1. AN INTRODUCTION TO TELEMEDICINE

Telemedicine, a term coined in the 1970s, which literally means "healing at a distance", is defined as the use of telecommunications to provide medical information and services. It may be as simple as two health professionals discussing a case over the telephone, or as sophisticated as using satellite technology to broadcast a consultation between providers at facilities in two countries, using videoconferencing equipment or robotic technology. It signifies the use of ICT (Information and Communication technology) to improve patient outcomes by increasing access to care and medical information. Recognizing that there is no one definitive definition of telemedicine – a 2007 study found 104 peer-reviewed definitions of the word. The World Health Organization has adopted the following broad description:

"The delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities".

The many definitions highlight that telemedicine is an open and constantly evolving science, as it incorporates new advancements in technology and responds and adapts to the changing health needs and contexts of societies. Some distinguish telemedicine from telehealth with the former restricted to service delivery by physicians only, and the latter signifying services provided by health professionals in general, including nurses, pharmacists, and others. However, for the purpose of this report, telemedicine and telehealth are synonymous and used interchangeably.

Four elements are germane to telemedicine:

1. Its purpose is to provide clinical support.

2. It is intended to overcome geographical barriers, connecting users who are not in the same physical location.

3. It involves the use of various types of ICT.

4. Its goal is to improve health outcomes.

1.1 Origin and History:

Care at a distance (also called "in absentia" care), is an old practice which was often conducted via post. There has been a long and successful history of in absentia health care which, thanks to modern communication technology, has evolved into what we know as modern telemedicine.

In its early manifestations, African villagers used smoke signals to warn people to stay away from the village in case of serious disease. In the early 1900s, people living in remote areas in Australia used two-way radios, powered by a dynamo driven by a set of bicycle pedals, to communicate with the Royal Flying Doctor Service of Australia.

One of the first published accounts of telemedicine occurred in the early 20th century when electrocardiograph data were transmitted over telephone wires. Telemedicine, in its modern form, started in the 1960s in large part driven by the military and space technology sectors, as well as a few individuals using readily available commercial equipment. Examples of early technological milestones in telemedicine include the use of television to facilitate consultations between specialists at a psychiatric institute and general practitioners at a state mental hospital, and the provision of expert medical advice from a major teaching hospital to an airport medical centre.

1.2 Present Day Telemedicine:

Recent advancements in, and increasing availability and utilization of, ICTs by the general population have been the biggest drivers of telemedicine over the past decade, rapidly creating new possibilities for health care service and delivery. This has been true for developing countries and underserved areas of industrialized nation. The replacement of analogue forms of communication with digital methods, combined with a rapid drop in the cost of ICTs, have sparked wide interest in the application of telemedicine among health-care providers, and have enabled health care organizations to envision and implement new and more efficient ways of providing care. The introduction and popularization of the Internet has further accelerated the pace of ICT advancements, thereby expanding the scope of telemedicine to encompass Web-based applications (e.g. e-mail, teleconsultations and conferences via the Internet) and multimedia approaches (e.g. digital imagery and video). These advancements have led to the creation of a rich tapestry of telemedicine applications that the world is coming to use.

1.3 Services rendered by telemedicine:

Sometimes telemedicine is best understood in terms of the services provided and the mechanisms used to provide those services. Here are some examples:

- **Primary care and specialist referral services** may involve a primary care or allied health professional providing a consultation with a patient or a specialist assisting the primary care physician in rendering a diagnosis. This may involve the use of live interactive video or the use of store and forward transmission of diagnostic images, vital signs and/or video clips along with patient data for later review.

- **Remote patient monitoring**, including home telehealth, uses devices to remotely collect and send data to a home health agency or a remote diagnostic testing facility (RDTF) for interpretation. Such applications might include a specific vital sign, such as blood glucose or heart ECG or a variety of indicators for homebound patients. Such services can be used to supplement the use of visiting nurses.

- **Consumer medical and health information** includes the use of the Internet and wireless devices for consumers to obtain specialized health information and on-line discussion groups to provide peer-to-peer support.

- **Medical education** provides continuing medical education credits for health professionals and special medical education seminars for targeted groups in remote locations.

1.4 Telemedicine in India:

Telemedicine in India has been made possible with the help of ISRO (Indian Space Research Organization) which has successfully implemented a number of projects in Telemedicine/Tele-health, which is of great social relevance to the country for enabling Specialty Healthcare to the remote, rural and under reserved population.

With the advent of Communication Technology, especially the Satellite Communications (SatCom) combined with Information Technology, we have means to extend the benefits from the advanced medical sciences even to the remote and inaccessible areas. It is known that 75% of the qualified doctors practice in urban centers, whereas the vast majority of India's population lives in the rural areas.

The Indian Space Programme is driven by the developmental needs of the country and has endeavored to reach out to the grassroots. Today, the national space systems comprising of advanced communication and remote sensing satellites address a variety of national needs including communications and natural resources management.

Telemedicine facilitates the provision of medical aid from a distance. It is an effective solution for providing specialty healthcare in the form of improved access and reduced cost to the rural patients and the reduced professional isolation of the rural doctors. Telemedicine can enable ordinary doctors to perform extra-ordinary tasks.

Through its Telemedicine projects, ISRO has successfully linked hospitals and healthcare centers in remote rural areas with specialty hospitals in cities through INSAT satellites. Thus, connectivity between patients at remote end and the specialist doctors at urban centers has been effectively established.

With a large and skilled medical community receptive to new ideas, a modest beginning in Telemedicine was made by ISRO in the form of a Telemedicine Pilot Project in the year 2001, linking Apollo Hospital at Chennai with the Apollo Rural Hospital at Aragonda village in the Chittor district of Andhra Pradesh. Later in March 2002, the Karnataka Telemedicine project linked the Narayana Hrudayalaya, a super specialty hospital for cardiac care at Bangalore with the district hospital, Chamarajanagar and the Vivekananda Memorial Trust Hospital at Saragur in south interior Karnataka.The valuable experience gained during these Pilot Projects encouraged ISRO to further endeavour for enabling specialty healthcare delivery to the rural population. In India, the healthcare is a state subject, administered and managed by the state governments. There are also a few trust/NGO run hospitals apart from the large number of private hospitals/clinics. Thus, the thrust of ISRO has been to introduce SatCom based Telemedicine Technology in various parts of the country through Pilot Projects.

1.5 Telemedicine Technology:

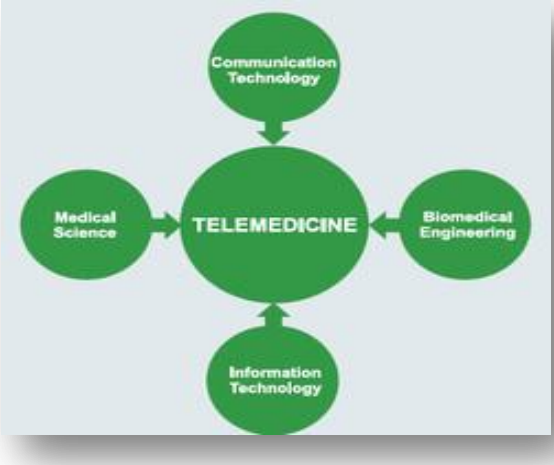

Fig 1.5 Ingredients constituting telemedicine

Telemedicine is a confluence of Communication Technology, Information Technology, Biomedical Engineering and Medical Science. The Telemedicine system consists of customised hardware and software at both the Patient and Specialist doctor ends with some of the Diagnostic Equipments like ECG, X-ray and pathology Microscope/Camera provided at the patient end. They are connected through a Very Small Aperture Terminal (VSAT) system and controlled by the Network Hub Station of ISRO. Through a Telemedicine system consisting of simple computer with communication systems, the medical images and other information pertaining to the patients can be sent to the specialist doctors, either in advance or on a real time

basis through the satellite link in the form of Digital Data Packets. These packets are received at the specialist centre, the images and other information is reconstructed so that the specialist doctor can study the data, perform diagnosis, interact with the patient and suggest the appropriate treatment during a Video Conference with the patient end. Telemedicine facility thus enables the specialist doctor and the patient separated by thousands of kilometers to see visually and talk to each other. This enables the specialist doctor to assess the physical and psychological state of the patient and suggest treatment. This remote tele-consultation and treatment is much more valuable in case of post operation (Post Surgery) follow up since the patient is not required to travel unnecessarily and hence saving money and time. In this way, the systematic application of Information and Communication Technologies to the practice of healthcare rapidly expands the outreach of the healthcare system.

1.6 Types of connectivity:

1.6.1 Point-to-Point System

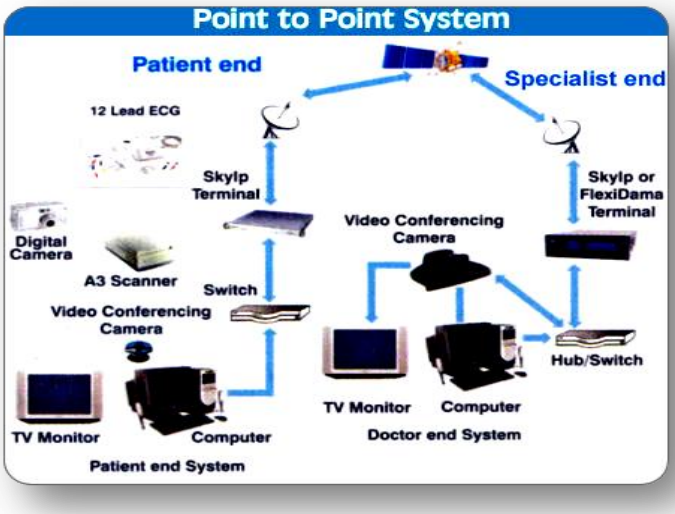

Fig 1.6.1 Point to point system

In networking, the point-to-point (PPP), is a data link protocol commonly used to establish a direct connection between two nodes over terrestrial and satellite link. Based on the need, utility, operation and maintenance and the acceptability considerations of this newer application; the initial pilot Telemedicine efforts had adopted the 'Point-to-Point' Telemedicine System- wherein, at a given time one rural end could have tele-interaction/Telemedicine consultation with one specialist end. For eg, SGPGIMS, Lucknow is connected to the medical colleges of Orissa through point to pint connectivity via satellite link and district hospital, Rae Bareli via fibre optic cable network.

1.6.2 Point to multipoint system

It is a term used in telecommunication to indicate multiple paths from a single location to multiple location. With the growing demands for Telemedicine facilities across the country; and several district/ rural hospitals desiring to have connectivity and also with more than one specialist hospital; further compounded by the willingness expressed by a number of specialist hospitals to provide

Telemedicine service to more rural hospitals; the importance of introducing the 'Multi-Point' connectivity at the speciality hospitals was realized. Accordingly, at one of the super speciality hospitals, multi-point speciality consultation nodes were set up across selected departments connected through Local Area Network (LAN) for distributed consultation.

1.7 Design goal:

The overall goal of the nation wide telemedicine network design is to provide affordable and low cost system that facilitates communication between physicians and healthcare professionals across the country. The system implements connectivity among rural clinics and urban area hospitals to be used mainly for tele-consultation, and maintaining patient information.

As the main design goals, the network should be cost effective, expandable, secure which provides state-of-theart ICT access scheme to rural area clinics. Existing ICT infrastructure will be given priority to minimize cost of implementing the network. In this design the following specific design goals were given priority.

1.7.1 Expandability

Expandability is a concern in the telemedicine network design for the following reasons: First, the number of hospitals built in the county is few in number. However there are more clinics being added to the health system of the country every year. There is also a chance to incorporate private hospitals in the nation wide telemedicine network as necessary, which will ultimately increases the number of sites to be connected in the future. Second, the area of telemedicine applications will not be limited to some specific diseases, but will be expected to increase in type and number in the future. Third, the network should also support advanced applications, which require real time connectivity such as video conferencing in the future.

1.7.2. Security

During consultation or patient referral, most of the data exchanged over the network is sensitive patient information. Confidentiality of patient information must always be respected. For a secure communication, protocols such as Secure Socket Layer (SSL) could be used. SSL permits users to conduct secure communication over web-based applications. This provides the ability to safely exchange patient information across the network. When doctors exchange patient information, they should adhere to medical protocol that defines the rules to be followed during this process. In addition to these the network and involved servers should be protected by firewall against external

invader. Firewalls could be software or hardware for the sole purpose of keeping digital pests such as viruses, worms, and hackers out of the network .

1.7.3. Cost

Implementing a nation-wide telemedicine network may seem to be more expensive than building clinics or equipping existing regional clinics with medical personnel and medical instruments. A cost benefit analysis, comparing various approaches has to be done, to come up with a lower cost solution to the problem of delivering proper healthcare to rural areas. However, network connectivity among the healthcare facilities, both in the urban and rural areas over an existing ICT infrastructure is considered as a cost-effective solution.

1.8 Design summary:

In these days of increased bandwidth and better connectivity, we have seen many types of technologies that offer the above. Most of these technologies connect the user to the main system by using different types of cables. They have their inherent disadvantages, but now 'Enter VSAT'. VSAT or (Very Small Aperture Terminals) are small, software-driven earth stations that are used for the reliable transmission of data or voice via satellite with maximum speeds reaching 2Mbps. VSAT equipment consists of two units: One is placed outdoors for a line-of-sight to the satellite and the second is placed indoors to interface with the user's communication device (e.g. data terminal equipment).

The outdoor unit consists of small antenna, mount and electronics for signal reception and transmission. The indoor unit is a small desktop box that contains the receiver and transmitter boards and an interface to the user's equipment. Many remote locations with end user terminals can be connected through VSATs to a centralized processing centre or the hub. Outbound information (from the hub to the VSATs) is sent up to the communication satellite's transponder, which beams the information down for reception to the remote VSATs. The VSATs at the remote location send information inbound (from the VSATs to the hub) via the same satellite transponder to the hub station. This arrangement where all network communication passes through the network's hub processor is called a 'STAR' configuration. The hub station serves as the centre of the star-configured network. The VSAT network in a STAR configuration works through the Time Division Multiple Access (TDMA) method. The important operations in the transmission occur on the ground. The hub controls the entire operation of the communication network. At the hub, there is a network management system server, which allows the network operator to monitor and control the communications network through the integration of sophisticated hardware and software

components. The VSAT Network could operate in a STAR arrangement with the satellite bandwidth being dedicated for each remote link analogous to a leased line and this arrangement is known as ‘Single Carrier Per Channel’ (SCPC) Configuration. This type of configuration is used in continuous streaming data applications. It is mainly used for voice transmission and used in a hub less environment for remote to remote communication.