] scan, positron imaging techniques and applications of ultrasound in diagnostics. There is one more dimension where computers already play an important part. This is in clinical laboratories and pathological investigations.

Thus, one sees that there is a whole plethora of computer applications in medicine, surgery, hospital management, patient care, and most importantly, in the development of human resources. Patterning tomorrow's curricular planning and implementation, with computer bias, for students of medicine, therefore, needs to receive high priority from educational planners.

Importance of Information Technology as to related the health care industry[22]

Information Technology in general and computers in particular are well accepted the world over, as clinical and diagnostic aids to improve patient care, tone up the administration, facilitate accounting, and enable effective management control. An important application has been in hospital management, where computers have been an effective tool for doctors, nurses, administration, and management alike.

Computer Aided Hospital Management (CAHM) is nevertheless a relatively new area except possibly in the USA. There have been a few attempts at computerising billing or medical records as off-line[23], stand-alone[24] applications. Apart from these there is hardly anything in use currently.

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[20] **MRI** Magnetic Resonance Imaging; also known as **NMR** or nuclear magnetic resonance. A high magnetic field is applied which causes the hydrogen ions in the tissues to get polarised. Once the magnetic field is switch off, the hydrogen ions depolarise but at various rates according to the qualities of the tissues in which they are present. The scintillating scanner takes pictures of this depolarisation in real time and using computer software, reconstructs the picture of the various tissues, and therefore the organs, of the body part being examined. The picture allows stereoscopic analysis of the body part and in sagittal or vertical sections or slices. Considered to be superior to CAT scan as the part being examined is not subjected to any radiation.

[21] **CAT** Computerised Axial Tomography. Here the part being examined is subjected to a 360° rotation of a thin line of x-ray the picture being taken at a 180° angle. The 360° picture is then subjected to a reconstruction of the part being examined with the help of computer software. This helps us to stereoscopically view the body in coronal or horizontal sections or slices.

[22] From FT, edition of February 5, 1997

[23] **Off-line** 1. Denoting computer equipment that is not usable, either because it is not connected to a computer or because the system has forbidden it. 2. Denoting computer equipment that is functioning completely independently and is *not connected to any other computer by any means whatsoever*.

Successful computerisation has been found to yield many tangible benefits to hospital management. Furthermore, the process of computerisation is complex and requires considerable preparation and specialist expertise. Given the universal trend of falling prices of computer equipment and the emergence of excellent software, specially designed for hospitals, there is no doubt that in the coming years a major wave of computerisation in the health care sector will be witnessed.

Computers and robotics are being utilised everywhere to increase efficiency and speed. The health care industry has not been able to escape from being affected by this. While computers connected via telephone and satellite link-ups transcendenting national and geographical borders has helped in information sharing, such link-ups have also opened up the possibility of treating patients with the consulting medical personnel stationed at long distances away. With the introduction of robotics, one would very soon be able to see surgeons performing a host of surgical procedures of varying degrees of complexity from distant locales with consummate ease. This would not only make the best doctors available for treating patients who cannot afford to come and visit them personally, but also free the patients from undertaking costly and often hazardous travel and yet receive the very best of care.

Information Technology solutions on offer today[25]

1. Telemedicine.
2. Automated administrative procedures.
3. Clinical management systems - for supporting and managing the delivery of medical care. It is designed to provide patient information, enable physicians to order services such as X-rays, body fluid tests, ultra-sound scans, etc., and enter details of the treatments they have prescribed for their patients. Such systems are also used to manage the care that patients receive by providing doctors with guidance on how to treat patients through a set of "care protocols," standard treatments for particular conditions, etc. The protocols cover everything from what drugs a patient should typically be given to how long they should remain in hospital to what nursing care they require.
4. Remeds Project (Research Multimedia Europeanne pour Docteurs et etablissements de Sante) - aims to enable local doctors to request tests, hospital beds, and arrange appointments with consultants electronically.
5. High-speed Asynchronous Transfer Mode (ATM) network - for exchanging medical images electronically.
6. Smart-cards having micro-processor chips, which can carry information downloaded onto it, as a means of transferring medical records cheaply while at the same time giving patients control over sensitive information.
7. Online reservation of tests and hospital services by practitioners.
8. Transplant matching.
9. Star Project (1996) - a 3 year project with a budget of USD $ 6.1 million seeks to create, in Europe, region-wide networks that allow patients to book appointments, and practitioners to view on-line medical record, radiological scans, or other information on a patient irrespective of where the information is held in a region. A central server would contain basic patient data and act as a gateway to medical information stored on other servers in the various hospitals of

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[24] **Stand-alone Computer** A self-contained computer that can be operated without having to be connected to a central computing facility or to a network.

[25] From FT, edition of February 5, 1997

the region. Various classes of security clearances allow different health care professionals to access some or all of the information about a patient.

10. Electronic Patient Record (EPR) - the health care staff would be able to track the progress of a patient through the hospital by adopting an open client/server architecture, with the client being a desktop or a lap-top personal computer and the servers being a set of central systems. Future systems of this type could comprise the processing of patients' notes as digitised documents, an order communication function, and medical imaging. This would probably require more robust telecommunication services, based on asynchronous transmission mode (ATM) or fibre distributed data interface (FDDI) technology.[26] Such an electronic patient record system (EPRS) could avoid much duplication of effort and re-keying. By the introduction of relational databases, it could allow hospital staff to study patient information from various viewpoints and get a broader view both of individual cases and of hospital management issues. The EPRS could also help hospital managers in the process of medical audit where the "outcomes" are assessed, i.e., the effectiveness of treatments gauged.

Immediate Gains or Advantages of Information Technology

1. Better management and care due to:
   - Faster access and retrieval of relevant informations;
   - Automatic update of all informations;
   - Less repeat tests as a result of having available the results of tests already carried out;
   - Less repetition of information already supplied as these can be readily available at all times literally at the touch of button;
   - "Intelligent" display of relevant information and scheduling;
   - Better inventory control of instruments, medications, patients, etc.;
   - Better management information systems and informations management with automatic and quicker availability of information;
   - Improved statistical information handling, display, and analysis;
   - Epidemiological information available which is current as soon as the relevant data is input;
   - 'What iffing' possible for the providers to review possible consequences of their actions/decisions under various scenarios - e.g., management of care, financial decisions (how costly is a certain procedure likely to be, how much the patient can afford, etc.), allowing patients to actively participate in the decision-making process in the management of their condition, etc.
2. Allow the treatment/providing care to the remotest of places. No matter where the provider and the consumer are located and what distance separates them, care may still be provided through the proper and intelligent utilisation of information technology.

Immediate dangers/threats of Information Technology

1. *Loss of secrecy*. At least the potential of the same. Anyone having access to the information systems may be able to retrieve ultra-sensitive data and use them for all sorts of unscrupulous purposes. Hackers are everywhere and there is yet any

[26] Centralised patient records - by George Nairn; A vision for linking 'islands of technology.' FT, February 5, 1997

totally full-proof hacker-safe systems to be developed. This is however not that much of a serious problem as it was first it would be.

2. *All technologies under the sun are prone to failure*. Information technology too is not immune from this affliction. While a well-tested technology is reasonably safe from failure, how can one ensure that no power failure/equipment failure will never occur? The word “never” is too absolute a term to be safely used here. Should the system ever fail, the whole process may collapse in no time and providing even the basic of facilities may be seriously compromised.
3. *Dependencies of all sorts are extremely dangerous*. Information technology too suffers from the consequences of hopeless dependency on it.
4. *Unstable and untried technology is very dangerous*. Unless a particular technology is well-tested and well-tried and has proved to be relatively true in most of the situations, it should be used with extreme care and great deal of circumspection.

Computers and Medicine

Introduction

The use of computers and electronics (in the form of Integrated Circuit chips, etc.) encompasses virtually every aspect of modern medicine.[27] Computers are used widely in medical research, where an important need is for better micro-electronic sensors for data acquisition. In medical practice, data acquisition from patients as well as subsequent storage, retrieval and manipulation of data are enhanced by the computer. In medical decision-making computers improve accuracy, increase cost-efficiency and advance the understanding of the structure of the medical knowledge and of the decision-making process itself. Powerful, new non-invasive diagnostic instruments including X-ray, computerised axial tomography (CAT) scanners and ultrasonic imaging systems are based on computers. The efficiency and scope of clinical laboratory procedures and advanced analytical instruments are greatly increased by computerisation. All semi-automatic and fully-automated laboratory analysers are micro-processor based.

Careful application of computers has improved the interpretation of diagnostic tests, such as the electrocardiogram (ECG), and monitoring critically ill patients. In fact, no modern day ICU[28] or ICCU[29] has not at least one component which is based on electronic technology and still be classified as being a fully-equipped unit as such. The cardiac monitors and the machine for cardioversion[30] are only two of the most vital ones. The powerful sensory, computational memory and display capabilities of microcomputer systems and their compact size offer new opportunities to relieve functional deficiencies associated with loss of limbs, paralysis, speech impediments, deafness and blindness. Finally, in this era of 'information explosion', the computer's capacity for accurate and effective data storage and speedy retrieval has become a boon. The workstation or PC on his desk has changed the physician's approach to medical literature searching, apart from performing other equally vital functions like patient scheduling, patient data base management, etc., with extreme ease, comfort and finesse.

There is also an entire range of patient monitoring systems which now provide medical specialists with the kind of tools that have greatly helped to enhance their capabilities for diagnosis, therapy, and follow-up. This must, of course, be combined with intuitive clinical skills of the professional and the experience acquired painstakingly through years of training.

The Structure of Medical Informatics[31]

Medical informatics comprises of the theoretical and practical aspects of information processing and communication, based on knowledge and experience derived from processes in medicine and health care.

Prof. Van Bemmel of the Free University of Amsterdam has described the interface of medicine and computer technology at six different 'levels of complexity'.

Level 1. *Communication and recording*

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[27] Computers in Medicine, R.D.Lele, pp 5, JPB Publishing, 1989
[28] **ICU** Intensive Care Unit
[29] **ICCU** Intensive *Coronary* Care unit
[30] **Cardioversion** The procedure by which DC shock of around 200 J is applied to the heart over the chest to correct the rhythm irregularities of the heart.
[31] Computers in Medicine, R.D.Lele, pp 7-8, JPB Publishing, 1989

Applications include the visualisation of biological variables on a CRT, connected to a processor, e.g., during intensive care, and a communication network of terminals in a hospital connected via LAN[32] or WAN a number of hospitals or through telephone lines and/or satellite links and/or Internet anywhere in this whole wide world. Over this a result or an e-mail from a laboratory (pathology and/or radio-diagnosis) can be sent to a nursing station/ward/physician's clinic/another hospital located anywhere on the network.

Level 2. *Storage and retrieval of data bases*

Applications include a patient registry, billing department, etc. Where data is stored in files as they arrive and are also used for statistical purposes; nation-wide/world-wide data bases of relevant hospital statistics, or data related to primary/secondary/tertiary care, epidemiology etc. and the patient record, with reports and all communication related to discharge etc. All kinds of reporting systems such as those for radio-diagnosis come under this heading.

Level 3. *Computation and automation*

Laboratory equipment now have microprocessors built into the analysing equipment itself and connected to centralised laboratory computers that take care of quality control and reporting. Nuclear medicine, ECG[33], EEG[34], EMG[35], CT Scans, USG Scans, MRI Scans, TMT[36] Tests, pulmonary (lung) function test analysis, etc. are examples of dedicated computerised data processing and automation.

Level 4. *Recognition and diagnosis*

This comprises of the development and use of diagnostic models, e.g., by using truth tables, decision trees, multivariate statistics (including Bayes' theorem) and expert systems. It also includes recognition of objects and patterns in images and signals as in x-rays, ECG interpretation and cell/chromosome/cervical smear recognition, etc. At the root of all such systems lies a data base of well-documented signals or objects, the learning or training population. Every system however has to be verified with an independent test set.

Level 5. *Therapy and control*

A good example is automated control of the patient's fluid balance in a post-operative intensive care unit. Some research teams have developed implantable micro-system to be carried by the patient subcutaneously, e.g., insulin pump for the diabetic.

Level 6. *Research and modelling*

Models for cardiovascular physiology in terms of mechanical (flows, pressures, volumes) and electrical (depolarisation and repolarisation) parameters have been developed.

In epidemiology, models have been developed for the dissemination of diseases and to study the effect of counter-actions. Many such models explain the behaviour of disease process in statistical terms by implementing causal relationships between events.

A practical way to adopt is to construct systems in such a way that they can interact fully with the medical user. At lower levels, mainly *syntactic* aspects are important, while at the higher levels *semantic* or *pragmatic* aspects are more often operative. In health care, the models and algorithms display a *heuristic* character most of the time.

The emerging medical information systems can be grouped into two categories:

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[32] **LAN** Local Area Network; **WAN** Wide Area Network

[33] **ECG** Electro-Cardio-Graph - to record and view the electrical impulses driving the heart

[34] **EEG** Electro-Encephalo-Graph - to record and view the electrical impulses generated by the brain

[35] **EMG** Electro-Myo-Graph - to record and view the electrical impulses generated by the nerves to drive a particular group of muscles of the body.

[36] **TMT** Treat Mill Test - - to record and view the changes in the cardiac rhythm due to physical stress under controlled conditions (as known as the *Stress Test*)

- *communication systems* which store medical information, retrieve it selectively and transmit it, and *advice systems* which apply the information to help doctors diagnose a patient's condition,
- to propose, monitor and help to manage a course of treatment.

LAN technology has made it possible to add to the hospital information systems a specialised advice system, and a facility to bring patient data, x-rays, sonograms, CT scans and other imagery to a terminal in the operation theatre or at the bed-side or in the consulting room.

The HELP (Health Evaluation through Logical Processing) system, pioneered by Dr. Homar Warner and his colleagues at the LDS Hospital in Salt Lake City, Utah, USA is designed to provide consultation based on current medical knowledge, to the specialist caring for a patient who has problems outside his special area of expertise and to the generalist who is faced with a problem he may not recognise or a situation in which he lacks experience. Since the system reacts automatically to each new data entry by examining new data in the context of all pertinent previous data on this patient according to the rules specified and the medical logic stored in the form of decision criteria, the appropriate medical knowledge will always be promptly brought to bear on each patient's problem. When any new knowledge is acquired, an additional modification can easily be made to appropriate component of the system and that new knowledge will automatically be applied in solving the patient's problem from that moment onwards. This system is a superb example of how the flexibility and effectiveness of an advice system can be heightened when integrated with a communications system.

Evaluation of Telemedicine[37]

The goals of telemedicine appear consistent with the national agenda for health care reform in the US, as well as in other countries (both developed, developing, and underdeveloped) around the globe. Telemedicine is being propelled by two converging megatrends: advances in enabling technologies (e.g., digital compressed video) and telecommunications and increasing demand for access to high-quality medical care irrespective of location. *Telemedicine is not a speciality in medicine but rather a vehicle for delivering care*. Telemedicine encompasses the exchange of medical information, not only for patient care, but also for education. Telemedicine has relevance to the full spectrum of medical specialities. As a result, it is difficult to keep abreast of changes in a field whose developments may be scattered among the literatures of radiology, pathology, cardiology, emergency medicine, surgery, psychiatry, informatics, engineering, etc.

Use of Present Technology

It must be realised that telemedicine is in its infancy about to move into its childhood. Therefore, it is a new technology which is evolving, albeit at a very rapid rate. It has been around, in theory at least, for the past forty years now (ref.: *ut supra*). Naturally it is now entering a phase where the theory can be put to practice. With the wider availability of computing power, related technology, easy connectivity through a readily available infrastructure, it has become extremely cost-effective to communicate with each other, distances being no barrier even worth the mention.

The computing power and technology on offer today allows us not only to exchange files and documents but also sounds and pictures, that too in real time. Thus, through

[37] "A New Journal for a New Age' - Editorial; Telemedicine Journal; Vol. 1, No. 1, 1995; Mary Ann Liebert, Inc., Publishers; Mark A. Goldberg, MD

information technology, one can see, hear and talk to each other as if they were physically present in the same room.

There are various areas, largely concentrated in the rural, as well as desert and hilly and other such remote places, which are still not very well connected with the booming metro areas, even in the “highly developed” countries of the late twentieth century.

Even if such areas may be able to boast of having a tolerable modicum of health care, they nevertheless lack the expertise of highly qualified consultants. Even in the most modern metros of the globe, more often than not, a medical condition needs expert advice and guidance which cannot be delivered on time simply because the consultant and the patient cannot meet each other for lack time or transport problems, etc.

Telemedicine technology would be a wonderful panacea for all such problems. Since distance would no longer be a barrier, expert advice would always be available at hand. Fewer to none would be uncared for simply because the care provider was too far away and could not arrive on time or have all the necessary results and information on hand to provide the best, most effective, expert and well-informed advice.

Furthermore, any person could be cared for under the supervision of an expert who might physically happen to be in a place halfway across the planet. Since all test results, informations, etc., may be transmitted to him and he may be able to see, hear and talk to all the patients who may happen to be under his care, he can very effectively treat his patients no matter where he is.

Even telesurgery would be possible, though this would require some more time to develop and the technology needs to be matured enough to be made widely available. Some are of the opinion though that this would never catch on as, pilotless flying never did and for the very same reasons as well.

Truly, this technology would go a long way to make it possible to achieve the ambitious goal of the World Health Organisation (WHO) of delivering health for all the citizens of this world by the year 2000 AD.

Future of Information Technology in the Health Care Industry

Succinctly put, information technology has its foot firmly entrenched in this particular industry as much as it has in every other industry. Frankly, the health care industry cannot do without information technology within its midst. Communication is perhaps the most important part of any industry. “Communicate, communicate, communicate and communicate” seems to be the latest cry to rise from the office and shop floors of industries world-wide. But, nowhere is it of such great importance as it is in the health care industry. If the providers stopped communicating with their customers, payors or between themselves, the industry would be in the grips of a crisis of epic proportions almost instantaneously.

Information technology has undergone revolutionary changes, particularly in the last twenty odd years. With the power of computing guaranteed to continue to increase exponentially concomitantly with the speed of transmission of data between any two given points, communication will not only become extremely easy but also quite affordable.

As the costs come down, the health care industry would have on its hands at least one innovative technology which they would be in a position to offer at a price that the customer would view as being “value priced” and therefore more than willing to pay to avail it.

The health care industry has hitherto been severely restricted in its ability to offer at an affordable price all the new technological advances that has been made available to it for the past twenty-five years for better patient management and care. It can therefore justifiably boast that at last it can offer at least one technology that has immense possibilities of being available at affordable rates in very near future when it is used on a mass-scale even if the technology has quite a prohibitive price tag affixed on it not only in setting up but also making it available for the customers at this present point of time.

Conclusions

An Assessment of Telemedicine

Every organisation that can be categorised under the health care industry will not be able to survive unless they have some communicating link between them which is beyond the ordinary telephone, fax, courier service or face-to-face. The sheer pressures caused by the ever-relentless march of technology and the demands of the customers of the service would force even the most reluctant ones to embrace what the modern technology offers.

The technology that telemedicine offers not only allows for easier and better patient management but also in offering better care. While offering this technology would allow a particular service provider to create innovativeness of their product mix as well as develop a core competency in an area that would allow it to carve a distinct market niche. By the time the other providers manage to copy this idea and offer the same service, the provider that enters this market early would be able to establish a better competitive advantage and by virtue of being able to boldly say 'been there and done that' would not have to suffer from the time lag due to learning and experience curve defects that inevitably accompanies when any new technology is introduced for the very first time into any new environment.

The initial investment cost is high. Thus, every provider has to make a very careful study not only of its free cash flows for a period of at least five years - five years being taken as a sort of thumb rule since the changes in Information Technology are so very drastic in five years time that the present day technology would already be outmoded and outdated enough to demand a fresh investment.

However, the provider must not allow itself to be swayed solely by its free cash flows, NPVs and IRRs. It must also study the *follow-on investment option* as well as the *abandonment option*. This is because the investment into a new and emergent technology like telemedicine today along with its accompanying free cash flows would allow the provider to exercise a *call option* of sorts in five years time. This investment would also be possible since this technology, which is definitely here to stay, would allow itself to be upgraded with a better product which would almost certainly be available in five years time, if not before. That investment would cause a fresh set of free cash flows to occur allowing the provider to continue to profit and consequently benefit from going in for this technology today.

The abandonment option is an evaluation of the effects of going in for an investment which, even if not found to be viable enough, has a value that would justify the expenses. If and when the investment is abandoned, the value of abandoning and selling it off has a residual value of considerable proportions to justify the investment. This assessment would allow the provider to assess what the condition of his finances would be like if he did decide at a later stage not to carry out his follow on investment and abandons the project after its initial investment period altogether.

Considerations for the calculations of FCF would depend upon the FCF of high and low demands as determined by the possibility of potential gain or loss of market share due to the failure on the part of the provider in offering this technology and a competitor doing so instead. A decision tree analysis could also be performed to help in assessing the payoffs and the opportunity costs involved. The abandonment option is essentially a put option. The high demand would be reflected by the increased market share and the low by the loss or unrealisation of increase in customer volume.

The question that naturally springs to mind when confronted with this technology is the following. Given that this technology is indeed a most impressive, almost a fantastic one, where would its application be of most benefit?

The answer to this question clearly lies in two parts:

1. Whether a particular provider can afford (or not) to have such a technology on hand for improved patient management, and
2. Whether or not this technology would prove to be of any benefit as far as improvement patient management is concerned.

The first fact has already been dealt with when the opportunity of follow-on investment or a call option and an opportunity of abandonment or put option for this technology was discussed *ut supra*. It is the second part which is discussed in some more detail below.

It has been found that when information systems simply mirror existing manual systems there is enough evidence to suggest that productivity can actually decrease. Thus, developing a MIS which essentially is a carbon copy of the existing paperwork that is emanating from within the provider's organisation is actually a complete waste of valuable time and money.

If telemedicine technology is to be merely an extension of a MIS with hardly any interactivity, no "intelligent" data retrieval and analysis system in the form of data query analysis possibly by the use of SQL, or no electronic mailing system nor scheduling, then investing in such a system is a colossal mistake.

Furthermore, even though the introduction of information systems was supposed to revolutionise office systems and create a paper-less office, in reality the amount of use of paper has gone up. However, the interactivity and fast access and multi-point data handling has offered the opportunity of having up-to-date, as well as old, documents readily available, no matter where they exist or from where the request is made, as long as they are electronically linked up from the point of delivery to the processing of the request.

Also, the volume of information generated and required to be available as quickly as possible also determines the requirements for telemedicine or an equivalent information system. The questions that must be appropriately handled here should be:

1. Whether one can safely say that this technology is useless or unnecessary, even when it exists and is available, and
2. A customer can indeed be treated better (or with equal competence) and is in fact better off without the use of information systems.

Telemedicine embraces the whole concept of information systems in health care industry, plus some more, within its ambit. Not only data can be accessed and exchanged without any hindrance across all geographical boundaries at a very fast rate without inconveniencing the customer and the provider much, but this technology would make it possible that better management and care may be delivered that would otherwise have been practically impossible, time consuming, expensive, or highly improbable at the very least.

Moreover, getting a second or expert opinion is very important in many situations that arise in health care. With this technology, the expert may be available at the point of delivery of the service at all times even if the is physically located half-way around the globe. By the use of telerobotic technology, it is even possible to perform procedures at long distance.

Put very simply, '*Telemedicine*' is the delivery of care to patients anywhere in the world by combining communications technology with medical expertise. Telemedicine is an emerging field that could have a revolutionary impact on the delivery of medical care. Advocates envision the development of a global grid of medical providers and consumers linked by telecommunications networks for the exchange of medical information. The goal is to improve access to and the delivery of high-quality medical care at an affordable cost. However, policy makers, health care organisations, and providers are successfully challenged to distinguish excitement and hyperbole from the practical implications of this new suit of technologies and applications.

Effects of Telemedicine on Health Care Industry

The driving forces that the arrival of telemedicine technology is causing the health care industry's competitive structure and business strategy to change are:

1. *The buyer demands are changing*. They are people who are able to afford to spend higher to avail of the better and newer technological advances that are taking place in the field of health care. They do not like to travel (who does, unless forced or when bitten by the 'travel bug'?) and would like to have expert opinion available to them no matter where that expert happens to reside in.
2. *Telemedicine technology would broaden the industry's consumer base* by making those that reside in remote and rural areas in a position to avail of its facilities more effectively. An organisation successfully implementing the introduction of this technology will allow its market position to strengthen, usually at the expense of organisations who prefer to stick with their old service mix or are slow to follow with their offer of this technology.
3. The availability of telemedicine will definitely alter the industry's landscape dramatically. Organisations offering it would be *quickly able to capture a sizeable market segment* and *create entry barriers successfully due to higher capital expenditure requirements, switching costs of buyers and lagging in the learning/experience curve* which the organisations that would like to follow will inevitably encounter.
4. The organisation(s) which choose to introduce this technology would be able to have *a very powerful marketing tool in their hands to spark a burst of buyer interest, widen industry demand, and increase service mix differentiation*.
5. The industry without telemedicine is currently under a tremendous pressure to become cost-effective in order to *maintain profit margins and therefore acceptable return on investments, adequate FCFs* for use towards future capital expenditures that the advancement of technology would inevitably demand, and yet be able to *attract and increasingly wider market segment*. Telemedicine is expected to bring in sufficient revenues to help in this regard.
6. The customer is no more satisfied by being made to accept whatever the good old doctor says. He demands more information, better/second opinion and value for money so that he may continue to lead an acceptable level of quality of life. He knows that there is a technology out there that could help him to achieve all this. Consequently, the organisation that is in a position to offer him this facility would *create a strong brand loyalty almost instantaneously*.
7. Telecom deregulation and the Internet has opened up tremendous possibilities for a technology like telemedicine to be made available anywhere from anywhere. It would be wrong to be left behind.
8. The desire for healthier, back-to-nature, and increased awareness about health amongst the common man along with a growing concern for one's continued well-being has already led to the industry to open up and begin offering such services that satisfy the customer needs. Telemedicine would further this process dramatically, to say the least.

The Key Success Factors that Telemedicine would bring to the Health Care Industry

1. Scientific research expertise. The technology would make available epidemiological studies, statistical analysis, availability of online medical library, access to a regional/global depository or data warehouse of medical and health related information literally at the touch of a button.
2. The quality of service would increase as travel time and costs are cut down, repeat tests minimised, expert opinion more readily available even at long distances, physician's can be freed to perform the really complex tasks while the junior doctors/nursing/paramedical staff can successfully carry out the routine diagnosis and treatment. The consumers would love the innovativeness of this technology and it would also lead to cost-effectiveness even in only the medium run.
3. Access to adequate supply of skilled personnel be increased tremendously. The medical professional would literally be "always available" with the help of this technology.
4. The speed of delivery of adequate health care would definitely increase.
5. The customers would be able to avail of better service from the relative comfort of their home surroundings as they will be able to cut down on having to travel to see the doctor more often than not.
6. This one addition to the service mix would lead to the organisation offering this technology to be viewed as being a "caring" one in the eyes of its customers and would go a long way in creating a strong brand image and loyalty in their minds, something that the competitors would find very hard to break/switch even with great efforts and expenses.
7. Since the consultant, who possesses an acknowledged superior skill, need not be hired on a permanent basis by the organisation and would visit "virtually" if and when required with the help of this technology, the organisation saves both ways. On the one hand it has less expenditures by eliminating the necessity to keep consultants on its rolls on a permanent basis whose expertise is only infrequently called upon, while on the other hand by having an increased sales since more customers would visit this organisation in order to avail of the services of this "virtual" consultant.
8. Less expenditures on account of continuous medical education (CME) of its personnel which telemedicine can provide online thereby leading to less travel and costs thereof as well as less loss of facilities since the personnel would not have to be away from their workplace to get re-training or fresh training. The savings may be put to better use somewhere else. The organisation would consequently become more profitable.
9. It would lead to the organisation having superior information systems as all the details of health and consumer related information may be analysed quickly, thereby allowing the organisation to foresee future requirements and plan accordingly (ability to "see ahead"), something that its competitors without telemedicine would not be able to do. This would also lead to increased profitability.
10. The possession of telemedical facilities by a particular organisation would doubtlessly lead to the creation of a favourable image and build a huge reputation with its customers.
11. In the medium-to-long run, the overall costs would become low, thereby increasing profitability as well as FCFs as more and more customers begin to avail the facilities provided with the help of this technology.

12. An integrated information systems within the organisation, the inevitable consequence of having telemedicine in an organisation, would lead to a more cohesive and efficient functioning and administration of the organisation as a whole, the payoff of which is always positive in several ways - higher productivity, lower overall costs, low "losses" due to faulty communication within the organisation, etc.

Evaluation

Telemedicine is certainly not rocket science to its actual users. It is also not a sci-fi representation of a few bunch of loonies whose ideas have gone ballistics, certainly not any more.

However, one must not expect the sky when going in for it. Apart from a cool and rational assessment of the follow-on and abandonment options for a given organisation, the investors must realise one other vital fact. As with the implementation of any other revolutionary technology, implementation of telemedicine too would face teething problems. There might be equipment failures, it would prove to be a handful (though one most sincerely hopes that it does not), and since this technology is still evolving and as no pre-set standards as such have been defined as yet, telemedicine too might require to re-invent itself as the time goes by. It is not *manna from heaven*, but given patience and time it will be.

The road to implementation will be long and arduous. Let there be no doubt in anyone's mind to this fact. Several pitfalls would have to be sensitively and carefully negotiated and critical choices made after very careful considerations. Many perilous roads would appear seemingly out of nowhere and must be avoided with great prudence and dexterity. The inevitable pot-holes and rough roads would have to be deftly manoeuvred or smoothened out and when and wherever necessary.

Telemedicine has had a very long gestation period and has been born only recently. As it passes through its childhood, it will be a problem child. The question mark in the BCG matrix. What will its future be? It currently has a low market share with an expected high technology growth rate. It is a cash sink at present. It will cause large *negative* FCFs right now. Once it can be transformed into a star with high market share and growth rate of the technology, it will definitely produce large *positive* FCFs as its overall overheads would be low. It will become a cash cow before its technology growth rate falls. Of this I am fairly confident.

Implementation

As I can envisage, telemedicine in current times would work best as follows:

There would be a full-time online telemedicine administrator who would co-ordinate this part of the business. The administrator would receive "requests" from consultants, patients, payors, etc., and would then route them on to their correct destinations. This would be done after running "authentication" checks so that data security is maintained. There would also be a separate provision for putting through emergency calls which would be routed through without delay as top priority, something akin to a 100 or 999 or 911 type call. This would obviate the need for the provider from having to man a terminal at all times. A consultant responsible for each branch of service could be put "on call" to handle all cases and queries.

A scenario for a normal consultation could play out like this :-

1. A registered patient has pain abdomen. He "calls" up the telemedicine centre. His identification is authenticated and his call is put through to the consultant on call who advises what to do.

2. A patient is in his GP's office. The GP requests expert advice. He calls the telemedicine centre with whom he is registered. On authentication of identification, the call is routed onwards to a consultant on call for that subject.
3. A patient is having an emergency. He establishes contact via a special call which could involve powering up his PC and pressing a single hot-key or clicking on a single hot-area on the screen. The call is automatically routed on to the consultant on call.
4. A registered patient wants a follow-up with a registered specialist who can be connected to each other via the telemedicine line. This patient calls the telemedicine centre and the administrator routes the call on to the particular consultant after authentication. The consultant requests some information held in database or data-warehouse on this patient which is passed on by the administrator.

The administrator need not be a person. It could be a software or firmware supported with a database. All members (e.g., patients, providers, payors, etc.) should have their details current by frequent updates in the database so that the administrator may be able to identify them.

The costs could be a fixed-period subscription like an insurance premium plus a fixed charge for a fixed duration of consultation. The fees incurred by the consultants could be billed and either tagged on to the relevant patient/health care service provider/sponsoring party/payor. The subscription would ensure that the authenticating database is maintained as a current one and unsubscribed accounts deleted so that unsafe authentication/verification checks are minimised or eliminated to a negligible/harmless level.

Far too many wonderful and revolutionary ideas have never seen the light of day and thus have fallen by the wayside simple due to abominable implementation. We have learnt enough of management to help see that telemedicine does not suffer such an ignominy which would be a tragedy to us all.

Let us face it, we all possess a deep desire to live forever. With the successful cloning of *Dolly the sheep* by the group of eminent scientists in Edinburgh, Scotland, that time may not be far away when human beings are cloned too and the long cherished dream of ours is fulfilled. Patenting the technology would at best create a barrier of only a temporary nature. Clones may be used only for harvesting the organs and other body parts which are proving to be non-functional or in the need of replacement in the original being. This may take several hundred years to actually materialise yet. But as we are very much aware of, the incessant march of scientific discovery and the motivation for discoveries is derived from the successful implementation of them. One can only wonder what would have happened had fire been never used ever after being discovered simply because some of us got out fingers burnt or were afraid. What would the consequences for human existence and history of mankind be if the person who discovered the wheel carelessly cast the device away because his fertile brain could have found no rational use for it?

Expert systems in the form of artificial intelligence has truly arrived in all its awesome munificence just the other day when *Deep Blue II* from the laboratories of IBM beat the chess champion of the world Garry Kasparov. It had a tremendous advantage over the champion, as it had no emotions it could fight on tirelessly even in a seemingly hopeless situation calculating and analysing 200 million moves a second (!) and 'learn' from its mistakes as it is actively involved in playing. Our history books are replete with numerous instances of human effort not having seen its correct conclusion simply because the mind surrendered as a lost cause a seemingly hopeless situation which perseverance would have resulted in definite victory. How many times have we managed to snatch defeat from the jaws of victory?

Telemedicine is fascinating. Its implementation would be equally challenging. My personal assessments are that it would be very wrong to try to implement all the components as a complete package from day one. One must use those parts of it that are easily implementable and feels to be most important and advantageous for the organisation that is offering it.

Since legal issues are involved, let me address them first. As of now, there is no bar on any medical doctor with proper credentials in his country calls up another doctor residing anywhere and seek his opinion about a case or cases. No malpractice suit can affect the other person as it is the first doctor with whom lies the ultimate authority and responsibility to decide and provide the necessary advice regarding the management of any particular case. Telemedicine can begin by providing precisely such a facility at the disposal of the doctors for expert opinion and advice. Videoconferencing can be carried out and the patient examined long distance by the expert. It should be the referring doctor who must assume all responsibilities.

As this technology becomes standardised and its acceptance as well as reliance stabilised, the medical fraternity may assign a few of its eminent members to practise the trade world wide and therefore assume the legal responsibility in all its ramifications everywhere. The care would be delivered in actuality by a suitably trained nurse or junior doctor to the patient. My best guess estimate is that should the referral telemedicine be a reality by the year 2000, the next "upgradation" towards a world wide licensing procedure made available would take another twenty years to mature as the medical fraternities the world over would have to agree on them as will have to the various regulatory and other local governmental bodies. Thus, the health care industry of the world would be excellently served if it can already have a programme in place so that enough number of well qualified and highly trained personnel are available within the next five to ten years for this very purpose.

Right now telemedicine would help tremendously in data warehousing of the details of the patients and the findings thereof. Not only would there be a substantial pool of data built up in the next ten years, but also when telemedicine comes of age, any doctor would have at his disposal an excellent database for better management and care. This database would not only improve his knowledge base but also minimise the mistakes in the handling of a particular case, no matter how simple or complex it is, by providing similar findings in previous cases and all the details stored in them in a matter of minutes from the existing database. This is quite feasible. The database would also help in DSS[38] protocols for care and management.

In my humble opinion it is most futile to try and implement videoconferencing, portable monitoring, etc., right now and expect it to catch on in the minds of the consumers real fast as far as its usefulness is concerned so that healthy financial returns are generated. The users must first become experienced enough to use this high-end technology. Furthermore, the costs to have those facilities would almost ensure that the common man on the street is almost never served ever for he will not be able to pay the requisite fees for it. The associated gizmos and computer wizardry would successfully scare most medical professionals away. The medical professionals of today are already under tremendous pressure having to re-train and refresh their KASOCs far too often for comfort. Adding the requirements of mastering this technology too would ensure that it would encounter a great

[38] **DSS** Decision Support Systems

wall of hostility, antagonism and scepticism, the breaching of which would be near to impossible.

Since various software vendors would be more than keen to provide their own version of the DBMS[39], the database browsers should ideally be able to access and retrieve information from each and everyone of them. These browsers should be able to function independent of the operating systems, something like what current the Internet browsers in use can.

Artificially intelligent expert systems would have a very definite role to play in the health care management area soon enough, but it should be an adjunct to the qualified medical personnel. It should not be a substitute. The human race is accustomed to the "human touch" since our birth. I cannot imagine this touch being substituted by a non-life form one, thank you very much!

My planning decision sheet would therefore look as follows:

1. A DBMS able to store information in multimedia should be made available first. This RDBMS, as it must certainly be, should not merely mirror existing filing/data/record maintaining systems as then the productivity and usefulness of it would decrease.
2. A browser/search engine able to access the abovementioned database and "intelligently" as well as ergonomically be able to search and present the requested data in a pre-formatted or customisable summary form after authenticating the requester's identity.
3. Start with the process of collecting and storing data on a local or micro level for all of the population (all relevant data thus being placed on an electronic filing system rather than on paper ones as is currently being done).
4. Add several interconnected micro levels to ultimately make it a macro level one covering a wider geographical area or population base.
5. Where feasible, of videoconferencing facility be made available.
6. Provide continuous medical education. This is a very strong feature of this technology and must be put to good use as soon as possible.
7. Teleradiology, telepathology, telecardiology, and telepsychiatry operations implemented and promoted.
8. Development of a one-to-one medical help (chat) line, both on an known-to-known as well as on an anonymous-to-anonymous style, for minor and/or essentially general health related consultations/conversations. This may initially be developed on the lines of the medical/agony columns of newspapers. As the response of the public is gauged and they feel at ease with this technology, further and more innovative offerings may be undertaken.
9. Seek various avenues to develop and enhance existing telemedicine technology as the advancement of IT and IS opens up newer and better possibilities.

Initially, the various pharmaceutical companies, medical equipment makers and hospitals could pay for advertisements and therefore sponsor a particular service or a part thereof. The general public or the customer will only pay his ISP[40] and the telephone call charges, the rest of the service being free. Naturally the content material of the advertisements would depend on the target customer. However, when a medical professional interacts with another on a one-to-one basis, by e-mail or videoconferencing, etc., no advertisements should be allowed (unless as a static, solus or semi-solus one), as this could interfere with the serious discussion process that the service is being utilised for. The

[39] **DBMS** Data Base Management System; **RDBMS** Relational Data Base Management System
[40] **ISP** Internet Service Provider

clinic or hospital providing this facility should bear all related costs and the end from where the call is being initiated should be the payor. Charges for the time of the consultant being called should be agreed upon beforehand by mutual consent and the billings done accordingly.

As the technology as well as the service is well underway and its effectivity, acceptance and reliability able to be judged, further changes by way of alterations, deletions, and additions could be undertaken. Even the service mix would need revisions, possibly extensive. This must be borne in mind as someone begins to seriously think in terms of bringing this technology into the market place.

The fact that the recently installed "New" Labour government in the UK (1997) has an under-secretary, answerable to the Parliament, responsible for IT, while the outgoing Tory government had only a corresponding junior minister, amply demonstrates how importantly IT is increasingly being viewed at the very top echelons of political decision-making hierarchy in the important economies of the world today. Even the White House and the President as well as the Vice-President of USA are "on-line". It may humorously added that there are three things one cannot run away from, viz., death, taxes, IT, and if one is religious, God.

Appendices

Appendix A - Using Information Technology to support the evolution of the Health Care Enterprise[41]

The alignment of an organisation's IT strategy with its business strategy would ultimately determine whether the senior management views IT as a cost or a strategic asset.

It must be prepared to address the massive restructuring that is the current characteristic of health care enterprises.

The health care industry is struggling to respond to a number of simultaneous and potentially overwhelming pressures with the over-riding need to be able to transform itself quickly from separate provider and payor businesses into real or "virtual" integrated systems supporting the continuum of care.

However, unlike the traditional organisations from which it has evolved, these integrated systems are focused on taking risk for effectively managing the health and illnesses of its members across a variety of settings.

There are a number of related pressures too. The determination of a strategy for geographic access and networking, appropriate governance and financial models, development of plans for co-ordination of clinical services. These pressures are driven by the geometrically progressing demand in the marketplace for better cost and quality management.

One of the key success factors for these organisations will be the extent to which they can establish ways to strategically align information technology with their business objectives and harness the exploding potential for new technologies.

All this creates a series of challenges of organisational and technical types for the IT organisations.

The technical ones are:

1. Addressing the growing and increasingly complex requirements of the end users.
2. Accomplishing the implementation, maintenance and support of a growing number of heterogeneous applications and platforms.
3. Managing the technical complexities of the current and future network while providing flexibility and extensibility for future needs.

The key IT requirements identified are:[42]

- Transparent global access: There must be transparent access to data and applications wherever users reside.
- Interoperability: Products from all suppliers must be able to work together in a multi-vendor, heterogeneous environment.
- Desktop usability: Users must be able to perceive the network as a single system, and developers must be able to use graphical user interfaces (GUI's) to create an easy-to-use personal computing environment.
- Platform flexibility: Users must have access to functions they need, without being restricted to a single hardware or software platform. Applications need to be scaleable and portable between platforms.

[41] Karen Keeter, RN, IBM Health care Solutions
[42] Introduction to the Open Blueprint: A Guide to Distributed Computing, IBM Corporation, 1995 Publication number F326-0395-01.

- Fast, efficient application development: A tool-rich application development environment is needed for creation of distributed client/server solutions that hide the complexity of the network.
- Manageability: Tools and automation are needed to simplify administration and management of systems in an open distributed environment. This includes tools to address issues such as security and software distribution.
- Investment protection: Systems must provide the ability to protect current investments in legacy systems while enabling exploitation of new technologies.

Appendix B - Telemedicine: It's place on the Information Highway[43]

Health care is a major candidate for improvement in any vision of the kinds of "information highways" that are now being visualised. The concept of telemedicine captures much of what is developing in terms of technology implementation. A priority for telemedical applications is innovative policy-making as world-wide deregulation of telecommunications ushers in an unleashing of investment in this area. Health care is a public interest application. It cannot and must not be left behind in the certain mad rush to build the information highway. The attitude too that effective health care is good business not only for the population at large, but for the many opportunities it offers for business entrepreneurship and technology transfer is of vital necessity too.

The concept typically refers to the use of telecommunications technology to facilitate health care delivery. Telemedicine dates back to the 1920s, when radio was used to link public health physicians standing watch at shore stations in order to assist ships at sea that had medical emergencies. Much later came the large-scale demonstrations in telemedicine involving the ATS-6 satellite projects in the 1970s, wherein paramedics in remote Alaskan and Canadian villages were linked with hospitals in distant towns or cities.[44]

"Medical informatics" is often used in conjunction with modern applications of telemedicine. While the former generally refers to a wide range of information technologies - e.g., specialised computing systems, computer work-stations, database designs, softwares - used in medical practices, the latter refers to the uses of telecommunications to distribute such services. Many telemedical applications include informatics components, making it often difficult to separate the two.

Today, there are assorted specific projects representing a wide variety of telemedical or combined informatics applications. Examples of these applications include:

- networking of large health care groups, multicampus linking of hospitals and research centres, linkages among rural health clinics and to a central hospital;
- physician-to-hospital links for transfer of patient information, diagnostic consultations, patient scheduling, and research literature searches video program distribution for public education on health care issues;
- use of video and satellite relay to train health care professionals in widely distributed or remote clinical settings;
- transfer of diagnostic information such as electrocardiograms or X-rays videoconferencing among members of health care teams;
- video links between patient and physician for diagnostic interview purposes;
- capturing "grand rounds" on video for use in remote consultation or training;
- instant access to, and aided search techniques for, gathering information from databases or electronic library collections.

[43] Frederick Williams and Mary Moore
[44] Hudson, H. (1990). Communication satellites: Their development and impact. New York: The Freee Press

Benefits

Simply from the uses of telecommunications for distance-reducing or time-saving, telemedicine can offer many benefits. The following points are drawn from an analysis by Moore (1993a) of recent telemedicine projects.

1. Improved Access. Telemedicine can provide access to health care in previously unserved or underserved areas. These areas include both rural and inner city or barrio locations, which typically have a lower health care practitioner-to-population ratio. Access to speciality care is also improved as those using telemedicine can use the services of speciality practitioners. For example, teleradiology services are often used to provide the services of a radiologist to many remote locations which do not have a local radiologist. Telemedicine can also accelerate diagnosis and treatment by reducing the time required for patients to be first seen by their family physician, then be referred to other locations, travel to those locations, receive speciality care, return home, and re-visit their family physicians. With telemedicine, need for travel is reduced, and since the family physician is often present for the telemedicine consultation, the need to re-visit the family physician after the consultation is obviated. Traditionally, a fair amount of time is often required for patient records to be dictated, transcribed, and sent to referring physicians. After the traditional consultation, the referring physician must then dictate his own records, and send them to the family physician requesting the consultation. This can become a problem; according to the Institute of Medicine, 30% of physicians could not access patients' records; 70% of hospital records were incomplete; and 22 people in hospitals depended on access to patient records at a given time. With telemedicine consultations the referring physician, consulting specialists and patients often gather together for the consultation. Telemedicine services integrated with electronic medical records can further alleviate these problems by providing enhanced access to the records, and alerting those writing medical records to gaps in information or obvious inconsistencies identified through computerised validity checks.
2. Reduced Costs. One of the most obvious cost reductions is the reduced necessity for travel. Travel costs can apply to patients, travelling for speciality care, or to health care professionals, travelling for continuing education. Both of these services can be provided locally through telemedicine. Telemedicine can reduce costs by decreasing the duplication of services, technologies and specialists. For example, one pathologist can provide services to a number of locations using telepathology. Rural physicians have been able to reduce the costs of emergency on-call services by using telemedicine. Two or more distantly located physicians have joined together to use telemedicine to provide emergency services, so that each physician does not have to be on call every single night in his own location. Instead, each physician takes a turn at being on call through telemedicine services. If emergencies take place that cannot be handled through telemedicine the local physician is summoned for in-person care. During times of crisis or disaster when the need exceeds the number of physicians available at a location, telemedicine can provide remote physician supervision to para-professionals. Further cost reductions are available when health care is provided locally in rural hospitals rather than in speciality care centres. Small, rural hospitals often have less overhead costs due to the lack of speciality equipment, and they have lower personnel costs.

3. Reduced Isolation. Telemedicine has been shown to reduce professional isolation, by providing peer and specialist contact for patient consultations and continuing education. It has been established that 76% of those physicians, 92% of nurses and 88% of allied health professionals participating in telemedicine continuing education programs reported their sense of professional isolation was reduced. They reported that, not only was their access to continuing education increased, their participation in the programs allowed them a closer sense of contact with colleagues in other locations. Although many technologies may provide the technical accuracy needed for telemedical diagnosis and treatment, when reduced isolation is the goal, colour, full motion video is critical. Anything short of full-duplex colour telecommunications would be viewed as sub optimal for the health professional user. This format allowed the closest replication of the face-to-face communication between colleagues in consultations and between patients and physician, hence, would be, in effect an absolute requirement.
4. Improved Quality of Care. Telemedicine provides enhanced decision making through heretofore impractical collaborative efforts. These take place when the referring physician, the consulting physician, the patient and the patient's family meet together through interactive video. Rarely in face-to-face medical care do encounters of this type take place. Instead the patient visits each physician in succession. Patient records may be lost in the process. Because physicians sometimes cannot read the records of other physicians, each visit may take place in isolation, without critical information on past diagnosis, treatment and outcomes. With telemedicine, patient visits to referring and consulting physicians can take place simultaneously, providing the synergy derived from a health care team approach. Since both physicians and the patient are often present, the patient can relate history and symptoms directly. The result is often greater patient involvement, increased knowledge and enhanced compliance with treatment, as the patient becomes an active part of the patient care team. In addition, social therapeutic applications of telemedicine, when patients who were hospitalised at great distance from their families were provided hospital visits through interactive television. Hartman and Moore (1992) described the potential positive impact on patient care and compliance of the simultaneous presence of the referring physician, the consulting physician, the patient and the patient's family. Furthermore the patient visit is frequently recorded on video, and can be reviewed repeatedly if necessary. One further benefit to the quality of care occurs with telemedicine. Physicians have also reported that quality of care is improved because they are educated by the consultations with speciality physicians, increasing their ability to treat other, similar cases in the future.

Advances in Telecommunications

Although the "information highway" is a vague term, it does refer to enhancements in telecommunications, and many of these can expand the telemedicine benefits just described. Some of these enhancements represent transfer of advances from military applications, the coalescence of computing and telecommunications technologies over the past 25 years, and the burst in new and competitive services following the break-up of AT&T in 1984. There are also many opportunities for technology commercialisation in the health care area.

The Public Switched Telephone Network

Modern telecommunications networks are both managed by computers (mainly the "switches" that route messages) and offer a wide range of linkages to computer services. In some respects, modern networks are increasingly taking on the character of giant distributed computing systems as services from the latter are available to anyone who has access to the network. As computers become more ubiquitous in the network, we tend to call these networks "intelligent". In telemedicine, for example, many new network-based services represent a telecommunications link to computer capabilities-that is, intelligent network applications. The largest and most accessible network is the public switched network that is operated mainly by telephone companies, local as well as long distance. The public network is a "common carrier," so to speak; it is available to anyone or any organisation that can afford to use it. Any information or message can be transmitted without the telecommunications company interfering with content.

Most of the telemedical services using the public network are traditional voice, facsimile, or data transmissions. Because the original public network was designed with only intelligible voice transmission ("voice grade") as a requirement, its capacity is limited in both signal complexity and speed. That your voice sounds a bit flat over the phone is an example of the limits of complexity because the higher and lower frequency ranges of voice are not transmitted. A visible example of speed limitations is that if you connect your personal computer to voice grade lines, such as to link with a service like Medline or connect to the Internet, you are severely restricted to slow data transmission rates (without very expensive "modem" connections, currently at 2400 baud, only a little faster than you can read). Of course, we do use the voice grade network for many health care applications including voice consultations and administration, faxing records, exchanging data in batches such as to download research reports from a medical information service or to exchange billing data over an electronic network. For some years now, it has been possible to transmit electrocardiographic readings or the diagnostic data material earlier described from a family physician's office or rural clinic to a specialist's laboratory or a distant hospital. Although it is possible to pack more into the voice grade network, it is both technically and economically desirable to upgrade services.

The most important priority is to promote advances that improve the capacity of the public network and to make these services as easily available as today's "dial tone." Enhancements have been bound up in local and federal telecommunication regulations that slow the process of network upgrades in order to keep the price of basic service low for the residential customer. One can purchase more telecommunications capacity (as with a "T1 line" for example, equivalent to 24 voice channels), but it comes at a price considerably above usual costs for traditional business lines. Thus, for example, the costs of maintaining a network of computers linked among several hospitals or medical centres may be as much for special telecommunications services as in operating the computers themselves. Another problem is that an organisation wishing special telecommunications services may find it necessary to deal with different vendors in order to put together a single service. This process was so cumbersome in the South Texas area that a database guide to vendors and services, and especially the critical "contact person" in the company, was developed.

Ideally, there should be a public network on which one can as easily make a data or video call as we now do a voice one. It should also greatly facilitate ease and expense of availability to information services. Thus, for example, a patient in a rural Appalachian clinic could "visit" a specialist in Chicago via a high definition video link, one sufficient for showing a recent X-ray image of lung damage, and where the shared video images are of sufficient quality to convey a sense of "personalness" in the patient-physician exchange. Data service could be used to retrieve any published medical reference, including computer-based services that could provide alternative treatment protocols, given an input of symptoms.

There are, of course, many networks-government, military, multinational industry, financial- that remain private, secure, proprietary, and purposively isolated from public use. Not all telecommunications networks are publicly accessible, although they may operate on leased public lines. What we need is a wholesale upgrade of the public network. Some experts argue that this is the coming of an all digital network, called "ISDN."

Integrated Systems Digital Network ("ISDN")

In the plans of many telephone companies, the next major upgrade of the public switched network is the "integrated systems digital network." In this network, all traffic is digitally coded which allows for more use of intelligent services, as well as a substantial compression of signals so that traditional telephone lines have a much greater capacity. The advantage of this service to the customer is that several services can be operated simultaneously with a single call. For example, two medical researchers could confer by voice on the outcome of a study while sharing linked computer screens showing graphs of numerical results; a fax might be sent in the meantime on the same connection. If ISDN were available in the home, a patient could transmit information from a vital signs monitor while conferring by voice with a nurse in the physician's office. Reasonable quality (but not broadcast quality) video can be transmitted over ISDN, which could make patient interviewing or even psychological counselling more personal and with visual information included. The advantage of ISDN to the residential or business customer is that "one call" can connect a range of voice, data, and video alternatives, and even some combinations of same. A computer can be plugged in and "dialled" as easily as a voice call. In fact, we could see some type of communications terminal that combines voice, data, and video replace traditional telephone.

The advantage to the nation's telecommunications companies is that a basic form of ISDN service does not require replacing all the existing telephone lines; it simply packs more information into them. However, new switching equipment is required, as are interface devices that connect the customer's residential or business equipment with the ISDN system (if the equipment does not already have that capability, which some now does).

Although in the last of the 1980s and early in the new decade, we have seen increased availability of ISDN, there are still debates as to whether it will fully develop as the next version of the public network. Some industry watchers are betting that ISDN may be leap-frogged in favour of moving to a broadband network fully capable of switching high quality video images (along with multiple voice channels, and relatively high speed data transfer). This may be among the reasons why we have not seen a burst of new ISDN-based technologies for telemedical applications.

Broadband Switched Network

Probably along with all of the publicity given to the coming of the information highway, you have seen examples of a residential customer interacting with a TV presentation like a game-show or a news display that can be accessed via branching menus, or a school child doing math "interactively" on a home TV set. This is based on a telecommunications network with video channels having the capacity to send signals "upstream" to the cable company or who ever is disseminating the programs. Unlike your current cable service, this system will be digital, capable of transmitting high definition TV images (roughly the same quality of a 35mm movie film), and will likely combine a wide variety of additional services, including optional telephones. That it can simultaneously provide mixes of voice, text, graphics, and moving image displays qualifies it as "multimedia."

The current engineering, as well as business, thrusts in this area are able to offer "dial-up" multimedia services for the home, business, or school. The programming materials are stored in highly compressed digital form in "video file servers," that when accessed by the customer can "download" program material (like an exercise video) in a matter of seconds into the memory of your video receiver. You can then watch the presentation on your own time schedule, and in some cases interact with it (like a computer program). In some services, you may be interacting directly with a very high speed remote computer.

It is with interactive broadband and multimedia services that we will probably see the most visible changes in full scale telemedical applications. High definition television has many advantages in depicting details of patient appearance, or results of X-ray or ultra-sound diagnostic images. Interactive multimedia also has numerous applications for training in medical settings, or fulfilling requests from physicians in widely diverse settings for treatment protocols and other resource materials.

Multimedia patient records are another area of development (Stead & Hammond, 1988). Take one example, say, a patient with a knee injury. The multimedia record would contain a brief video clip of knee movement. This is stored and repeated over the duration of the patient's recovery. Graphic records such as X-rays could be stored along with oral commentary. Hand-held digital communicators could be used for routine entry of verbal commentary or treatment guidance. Links to vital signs monitors could feed information into the record. Although we now have the capability to do each different applications often with separate technologies, the time is approaching when single communications devices and their telecommunications links will easily accommodate multimedia services. The question in health care will be to identify priority areas of applications. There is also much potential for technology commercialisation in this area.

Unlike ISDN, a nation's entire public network would have to be rebuilt for switched broadband. Although many advancements in telecommunications technologies build upon one another, as when ISDN can be added to the present network, the move to a fully switched broadband network is not a logical technological step beyond ISDN; it is a much different technology. Industry estimates of the costs of installing a national broadband network vary widely to as much as a total of USD $100 billion. Given the limits to government funding of the last several decades and the political restrictions of high taxes, it is unlikely that the national governments can build the network. Industry, especially the former regional Bell companies, AT&T, and other large telecommunications providers, assert that they can build it if given incentives, including freedom from regulation. But there are many serious questions, including, for example, of where the cable TV operators would fit into this picture, how to keep one or several companies from dominating over-control of the services (one of the worries with the aborted Bell Atlantic-Telecommunications, Inc. failed merger), and most of all, how can universal availability of services to the entire population be promoted? Public interest critics are already complaining that plans to build advanced services appear to focus mainly upon wealthy areas of cities. Mainly by regulation, telephone services have become virtually universally available, and by regulation and advertising, so has television. Nobody is yet sure about the information highway, and that is a major barrier not only to growth, but to assuring that services like health care will be a part of this development.

The Internet

The Internet is an interesting parallel telecommunications development compared to the services just described. Beginning in the early 1970s, the U.S. military and various universities began to link their computers, so that data and messages can be communicated among co-operating groups. An early network, ARPANET, was organised by the Advanced Research Projects Agency, a branch of the Department of Defence. An important requirement was to design a network over which computers with different operating systems could share information - a kind of "communications standard." This network initiative expanded, eventually being a project promoted by the National Science Foundation (NSFNET), until finally the inter-linking of a large number of networks by a standard known as Transmission Control Protocol/Internet Protocol (TCP/IP) allowed the world-wide growth of a more or less "network of networks." This is essentially the Internet that has attracted so much attention in the 1990s.

The Internet is unusual for a number of reasons, the main one of which is that unlike virtually all other major networks, it is not "owned" by any one entity. It is a co-operative arrangement primarily influenced by its educational, research, governmental and a growing number of commercial users. By agreeing to a set of operating protocols, users of the Internet have developed many innovations for seeking out information from different databases accessible via the network, methods for sharing documents, and an explosively growing international e-mail system.

Already the Internet is popular among researchers who can easily use e-mail to share information, query one another, or simply communicate about common interests and needs. File transfer options can also be employed for distributing longer documents and reports. Remote medical sites that could not otherwise afford a special data network or extensive long distance phone charges can use the Internet for management co-ordination purposes. Also, as described below, file servers can be established for the storage and retrieval of medical information, publications, statistics, or reports.

Whether the Internet in some advanced version of its current form or some other enhanced but largely "open" digital telecommunications network is widely available, many of the current practices and innovations will be the basis for product or service development. With a little patience, the Internet is a useable service for certain telemedical applications as of this writing, but importantly it is an inexpensive and easily available testbed for technology commercialisation in telemedicine. There is already a growing array of software and services businesses for improving access to and use of the Internet. A main problem in looking ahead at further development of the Internet is that its operation is mainly subsidised by government grants, industry participation, and support by university computing centres. To survive, it will have to become more commercialised, and the challenge is in how to accomplish this without compromising its openness, democratic quality, lack of regulatory barriers, and attraction to entrepreneurship without a requirement of high entry costs. There are also widely different thoughts on how or where revenue-producing components could be integrated into the Internet so it could become self supporting. Should there be subscriber and sometimes measured service costs as in the telephone business? Should commercial operators be taxed to support public services? Can advertising help to support it, or would it drastically deter further development of public service and other non-commercial uses? Finally, opinions differ widely on how the Internet might fit in with national initiatives for an "information superhighway." Surely, the Internet has opened many opportunities for users in telemedicine, but further development will depend highly upon the direction of U.S. policy in advancing digital network services.

Mobility: Digital Radio Links

Advances in digital radio technology are leading to increased portability of terminals, services, and integration of broadcast and wired networks (like paging and voice telephone). Increased portability carries many locational or spatial implications, allowing for increased flexibility and decentralisation. Achieving portability requires advances in terminal instruments capable of multimedia uses as well as independence from stationary power sources. One means for achieving portability is to have digital radio links to voice-telephone, computer laptop terminals, palm-sized terminals, and even fax machines. Increasingly this is called the development of a "Personal Communications Network" (or PCN) and it is on the planning boards of many telecommunications vendors. There are at least two applications of digital radio services that are immediately relevant to telemedicine. One is the PCN (or PCS for "service") mentioned above. This could offer many advantages for health care professionals working in the field. A digital terminal could not only provide immediately connections to the voice network, but also make it easily possible to exchange text or numeric data or messages between the worker and the "home" clinic, hospital or research centre. A personal digital communicator could be used to access a specially formatted version of a patient's medical records, insurance eligibility, or even an on-the-spot treatment protocol. We can expect, too, that with medical services being improved for underserved populations, there will be a need for much gathering of field research data. Survey workers equipped with digital communicators could download computer-assisted interview questions, and then enter responses for immediate transmittal to a data collection centre. The need for immediate information on the incidence of certain illnesses or the use of immunisation services by designated populations has traditionally been hampered by the slowness of survey research methods. With input from hand-held communications units, a survey can begin to generate results almost immediately. Individuals using these communicators can have personal electronic addresses that can locate them anywhere within range of the digital radio transmission-reception facilities.

Another application of digital radio is in the development of Wireless Information Network facilities. This is where a medical campus, a research park, or any large building complex can be equipped for switching digital communications signals among all stationary or mobile units in the immediate area. This means, for example, that a medical researcher carrying a laptop computer or digital communicator can transfer data or messages while located anywhere in the immediate range of the facility-even from an automobile or ambulance. Given connections among wireless information networks, national or regional networks, and PCN networks, it will be increasingly possible to establish mobile "dial-up" voice, data, text, or simple image connections between any two individuals or stations using the services. We can expect at some point, translation, speech recognition, and speech interpretation services (see *ut infra*) could be added to the network.

Medical Informatics

Medical informatics generally represents applications of information technologies and services, some of which are integrated with telecommunications. In accordance towards the fulfilment of these goals, the following applications have emerged:

1. Integrated Academic Information Management System programmes grew out of the application of information technologies in medical library settings, dating back to the 1960s, to an expanded role of information management in the 1980s and 90s.
2. Decentralised Hospital Computer Programme - an integrated system based on a powerful set of software tools with shared data accessible from any of its application modules which includes many functionally specific application

subsystems such as laboratory, pharmacy, radiology, and dietetics. Physicians need applications that cross these application boundaries to provide useful and convenient patient data. One of these multi-speciality applications, the DHCP Imaging System, integrates multimedia data to provide clinicians with comprehensive patient-oriented information. User requirements for cross-disciplinary image access have been studied. Integration approaches are evaluated both for their ability to deliver patient-oriented text data rapidly and their ability to integrate multimedia data objects.

3. Artificial Intelligence/Expert Systems - capable of emulating human decision capabilities, it is not just automation but the interpretation of information and posing of decisions, including in some cases with attached probability weighting of alternatives.
4. Language Translation. Softwares that can assist in the "machine-translation" of languages. There now exist capabilities for integrating machine translation services directly into a telemedicine network, another challenging area for commercialisation.

Human and Organisational Factors

Improved Human Interface

Most researchers agree that the weakest link in modern network services remains the interface between the human and the technology. Keyboards, complex program commands, and complicated screen layouts are a major barrier to full human access to network services. However, just as some computer users have found "mouse," "pull down" menus, or "touch screen" interfaces an improvement over the entry of keyboard commands, we can expect improvements in how we communicate with the network. One is spoken commands which is discussed below. Another is the entry of ordinary language by writing on a input screen with a stylus (as with the new digital hand-held communicators). "Hypermedia" techniques are constantly being refined. This is where a text or graphics presentation has "buttons" for mouse or touch-screen entry to call for further details, "sidebars," or other related presentations. Some new multimedia screen designs (e.g., Compton Encyclopaedia CD-ROM Edition) allow the user to create interim "maps" of the information they are compiling. The maps can be stored, recalled, or rearranged to control organisation of information that will be consulted or communicated. Visualise, for example, an epidemiologist gathering data from several sub-files of different databases, perhaps discarding some and replacing with others in the process. Rather than download and save each of the files, the "map" can be used to record the design of the intended report. When the final selections are decided, the map can automatically access the desired data sets and place them into one file in a requested standardised format.

We can expect that the network will have an increasing capability to recognise speech, which, for practical purposes, means creating a system for either input of computer commands or generating text from speech. Both are now technically possible, although the former is more reliable than the latter because of its much smaller operating vocabulary. Both capabilities should have wide use when accessing networks with hand-held devices where typing input is not convenient. A health care survey worker, for example, could input data, including brief memorandum entries solely by speech. There are also many applications for e-mail, including where voice input messages could be text-translated and faxed to a destination. A physician's commentary could be directly dictated at a distance and automatically converted to text for insertion into a medical record held at a central location.

It is one step to transform spoken utterances into text but still another to have some type of “understanding” of that text so it can be acted upon. Typically this means that “free speech” is able to be interpreted as more than a set of commands or a limited vocabulary. Currently there is software that once a specific database is accessed (through limited spoken commands), a combination of agreed-upon commands can be combined with free speech to locate file entries. The agreed commands might be “Search for,” plus “and” then free speech is used to communicate individual words or phrases (e.g., “Search for diphtheria and children under three”). Given feedback on the number and size of files located, a further command could narrow the search (“Delimit to year 1995”). Currently a priority is to develop a system where the network can answer simple spoken questions on a well defined subject matter area, for example, directory information. It will be increasingly possible for this technology to be used for interrogating databases. For example, selected standard medical references could be put into a database form that could be accessed by spoken requests - as, for example, “list symptoms, endocarditis.” Again, translation services could be also integrated into the system.

Technology-Assisted Management

Another major opportunity offered by advances in telecommunication are the applications in health care management. There are several generalisations of overall importance here. One is that intelligent networks give us new capabilities for management, none the least of which is the ability of individual managers to increase the scope of their supervision. Another is that network services make a much wider range of updated information more readily available for decision-makers. However, for these advantages to be gained, it is usually necessary to revise existing management practices, or as some say “reinvent the organisation.” Much of the current literature on organisational change comes from the reorganisation of large businesses. For contemporary views on this concept, let us turn briefly to the works of several of today's management experts.

Business analyst Tom Peters (1988) holds that successful organisations will ride through this revolution by being:

- flatter;
- populated by more autonomous units with more local authority to define products and set prices;
- oriented more toward niche markets providing high-value-added goods and services;
- quality conscious;
- service conscious;
- more responsive;
- faster at innovation; and
- a user of highly trained flexible people who may not all be employees of the organisation. The same holds for most of the analogous components of public services.

Just as major businesses are moving away from a rigid hierarchical bureaucracy to more decentralised operational clusters or forms of project management, public service organisations need to move more of their resources and decision-making authority out into the field. Resources and decision-making need to be near the clients they are serving, as a business needs to be close to its markets. The new telecommunications infrastructure allows intelligence to be more accessible to individuals working in the field. We are seeing an evolution from a hierarchical or bureaucratic structure toward matrix forms of organisations (Drucker, 1989, 1992; Benjamin & Blunt, 1992).

The health care delivery organisation of the future can use telecommunication-based management to move more resources from the central organisation out to the patient. The administrative agency can become more of an information centre rather than a concentration of services because telecommunications allows moving the services closer to the people who need them. The health care organisation can exist as much on the network as a "virtual organisation" combining clinics, hospitals, and physicians' offices, as it now does in central facilities. Increasingly, even the home, school, or work place can be integrated to some degree into that network. Administrators, physicians, researchers and field workers can be interconnected by intelligent networks that share skills, access to information resources, and financial transaction services, in a decentralised and collaborative network organisation. This could mean a literal reinvention of the health care organisation in an era where the demands of underserved populations are gaining increased recognition. Just as health care has been a relatively eager adopter of many technologies, it faces the challenge of applying technology-assisted management as a major advance in telemedicine. In fact, the virtual health care organisation may be the key "platform" for delivery of medical services in the new century. On the other hand, technology is only as effective as the ability of users to adopt and apply it, our next topic of discussion.

Barriers to Technology Adoption

1. Technological Issues. Although one might speculate that the major barrier to full scale implementation would be the technology for telemedicine delivery, technology has not been reported as a major problem in the implementation of current individual telemedicine projects (Moore, 1993a). There are, however, problems when existing equipment cannot be integrated to work with each other. The Consensus Conference from the Mayo Telemedicine Symposium (1994) recommended that vendors work together to assure that various equipment communicate in the future. In order to assure a minimum standard of quality, it was also recommended that professional groups within the medical community develop technology standards.[45] Telemedicine technology is dependent on advanced telecommunications networks. Yet in rural Texas many areas do not yet have fibre optic lines. Instead there are twisted pair telephone lines installed by the WPA in the 1930s. In some locations it has been difficult even to map where fibre optic lines are located. Lines may run within a mile of each other, yet still the networks are unconnected. Furthermore, when dedicated fibre optic lines must be used for telemedicine, the costs can be enormous. The tariff rates, especially for T1 services within local calling areas, may inhibit rural access to interactive video. Within Texas there have been efforts to provide a 25% reduction in fees when lines are used for educational or non-profit services.
2. Regulatory Barriers. The fear of malpractice and problems arising licensing issues has been a concern to some implementing telemedicine services. The concern arises over what might happen if a misdiagnosis were made. Those implementing telemedicine have suggested, however, that telemedicine can increase the effectiveness of distant consultation. Since many consultations in the past were performed physician-to-physician over telephone, telemedicine video imaging helps improve the accuracy of diagnosis. There have been no published reports of malpractice judgements against physicians performing telemedicine consultations.

[45] Currently IBM is actively working towards building 'integration engines' for this very purpose and have a product named Cloverleaf® already in the market (April 1997).

Problems may arise when telemedicine consultations are performed across legal boundaries as defined by national and international boundaries. Consequently, the medical fraternity would have to seriously address this issue in very near future as this technology begins to be widely used and becomes increasingly popular. Legal and regulatory framework should be drawn up as soon as possible so that they are in place when telemedicine moves away from the fantasy of its developers onto the world of reality. Thinking about it then would unnecessarily complicate matters and the technology as well as the equipment would be left to gather dust as the concerned authorities spend endless hours grappling with these issues and find a really water-tight solution in double-quick time. Concerns with patient confidentiality could be a barrier to implementation as well. While none of the directors of successful telemedicine projects thought that problems with patient confidentiality had significantly hindered provision of services, several were able to relate instances when patients had refused telemedicine services because of fear of lack of privacy. There was also consensus among the directors that all forms of patient records, both traditional paper records and information transmitted through telecommunications, could allow breaches of confidentiality (Moore, 1993a). In addition, questions must still be resolved regarding the ownership of patient records, especially electronic patient records. These may be more easily distributed to multiple locations than traditional paper records or X-rays, for example. Directors felt that privacy and information dissemination concerns were not so formidable, however, as to inhibit adoption of telemedicine services.

3. Financial Issues. Telemedicine services are often undertaken to control the costs of health care. In rural areas the goal is to control the cost of transportation and distant referral. In urban areas the goal may be to avoid referring patients, and losing the income associated with those patients, to other facilities. Both environments have attempted to use non-physician care providers, supervised via telemedical links by physicians, to control costs. Calculations of the costs of telemedicine must include the one-time expenditure for equipment, recurring expenditures for network services, maintenance and personnel, and intangibles such as time spent learning how to use a new service, inconvenience to health care providers when they must leave their offices to use the new service, and lost opportunity costs. Generally, in the past, the cost of equipment was the most serious deterrent to adoption. This is less of a deterrent today, when equivalent equipment costing over USD $100,000 a few years ago can be obtained for USD $15,000 or less. Cost analysis is hampered because telemedicine consultations are rarely reimbursed by Medicare, Medicaid, or third party insurers. Lack of a reimbursement strategy is a serious barrier to implementation. Recently the Health Care Financing Administration has taken a first step toward a reimbursement policy, considering case-by-case reimbursement for telemedicine consultations conducted in a project in Georgia.

Although there has been no definitive cost benefit study across projects, several studies have addressed cost issues:

- Georgia's test of 30 patient seen live and then over video showed no changes in their diagnosis between methods. Most of the patients seen (81%) were kept and treated locally; demonstrating increased revenue to local provider, increased revenue to the consultant and decreased cost of care to the patient.

- Texas Tech MEDNET demonstrated savings of USD $1000 per patient when the patient was treated locally instead of referred to speciality care centres. In addition, those at one local site attributed the community's restoration of confidence in the local hospital to the telemedicine services, resulting in increased patronage of the hospital.
- Texas Telemedicine demonstrated a break-even analysis in 2.7 years, when the lower costs of treating in rural communities, travel time for physicians and patients, and lost opportunity costs were considered.
- Both Telemedicine Canada (Toronto) and Memorial University (Newfoundland) have demonstrated full cost recovery for educational efforts. The director of the Newfoundland service also reported that, during a trial of slow scan technology to an oil rig, three medical airlifts were saved.

The nature of the health care organisation has demonstrated potential for reducing manpower costs by allowing support personnel to perform routine diagnosis and treatment, and freeing physicians to perform more complex tasks. As health care reform proposals emerge, it appears that a re-definition of roles will be an element in the final plan. *The potential for non-physician health care providers taking increased responsibilities has long been a tenet of telemedicine*. Muller et al., (1977) and Cunningham et al., (1978) described an inner city project in New York with the objective of minimising costs by using nurses, and not making unnecessary referrals. Cunningham et al. examined whether physicians could be replaced with nurse practitioners assisted by telemedicine links, and concluded that paediatric nurse practitioners could function with televised consultation, rather than on-site supervision, 40% of the time. Muller identified that, because the physician was needed only rarely for consultations, the addition of a physician devoted to telemedicine consultations was only justified if there were at least five satellite clinics and full network utilisation of 1,750 hours per year.

In evaluating costs of telemedicine one must also consider the value of the services. Measuring the effect of telemedicine on costs alone may not be an adequate basis for deciding whether to introduce a telemedicine system. Improvements in health care and patient outcomes are difficult to measure financially. There is another consideration as well: "The value of telemedicine systems to individuals and communities can go well beyond the simple calculations of dollars saved and additional care provided. This value includes the creation of markets, which then attracts investment and delivery of goods and services to these new markets."[46]

1. <u>Organisational Issues</u>. Since health care takes place within an organisation, the organisation has substantial impact on whether or not telemedicine is successfully adopted. Studies have referred to different usage rates of telemedicine at different locations. There are no recent studies on site selection, although Bashshur and Armstrong (1976) wrote, "The choice of demonstration sites for telemedicine projects is a critical factor in the eventual success of these projects." Reports from the directors of telemedicine projects have confirmed this observation. One director of a successful telemedicine project attributed the success solely to the organisational culture and a firm commitment from management to adopt

[46] Proceedings of the Mayo Telemedicine Symposium, p. 8

telemedicine. Another said the managers of his health care organisation almost killed his project before it ever began. A third director described how organisational support for telemedicine was not a forgone conclusion, even after equipment had been purchased (Moore, 1993a).

In addition to organisational support, there are other elements of the organisational culture that may have an impact on adoption. The success of a project often has to do with the efficiency and smoothness of its administration. With Texas Tech MEDNET, problems reported in the project with locating specialists and scheduling telemedicine consultations led one rural site to prefer one medical centre to another, altering the existing patient referral patterns. In another project it was identified that only 30% of telemedicine recommendations were acted upon, due to administrative inefficiencies. Physician-to-physician contact with this system was rare. In some cases the consultants' recommendations were not transmitted to the attending physicians. Some recommendations were simply not acted upon, some were partially implemented, and others were lost to follow-up.

It is obvious that even if the technical aspects of telemedicine were flawless, administrative problems could result in frustration and disenchantment. The directors of successful telemedicine projects agreed that one key to success was to simplify everything that could be simplified.

- Equipment should be user friendly;
- only critical paperwork should be required;
- forms should be simplified; and
- procedures for conducting consultations should be as effortless as possible.

1. Individual Adopters. Just as organisations do, individuals also evince characteristics that lead to the successful adoption of telemedicine. Some individuals are much more willing to accept and use telemedicine services than others, leading to questions such as:
   - Who uses telemedicine the most, and why?
   - Why do some individuals never use telemedicine systems?
   - What are the individual characteristics of early adopters and heavy users of telemedicine?

Although some individuals embrace telemedicine, others resist. Hartman and Moore (1992) described a radiologist who resisted teleradiology, even though it could reduce substantial travel time for him. *One explanation for resistance might be fear of the impact of telemedicine on the health care system. These fears may include the fear of lost income perhaps resulting from altered referral patterns, or the fear of increased responsibility of non-physician health care providers which has been an outcome in some projects.*

Interviews with ten telemedicine directors led to the following observations about the characteristics individuals most likely to use telemedicine.

- In many cases those leading the projects could be described as charismatic entrepreneurs (Conger & Kanungo, 1988; Conger, 1989). They were articulate, enthusiastic, energetic, self sacrificing, obsessed with their users, impatient for change, and true believers in their causes.
- Several directors interviewed discussed the personal characteristics of those referring physicians and health care providers who were most likely to use telemedicine services and help make it a success. These individuals were

inquisitive, confident enough to ask questions and not be intimidated by specialists, and humble enough to believe that they did not know all the answers. They demonstrated qualities of lifelong learning, often used many sources for information, were often outgoing, preferring personal contact for consultations, and were often, in Morris' (1970) terms, "information influentials" who conducted telemedicine consultations, and then often went on to educate other local colleagues about the outcomes of the consultations.

- Those consulting specialists who provided telemedicine services were characterised as being opinion leaders in their fields, experienced, providing a high standard of care, being flexible and adaptable and as being altruistic, since only rarely are these physicians reimbursed for the their services in the consultations.
- Several directors expressed the view that technical support personnel for telemedicine must be experienced, capable, and flexible, since telemedicine needs vary and may be unpredictable. Successful technical support staff were described as being technically competent, committed, having attention to detail and accuracy, being obsessed with quality, and having a projecting their recognition of the sense of urgency in many telemedicine applications.

Appendix C - Elements of Success in Telemedicine Projects[47]

Technology

The projects use various technologies. While the technologies are diverse, the recommendations were generalisable, regardless of specific equipment used.

Technology was not reported to be a problem in the implementation of telemedicine projects. All project directors reported that they had found their technologies selected to be adequate for providing telemedicine services. One director expressed the views many of the others when he said:

"The problems aren't with the technology. There are some problems, yes, like getting people to use the darn thing in the first place, getting the regulatory bodies not to obstruct use, and getting reimbursement for services rendered. But the quality of the image, and the acceptance of patients, and even patient confidentiality simply are not problems."

Equipment characteristics

Directors agreed that equipment should be reliable, adequately accurate, and flexible enough to meet varying needs. Several stated it was important to remember that audio quality was as important as video quality. Many recommended redundant equipment. While some recommended "the best equipment you can buy" others were equally emphatic in recommending "the simplest and least expensive technology that will meet the needs."

Patient confidentiality

Those who mentioned patient confidentiality issues reported that they were satisfied with the solutions provided by the technology (although one added, "But let me tell you, if you think you have patient confidentiality now in existing health care, though, you are sadly misguided.").

Purchasing

Two directors lamented their inability to see and compare equipment when they were purchasing, and recommended that vendors be required to present demonstrations

[47] Mary Moore, Ph.D.

simultaneously, transmitting the same images over the same bandwidth. Others flatly stated that some vendors were not honest, and were attempting to sell low end equipment to isolated physicians that simply was not adequate to accurately provide the quality required for telemedicine services. One said, "I see lots of vendors selling equipment in rural communities that doesn't help, work, or is too sophisticated."

User friendliness

The need for simplicity was a recurring theme as well: "You've got to make the equipment simple, easier than programming a VCR. So you just push one button. Anything harder than that, and the docs won't use it." Another qualified, "Well, the older physicians want somebody to be there with them to operate the system. The young ones, though, they want to push all the buttons just to see what happens."

Networks

Most of those using T1 lines identified that they had faced networking problems in connecting remote locations, but had resolved the problems by bringing together different groups such as the RUS, telephone companies, and vendors. Resolving problems had taken substantial time and effort in these cases. Several reported problems with high inter LATA tariff rates, and the high cost of the required dedicated 24-hour transmission lines. As of 1996 there had been a number of US state and federal provisions reducing network costs for telemedicine.

Administration

Administrative support from the top of the sponsoring organisation was mentioned by one director who said it was the "sole secret for our success," and by another who said that lack of it almost killed his project before it ever began. This problem is apparently not uncommon. Another stated, "You must get the administrative support of participating hospitals or nursing homes, of course, but also you must get the support of your administration. And you may just find that you don't get the support of your own administration."

Planning

Almost all directors acknowledged that planning was a critical strategy in success. ("Success is no accident. Shakespeare didn't spill the alphabets on the ground and pick up Hamlet.") Many mentioned the temptation to try to do too much at first, since the technology makes so many things possible. One said, "My best advice is to have a plan that focuses on priorities. Start out small, and get functioning before your expand." In a similar vein, another said: "You have to have a plan, and you have to know what your goal is. Is it to improve access to health care, to reduce costs, to reduce professional isolation? It is so tempting to get confused, because, you know, you can do all of that. But first you must know which one of these things is most important to you. Then, and only then, you can plan."

One must remember though that, motivation is not the same thing as goals, and goals are not the same things as accomplished actions. Sometimes, the more motivation and enthusiasm there is, the more simplistic the solutions. There were two physicians who didn't want to be on call every night, so they hooked their two small hospitals hooked together. That is a simple solution to a simple problem. But with a more carefully developed plan they could have been linked to an entire network of speciality care.

Several directors who were involved in cost recovery efforts mentioned the importance of a good business plan.

Marketing

Involving the users in the planning the project. Dr. Max House described the need for involving the medical community in the planning for a new telemedicine project.

You have to decide that there is support out there for you to do it. Very early on must have a dialogue with people in peripheral sites. Once you start talking to them, must get some support, some help. They must welcome you. You must have at least the support of the administrator, senior physicians and nursing. One of these is not enough. When you develop your project you must look at human factors. You must have a great deal of commitment at the site.

Promotion

Continuing education service attributes part of their success to marketing and planning.

Efficient administration

The directors agreed that one key to success was to simplify everything that could be simplified. Equipment should be user friendly; only critical paperwork should be required; forms should be simplified; and procedures for conducting consultations should be as effortless as possible.

Training

Directors stressed that although technology and procedures must be simplified, and equipment must be user friendly, you cannot over-train in telemedicine. Throughout the interview one director repeated, “Plan and educate, plan and educate.”

Appendix D - A View from the Future Highway

Given progress in overcoming the barriers just discussed, and the national interest in universal health care now aroused, it seems clear that there will be a steady growth of applications in telemedicine. Simply the debate over health care reform promotes attention to needed improvements in the delivery of services, and it seems a truism of our age that technology is called upon as an agent of change. Some of the enhancements we should expect include:

- There will be an improvement in the overall administration of health care in the United States.
- Physicians will have improved access (ease, speed, accuracy) to information vital to diagnosis and treatment.
- Physicians will have easier access to consultative services through enhanced telecommunications links with major medical centres, including remote analyses of diagnostic data.
- Third party reimbursement for medical cases will extend to telemedical services.
- Expansion of information services into the home will improve opportunities for emergency communications, remote monitoring of vital signs, as well as public education in health matters.
- Training of health care professionals will be more widely available due to advances in distance and on-site instructional media.
- There will be improved diffusion of medical services in traditionally underserved areas by networking rural clinics with each other and with major medical facilities, as well as by improved links for emergency and consultant services directly to homes.

- Public health services can move their intelligence and resources closer to their client populations through administrative decentralisation.
- Medical information systems, by improved methods of information gathering, storage, and retrieval, will enhance the efficiency of transferring knowledge from research into training or practice.
- Improved methods for gathering, assembling, and interpreting data from the field will enhance the analytical power and hence, medical planning, policy-making, and evaluation of programs.
- Many of the most successful applications of telemedicine will be evaluated at the outset for their commercialisation potential.

In conclusion, as inviting as the above prospects seem for the future of health care, they will not be realised without two major emphases in governmental policy and attitude regarding telemedicine.

First is that although we must face up to building a national telecommunications infrastructure, it is critical that this be done with an eye toward benefits for the population of the world. If we have a network only accessible by the “information haves,” we will only increase the socio-economic and increasingly political gap between the classes in our society. Like public education or transportation, and the public switched network, the highway must be accessible to all who wish to partake of its services. In a large scale view, this is not only a positive economic policy but also one that can make available new tools for trying to solve the mounting problems in education and health care.

Second, and finally, we should not assume that improvements in telemedicine will necessarily only involve government and big business. There are many areas for technology commercialisation, from developing specialised hardware or software for medical applications, that will likely come from the small business, technology-based entrepreneurial community. There will be no future view of health care improvements from the information highway without a full range involvement. It will need more than government and big business. Critical at the grass-roots level are the individual physician, nurse, administrator, benchtop inventor and entrepreneur.

Appendix E - Telemedicine’s Potential for Revolutionising Medicine

Improved access to care:

- Provides health care to previously underserved or unserved areas;
- Increases speed of diagnosis and treatment, providing immediate access to health care;
- Allows access to speciality care;

Reduced costs:

- Helps avoid expensive duplication of services, technologies and specialists;
- Provides back-up services (in general, or specifically during times of crisis or disaster);
- Provides a method for moving resources around to where they are needed most;
- Allows services to be provided without incurring the costs associated with travel (both money and time);
- Allows services to be provided in the locations where the costs of providing those services may be lower (rural centres vs. speciality care centres).

Reduced isolation:

It may help in reducing professional isolation, allowing more freedom in location of practice by providing:

- education;
- speciality consultation;
- administrative support;
- collaboration and peer support.

Improved quality of care:

- Enhances decision making through heretofore unavailable collaborative effort (referring physician, consulting physician and patient work together, simultaneously);
- Provides continuity of care and centralised patient records;
- Educates the referring physician so similar cases can be treated as well;
- May improve patient involvement, knowledge and compliance, since the patient is an active part of the patient care team.

Provides sociological benefits important for healing when family participates in consultation with the patient.

Appendix F - Telehealth Cost Justification[48]

In 1992 Arthur D. Little completed a study identifying savings of USD $36 billion annually from several telemedicine applications. Video-conferencing for patient care and continuing education could cut costs up to USD $235 million per year. This report reviews general issues in telemedicine cost justification studies, summarises results of some specific cost justification studies, and provides a worksheet for those developing cost justification studies. This document is organised into the three applications that telemedicine projects address: patient consultation, professional and continuing education, and administration. Regardless of application (consultation, education or administration) the costs of telemedicine generally include teleconferencing equipment purchase price and associated software, peripheral equipment, installation costs, transmission costs, costs for training employees to use the equipment, maintenance costs, personnel expenditures, and associated overhead expenses.

Patient Consultation

In examining cost justification of telemedicine it is necessary to consider who might benefit from the savings. Savings could conceivably accrue to an individual provider, a health care institution, an individual patient, a third party reimbursement agent, and/or society as a whole.

1. Reimbursement: The largest concern with providing reimbursement for general telemedicine appears to be that telemedicine will increase third party reimbursements for medical care, since telemedicine will make health care more readily accessible to underserved populations. Organisations that are immune to third party reimbursement issues have readily adopted telemedicine.
2. Cost savings: Potential savings can include provider time and travel, patient time and travel, savings from reductions or substitutions in personnel needed, the reduction of redundant tests, and treatment early in the course of the disease when treatment is less costly. *While telemedicine may increase the number of reimbursements, it may reduce the average amount of reimbursement.*

[48] Mary Moore, Ph.D.

Telemedicine ultimately appears to reduce overall costs to society associated with avoidable morbidity and mortality.

3. Revenue generation: *The most obvious example of revenue generation comes to the physician and the clinic who are able to accrue additional income from patient consultations*. Most of these examples come from teleradiology, telepathology, those with approved third party reimbursement, and managed care organisations.

- Additional revenue may be generated by expanding services since certain services may be supervised via telemedicine. Other revenue may be generated by re-selling bandwidth to other professionals to consult with patients or clients at a distance.
- Since some benefits are difficult to quantify, they may go unreported in cost benefit studies. Texas Tech MEDNET reported how the availability of telemedicine services resulted in increased levels of confidence in a rural hospital by the local community and subsequent cost benefits (Hartman & Moore, 1992). According to the hospital administrator the availability of telemedicine services led to increased patronage of and increased revenues for the rural hospital, allowing it to remain open, where once it had been threatened with closure. This is only one example of increased revenue generation that may not be quantifiable.

Early Studies on Cost Justification of Patient Consultation:

1. Personnel savings: Muller et al. (1977) and Cunningham, Marshall, & Glazer (1978) wrote of an inner city project in New York with the objectives of minimising costs by using nurses instead of physicians, and not making unnecessary referrals. Cunningham et al. (1978) examined whether physicians could be replaced with nurse practitioners assisted by telemedicine links, and concluded that paediatric nurse practitioners could function with televised consultation rather than on-site supervision 40% of the time. Muller et al. (1977) identified that, because the physician was needed only rarely for consultations, the addition of a physician devoted to telemedicine consultations was unjustified unless there were at least five satellite clinics and full network utilisation of 1,750 hours per year. The cost, including network charges, would be two-thirds the cost of a physician's providing direct care.
2. Technology cost effectiveness: Several authors (Conrath et al., 1977; Dohner et al., 1975; Dunn et al., 1977; Grundy, Jones, & Lovitt, 1982; Muller et al., 1977) attempted cost-effectiveness analyses of different types of information-delivering technologies, sometimes with conflicting results. *It is often noted by others that comparisons of types of technologies show no significant difference in diagnostic accuracy, and therefore the cheapest technology (telephone) was the most effective. Since several authors have written about the same experiment, this report may appear to have more acceptance than some of the others (Conrath et al., 1977; Dohner et al., 1975; Dunn et al., 1977).* Before accepting the authors' conclusions, it is necessary to examine the methods used in the original study and their applicability to dissimilar settings, as well as changes due to emerging technologies.

Current Cases - Patient Consultation

1. Baylor College of Medicine: A representative for the urban telemedicine project reported that if the base system cost were USD $50,000 per site, cost

justification could be reached at 100 hours of use per year. (Global Telemedicine Report, July 1994, p. 14).

2. Eastern Montana Telemedicine Network: Deaconess Medical Centre in Billings provides about 20 consults each month in dermatology, orthopaedics and psychiatry. It is estimated to save patients USD $200 per consultation. One consultation saved USD $3500 in air ambulance costs.
3. Medical College of Georgia: This program found that 81% of patients seen over telemedicine did not require transfer to secondary or tertiary care centres. In Georgia the cost differential between rural hospital beds and MCG beds is USD $800. In addition to that savings, telemedicine allows savings in transportation, increased productivity, and decreased hospitalisation days from treating a patient at an earlier stage. MCG reported that if rural hospitals were to retain telemedicine patients, the increase of a single patient per day to the rural hospital census would represent a net cash flow of USD $150,000 per year for the hospital.
4. Texas Telemedicine: Arthur D. Little, Inc. (1992) reported that the Texas Telemedicine Project in Austin, Texas, produced "at least a 14% savings" over more standard medical services. According to their model, reduction in overhead and travel time were the primary sources of savings from teleconferencing (said to approximate USD $131.6 million per year nationally). Over two years a total 2696 patients were treated. Six lives were reported saved. Equipment pay-back time was estimated at 3.5 years. In addition, Lee Memorial Hospital reported USD $8000 profit per quarter. Increased revenues of USD $37,000 were attributed to re-instituting infant deliveries and retaining local patients. Austin Diagnostic Clinic reported a net profit of USD $9000 per quarter; a cost/benefit ratio of 2.25; and equipment pay-back in 2.2 years.
5. Texas Tech HealthNet: In 1992 Texas Tech University Health Sciences Centre commissioned an independent cost analysis of telemedicine services used in its project (Hartman and Moore, 1992). The accounting firm compared the costs of using telemedicine with 11 randomly selected patients to the costs that were likely to be incurred if telemedicine were not available. An average saving of USD $1500 per patient was reported. Most of the saving was due to the reduced cost of treating patients locally at a rural primary care centre (as opposed to an urban tertiary care Centre) and to reduced need for emergency transport.

Professional and Continuing Education

1. Costs: Costs for professional and continuing education must include equipment purchase price for basic teleconferencing equipment; peripherals purchased especially to support education (for example, press-to-speak microphones or camera tracking devises); installation costs; transmission costs; training costs for using the equipment; maintenance costs; and personnel and overhead costs.
2. Savings: Potential savings include travel costs and unproductive travel time that are avoided when participants do not have to leave home for continuing education. In some health care facilities temporary personnel also must be hired to cover while others are away for training.
3. Revenue generation: In addition to saving money, teleconferenced continuing education has been well documented as a source of revenue generation. Increased revenue has resulted from re-selling bandwidth, income from inviting others to training at their site, income from providing training to others through

teleconferencing, and increased services that can be provided as a result of continuing education.

4. Intangibles resulting in savings or revenue: Some cost savings are difficult to calculate specifically, but have been documented in anecdotal reports. For example, cost savings resulting from how trainees apply the information obtained from continuing education may be difficult to obtain. Some sites have used opinion questionnaires to ask whether participants would change certain aspects of patient care as a result of education obtained. In the literature there is a report of how information from a continuing education program on emergency procedures was directly applied to treat an oil field worker with abdominal trauma. The director of nursing said, “It was real graphic. The patient exhibited all the signs and symptoms that the lecturer had described” (Jordan and Ramirez, 1995, p 59).

Another example has to do with reports that the availability of up-to-date continuing education allowed increased community confidence in a rural hospital, increasing the patient census and keeping the hospital from impending closure. Teleconferencing can also reduce the isolation of health care professionals, and help retain personnel. Those participating in videoconferenced continuing education have reported their sense of isolation was reduced and their contact with distant peers increased. While retention of personnel clearly results in cost savings, the exact amount saved has not been documented. It has also been suggested that videoconferenced training is more carefully planned, more succinct, more concise, and less time consuming than training offered through other methods. In addition, health care providers might have additional opportunities to take training that might otherwise be denied or delayed. The exact cost saving of these benefits has not been calculated.

Cases - Continuing Education

1. Eastern Montana Telemedicine Project: This service from Billings provides continuing education to five eastern Montana communities. Continuing education programs are delivered to physicians, physician assistants, nurses and other health providers. There were 103 programs provided during the first year of operation. with cost savings to participants were reported to be USD $174,996. These savings were calculated based on the number of participants in the programs, applying average wages lost to travel (MDs were estimated at USD $100 per hour; EMTs at USD $8 per hour; pharmacists at USD $17 per hour), plus mileage, meals and lodging.
2. Texas Tech University Health Sciences Centre HealthNet: HealthNet reports that continuing education through video conferencing is a revenue Centre for the University. HealthNet provides programs to over 90 locations. It provides 450 hours of continuing education programs to 1500 health professionals. While specific figure are unavailable, the system is reported to have surpassed cost recovery and is generating revenue.
3. Texas A&M University Health Science Centre: In a trial providing 62 physicians with 8 classes of continuing medical education, Texas A&M reported net savings (after subtracting the costs of using VSAT/ITV system equipment) of USD $16,895. The savings were attributable to travel costs avoided and time saved.

Administration

Administrative cost savings have been some of the best documented. These savings often are calculated among multi-site health care institutions. Managed health care systems report large savings for using telemedicine for administrative meetings, interviews of candidates for hiring, quality control meetings, and training, obviating travel costs and lost productivity. Revenue has been generated from re-selling bandwidth and income from selling videoconferencing meeting services to other.

Cases

1. Baxter Health care Corporation: Baxter provides over 100,000 products to health providers in over 100 countries. Telemedicine services are used primarily for administrative meetings and collaborative research. Several sites cost-justified equipment by travel savings, but report the real gain from improved productivity, timely decisions and competitive advantage.
2. HBO & Company: HBOC provides health care information systems and services to 3500 hospitals internationally. Over a 7 month period in 1993 HBOC reported USD $290,927 saved in travel, excluding the productivity savings by avoiding 3888 employee travel hours. Human resources used videoconferencing for first interviews, recording the videotapes to show to others throughout the organisation. Continuous quality improvement meetings also were held remotely.

A Format for Calculating Cost Justifications

1. **Costs**

Telemedicine equipment purchase price =

(Includes basic units, codecs, cameras, peripherals, VCR, etc.)

Network transmission and switching costs: T-1 lines (cost per month) =

Personnel =

Training =

Installation =

Maintenance and upkeep =

Total =

Patient Consultation =

Savings =

Physician expense (Would the specialist or consulting physician have to travel? If so, complete this section for each travelling physician. If the physician would not have to travel, continue with Alternative action without telemedicine section.) =

Cost of air transportation =

Cost of ground transportation (USD $.22/per mile X number of miles) =

Hotel (cost per night X # of nights) =

Meals = (per diem 5# of days) =

Miscellaneous =

Lost productivity time = Average hourly salary plus benefits X number of hours lost to travel (or time away from job - time spent in actual consultation or training) =

Total =

Alternative action without telemedicine:

Savings from avoiding cost of travel (ambulance, air ambulance) =

Savings from local treatment vs. distant treatment =

difference in cost of procedure(s) +

difference in cost of stay +

difference in length of stay +

Total =

[Note: This once was calculated at approximately 25% less than urban costs based on Medicare reimbursement figures. The primary methods responsible for cost differentials now are related to wage index adjustments. The differential may be more like 6-10% lower now.]

2. **Professional and Continuing Education**

Savings

Productivity gains:

Number of physicians trained X travel time lost X average salary per physician =

Number of RNs trained X travel time lost X average salary per RN =

Number of LVNs trained X travel time lost X average salary per LVN =

Number of allied health personnel trained X travel time lost X average salary =

Number of administrative staff trained X travel time lost X average salary =

Number of support staff trained X travel time lost X average salary =

Number of others trained X travel time lost X average salary =

Total saved =

Employee expense avoided =

Advance purchase air travel costs =

One night room expense X days in travel =

Meals =

Ground transportation =

Miscellaneous (phone to office, airport parking, tips) =

Total (Conservative X # of employees attending continuing education X # of trips avoided) =

3. **Administration**

Savings

Productivity gains (Calculate for each employee) =

Number of meetings per week on average =

Amount of time saved by not driving to the meeting (hours) =

Hourly salary of participant =

Employee expense avoided (Calculate cost for each employee) =

Cost of travel to meetings

Air transport =

Land transport =

Meals =

Hotel =

Total travel savings =

Interview or consulting expense avoided (Calculate for each candidate) =

Cost of travel for interviews

Air transport =

Land transport =

Meals =

Hotel =

Total travel savings =

Costs per video meeting calculation

Average # sites per meeting X # hours per video meeting

= total time of connect time per video meeting

Average network connect cost per hour (consider minimum connect times)

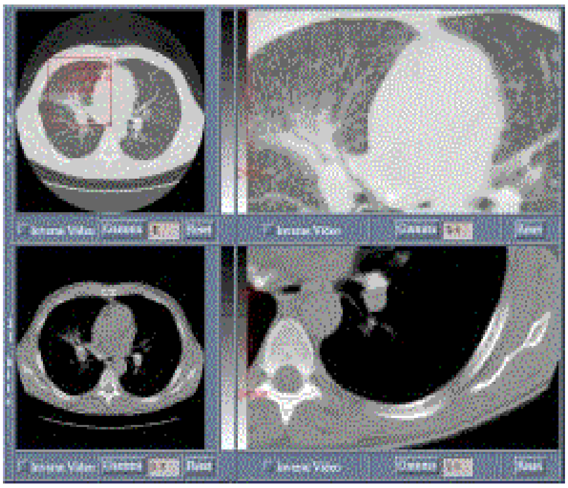
= total network charges per video meeting

Videoconferencing equipment is often used for multiple purposes. The three most common uses are patient consultation, professional and continuing education, and administration. A total cost justification study would consider all uses.

Sometimes a cost justification study addresses only one application, for example, educational videoconferencing. If the teleconferencing equipment is used for multiple purposes, the cost study of educational teleconferencing should use an appropriate percentage of the cost of the equipment. One way to calculate costs might be to examine the amount of time used for the application. If the teleconferencing equipment is used 40% of the time for education, calculations would use 40% of the basic equipment cost. One would not include the cost of peripherals used solely for medical consultation. If certain peripherals are used solely for education, their total cost would be included (100%).

For example, if a dermatology scope was purchased for use in patient consultation and not in education, do not include the cost of the scope. If remote microphones are used solely for continuing education, 100% of their cost would be included.

Appendix G - An MRI Scan retrieved from the Internet:



Appendix H - Telecom Services for the Health Care Industry: Predicting the Future[49]

It is estimated that by the year 2001, annual revenues for the combined LEC (local exchange carriers = regional Bell operating companies = RBOCs = SW Bell, PacBell etc.)

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[49] Abridged from an interview with Mona Johnson and other analysts at The Insight Research Corporation (Livingston, NJ), a telecommunications market research company which recently published "Telecom Services for the Health Care Industry: Telemedicine and Health Information Networks," a comprehensive market study focusing on the effect of telemedicine on the telecom industry.

and IEC (interexchange carriers = AT&T, Sprint, MCI etc.) markets will be about USD $202 billion. Of that, only about USD $2 billion will come from telemedicine and health information networks. On the one hand, that is less than 1% of the market. On the other hand, that is USD $2 billion.

These revenue projections do not include equipment sales by telecom services, systems integration fees, network management fees, or transaction fees. Right now, for example, most of the telecom services are reselling (or in some cases are themselves manufacturing) telemedicine equipment and providing the technical support needed to make the stuff operate properly. Some companies have gone a step further, and are developing and providing educational materials and workshops for erstwhile users. Many of the carriers are moving past the concept of simply selling bandwidth, and are starting to position themselves as turn-key telemedicine solution providers. They recognise that, unless they completely miss the mark, their revenue opportunities from telemedicine and health networks will increase nearly 50 times between 1996 and 2001.

The two biggest areas will be health information networks and home health care. In the area of health information networks many telecom services are partnering with health care systems to "beta test" digital distributed networks that can support voice, data, and video. Some examples are:

- PacBell has deployed CalREN, funded with USD $25 million to encourage new apps for high-speed digital service;
- Sprint is working on its Navigen system;
- an MCI / British Telecom partnership, and AT&T, are working on international group conferencing capabilities with their "Concert" and "InterSpan" services, while Bell Atlantic is doing this on a regional level with its All@once Group Video Link Service; GTE and PacBell are working on Asymmetric Digital Subscriber Line trials, which will support WAN-like capabilities over large areas, at low cost.
- Tele-home health care (or home health care) is very much in its infancy, and it is believed that the telecom services can play an important role in "growing the industry" if they really pay attention to assuring that the necessary infrastructure is in place, affordable, and reliable - be it ISDN, ADSL, POTS[50], or cable to the home. This last player is very important. Cable companies may be in a great position to take advantage of the need for reliable, cheap, switchable bandwidth to the home. Their organisational structure and technology is not yet up to snuff (they don't "do" interactive real-time dial-up connections except in a few testbeds). If they figure it out, they could really take advantage of their current franchise on big bandwidth going right to the home.

Based on the assumptions made, which were derived from the understanding of average industry practices and costs, it has been figured that by the year 2001 there would be about 200 prototype HINs similar to an INSIGHT prototype HIN[51], each with an average 10 hospitals, 40 clinics or large groups, 1,000 small offices, 200 pharmacies and 10 payors, and that the annual revenues for these would be about USD $608 million. This however does not include most of the revenues for "value added" services mentioned above, such as equipment sales, integration fees, etc.

Unfortunately, health care information systems today tend to be "70's infrastructure in a 90's world." There are very few open standards-based systems in hospitals today. Most are still mainframe-based, inflexible, isolated from other systems, and incapable of adding

[50] **POTS** Plain Old Telephone Systems
[51] **HIN** Health Information Network

new capabilities and applications (like interactive video). Also, the issues of privacy and confidentiality still need to be better worked out.

ISDN was supposed to really open up the world to video and data conferencing. There have been serious problems in deploying the technology uniformly across the U.S., and it remains difficult to install. Also, many of the ISDN installations are being used for Internet connectivity, which often means keeping the circuit open for long periods-even all day. The same thing is happening with modem connections to Internet Service Providers over regular phone lines. The problem is that the central office switches were engineered for a few voice calls per day per subscriber, with short holding times (in the 3-minute range). Internet access has much longer holding times, which really bogs down the switches. All of the carriers are looking at ways to offload their networks for data switching.

There is also a lot of marketing confusiontoo. Prices are all over the map. Installation fees range from USD $300 to USD $1,500 per line, which turns off a lot of companies. People are confused about terminology-BRI lines (Basic Rate Interface, consisting of 2 x 64 Kbps channels), PRI lines (Primary Rate Interface, equivalent to a T1 line with 1.544 Kbps transmission), and other jargon. Local access fees can range from USD $25/month to USD $125/month for a 128 Kbps connection. Also, additional premise equipment is needed to terminate an ISDN line-which means more money.

It is still premature to say that pure market forces are driving the deployment of telemedicine, since so many programs are in a trial stage. The most obvious market condition that will pull this along over the next few years are the continued need for improving access and decreasing costs by eliminating travel for patients, physicians, and nurses.

Appendix I - Telemedicine: Fad or Future?[52]

In the editorial of it's 14th January, 1995, edition, The Lancet, under the above title, posed and sought to answer the following questions:

What exactly is this medical neologism - telemedicine?

Will telemedicine really revolutionise medical practise as is claimed, or is this simply another passing fashion for technological gimmickry?

Telemedicine is medicine carried out at a distance - images are transmitted so that the patient and doctor not longer have to be present in the same place at the same time. This use of telecommunication networks for clinical purposes, contrasts with previous use of the "information superhighway" by doctors, which has largely been for education and research. So far most telemedicine has involved isolated or under-doctored regions.

The initial experience were no great technological feat, being limited by slow data handling capacity to the transmission of still images. The frozen histological specimens from patients undergoing surgery in rural Scandinavia were reported on in a specialist centre hundreds of kilometres away, and CT scans in the Middle East were transmitted via the public telephone network to the USA for diagnosis.

Advances in telecommunications infrastructure then allowed transmission of video and real time data.

Video links between centre within Norway and between remote Pacific islands have been used to make diagnoses in specialities as diverse as dermatology, cardiology, urology, ophthalmology, and psychiatry. Current services in the UK include mainland provision of trauma advice to oil rigs and remote foetal diagnosis in ultrasound images.

Apart from demonstration projects, there has so far been little impact on mainstream medical services. Strictly speaking, patients can only be diagnosed but not treated by telemedicine. Nevertheless, therapeutic advice can be given, or referral for treatment

[52] Abridged from The Lancet; Volume 345, Number 8942, 14-Jan-95

recommended. Remote surgery of course is technically feasible, as is unpiloted aeroplane flight, and for the same reason is unlikely to catch on.

The crystal ball reveals that in the second millennium remote consultation will be commonplace in the image-based specialities, both for non-specialist centre to get specialist opinions and for specialists to get second opinions. In radiology, pathology, and ultrasound the two centres will interact electronically in real time to obtain image or specimen positioning and will highlight relevant areas. In other specialities such as dermatology, accident and emergency, and foetal medicine, concomitant videoconferencing will allow the doctor in the specialist centre to counsel the patient directly. Sometimes it will be more appropriate to discuss management confidentially with the referring practitioner (via headphones), who in turn may be better placed to counsel his patient.

Face-to-face video consultation will be used in undoctored areas (space stations, Antarctica), and in psychiatry, where patients find telemedicine consultation less threatening than the real thing.

Workstations with the software for image transmission may become a feature not merely of specialists' workplaces but also of their homes.

Telemedicine will also make an important contribution to the safety of out-of-hours care by junior hospital staff in areas as diverse as neurosurgery and obstetrics.

Telemedicine may well be the method by which the large teaching hospitals can export their skills to the primary care sector. Since distance is immaterial, remote centres will be able to tap a much greater variety of specialist skills, including those in different countries. Patient acceptability seems high for most applications. Other spin-offs of telemedicine include remote access to archived electronic scans and records, and the provision of health care information (preoperative, antenatal, support groups, etc.) direct to patients' homes. Telemedicine seems good not only for patients but also for health care workers, in remote areas, who can increase their education through rapid feedback and their job satisfaction by involvement in the ongoing care of patients in their own community.

The drawbacks are as follows:

First, early reports suggested that diagnoses based on transmitted images may be less accurate than the originals; this objection can be attributed to lack of familiarity, since with more experience diagnostic accuracy is not materially affected by the image transfer process.

Second, with little disincentive to referral, patients may increasingly demand specialist consultation and thereby overburden provision.

Third, there will be pressure on specialist centres to provide services with rapidity; undue delays in consultation availability may render some services little better than review of a posted videotape.

Confidentiality is an issue, as with all health care records.

The over-riding drawback is the lack of formal studies of cost-effectiveness. The capital outlay for a codec remains substantial (up to GB £ Sterling 30,000 or around USD $ 45,000 with incidentals), although this should fall, as has happened with other hardware. Then there are the telephone charges, and the consultant's time. This cost will need to be offset against savings from reducing patient and doctor travel and avoiding conventional consultation, and from improved outcomes. There will also be intangible savings from reduced patient anxiety and inconvenience.

Ironically, areas world wide most likely to benefit from telemedicine are those least likely to afford it or lack the requisite communications infrastructure. Cost considerations will probably confine telemedicine services to developed countries, where substantial savings seem realistic once the appropriate infrastructures are in place.

Finally, the legal implications are uncertain. One view is that remote diagnosis raises no new issues other than those that pertain to the everyday practice of seeking telephone advice from a colleague. However, this opinion seems untenable where written reports are generated or management advice is given directly to the patient. And who should be responsible for equipment failure?

There is also the possibility of legal action against a practitioner not registered in the country in which the medical service was provided.

Although much is claimed, the economic benefits of telemedicine have yet to be proved. How much of its huge potential is ever realised must await the formal evaluation now underway.

One is thing is clear - we are going to hear a lot more of telemedicine.

Appendix J - Appropriate vehicle for supporting Telemedicine: Internet or Intranet?[53]

Often asked whether the Internet is an appropriate vehicle for supporting telemedicine and health care information systems, the answer usually starts with "it depends" - on whether:

- one can guarantee the level of service (e.g., bandwidth[54] end-to-end);
- one can insure the security of transactions;
- the Internet will support the legacy applications needed to run the Hospital Information Systems (HIS) applications;
- the Internet vendor provides alternate routing to maximise up-time.

In each of these cases the answer is, "you usually cannot, with the Internet."

In general, using the Internet for mission critical health care applications cannot be strongly advocated. However, using the INTRANET is strongly recommended. The Intranet is growing in popularity among many organisations, and bypasses or eliminates many of the negatives of the Internet.

Intranet is a "private Internet" that is linked to the public Internet through tightly managed and controlled gateways. A private Internet is a wide area network which employs the TCP/IP communications protocols used over the Internet. An Intranet can take advantage of the growing number of tools for information distribution and retrieval common to the Internet, such as Web browsers and applets, yet with the ability to control the level of service and security of the network needed for mission critical applications. Since Web tools are cheap, effective and easy to use, many large organisations are exploring them for internal applications. Gateways that protect the Intranet from the Internet by a firewall enable users to accomplish their internal business, as well as "surf the net" for information, email, and data transfer. The main weakness with the Intranet is the cost of building dedicated wide area links to health care facilities outside of a local region. The use of private on- demand frame relay circuits is a way to reduce these wide area network costs.

Eventually, these weaknesses will be addressed and health care organisations will be able to use the inexpensive Internet for mission-critical applications. Until that time, it is wise

[53] Abridged from TECHTALK; Dave Swartz, One Grand Park, 777 NW Grand Blvd. #145, Oklahoma City, OK 73118

[54] **Bandwidth** The speed of the network which essentially is the amount of information that can be put in the network over a short period of time. The higher the bandwidth, the faster the network.

to employ the Intranet concept introduced here to position one's organisation for the future, without incurring the current risks of reliance on the Internet.

Implications of Telecommunications Deregulation:

The good things one can expect from the new deregulation include:

- lower costs of local service in urban areas;
- lower costs of some long distance links;
- lower costs of cable service for HBO (Home Box Office), etc;
- new services, such as high speed Internet access to the home (which may be 2-way and interactive) for home health services or distant learning programs.

Probably for urban dwellers everything is rosy with deregulation. For rural dwellers the picture is less clear. One of the original reasons for telecommunications regulation was to insure equal access to phones for rural dwellers. Without regulation, the costs of much rural phone service would be prohibitive. Regulation helps apportion the costs of phone service between the urban and rural communities. At the present time much of the regulatory protection for rural phone users will be retained. However, there is not currently a great deal of incentive for phone companies to invest in rural communities. The reason is that the return on capital, with deregulation, will be much greater in urban markets, particularly for home entertainment and business network applications. We can only hope that rural communities will get upgraded to ISDN before this shift occurs.

Partnerships between long distance telephone carriers, wireless companies and cable providers are evolving to take on the Regional Bell Operating Companies (RBOCs) such as South-western Bell, Bell Atlantic, etc. RBOCs are seeking to consolidate their LATAS (regulated regional service areas) and provide long distance service as well as traditional cable services to the home. In some areas, small independent companies are upgrading their telephony switches to support ISDN and broad bandwidth services.

Some market failures arising in rural areas as a result of deregulation that may demand the intervention of public entities is foreseen. Some states can point to successful public networks, others to dismal failures. West Virginia has been impressive with their state network (WVNET) which supports all state education and government. Like other similar networks, they are exploring the option of expanding to health care as well. They do not own fibre, but lease bandwidth and services from the private sector. This type of partnership is likely to arise in many states to help rural communities address the need for broad bandwidth services that do not get addressed adequately by the private sector alone.

A question frequently asked is, particularly by senior Information Systems Administrators, whether it is necessary to support online medical records to do telemedicine. The simple answer is: no. Few existing telemedicine projects today support online medical records, though the times are changing. With teleradiology, one of the most evolved telemedicine applications, we see the emergence of the linkage between picture archiving and communications systems (PACS) and online medical records systems. The goal of such linkage is to reduce the need for multiple entry of the same patient data, as well as to retain congruence of data. Some PACS are able to extract important patient data as well as communicate with radiology information systems (RIS) in order to support billing, generation of reports, and update of medical records. The communication between these systems usually occurs through HL7 interfaces[55]. A number of telemedicine systems have developed mature interfaces to popular hospital information systems that can be linked to other systems using interface engines. Telemedicine will be more effective and efficient when these systems

[55] **HL7** a standard interface between hospital information systems

are linked to medical records systems in the physician's practice and in the greater hospital environment. Therefore, it is wise to explore this capability with vendors when considering the purchase of a telemedicine system.

Online Medical Protocols - A Cheap Form of Telemedicine

One of the most cost effective forms of telemedicine is the *online medical protocol*. These are also called *critical pathways and practice parameters*. Protocols have been common to medical areas such as oncology for some time. They are growing in popularity in other medical areas such as cardiology, paediatrics and emergency medicine. Protocols are a way to insure the level of medical care, and to get control of costs. In the era of managed care we can expect the demand for protocols to grow. There is a growing demand for protocols among rural physicians. By keeping protocols up to date and available online, tertiary medical centres can export their expertise to rural physicians using telecommunications - a form of telemedicine.

An effective tool for distributing protocols is Lotus Notes. Using a modern form of client-server interface, Lotus Notes can effectively communicate needed protocols using a wide range of communication modalities. They can be sent over standard e-mail interfaces to a wide range of e-mail systems as well as via fax, alphanumeric pager, and even voice mail systems. The request for the protocol could occur via a phone call from the rural hospital to the tertiary hospital. Using a simple interface, the system can be set up to guide the user to the correct protocol. Due to the client/server architecture of Lotus Notes the client can communicate with the server using inexpensive dial-up lines, rather than expensive dedicated lines. Oklahoma currently has 40 hospitals connected with Lotus Notes and are exploring the use of this system for the export of protocols.

Appendix K - Telecardiology[56]

In over 100 needs assessments I have conducted at rural hospitals over the past 5 years, I have observed that cardiology always emerges as one of the top needs of rural hospitals, often in the top two priorities alongside radiology. Telecardiology has been conducted for more than 25 years through remote cardiac monitoring, which emerged in Oklahoma during the late 60's. More recently the electronic transfer of ECGs, through direct electronic transfer of the waveform signals or through fax of printouts, has become commonplace. Cardiologists also receive and analyse nuclear medicine studies as well as X-rays using teleradiology.

Interactive Video (ITV)-based Telemedicine

Contrast the success of these applications to the lack of wide acceptance of interactive video (ITV)-based telemedicine approaches for cardiology up to now. Use of ITV for cardiology is hampered by the lack of reimbursement, inconvenience of access to ITV facilities, and lack of standards for telecardiology. However, the application of compressed ITV is becoming acceptable to a growing group of physicians that desire to provide support for analysis of the moving modalities such as echocardiography, fluorography and ultrasound. Many of these studies can be transmitted in a store-and-forward fashion as well as interactively.

T-1 Lines: Projects across the US and Canada are supporting remote echocardiography using compressed ITV. Bandwidth ranges of 384 Kbps to 768 Kbps are being used. Leased T1 (1.54 Mbps) lines to support both static imaging for teleradiology and ITV for moving modalities may be used. A good approach is to channelize the T1 line

[56] TechTalk: Dave Swartz WVNET 837 Chestnut Ridge Rd. Morgantown, WV 26505

into two channels, one running at 1 Mbps to support teleradiology applications and the other set to 512 Kbps for ITV and the moving modalities. In order to fractionate the T1 line a multiplexer will be needed. These devices typically run from USD $7,000 to USD $15,000, with features that support dynamic re-allocation of channels. However, some multi-channel DSU/CSUs costing no more than USD $3,000 can substitute and serve as a “poor mans MUX” and save thousands of dollars.

Real-time Echocardiography

In contrast to most applications of ITV, real-time interactive echocardiography is currently considered to be reimbursable by most payors. With the advent of desktop ITV the convenience and reduced cost of supporting echocardiography should facilitate its adoption. Some of the newer desktop units reviewed in a recent edition of TT [see Buyer's Guide, pp. 42-47 - Ed.] can support this application. Clearly what is needed is the setting of standards for moving modalities, in a fashion similar to those adopted by the ACR for still images (X-rays, CTs, MRIs, nuclear medicine, and ultrasound).

New Applications

While we await the creation of these standards, exciting new applications of telecardiology are emerging. New FDA-approved devices are available that permit the transmission of ECGs over phone lines . Devices can be plugged into the phone jack and the rhythm strips and selected lead tracings can be transmitted directly to the physician. These new devices allow doctors to interact directly with their patients on an anytime, anywhere basis. Patients record their ECG using a simple device and dial their physician's phone number. The nurse or doctor answers the call, speaking directly to the patient as they have them transmit their ECG. Using this approach the provider can give immediate feedback to the patient. This direct method provides an easy way to produce event reports for insurance submittal and record keeping. Physicians will find the improved quality of care possible very attractive, since it reduces delay and is under their direct control. Furthermore, physicians will be able to bill not only for the USD $30 professional fee, but also for the USD $300 technical fee.

This approach removes the intervention of third parties that have traditionally taken the ECG and transmitted it to the physician. It will help to keep patients from going to the ER unless it is required and thereby help to reduce unnecessary ER admissions. There are enhancements to this technology that will make it possible to transmit the ECG over wireless paging frequencies, enabling transmission directly to the physician wherever he may be. This eliminates the need of the physician to be near a fax machine or networked computer in order to receive a copy of the ECG. Using a palmtop device that has a paging interface card, the ECG is transmitted directly to the palmtop. This technology has recently become available from Data Critical Corporation of Oklahoma City. It was originally developed to serve the needs of two cardiologists that spent much of their free time bass fishing. After the cardiologist receives the ECG, direct communication with the patient or the referring physician is possible via a cellular phone.

In-house Monitoring

Additional technology is emerging to improve the in-house monitoring of cardiac patients. Traditionally, computer-based monitoring systems have alarms that tend to be very sensitive so that they generate false positives rather than missing a true alarm. The alarms need to be verified by a qualified employee. This has historically been the role of the monitoring technician and a nurse. Ultimately the nurse is responsible for the care of the patient and must be brought in to check the status of the patient. A new product under FDA review works in conjunction with existing monitoring networks to augment the alarm system. The system allows the data captured during an "alarm" period, including text and waveform information, to be sent quickly over an in-house paging system to key personnel who can verify the alarm and then check the well-being of the patient. The information can also be sent over wide-area paging networks, as in the above palmtop example. This streamlining of information flow directly to responsible people can minimise middle layers of personnel, such as monitoring technicians. It also gives nurses the ability to address patient needs in a timely manner.

Outlook

Hospitals seek to become more cost effective while maintaining a high level of patient care. "Right sizing" of health care organisations is dependent upon the ability to eliminate redundant or unnecessary processes. Some large health care centres spend hundreds of thousands of dollars per year on monitoring technicians. If this technology can eliminate or reduce the numbers of technicians needed, it will likely become a very successful application of telecardiology.

Appendix L - Telemammography[57]

Mammography has some unique resolution requirements that have retarded its adoption by teleradiologists. Recognising that a major hurdle to breast cancer control has been timely access to high quality mammography, the NDMDG[58] has been testing the feasibility of doing satellite-mediated studies. The long term evaluation strategy involves a methodical progression from feasibility studies (just completed) to efficacy and costs studies (soon to be undertaken).

Over the past year, the NDMDG consortium has tested the feasibility of using a T1 (1.544 Mbps) satellite link for transmitting mammograms. Since mammograms are extremely data intensive - a typical uncompressed 4k x 4k x 12 bit image is 32 MB - a primary concern was whether any telecommunications modality short of fibre could transmit efficiently enough to make clinical and financial sense. Satellite uplinks were selected because they are independent of scarce land-based T1 access points, can be made available anywhere a mobile van can park, and because the investigators wanted to assure that transmission was dependable under extreme weather and atmospheric conditions. Also, new Very Small Aperture Telecommunications (VSAT) satellite technology promises to make inexpensive, on-demand, scaleable bandwidth ubiquitously available in the next few years. Data transmitted over VSAT can be priced according to the actual bits sent, making for predictable cost accounting in a telemammography practice.

For the trial, standard hardcopy mammograms were digitised at 50 micron resolution using commercially available film digitisers at MGH and the GE Research and Development Centre. The uncompressed digitised images (each 4k x 4k x 16 bits) were transformed in the standard DICOM format, then transmitted via T1 satellite from the GE R&D Centre in Schenectady to Massachusetts General Hospital (MGH) in Boston, where they were analysed electronically to see whether there was any loss of data bits. There was no loss in thousands of repeated image transfers. The average satellite transmission time for a single image, under various weather conditions, was about 3.25 minutes (32 MB file / 1.544

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[57] Telemammography Feasibility: Aiman Abdel-Malek, Ph.D. Manager, Digital and Networked Systems, General Electric Research and Development, Schenectady, NY, with: Glenn Wachter, Research Associate, Telemedicine Research Centre, Portland, OR

[58] National Digital Mammography Development Group

Mb/sec = 166 seconds/file; recognising that there is some "overhead" due to the DICOM TCP/IP protocol and the satellite transmission process). This trial suggests that the raw feasibility of the process has been demonstrated.

The next issues to tackle are efficacy, cost analysis, and how this technology fits into the workflow of a radiology office.

Mammograms may contain diagnostically vital information in very small units - specifically microcalcifications as small as 100 microns (0.1 mm). In fact, as a rule the smaller the calcifications, the more likelihood they indicate early breast cancer. Thus, the resolving power of the image scanner and display, the compression technology used, and the dependability of accurate transfer, are critical since the loss of even a few pixels of data can lead to misdiagnosis, with serious clinical and legal repercussions. The scanning resolution of 50 microns should be entirely adequate for mammography, but controlled studies must still be done. The repeated transfer of images under varying weather conditions without data loss indicates a robust technology. The transmitted images will be displayed both on 2Kx2Kx12 bit high-resolution monitors and as high-resolution printouts, and compared to the original hard copy. Various compression strategies will be tested to see what the limits of “lossless” compression are for digital mammography. Most current experience suggests that JPEG compression beyond 3:1 starts to lose information (“lossy” compression). Wavelets technology may enable higher lossless compression ratios.

Cost is a serious issue. Current T1 satellite uplinks can cost hundreds of dollars/hour, and even land-based leased T1 lines can cost up to USD $100/hour. While these costs can be decreased by unlimited-use leasing, the high fixed monthly costs of leasing must be amortised by high utilisation, which leads to the final issue to be studied: fitting telemammography into the workflow of a radiology office. In the foreseeable future, the high data transmission needs and equipment costs of running a telemammography operation will necessitate an extremely efficient, high-volume operation. Because teleradiology has different time-motion and training parameters than standard radiology, it will take some serious study to determine whether in fact radiologists can read studies quickly and confidently enough to enable them to practice cost effective medicine.

Conclusion

Telemammography has been shown to be feasible, and could provide a critical link in access to preventive cancer care for millions of underserved, primarily rural women. Especially important is the rapid turnaround time for mammograms. This would enable suspicious lesions to be evaluated immediately, without requiring a return visit and the subsequent anxiety and possible delay in final diagnosis and treatment. Some recent research by Dr. Etta Pisano’s team at the University of North Carolina Department of Radiology found that nearly 40% of rural women with a positive screening mammogram did not comply with follow-up recommendations. Efficacy and cost studies are being planned. The most significant barrier to widespread deployment may be access to bandwidth. Fortunately, an emerging VSAT technology, and increasing access to high bit-rate digital services in rural areas, may overcome this barrier in the next few years. Finally, new technology is being developed that would allow efficient, direct acquisition of digitised images with resolution to 50 microns, eliminating the need for hardcopy mammograms.

Appendix M - TeleOphthalmology[59]

Ophthalmology is a greatly under-utilised telemedicine application-perhaps because the stakes for misdiagnosing visual problems are so high, and because retinoscopy is such a specialised discipline requiring very high resolution images. Since November of 1995, the teleophthalmology program at UTMB-Galveston has gone through an important learning process in terms of technology as well as operational aspects of teleophthalmology.

In ophthalmology store-and-forward (S&F) capabilities to capture still images are essential for several reasons:

- higher resolution can be captured with still images than with video images;
- those high resolution still images can be used to monitor disease progression (e.g., diabetic retinopathy, CMV retinitis, glaucoma) serially for advance or regression;
- S&F images don't require immediate, online evaluation by a consultant;
- teaching files can be easily developed.

Generally in ophthalmology a real-time system (videoconferencing) has not been a major focus due to the importance of the still image resolution. However, teleophthalmology would be limited only to those subspecialties where the still image alone is the entire essence of the evaluation, and would exclude subspecialties such as neuro-ophthalmology, where the history and a dynamic exam are a must for diagnosis.

As the importance of both S&F and videoconferencing technologies were recognised by the authors, a "hybrid" system combining both was developed. This hybrid system used videoconferencing software operating on a Pentium PC with an image-capture board, running over ISDN lines. This enabled some interactivity while the high-resolution pictures were downloaded for review either during the patient visit (e.g., the consultant may be on line with the patient for the videoconferencing part of the encounter, while the images are transmitted) or at a later time.

The S&F system integrated with a videoconferencing system allows white-boarding and audio conversation, while a small window runs on the monitor and allows the specialist to observe and direct the remote examination grossly. The examiner can't see the details of what the remote site examiner is seeing, but can see the examiner and can direct, for example, the angle of the slit lamp. As conceived by the authors, the videoconferencing technology can be used to "plug into" the same camera that is used to take the still images. This allows the consultant to see the details of what the remote site examiner is seeing (e.g., on the slit lamp) so that the consultant gets a more panoramic view as opposed to just a one section slice, enabling a better grasp of the condition at hand. Additionally, the consultant can contribute to the decision as to what view should be captured in higher resolution. To be cost efficient, this technology was designed to transmit over one ISDN line (128 Kbps). However, this bandwidth[60] appears to be inadequate for assessing the subtleties of the pupillary examination and eye movements. Solutions considered to overcome this problem were to multiplex the transmission rate to full or fractional T1 speeds (384+ Kbps) and/or to capture full-motion clips for subsequent downloading (independent of bandwidth).

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[59] New Tools for TeleOphthalmology: Rosa A. Tang, M.D., MPH, Professor, Department of Ophthalmology, U. of Texas Medical Branch (UTMB), Galveston, TX. Director, TeleOphthalmology Project, Texas Department of Criminal Justice. 409/772-2176; Jade S. Schiffman, M.D., Adjunct Assoc. Professor, Dept. of Ophthalmology, Univ. of Texas Medical Branch (UTMB), Galveston, TX

[60] **Bandwidth** In relation to computer systems, the difference, expressed in *hertz*, between the highest and lowest frequencies available on a transmission channel; this sets the limit on the amount of data that can be sent through that channel. As a result of the increase in computer processing power, many systems now offer the option of transmitting text, voice, still pictures, and full video. Transmission systems installed only a few years ago, to deal with simple text applications, do not now have the bandwidth to carry all the data that is available.

Some of the most vexing problems have been in adapting standard ophthalmology examination equipment for digital video and still-image capture. As it happens, any deficits in standard equipment are accentuated when adapted to digital imaging. Since slit-lamps that can integrate with this technology are priced from USD $3,800 (at the low end), the importance of selecting and modifying the right equipment is extremely important. Both Zeiss and Haag-Streit slit-lamps have worked well, as have Heine and Keeler indirect ophthalmoscopes.

A particular problem has been in converting to the monocular (2-D) digital view from the binocular (3-D) standard view, with the potentially important loss of perspective and dimensionally. Another potentially important problem with digital conversion systems that evaluate the fundus has been uncertainty about colour verisimilitude. For example, at times an optic nerve might display on the specialist's monitor as “white” - signalling optic atrophy- when in fact this may simply be an artefact or misrepresentation of the true colour. A 3-CCD camera could solve this colour problem, but is very expensive (about USD $10,000) compared to well under USD $1,000 for a 1-CCD camera. In conjunction with Dr. Helen Li, the authors are evaluating this technology.

Evaluation of the technology for diagnosing CMV retinitis has been directed by Dr. Helen Li, Director of Retina Service at UTMB. Patients with eye problems (cataracts, corneal ulcers, glaucoma, retinal degeneration, herpes) are being assessed via telemedicine diagnosis, compared on a randomised basis with face-to-face examinations. S&F technology is being tested at a Family Practice Clinic, screening for diabetic retinopathy and glaucoma. Implementation and validation of technology are also being done at the U. of Houston School of Optometry in collaboration with Nass Pass, OD, using the same sort of hybrid technology.

Appendix N - Telepathology[61]

Introduction

Many aspects of telemedicine, especially teleradiology, have come of age. Telepathology, however, has lagged behind. Some promising reports on diagnostic accuracy of videomicroscopy exist, but few papers refer to telepathology as an integrated part of the infrastructure of services in surgical pathology. Briefly described below is the present status of telepathology in Norway and Europe, comment on the “take off” problems, and review future prospects.

Status in Norway

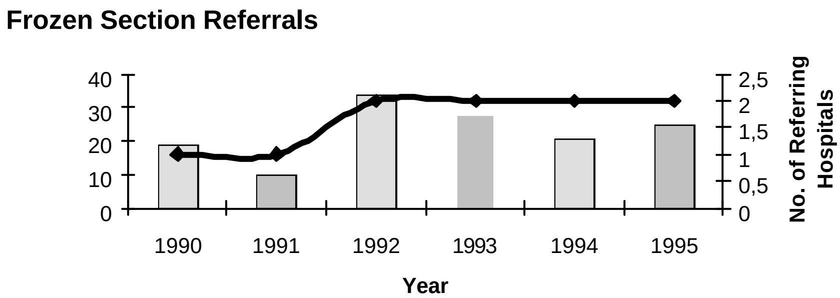
A remote frozen section service, using dynamic, real time video images and remotely controlled motorised microscopes, was established in northern Norway in 1990. Today, three Norwegian hospital-based pathology departments provide frozen section services to five remote hospitals that do not have on-site surgical pathology. These eight hospitals are connected with ISDN (6 B-channels), and they are equipped with the same dynamic telepathology workstation (Telemed A200, Applied Multimedia Electronic AS, Norway). Pathology conferences and other surgical pathology consultations can also be arranged with this equipment. At present, we are implementing an email-based, still image, expert consultation system between two departments of pathology in northern Norway. Equipment includes a single chip (1 CCD) video camera (PAL) attached to a light microscope, a frame

[61] TELEPATHOLOGY: IS THERE A FUTURE? A Special Report on European Telepathology - Dr. Ivar Nordrum, Consultant Pathologist, University Hospital of Tromso, Department of Pathology, PO Box 27, Tromso N-9038, Norway.

grabber card (Screen Machine, Germany) and locally produced PC-based software (Vida 3.0, Norway). The software is built around the "consultation concept," with each case consisting of a number of images and an accompanying text. Actual utilisation of our telepathology system is as follows:

Frozen Sections:

Year	Number of cases	No. of referring hospitals
1990	19	1
1991	10	1
1992	34	2
1993	28	2
1994	21	2
1995	25	2



The two hospitals cover a population of 30,000 and 40,000 inhabitants. The most remote hospital has a high staff turnover, especially among surgeons, which affects the number of frozen section cases. The accrued cases is below what was anticipated. Nevertheless, our remote frozen section service is unique in several aspects: the technology used; successful transformation from a pilot to regular practice (1991); six years of user experience; adequate technical quality of the frozen sections despite of low usage; other hospitals have adopted our concept and equipment. We recognise that the numbers are small, and that on an epidemiologic basis (impact on morbidity/mortality) this program has little significance. Nevertheless, we feel it may pave the way for more consequential deployments in the future.

Status in Europe

The First European Meeting on Telepathology was held in Heidelberg, Germany, in 1992. Here were gathered, for the first time, the world's telepathologists. Since then, several European meetings, symposia, and conferences have taken place. Symposiums on telepathology have been arranged at both international and European congresses of pathology. Several projects have been established in Europe. Three remote frozen section services, transmitting still images, have been established in Switzerland and Germany. In France, 32 pathology laboratories are linked together in a telepathology network designed for expert consultations. The Canary Islands, Spain, has a still-image connection to continental Europe, and in Sweden videoconferencing is used for clinical pathology meetings.

Take off problems

"Telemedicine: fad or future?" and "Telemedicine: lessons remain unheeded." These headlines may be especially relevant to telepathology, which is in regular use in only a few places, despite the fanfare from all of the conferences and published papers. The fact that telepathology is infrequently deployed suggests that there might be some real problems:

- Is the existing technology acceptable?
- Has the diffusion of telepathology reached the critical point of takeoff?
- Have we, the first generation of telepathologists, forgotten that technology is a remedy and not a goal? Were we too interested in the technological possibilities rather than the need for telepathology?
- Is telepathology cost-effective?

The evidence that telepathology will find a place is very convincing indeed. However, we must realise that the total potential number of teletransmitted cases is limited. The challenge today is not so much in overcoming technical barriers, although available technology in many ways is immature. Rather, the challenge is why, where, and how to implement which technology. A needs assessment is critical. Perceived and actual needs for telepathology services tend to be dynamic and time dependent. A specific application of telepathology must fit into or be an extension of an already existing infrastructure. Lack of published studies is a "deficiency disease" in telepathology today. Research and dissemination of results is critical in the areas of diagnostic accuracy, selection of images, and cost-benefit analysis.

Applications

Below are some current and potential applications of telepathology:

Diagnostic telepathology

1. Remote primary diagnosis. Primarily, this encompasses remote frozen section service for hospitals lacking local surgical pathology. A dynamic workstation with macrotable and remotely controlled motorised microscope, and transmission of real-time video images with a still-image option is recommended. A remote frozen section service may be of interest to many hospitals, even if the annual number of cases is limited.
2. Expert consultations. Instead of mailing slides, the referring pathologist can use a store-and-forward (e.g. e-mail) still-image system to obtain a second opinion. The potential of this application promising, and it could have an important effect on diagnostic reliability. The value may be more pronounced within certain areas of surgical pathology, such as neuropathology and transplantation pathology, and in laboratories with few pathologists. Appropriate equipment is inexpensive and easy to use. In the absence of standards, software compatibility can be a problem. Digital cameras with image quality 10 to 20 times better than today's still images based on video cameras will be standard in the future, but are at present expensive.
3. Digital image analyses. Quantitative digital image analyses of muscle tissue, hormone receptors, other antigen markers, tumour ploidy and chromosomes are new fields in surgical pathology. Digital images can be transmitted via a network to centres specialising in image analysis. The percentage of specimens in a given path lab with a need for specialised analyses is low, and there are many pitfalls in appropriate tissue preparation and image selection. Such supplementary examinations should be closely linked to processing of the original tissue/cell material within a laboratory.

Supporting telepathology

1. Continuing medical education. Course material in diagnostic pathology, based on still images distributed through a network or through the Internet, will improve quality assurance and more generalised adoption of diagnostic criteria. This is a simple telepathology application with good prospects.
2. Conferences/meetings. Clinical pathology videoconferencing is a useful service to hospitals without a local service in surgical pathology.
3. Digital image banks. Small still image banks can already be addressed on the Internet. Several CD's with images and text for local use already exist, produced by Intellipath and the AFIP. An image bank can have either an interactive user interface or be a passive reference work. Image banks accessible on the Internet and on dedicated networks (e.g. departmental or national networks) will increase.

Conclusion

Telepathology is here to stay. Expert consultation and continuing medical education are probably the areas of pathology that will benefit most from the technology.

Appendix P - Telemedicine in Japan[62]

Japan is at the edge of a major push into telemedicine. While interesting research and implementation have been going on for many years, several federal policy factors have hindered wider adoption until very recently. However, the headline in the Japan Times of September 23, 1996 heralds the coming change: "Ministry To Approve Remote Health Care." The Medical Services Law "bans the treatment or the prescription of medication without face-to-face diagnosis," the report states, "but the Ministry (Koseisho, the Ministry of Health and Welfare) interpretation of the law holds that "face-to-face diagnosis is not necessary."

The second barrier, reimbursement under the national health insurance scheme, is also coming down. Koseisho announced in July that it will reimburse for specified telemedicine procedures beginning April, 1997. A committee headed by Prof. Shigekoto Kaihara, President of the Japan Association of Medical Informatics, has been established to advise on which applications should get the golden nod.

Symbolic of these changes is the large international map on the office wall of Dr. Hirozo Ueda, Director of Koseisho's Office of Medical Technology and Information Development and perhaps the official most closely involved in telemedicine development. The map details the sites of telemedicine programs throughout the world.

As most Japanese are covered under the national insurance scheme, Koseisho's approval has already resulted in a noticeable increase in telemedicine activity. Importantly, with medical licensing in this country of 125 million done on a national basis, Japan will avoid the thicket of cross-state licensure problems faced in the United States. Add to this a bureaucracy and industrial base eager to catch up to the U.S. in the wider multimedia and networking fields and the aged-care problems posed by the most rapidly ageing population on the planet, and the scene is set for an interesting few years. In 1995 the lifetime birth rate fell to 1.4 births per women; if sustained, one government projection has the population falling to 55 million in 2100. Currently, 15% of Japan's population is older than 65; by 2025 this will increase to 25%. Recently, Yuseisho, the Ministry of Posts and Telecommunications, has funded a number of telemedicine programs to address the issue of providing health care

[62] (Telemedicine Today, v.4(6):20-21, 1996) Correspondent: Dr. Guy Harris, President, Digital Medical Communications, Tokyo; Conference Secretariat to the 3rd International Conference on the Medical Aspects of Telemedicine

efficiently to older people, in an attempt to leverage the ability of the medical community to provide care.

Given the constraints that have hampered activity hitherto, the degree of current activity is surprisingly high. The September issue of 'This is Medicine in Japan' lists some 141 programs, most operating via Japan's highly developed ISDN network. Teleradiology is the most frequent application. Prof. Kiyonari Inamura and colleagues at Osaka University note that the total number of PACS installations rose from around 100 in 1990 to 300 in 1995, while around 40 universities now operate teleradiology programs. Half of these are "mini-PACS" in neurosurgery departments. Among the largest is an emergency stroke network running out of Ohta Memorial Hospital, linking 25 regional centres. Due to the current lack of reimbursement, however, most programs are still used just for education and consultation. Only a few commercial operations have been established; the largest of these is operated by Secom, a noted security company. Their teleradiology centre provides MRI and CT readings from a specifically designed and built hub in suburban Tokyo. Operating over 64-Kbps ISDN lines, the Centre employs radiologists and serves a network of 40 hospitals, many of which act as sub-hubs for smaller institutions. The company is understandably coy about the number of consultations it provides, but Mr. Tsuneo Komatsuzaki, General Manager of the Home Health Care group, says that expansion into other fields is planned. (In the U.S. a typical radiologist interprets 10-12,000 cases/year. Thus, we may guess that the Secom operation handles at least 60,000 cases/year, over half the aggregate number done by the 12 interfacility teleradiology providers in our survey of U.S. providers). While a number of links between Japanese and U.S. academic centres have been established, the international WellCare group abandoned efforts in Japan after only very early investigation.

Perhaps even greater potential exists for telepathology services. With a board certified population of only 1,535 pathologists, few but the largest institutions employ full-time pathologists. This leaves much surgery done without intraoperative pathological diagnosis, relying instead on the tedious prior step of biopsy confirmation. This situation contrasts strongly with that in the U.S. There, if anything, there is an oversupply of pathologists. A telepathology meeting hosted by Koseisho this October saw lively debate on the future of telepathology, with some of the 150 attendees concerned over the reliability of telediagnosis, and fearful of increased workload. Nevertheless, according to co-chair Prof. Tsukasa Ashihara of Kyoto Prefectural University of Medicine, the meeting was deemed a great success by all, and interest in the field is growing rapidly. Should widespread implementation be given a priority, the required investment in hardware will be immense.

Among current telepathology programs, a promising system was recently introduced by Dr. Masayoshi Takahashi and colleagues at SRL, Japan's largest pathology lab. Operating at 128 Kbps over paired ISDN lines, initial scanning is done at 320 x 240 lines, giving a download time of around 1-3 sec. Areas of interest are then captured at 640 x 480 resolution (download time: 7 sec.), while selected final views are obtained at 1,280 x 960 lines (download time: 40 sec.). Operating preferably over 3 monitors with voice and text annotation, the system offers real-time capability at relatively low bandwidth. Since set-up in May, 120 intraoperative diagnoses in breast carcinoma have been done. Tellingly, Dr. Takahashi's biggest challenge is convincing SRL's sales force to promote the system. No doubt the situation will change with the advent of reimbursement.

The single most significant project for the future of telemedicine in Japan is the Hosp-Net network now being developed by Dr. Hiroshi Mizushima and colleagues at the Tokyo-based National Cancer Centre, Koseisho's lead Centre for telemedicine development. In his SGI workstation-bedecked lab, Dr. Mizushima described the network as linking all 251 national hospitals and sanitoria by a Tokyo-centred north-south figure-of-eight ATM network running at 1.5 Mbps. Due to start operations in April 1997, the network will form the backbone upon which a variety of initially HIS and later telemedicine applications can be based. With favourable government support, a hungry electronics industry, and the absence of state licensure restrictions, few telemedicalists in Japan doubt that Hosp-Net will develop into one of the world's most exciting and broad-based telemedicine systems.

Further impetus to the development of telemedicine in Japan will come with a conference to be held in Kobe next year. First held in Tromsø, Norway in 1993 and in Rochester, MN in 1995, this 3rd International Conference on the Medical Aspects of Telemedicine is organised under the auspices of the Japan Association of Medical Informatics and with the sponsorship of the WHO, Koseisho, Yuseisho, and MITI among others. It promises to highlight telemedicine to a wider Japanese, Asian and global audience.

As Prof. J. Patrick Barron, Director of the International Medical Communications Centre at Tokyo Medical College, commented in October, “Although aware of the increasing interest in telemedicine in Japan in the past two years, especially since plans for the Kobe meeting became publicised, I have been astounded at developments in all areas related to telemedicine in the last five months, both in terms of software and hardware. I believe that there is a dire need for professional societies in Japan and Asia to help direct areas of expansion and provide ethical and professional guidelines in this new global field, in relation to local cultural backgrounds.”

While many problems still face telemedicine, it is clear that the providers of information systems - and the very dissemination of information itself - are now in a much greater position of influence over the provision of care than at any time in human history. The commercial opportunities are immense, but so are the opportunities for providing care in a way unknown to previous generations of physicians. Telemedicine in Japan may have been slow off the mark, but the future looks exciting.

Appendix Q - Telerobotics

Robotics is used for the manipulation of highly radioactive and other similarly hazardous materials. The human manipulator sat at a safe distance and performed the necessary manoeuvres which were exactly replicated in the most precise terms by a robotic arm which actually handled those hazardous materials.

This concept is being tested within the ambit of telemedicine. Since the movement-duplicating instructions are transmitted via cables, there is no hindrance in transmitting the stream of electronic instructions in the same way through LAN and the Internet or Intranets (as the case may be).

Videoconferencing/Teleconferencing would allow the manipulator to see and hear and speak via computer link-ups and the manipulations exactly duplicated on-site by a robotic arm.

With the introduction of key-hole surgeries, the possibility of using robotic techniques has increased. Several assistants would nevertheless be required and all the accompanying problems that exist with any procedure of this type would not go away. The surgeon would also have to be highly skilled in order to successfully carry out such long-distance surgeries with the help of a telerobotic arm.

Since key-hole surgeries are performed with the areas being operated on being viewed through eye-pieces, all the eye-piece of the scopes may be attached to several video cameras that are all connected so that the surgeon and everyone else may interactively view them as and when necessary. Thus, the problem of visualisation is solvable.

A big problem does however loom large. The connection between the manipulator’s arm and the telerobotic arm. This has to be true all through the operation, no matter how long it may take. There can be no interference allowed and data loss should be no more than 0.00%. Since it is akin to pilotless flying, many experts opine that for similar reasons telesurgery or telerobotics would never really catch on.

Appendix R - Expert Systems in Medicine

"Expert computer systems", or "knowledge-based systems", are computer programs (software) that analyse data in a way that, if performed by a human, would be considered intelligent. They differ qualitatively from neural networks (see *ut infra*).

They are characterised by:

- symbolic logic rather than just numerical calculations,
- an explicit knowledge base that is understandable to an expert in that area of knowledge, and
- ability to explain its conclusions with concepts that are meaningful to the user.

They can be useful in two different ways:

- Decision support - to remind an experienced decision maker of options or issues to consider that he or she once knew but may have forgotten. This is the most common use in medicine.
- Decision making - to allow an unqualified person to make a decision that is beyond his or her level of training and experience. This is the most common use in many industrial systems.

The program popularly termed an "expert system" was developed in the early 1970's by Dr. Edward Shortliffe at Stanford University. It recommended the selection of antibiotics based on clinical data such as the site of infection and associated medical conditions. While not the first decision support program, it was the first to use symbolic knowledge in a rule-based format.

Over the past two decades, the computer programming methods used to create expert systems ("knowledge engineering") have been incorporated into the standard software engineering repertoire of techniques.

Expert systems are now used routinely in a variety of industries.

As stand-alone products, they are used by credit card companies to make rapid decisions whether to extend credit for individual transactions by customers, and by manufacturers.

When embedded inside another product, they are used by consumers in products such as grammar checkers and "wizards" in popular spreadsheet and graphics packages. A related technology, neural networks, is used in devices such as refrigerators and air conditioners.

Areas that are most suitable for analysis by expert systems have some or all of the following characteristics:

- The knowledge required to make decisions is fairly well circumscribed. Thus, the problem of analysing Swan-Ganz catheter[63] readings is much easier than that of managing a patient in cardiogenic shock, which in turn is easier than that of managing a patient with multi-organ failure.

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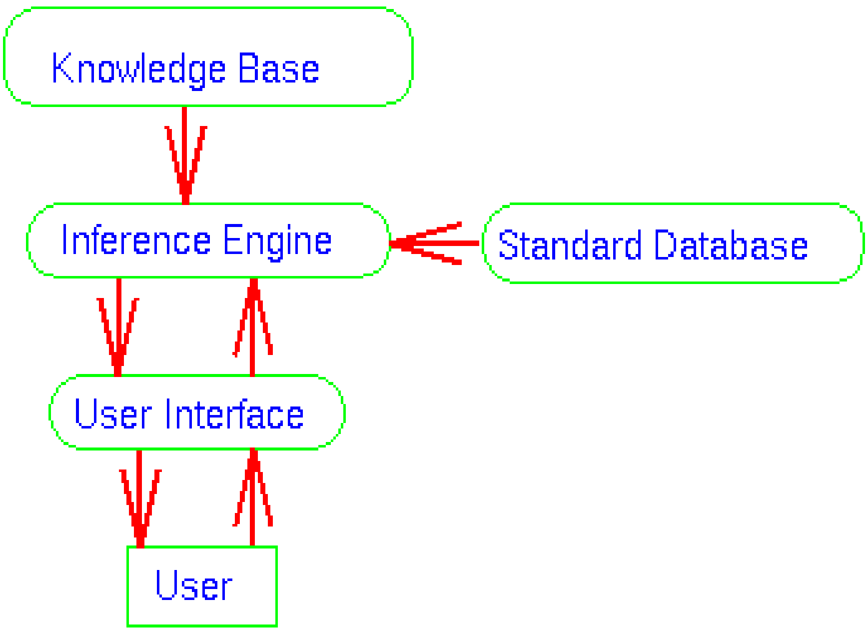
[63] **Swan-Ganz Catheter** Used for measuring pulmonary arterial pressures.

- People who are expert in the area can reach accurate solutions much more rapidly than can people who are not experts.
- There is considerable value in reaching accurate solutions rapidly (to justify the effort required to automate part or all of the decision-making process).
- The data required as input to the decision can be described objectively.

Areas in cardiology that meet these characteristics:

- Decision Support (critique decisions or recommend options);
- CCU admission versus telemetry versus floor versus outpatient for chest pain;
- Thrombolysis versus primary PTCA for acute myocardial infarction;
- Risk stratification following myocardial infarction;
- Other "standard" workups;
- Signal Processing (interpret signals);
- Electrocardiograms and rhythm strips;
- Thallium scintigrams;
- Signal-averaged electrocardiograms;
- Quality Control (identify rare events);
- Drug interactions;
- Third-party oversign of physician performance;
- Process Control;
- ? Closed loop devices such as drug infusion pumps ;

The overall structure of an expert system is:



The Inference Engine integrates:

- the input data obtained from the user and from standard databases,
- the goals specified by the user, and
- the expert knowledge in the knowledge base.

The three types of expert systems differ in how the Knowledge Base is structured and, consequently, how the Inference Engine works:

Production Rule-based or Frame-based systems specialize in associational information, such as "Osborne waves are associated with hypothermia." They are not designed to store causal information.

<u>Elements example of a production rule is</u>:

If the following conditions are true:

< wheezes are present > and

< prior history of congestive failure >

Then consider the following diagnoses and confidences:

< pulmonary edema, confidence 0.8 >

< asthma, confidence 0.5 >

< pulmonary embolism, confidence 0.2 >

- Model-based systems specialize in causal information, such as "Reduced blood pressure causes increased sympathetic nervous system tone." They are not designed to store individual case histories.
- Case-based systems specialise in case-based reasoning, in which individual case histories are indexed according to the presenting signs and symptoms, the laboratory findings, the treatments used, and/or any other factors that the user might later find interesting.
- Neural networks are, mathematically, non-linear regression equations whose coefficients are determined empirically from a large set of training cases. Once the coefficients are determined, the equations, or "network", can be tested with new cases. This method is very useful when explicit symbolic relationships are hard to articulate, such as in pattern matching. See below for a validated neural network for use in a medical setting.

Appendix S - Validated Medical Expert Systems - Quick Medical Reference (QMR) System

This program performs differential diagnosis in many areas of Internal Medicine, and is also useful for self-instruction and testing. (Note: its depth in the cardiovascular diseases is very limited.)

In a prospective trial on 31 unsolved cases from the Medical Service of two university hospitals, its diagnosis was compared with the best guess of the attending physician. The Gold standard was the diagnosis in the 20 cases that were solved after six-month follow-up.

Subject	Accuracy
Attending Physician	80%
Expert system	85% (p=NS)
Housestaff	60% (p=0.03)

Neural Network for CCU Admission Triage

This network identifies acute myocardial infarction in patients presenting to the Emergency Room with anterior chest pain. The tested network had 20 input variables, two hidden layers with 10 units each, and one output variable. It was trained on 351 cases.

It was tested prospectively on 331 new cases. The gold standard was the subsequent hospital course. The analysis compared the best guess of the ER physician (not the triage decision). Results:

	Network	Clinicians
Sensitivity	97%	78%
Specificity	96%	85%

Examples of systems available on the Internet

A compendium of artificial intelligence systems in routine clinical use is available. It includes acute care systems, educational systems, laboratory systems, It includes acute care systems, educational systems, laboratory systems, quality assurance and administration systems, and medical imaging systems.

Additional individual systems include:

- Cardiac Arrhythmia Interpretation (Univ. Oklahoma)
- Literature Searches based on Laboratory Data and Drugs (Columbia P&S). Select "InterMed", then select #6 Clinical Data Access and Sharing and run the CIS demo.
- TraumAID: Assessment of Trauma to the Chest (Univ. Pennsylvania)
- Polymer composite materials (nonmedical) (Michigan State Univ.)
- Prognosis of chronic liver diseases.
- CHORUS (Collaborative Hypertext Resource), a "quick reference" hypertext for medical education and clinical decision making. More than 1,100 documents describe diseases, radiological findings, differential diagnoses ("gamuts"), and pertinent anatomy, pathology, and physiology. CHORUS incorporates facilities for distributed authorship, anonymous peer review, and editorial supervision.

Conclusions

The obstacles to development of expert systems for medical applications are:

- Medical tasks are difficult because of differences between individual patients and the uncertainty of the available clinical data.;
- The range of acceptable error is small because of ethical concerns and malpractice risks;
- There is no perceived shortage of human experts;
- FDA requirements discourage vendor Research and Development;
- Funding for capital expenses is in short supply.

Factors that favour increasing dissemination of expert system technology are:

- Cost effectiveness in capitated and rural systems;
- Inproved quality of patient care (editorial opinion);
- Diminishing technical barriers (widespread access to the Internet, increased computer literacy by end-users, and availability of cheap but powerful computer hardware and software).

Appendix T - The Virtual Patient Record: A Key to Distributed Healthcare and Telemedicine[64]

Introduction

Healthcare is undergoing a revolution because of technological, political and sociological changes. In order for these changes to result in cost effective, quality healthcare, a fundamental change in the way healthcare providers and payers manage patient information is needed throughout the nation and around the world. The change requires treating patient data in a completely different way than has been considered until recently. In particular, it is

[64] David Forslund and David Kilman - Los Alamos National Laboratory

useful to think of the patient's medical record as an entity that exists on the network in its aggregate form simultaneously populated from multiple locations. We describe in this whitepaper some of the motivation for this change, what we mean by a virtual patient record, the potential impact of this change, what is required to support this shift in medical information and some results of some early implementations of a virtual patient record.

Background

Information technologies have begun to have profound impact on a variety of business and social applications. These technologies both improve the quality and lower the costs of business processes. Healthcare is no different in this respect. As an example, the increased mobility of the patient populations and changes in healthcare providers and payers has resulted in a patient’s medical information being accumulated in a variety of locations - hospitals, HMO’s and doctor’s offices - with little or no linkage between them. Because of these multiple points of entry of patient information into the healthcare system, both healthcare provider and payer get a fragmented picture of the health history of a patient, particularly if he has some kind of chronic illness such as asthma or diabetes. This fragmented view can occur over a regional network of clinics as well as over the entire country. We call this requirement for multiple entry points into the healthcare system “distributed healthcare.” Because of distributed healthcare, the patient frequently is the individual with the most complete historical information as to how her clinical illness has progressed.

In addition to the trend towards distributed healthcare, there is a rapid movement to computerised patient records within hospitals, HMO’s and even over CHIN’s (Community Health Information Networks). However, even electronic access over a region may not be sufficient to track a significant number of patients as job mobility increases. This increasingly wide diffusion of the population requires patient data to be accessible in an organised manner on a national and even global scale, independent of the healthcare provider or payer. To deal with this information explosion, there are a number of organisations working to standardise healthcare information and communication including the CEN (European Committee for Standardisation), UN/EDIFACT (United Nations rules for Electronic Data Interchange For Administration, Commerce and Transport), JWG-CDM (Joint Working Group for a Common Data Model), the Health Level 7 (HL7) group, the CPRI (Computerised Patient Record Institute) and recently the Object Management Group (OMG).

The impact on the healthcare industry of making healthcare information available over wide areas in a secure manner will be quite profound. Such availability could potentially allow for “data mining” of information. This information could then be used to discover and analyse associations between disease entities and previously unknown risk factors (recorded in the patient history), to test hypotheses regarding putative risk factors, or to study disease distribution using demographic data. Applications of “data mining” could also include enabling a physician to do a comparative analysis of a particular patient's symptoms with the symptoms of other patients with similar or different diseases. Having wide area access to healthcare information would allow for more intelligent video consultations. During these consultations, along with the video, specialists in multiple locations could simultaneously see and annotate a patient's record. HMO’s could do a better job of outcomes analysis, physicians would have access to better decision support information, and patients could be better educated to manage their health. All of these applications require advanced pattern matching techniques beyond simple database searches.

Virtual Patient Record Concept

For a long time healthcare providers and payers have realised that electronic records have real value and that moving this digital data around to areas where it is needed is highly desirable. There has been considerable success at the Veterans Affairs Hospitals and other locations implementing a decentralised patient record system, but these systems have not addressed the issue of doing so over a wide area network between different domains. With legacy systems, moving data between disparate databases has been a real problem that has been well addressed by the HL7 effort. However, we believe that for ease of access by end users such as physicians and patients, the patient's information must appear to the user as a unified set of data even though it may be spread all over the country. The user's view, of course, might access only a specially tailored subset of the records in order to handle issues of displaying the information in an intelligible manner. With distributed object technology, which can hide much of the vagaries of accessing information, such a view of data is now possible.

This virtual patient record is virtual in that it is a view of the data that might be configured differently at different locations, but that is mapped into a common format at the time the record is required. Creation of the virtual patient record must be done with minimal compromise in the integrity of the data while maintaining high accessibility. For example, simple store and forward systems have potentially serious difficulties because data is copied to multiple locations and then edited and amended locally. There typically is no mechanism to integrate new information entered into any local copy back into the primary record and all other local copies without considerable human effort.

Through a virtual patient record distributed healthcare data is made available through references (analogous to hypertext links of the World Wide Web) and is only brought together (or created) on demand by the end user. Since users generally access components of a record rather than the entire patient record, data movement is minimised. In the distributed system, reference counting capabilities and distributed transaction processing maintain the integrity of the data. Thus, full asynchronous access of the record that enables multiple physicians, other healthcare providers and healthcare payers to update the patient record is supported. Many of these capabilities have already been specified, for example, in the new CORBA services developed by the OMG.

This model does require ubiquitous network connectivity and accessibility, but high bandwidth transmission is not necessary unless large amounts of image or video data need to be moved. Such an infrastructure is rapidly coming into existence, even in rural areas (For example, in rural areas the virtual patient record can be assembled over the POTS [Plain Old Telephone System] for the price of a long-distance telephone call). The model also requires a robust security infrastructure to support authentication, confidentiality, and data integrity so that there is no single point of failure that, if compromised, would give access to all the information. This security model has been slow in coming, but with recent developments in electronic commerce, such security systems are imminent. In order to provide robust data access even when larger numbers of users are attempting to access data and a universal but secure way to identify and locate patient information, various replication servers are also required.

We believe that it is now possible to implement the virtual patient record concept if all stakeholders - government, public, and private - co-operate in making it a reality in the everyday practice of medicine. Many of the underlying standards are being put into place, but more standard representations of medical objects are needed. This is one of the goals of the new Healthcare Task Force created by the OMG (and also known as CORBAmed).

For example, the virtual patient record will depend heavily on the ability to quickly and securely identify patients and their respective healthcare providers and payers.8 This requirement can be met by a Master Patient Index (MPI). Besides the basic architecture to enable healthcare objects to work interchangeably and together, in order to avoid the chaos caused by using existing naming conventions, the virtual patient record system will have to be adopted by a large portion of the healthcare community in a short period of time. This requires use of the standards model similar to that used by Internet or World Wide Web model. We also believe that, in order to provide a cost effective approach to healthcare, the healthcare community must build on the much larger networking and software infrastructure that is being put into place by the nations business community.

Telemedicine or, more specifically teleconsultation systems have seen expansive growth from federal, state, and local initiatives. Although the data on the success of these telemedicine networks are meager, there are indications that many successes stem from using video technology in the referral process. A number of trials have concluded that the ability to have access to the full electronic medical record greatly enhances the teleconsultation and enables the evaluation of the effectiveness of the resulting treatments.

Implications

There are a number of events that must occur in order for a virtual patient record system to become the normal mode of operation of the nation's healthcare industry and there are a number of events that will follow from the extensive use of such a system. One can think of this model as the Internet approach to healthcare in which there is essentially no central control but rather a loosely coupled set of database systems with agreed upon standards for exchanging information. The MPI, for example, has some similarity to the Domain Name Service (DNS) of the Internet and the security model is closely related to DCE (Distributed Computing Environment) security. We believe that, in order for there to be a real standard way of healthcare information to be exchanged and interleaved, some easily adopted base implementations must be made available to the healthcare community. A few organisations need to demonstrate that this new environment, even on a small scale, can result in substantial cost savings as well as improved quality of healthcare. Others will then follow. It may be argued that a distributed system cannot work because of the enormous number of transactions that must occur. However, we believe that precisely because of the large number of nearly independent transactions, such a system can scale, or be expanded from the local to the national level. The same conclusion applies to security; it must be handled in a distributed manner so that single points of failure don't compromise the entire system. A centralised system, in fact, cannot possibly manage, either technically or economically, all of the information that will be contained in a National Health Information Infrastructure. The challenge to create such a scaleable, distributed national system is very great and will require co-operation of private industry, healthcare providers, and federal, state, and local governments.

A virtual patient record system cannot be constructed unless reusable healthcare data information components (i.e., objects) which can be assembled in a variety of ways to meet the highly varied needs of the healthcare practitioner are made available. This will require application of some of the most powerful software tools for enabling object reuse including adaptable, dynamic objects inheriting object behaviour. The virtual patient record will be quite dynamic and new data entered must be self-describing so that the computer patient record can evolve with changes in the industry. We believe that the healthcare software market will undergo a major revolution in the next years to accommodate these requirements. The healthcare business model will radically change because of some of the new deployment technologies coming into the marketplace. Businesses that help set the stage for the future will have a distinct advantage in this new marketplace.

With such a virtual patient record system in place, patients will be able to review their medical records and more actively participate in managing their own health. In addition, when combined with financial information, the system will enable the use of powerful metrics that measure the delivered quality of healthcare while minimising waste, fraud, and abuse. Such metrics are an essential component of a Clinical Decision Support System (CDSS). In addition, it should be possible for healthcare providers and payers to determine health trends on a national scale and to identify the most effective means of improving healthcare. Regulations may impact the deployment of such a system, but we envision the system primarily augmenting the existing referral practices rather than changing them.

Prototype experiences

Only recently have people attempted to build systems along the lines described above. One such effort has been at the Technical University of Berlin under the direction of Dr. Fleck and supported by DeTeBerkom. This BERMED system has similar goals to the TeleMed effort described below, although it is not built upon an object infrastructure. Additional efforts are going on at the West Virginia University at the CERC (Concurrent engineering Research Centre) in the ARTEMIS project to make patient information available over public networks in a secure manner.

In a joint effort with the National Jewish Centre for Immunology and Respiratory Medicine (NJC), we have constructed a prototype of such a system described above. This TeleMed system enables physicians at multiple locations to simultaneously see, edit and annotate a patient record at remote locations. It handles multimedia data including CT imaging and audio annotations. It is uses Object Request Brokers (ORBs) that abstract away the distributed databases that provide the persistent object storage of the multimedia data. It has object-level security implemented to provide authentication and encryption for confidentiality. It is built with the idea of providing easy-to-use access to complex information while providing advanced data-mining techniques accessible to an end user. It uses a simple ID-server to identify which databases have particular patient data so that the patient record which is graphically displayed is a combination of all the information in the multiple databases. Thus, TeleMed is an early implementation of the virtual patient record described above and demonstrates that the concept is achievable. It has been deployed at the NJC, the National Institutes of Health, and at the Texas Medical Centre for early testing and evaluation. Physicians at these three institutions can simultaneously view, edit, and annotate the patient data stored at multiple locations while each physicians can see the data the other physician has entered. To the physician using TeleMed, it appears as if all the data resides on her own desktop computer; there is no indication that multiple databases are involved. TeleMed supports basic data mining by providing abilities to compare images with “similar” features and to visually navigate through a image data base. We have also implemented, where the available bandwidth permits, the ability to support video teleconferencing within the TeleMed system.

Opportunities

One virtue of the virtual patient record system is that it can be extended to a wide variety of areas. For example, the concept can be used in engineering where one deals with a designed or a built system and needs to track its history over a wide region or a period of time. We believe this approach will become predominant over the next decade as the telecommunications and computer hardware and software infrastructure become more robust. We believe that the co-operation of all stakeholders working with together to build a common infrastructure will not only develop new business opportunities but also will make a positive impact on the healthcare delivery nationally and world-wide. The opportunity exists now to invest in a new healthcare infrastructure that will significantly enhance the delivery of quality of healthcare at a reasonable cost.

Appendix U - Small Abstracts

MedVision Supplies Telemedical Services in Flood

MedVision's VisiTran-MD™ is being used to expedite patient care during flooding of the Red River in North Dakota. The United Hospital of Grand Forks has requested the services, which will be used in an emergency facility temporarily housed in the Northwest Technical College in East Grand Forks. Flood victims and patients east of the Red River will be first assessed at the temporary facility. Physicians there will use VisiTran-MD to send a variety of medical images including x-rays and MRIs, audio messages, video clips and text for further review by physicians at United Hospital. Physicians will then determine treatment and co-ordinate with attending physicians at the emergency clinic. Access to the hospital has been eliminated for thousands of people by the flooding Red River, which has risen to its highest level this century, 50 feet above flood stage. The telemedicine system has been essential in delivering quality medical care during the flood. (Source: PR Newswire, April 21, 1997)

New Portable Interactive Device

Research studies have shown that up to 90% of patients make unintentional errors in taking their medication, resulting in billions of dollars in medical expenses and lost worker productivity. A portable Personal Medical Assistant (PMA) devised by InforMedix, Inc. was introduced last week to help lower that figure. Called the Medi-Monitor, the device is about the size of a video cassette. Three different models of the device will be produced for managed care organisations, clinical drug trial investigators, health care providers, pharmacists and consumers. The first model, demonstrated at the National Managed Health Care Congress last week in Washington DC, can dispense up to ten different medications. The average cost of the PMA is USD $1.50 per patient per day, and the company expects to sell 500,000 units (USD $100M) in the next five years. Medi-Monitor will alert patients to take their prescriptions, and has an interactive graphic screen which provides detailed information about their medications and health. It will also prompt patients to enter information in response to a series of questions about their medications, side effects, interactions, quality of life and general health. The collected data is then automatically uploaded by a built-in modem to the InforMedix communications Centre for analysis. Reports are then sent to the patient's provider pharmacist or other health care professional and can include early warning signals if the patient's condition is worsening. The device was invented by Dr. Bruce Kehr, MD, Chairman and President of InforMedix, and was produced by Logix. (Source: InforMedix, Inc. Press Release, April 14, 1997)

A cost analysis of an emergency CT teleradiology system[65]

We carried out a cost analysis of a teleradiology system for emergency computerised tomography (CT) examinations. Teleradiology was implemented by connecting two spiral CT scanners in the University Hospital in Innsbruck and the Regional Hospital in Zwettl. It enabled the remote hospital in Zwettl to get fast and competent reports of emergency CT examinations when there was no specialist radiologist available. In 13 months' use for routine

[65] Stoeger A , Strohmayr W , Giacomuzzi SM, Dessl A, Buchberger W and Jaschke W (1997) Journal of Telemedicine and Telecare 3(1): 35-39.

night and weekend service, the system proved fast and reliable. During the study period 121 emergency examinations of 116 patients were transmitted from Zwettl to Innsbruck. The fixed costs of teleradiology were for the ISDN[66] connection and amounted to DM230 plus DM696/year rental. The average cost of one emergency CT examination by teleradiology was DM372 (range 308-453). One possible alternative, transporting the films by taxi for reporting elsewhere, was cheaper (estimated cost DM156), but would have been much slower. Another alternative, transporting the patient to the nearest central hospital for scanning, was much more expensive: DM524 by road or DM4667 by helicopter ambulance.

The possible use of telemedicine in developing countries[67]

Telemedicine may be a useful technique for delivering health care in the developing world. However, there is little practical experience to draw on and real concerns that if additional resources were to become available telemedicine might not be the most appropriate use for them. The logical steps to determine the place of telemedicine in the developing world therefore must be:

1. to identify potential telemedicine projects-the Telecommunications Development Bureau of the International Telecommunication Union is trying to do this and has recently sponsored missions to various countries in Africa and Asia;
2. to carry out properly controlled pilot projects in order to demonstrate technical feasibility and to quantify the benefits to the health care system;
3. to calculate the costs of large-scale deployment. Assuming that telemedicine is shown to be beneficial, it is only at this final stage that a rational decision can be made about whether telemedicine would be an appropriate use of additional resources in a developing country, as opposed to alternative uses of those resources to solve other important problems of health care.

Appendix V - An Interesting Article Related to Medical Informatics[68]

Recent years have generated a good deal of heat but not much light concerning the evaluation of telemedicine’s effectiveness. Opinions are divided on the need and directions for research. According to some, the horse is already out of the barn, so research is of secondary importance to the task of cultivating clinical telemedicine. Others are persuaded that a systematic research agenda is important.

A good deal of resistance to conducting research arises from the fact that research requires the collection of data - a weird concept, to be sure. Scientists seem to have a fetish with data, while non-scientists (politicians, for example) get a lot more excited about good stories than they do about data. Ronald Reagan built a successful career around stories, from his account of the welfare queen who made as much money as Bill Gates and rode around in a sedan chair, to his theory that trees are responsible for over 90% of air pollution. If it was good enough for the President, isn’t it good enough for telemedicine?

A second major problem with data collection is that, not having studied Latin, most people are unsure whether to say “the data is” or “the data are.” If you want to get technical, Latin scholars will tell you that neither “is” nor “are” is (or are?) a Latin verb. Finally, clinical personnel, especially physicians, will hate you if you ask them to collect data. Perhaps you heard about the physician in Kansas City who allegedly poisoned her physician husband with

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[66] **ISDN** Integrated Services Digital Network - now being offered by many phone companies, this can offer 56Kbps or 128Kbps, depending on the hardware.

[67] Wootton R (1997). Journal of Telemedicine and Telecare 3(1): 23-26.

[68] The Last Word: a column by Jim Grigsby, Ph.D.: Sentenced to Life Without Parole Doing Outcomes Research

castor beans. He apparently had asked her to fill out a couple of questionnaires, temporarily forgetting that she was a busy, important person.

"So what's the point?" you ask.

Some people hope the need for research will go away if our elected representatives, in their infinite wisdom, would only pass legislation that forces telemedicine coverage down HCFA's throat. Here are a few reasons why it won't.

In spite of its limitations, research on health care outcomes is here to stay, and telemedicine is not exempt. Third-party payers are demanding evidence that health services work, and that they are not excessively costly. If you can't demonstrate the value of what you're doing, you may not get paid for it.

Managed care organisations soon will be required to collect outcome data in certain as yet unspecified areas. MCOs are certified by the National Committee on Quality Assurance (NCQA), and must provide NCQA with data collected in conformity with the Health Plan Employer Data & Information Set (HEDIS), a collection of criteria against which MCO performance is measured. Previously, the HEDIS measures were based almost exclusively on whether MCOs provided specific processes of care. It is thanks to HEDIS, for example, that MCOs (which always are looking for ways to make the practice of medicine more efficient) are no longer allowed to have LPNs perform routine craniotomies, and that anaesthesia during appendectomies is a covered service. With the advent of outcome-based performance measures, MCOs now will have to show that their patient outcomes are acceptable.

Over the past several years, the Health Care Financing Administration (HCFA) has emphasised the importance of patient outcomes as indices of quality of care, and toward this end established the Health Care Quality Improvement Program (HCQIP). The HCQIP now guides the activities of each state's Peer Review Organisations (PROs), which are set up to monitor the quality of care received by Medicare patients. Outcome-based quality assurance and performance improvement programs have been under development in several areas, including inpatient cardiac care, outpatient diabetes management, and home health care. HCFA recently published an RFP to develop an outcome-based QA and performance improvement (OBQI) program for the Program for all-inclusive Care for the Elderly (PACE).

Outcome research is challenging, and outcomes frequently are difficult to measure, let alone specify. Given the protean nature of telemedicine, the study of outcomes of care delivered by means of telecommunications technology can be quite complex. The easy way out is to try to study patient satisfaction in a one-size-fits-all manner, but results already published suggest that most patients find telemedicine an acceptable way to receive medical care. Why beat a dead horse? Research on patient satisfaction may be useful as a marketing tool, but the more interesting questions concern what happens to patients health when telemedicine is used. Are specific symptoms resolved? Does general health status improve? For patients with chronic progressive illness, does functional ability stabilise?

The concept of OBQI is simple, but its implementation is not. The basic idea is that you measure patients' clinical status at two or more timepoints while keeping track of the kinds and intensity of care they receive. You then analyse the data to determine which processes are associated with good outcomes, and which are associated with bad outcomes, and modify your practices (if necessary) in light of the results. In the context of clinical or health services research, an outcome is the difference between ratings during or following treatment. The effect of the treatment is the difference between the actual outcome and the expected outcome given no treatment. Simple enough, until you begin to think about how to do it.

One problem, for example, is that all illnesses do not have the same course. Many are acute and self-limited, and would probably resolve without treatment. Some are rapidly fatal, others are fatal only after an extended, debilitating course. Some degenerative diseases may cause inexorable functional decline in the presence of generally good health (e.g., Alzheimer's disease), while others may leave functional capacity intact for quite some time, while causing significant physiologic problems (e.g., moderate to severe hypertension, uncontrolled diabetes). Thus from one disease to another there is significant variability in what is considered favourable: stabilisation, improvement, or slowing of progression may be good outcomes, depending on the disorder. Likewise, the metric may be quite different: improvement in activities of daily living, decrease in chronic pain, or resolution of dermatologic symptoms. One solution may involve stratification of patients into categories. You might examine all diabetics, or all Type II diabetics, or all persons with progressive neurodegenerative diseases, or persons with fractures of the lower extremities. Depending on your focus, outcome measures may be disease-specific (e.g., haemoglobin A1c levels for diabetics), or global (e.g., a general health status measure such as the SF36).

A second difficulty is that not all patients with a given condition are alike. This is where risk-adjustment becomes important. Assume you are a geriatrician, and you want to study the outcomes of telemedicine care for a sample of geriatric outpatients. Older persons with serious illnesses and an alphabet soup of co-morbid conditions (e.g., COPD, CHF, NIDDM, degenerative diseases, etc.) are liable to have worse outcomes, regardless of the care they receive, than are healthier persons. It may be that they also are more likely to receive consultative services via telemedicine because of the complexity of their condition. If they are compared, without some kind of risk-adjustment (by stratification or statistical means), with individuals who are less ill and/or have a lower burden of co-morbid illness, you may incorrectly demonstrate that telemedicine outcomes are worse than those of conventional care.

Where does this leave us? As I see it, there's no escape from the need for some kind of outcome research. Third-party payers and credentialing organisations are going to expect it of you sooner or later, and you might even be curious enough about your patients' outcomes that you want to evaluate them and use the results to improve the care you provide. The least painful way to approach this task is to build a well thought out evaluation component into clinical telemedicine programs from the beginning. If you plan to get your staff to begin collecting data when they haven't had to do so previously, you should consider rotating staff members to taste your food and make sure you aren't being poisoned. Remember, I'm one of those persons with an intractable data fetish.

Bibliography

1. Barnett, G. et al. (1987). DXplain: An evolving diagnostic decision support system. JAMA, 258(7), 67-74.
2. Bashshur, R., & Armstrong, P. (1976). Telemedicine: A new mode for the delivery of health care. Inquiry, 13, 233-244.
3. Benjamin, R. I., & Blunt, J. (1992, Summer). Critical IT issues: The next ten years. Sloan Management Review,, 7-19.
4. Boeryd BRG. Experience with distant pathology demonstrations for clinicians without local pathologists through the Swedish telepathology work station. Arch Anat Cytol Path 1995; 43: 266-267.
5. Boor J. L., Schaad, D. C., & Evans, F. W. et al. (1981). Communications satellites in health education and health care delivery: Operational considerations. J Educ Tech Sys, 9(4), 371-377.
6. Broering, N. C., & Bagdoyan, H. E. (1992). The impact of IAIMS at Georgetown: Strategies and outcomes. Bulletin of the Medical Library Association,, 80(3).
7. Centralised patient records - by George Black; Elusive electronic goal. FT, Feb 5, 1997.
8. Clayton, P. D., Sideli, R. V., & Sengupta, S. (1992). Open architecture and integrated information at Columbia-Presbyterian Medical Centre. MD Computing, 9(5), 297-303.
9. Computers in Medicine - by Dr. R.D.Lele; Tata McGraw-Hill Publishing Company Limited.
10. Conger, J. A. (1989). The charismatic leader: behind the mystique of exceptional leadership. San Francisco: Jossey-Bass.
11. Conger, J. A., & Kanungo, R. N. (1988). Behavioral dimensions of charismatic leadership. In J.A. Conger, R.N. Kanungo & Associates (Eds.), Charismatic leadership. San Francisco: Jossey Bass.
12. Crafting and Implementing Strategy: Texts & Readings; Strickland and Thompson; Edition 6; Prenctice Hall
13. Cunningham, N., Marshall, C., & Glazer, E. (1978, December 15). Telemedicine in paediatric primary care. JAMA, 240(25), 2749-2751.
14. Davis, S., & Davidson,D. (1991). 2020 Vision: Transform your business today to succeed in tomorrow's economy, (Chapters 1-3). New York:Simon & Schuster.
15. Dohner, C.W., Cullen, T.J., & Zinser, E.A. (1975). ATS-6 evaluation: The final report of the communications satellite demonstrations in the WAMI Decentralised medical education program at the University of Washington. Prepared for Lister Hill National Centre of Biomedical Communications. Seattle: University of Washington.
16. Drucker, P. F. (1989). The new realities. In government and politics in economics and business, in society and world view. NY: Harper & Row.
17. Drucker, P. F. (1992, September-October). The new society of organisations. Harvard Business Review, 95-104.
18. Editorial. Telemedicine: fad or future? The Lancet 1995; 345: 73-74.
19. Eide TJ, Nordrum I. Current status of telepathology. APMIS 1995; 103: 881-890.

20. Furtado, R. (1982, March). Telemedicine: The next-best thing to being there. Dimensions, 10-12.
21. Gorry, G., Anthony et al. (1991). The virtual notebook system: An architecture for collaborative work. Journal of Organisational Computing, 1(3), 233-250.
22. Greenes, R. A., & Shortliffe, E. H. (1990). Medical informatics: An emerging academic discipline and institutional priority. JAMA, 263(8), 1114-1120.
23. Grundy, B.L., Jones, P.K., & Lovitt, A. (1982, July). Telemedicine in critical care: Problems in design, implementation and assessment. Critical Care Medicine, 10, 471-475.
24. Hartman, J. T., & Moore, M. (1992). Using telecommunications to improve rural health care: The Texas Tech MEDNET Demonstration Project. Prepared for the Office of Rural Health Policy, U.S. Department of Health and Human Services. Lubbock: Texas Tech University.
25. Health care at home - by Alasdair Barron; Big prospects for telemedicine. FT, Feb 5, 1997.
26. Hospital Administration - by Dr. C. M. Francis, JPB Publications.
27. How health-cards will help cut costs - by Geoffrey Nairn; Smart-cards hold great promise. FT, Feb 5, 1997.
28. Hudson, H. (1990). Communication satellites: Their development and impact. New York: The Free Press.
29. In E. H. Shortliffe & L. E. Perreault (Eds.), Medical informatics: Computer applications in health care (pp. 181-218). Reading, MA: Addison-Wesley.
30. Information Systems - a management perspective - by Stevel Alter; The Benjamin/Cummins Publishing Company, Ltd.
31. Information Systems Concepts for Management - by Henry C. Lucas, Jr.; McGraw-Hill Inc.
32. Kayser K, Fritz P, Drlicek M. Aspects of telepathology in routine diagnostic work with specific emphasis on ISDN. Arch Anat Cytol Path 1995; 43: 216-218.
33. Krupinski EA, Weinstein RS, Bloom KJ, Rozek LS. Progress in Telepathology: System Implementation and Testing. Advances in Pathology and Laboratory Medicine 1993; 6: 63-87.
34. Kuhn, R. L. (Ed.). (1988). Frontiers of medical information sciences. New York: Praeger.
35. Laird M, Deen M, Brooks S, Threlkeld A, Hull D, Shatz A, Louard R and Marcus D (1996) Telemedicine diagnosis of diabetic-retinopathy, cataract, and glaucoma by direct ophthalmoscopy. Investigative Ophthalmology & Visual Science 37(3):492.
36. Li HK, Tang RA, Schiffman JS, Sy RT, Temprano JE and Prager TC (1996) Diagnosing cytomegalovirus retinitis through telemedicine in a Texas correctional institution - a pilot study. Investigative Ophthalmology and Visual Science 37(3): 4155.
37. Lorenzi, N. M. (Ed.). (1992, July). Symposium: A decade of IAIMS. Bulletin of the Medical Library Association, 80(3).
38. MacDonald, C. J. & Barnett, G. O. (1990). Medical-record systems.
39. Management Practices for the Health Professional - by Beaufort B. Longest Jr., Reston Publishing Co.
40. Marion G (1995) Telemedicine: On-line screening for diabetic retinopathy. Ophthalmology World News 1(5): 1, 28-29.

41. Martin E, Dusserre P, Got C, Vieillefond A, Franc B, Brugal G, Retailliau B. Telepathology in France. Justifications and developments. Arch Anat Cytol Path 1995; 43: 191-195.
42. Masarie, F. E., Jr., Miller, R. A., & Myers, J. D. (1985). INTERNIST-1 Properties: representing common sense and good medical practice in a computerised medical knowledge base. Computers and Biomedical Research, 18, 458-479.
43. McLaren P, Ball CJ. Telemedicine: lessons remain unheeded. British Medical Journal (BMJ) 1995; 310: 1390-1391.
44. MEDLINE SEARCH: 1. Medical management information systems; 2. Decentralised hospital computer program. Centre for Research on Communication Technology and Society, The University of Texas at Austin, Austin, Texas.
45. Moore, M. (1993a). Elements of success in telemedicine projects. Report of a research grant from AT&T Graduate School of Library and Information Science, the University of Texas at Austin.
46. Moore, M. (1993b).
47. Morris, W.C. (1970). The information influential physician: The knowledge flow process among medical practitioners. Ann Arbor, MI: The University of Michigan.
48. Muller, C., Marshall, C.L., Krasner, M., Cunningham, N., Wallerstein, E., & Thomstad, B. (1977). Cost factors in urban telemedicine. Medical Care,15(3), 251-259.
49. Network Integration - by Geoffrey Nairn; A vision for linking 'islands of technology.' FT, Feb 5, 1997.
50. Nordrum I, Eide TJ. Remote frozen section service in Norway. Arch Anat Cytol Path 1995; 43: 253-256.
51. Nordrum I, Engum B, Rinde E, Finseth A, Ericsson H, Kearney M, Stalsberg H, Eide TJ. Remote Frozen Section Service: A Telepathology Project in Northern Norway. Hum Pathol 1991; 22: 514-518.
52. Oberholzer M, Fischer HR, Christen H, Gerber S, Bruhlmann M, Mihatsch M, Famos M, Winkler C, Fehr P, Buchthold L, Kayser K. Telepathology With an Integrated Services Digital Network-A New Tool of Image Transfer in Surgical Pathology. Hum Pathol 1993; 24: 1078-1085.
53. Outsourcing of health services - by Nuala Moran. Information Technology suppliers face complex problems in NHS market. FT, Feb 5, 1997.
54. Peters, T. (1988). Thriving on chaos. New York: Harper & Row.
55. Preventive and Social Medicine; Park & Park
56. Proceedings of the Mayo Telemedicine Symposium. Including "Telemedicine and access to care,"; A consensus conference to explore telemedicine as a vehicle for expanding access to cost effective health care. (1993). Rochester, MN: Mayo Clinic.
57. Rinde, E., Nordrum, I., & Nymo, B.J. (1993). Telemedicine in rural Norway. World Health Forum 14(1), 71-77.
58. Saranummi, N. et al: Health care Information Framework. International Journal of Bio-Medical Computing #39 (1995) 99-104.
59. Shortliffe, E. H., & Fagan, L. M. (1989, October). Research training in medical informatics: The Stanford experience. Academic Medicine, (64)10, 575-578.

60. Silva, J.S., and Ball, M.J.: The professional workstation as enabler: conference recommendations. International Journal of Bio-Medical Computing #34 (1994) 3-10.
61. Stauch G, Schweppe KW. One year experience with telepathology for frozen sections. Electronic Journal of Pathology and Histology, VaW (Verlag fur angewandte Wissenschaften), Munchen, Germany 1995; 1: fileref.: 954-08.txt (floppy disc).
62. Stead, W. W., & Hammond, W. E. (1988). Computer based medical records: The centrepiece of TMR. MD Computing, (5)5, 48-62.
63. Sung, L. (1993). The South Texas telecommunications inventory and database program for use in planning telecommunications-based training for health care applications. University of Texas Health Science Centre in San Antonio, San Antonio, Texas.
64. Telemedicine rollabout units: Battle of the titans. (1994, Spring). Telemedicine Today, 2(1), 1, 6-9.
65. The First International Telemedicine Trial to China: Zhu Lingling's Case- by Xin Li, Ph.D. Student, Medical imaging Division, School of Medicine, UCLA; John W. Aldis, M.D., AAFP, MPH & Tropical Medicine, U.S. Department of State; Daniel Valentino, Ph.D., Medical imaging Division, School of Medicine, UCLA
66. The quest 'to provide more with less' - by John Lamb; Health care agencies seek cost-saving Information Technology solutions. FT, Feb 5, 1997.
67. The Strategy Process - European Edition; Minzberg, Quinn, Ghoshal; Prenctice Hall
68. US health care administration - by Tom Foremski; Strong pressures to improve efficiency. FT, Feb 5, 1997.
69. Video on TeleMedicine - by WellCare, WCH International Inc.
70. Williams, F. (1991). The new telecommunications: Infrastructure for the information age. New York: The Free Press.

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