



Telemedicine: Present, Future and Applications

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20.1 Introduction

In today's era tremendous advancements are happening in healthcare systems. Telemedicine is one of the approaches that are excellent applications of advanced technology. The World Health Organization (WHO) defines telemedicine as, "Delivery of healthcare services, where patients and providers are separated by distance. Information exchange for the purpose of diagnosis and treatment of diseases, research, evaluation and for the continuing education the is carried by ICT in telehealth practice which can contribute in achievement of health coverage in remote areas, vulnerable groups and ageing populations with quality, cost-effective, health services A study performing detailed assessment of various definitions of telemedicine showed that there are four main perspectives those categories all the available definitions of the term. The four bases that withhold all the core definitions of this term are Medical, Technological, Spatial and Benefits [1–3].

Telemedicine approach/programmes are classified into two categories:

1. Synchronous Programmes—It includes a live interactive session between the patient and healthcare provider, e.g. a virtual appointment via technological media with a camera.
2. Asynchronous Programmes—Exchange of information between the patient and healthcare provider in the form of images, videos, written and audio content, etc. via telecommunication and internet [1].

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20.2 Origin and History of Telemedicine

The term Telemedicine was devised in the year 1970. It is commonly misconceived that the development of the idea of telemedicine also took place in the 1970s despite the fact that the concept came into existence even long before the invention of telephone and radio [1]. The origin of the core idea of the concept of telemedicine dates centuries back when, ancient African villages blew smoke signals to make the neighbouring villages aware of the prevailing disease, i.e. the purpose of exchanging important information was fulfilled. Similarly, some European settlements used bonfires to make adjoining villages aware of the bubonic plague in the Middle Ages [4]. In the last five centuries, the field of telemedicine witnessed technological development resulting in the capacity of exchanging any amount of information.

The invention of Guttenberg's printing press in 1452 opened a way to distribute important information [5]. The parameter distance creates a necessity for telemedicine and its options.

The advancement in the field of transportation with the invention of locomotive in 1819 and the invention of stethoscope in 1825 are some noteworthy events in telemedicine which helped counter one of the most important barriers, i.e. distance.

The next important event in the advancement of telemedicine is the invention of telegraph in the year 1844, which led to the invention of electrocardiography by Wilhelm Einthoven. Einthoven also invented the telecardiogram. The invention of the telephone in 1875 led to leaps in the field of telemedicine. The earliest records of the usage of telephone in the exchange of medical information dates back to the early 1900s—the Netherlands used telephone to transmit heart rhythms [1]. Similarly, telephone was used to transmit to radio consultation centres all over Europe. Wilhelm Einthoven himself transmitted electrocardiogram tracings via a telephone network in 1906 [2]. Furthermore, several significant inventions that complimented the execution of telemedicine were seen in the field of transportation, like the invention of automobile and airplane [5]. Following down the timeline, the invention of satellites created even more convenience in the telemedicine field. The beginning of utilization of television for transmission of information was seen in the 1950s in the Nebraska Project (Omaha). The project involved 2 close-circuit TVs set up in 2 hospitals for conduction of interviews involving patient monitoring and consultations with the patients from psychiatric ward [2]. The records show wide utilization of satellites in the field for various purposes—The National Library of Medicine invested in the research of the reliability of telemedicine via satellite communication [4].

The establishment of a microwave video link between MGH and Logan airport in Boston for radiology, dermatology and cardiology related consultations for airport employees and passengers [6]. NASA (National Aeronautics and Space Administration) has made important contributions to the arena of telemedicine with a chain of projects conducted in the decade of 1960. The projects were conducted for the benefit of astronauts. They were successful in providing medical assistance by using telemetric data transmitted from the spacesuits. This enabled them to monitor various vitals like heart rate, blood pressure, and ECG [6]. Furthermore, NASA

also designed telemedicine instrumentation packs containing various equipment like endoscope, macro-imaging lens, electrocardiograph, ophthalmoscope, blood pressure sensor, electronic stethoscope, pulse oximeter, etc. for the purpose of monitoring physiological actions of the spaceship boarders [6].

NASA also brought the Space Technology Applied to Rural Papago Advanced Health Care (STARPAHC) project on the Papago Indian Reservation in Arizona, USA, into action in 1972. The project involved a two-way microwave transmission to the Public Health Service Hospital and a van equipped with medical instruments and 2 paramedics.

It also established the 'Spacebridge' project after the earthquake disaster in Armenia which allowed telemedicine consultation between medical centres in the USA and Armenia [4].

In the late 1960s and 1980s, the introduction of the internet and the World Wide Web helped the practice of telemedicine. MIT Media Laboratory successfully developed prototypes of the low-cost portable telemedicine kit targeting patients in developing countries as part of the Little Intelligent Communities (LINCOS) project. The purpose of the LINCOS project was to deploy not only the telemedicine systems, but also high-speed internet, telecommunications and distant education to rural areas of developing countries where people suffer from a shortage of doctors or medical specialists, in 2000 [6].

However, now in the technologically advanced times and the reduced cost of computing there is a surge in fibre optic cable, virtual reality, immersive environments, haptic feedback and nano-technology, and these are proving to be the new promising advances of the present.

20.3 Advancements and Applications of Telemedicine

In earlier times, telemedicine was thought to be a secondary method which could only be used in emergencies and was considered inferior as the practitioner could not interact with the patient by being physically present [7]. Nevertheless, as time went by and advanced technologies were developed, the general opinion regarding telemedicine changed, and is still changing [7].

The beginning of advancements in telemedicines can be traced back to 1906 when a telecardiogram was created. It transmitted electrocardiograms through telephone lines [2]. In the 1950s, closed circuit TV was installed in two hospitals which were 150 kms away. Through this, the doctors interacted with psychiatric patients and interviews were held [2]. In 1968, a microwave video link was created which helped in consultations of cardiology, radiology and dermatology [6]. In the 1960s to 1970s, NASA conducted various telemedicine experiments as the well-being of astronauts in space was essential for the success of space missions. Telemetric transmission of data was used to monitor heart rate, blood pressure, and ECG from their space suits. However due to limited development in technology at that time and high cost of digital data transmission, the advancements were slowed down, which rapidly picked up pace in the 1990s as a result of fast developing information and telecommunication technologies [2].

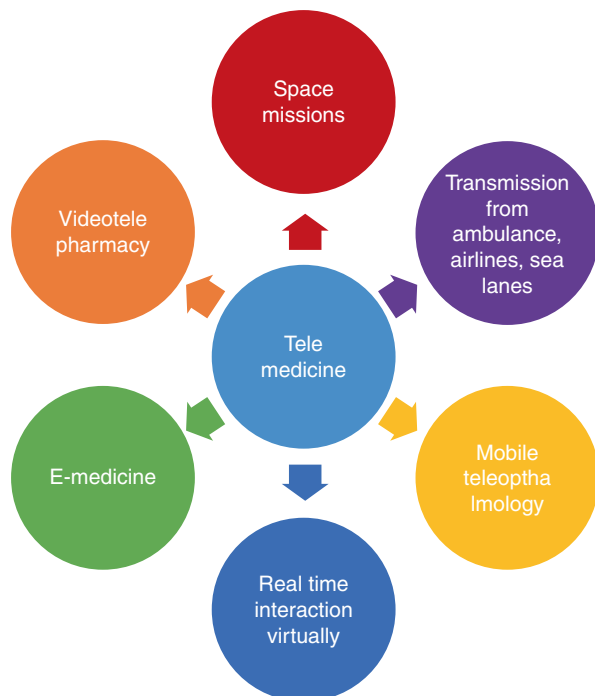
Today, the development of wireless local area networks, wireless personal area networks and 4G network has made it easier to access highly advanced telemedicine data transmission and medical databases [6]. The further increase in computer power and development of optic fibre cable and strong satellite communication has now increased safety, speed, and efficacy of telemedicine [5]. In India, the Department of Information Technology, Indian Space Research Organization, Ministry of Communications and Information Technology along with state governments and many other medical and technical institutes of the country have taken an initiative to launch various telemedicine joints throughout the country [8]. India's Ministry of External Affairs is also helping other countries to enable telemedicine healthcare under South Asian Association for Regional Cooperation (SAARC). Director General of Health Services has taken an initiative to develop electronic information resources throughout the country for medical field known as National Medical Library's Electronic Resources in Medicine Consortium [8].

There are four main categories in telemedicine application range:

- Telemedicine among medical facilities with practitioners.
- Telemedicine among one medical facility and one household.
- Telemedicine among medical facilities without doctors.
- Telemedicine among co-medicals and households [7].

Some of the general applications of telemedicine are shown in Fig. 20.1. Due to telemedicine, transmission of data is possible from within ambulances to hospitals

Fig. 20.1 General applications of telemedicine



which saves time and makes it easier to provide first aid, which in turn can save many lives. In the future we might see the same system in airlines and sea lanes [7]. Various institutes and eye hospitals in India, with ISRO's support under national blindness control programme, have established a mobile tele-ophthalmology service to help with early diagnosis and treatment of eye diseases. Many have established mobile tele-hospitals, mobile clinics as well as virtual channels that provide medical assistance instantly with an option of real-time interaction with doctors.

Overview of applications of telemedicine is shown in Fig. 20.1. The government has also launched an e-medicine system to reach all remote areas [8]. Telemedicine allows people from all types of geographic areas to reach healthcare whenever needed [8]. This allows healthcare delivery and makes up for the lack of infrastructure in areas owing to geographical infirmities [2]. Most of the time patients from these areas face long delays as they have to travel vast distances which can sometimes prove fatal. Another issue faced by them can be the unavailability of the same doctor who treated them last time. This can lead to differences in treatment method and understanding as well as difficulty in maintaining proper follow-up. This is where telemedicine plays an important role [8]. Telemedicine enables distribution of healthcare staff and resources throughout the system. It also increases availability of doctors due to reduced unnecessary hospital admission and emergency room visits [1]. Tele-dermatology is also a convenient and upcoming application of mobile telemedicine [1]. Home monitor teaching is also an imminent method for e-learning. Continuing education is important in the medical field to keep up with the rapid advancements in research and development. E-learning allows everyone to gain knowledge without restrictions of time and place, as has been true for all the students who are attending online classes in today's situation [2]. Telemedicine improves the quality of life in the long run as it provides instant and reliable healthcare which can turn out to be a lifesaver in situations where time is of essence and also reduce damage which could have been caused due to delay [9]. It was observed that in telemedicine, computer systems had a positive effect on the patient-healthcare provider relationship as patients were able to be more honest and were comfortable with the professional without feeling intimidated with physical presence. Depending on computer systems and electronic equipment for correctness of results and vital signs was also found to be reassuring for the patients [10]. With telemedicine technology, sky labs and space shuttles are well connected in real time and doctors are able to monitor astronaut's health, well-being, and extend support in various remote and extreme environments [5]. Developments like wearable ECG sensors and motion analysis systems make telemedicine easier [6]. Video telepharmacy is also an application of telemedicine through which pharmacists can dispense medicines as well as counsel patients without being physically present. This is helpful in cost reduction and is more efficient and patient specific [11, 12].

In this anxious situation of COVID-19 where the main problem is limited access to healthcare services, telemedicine can prove to be a breakthrough. These problems of uneven distribution of healthcare, lack of vigilance, and rise in costs are not going to end even after the pandemic. We need to make more use of telemedicine beyond

the role as an emergency connectivity tool [13]. Telemedicine is also very cost-effective and will help the country's economy in the situation we are facing today [14].

For the promotion and enhancement of the applications and utilization of telemedicine certain approaches like introducing incentive facilities to physicians, cost of telemedicine can be given health insurance coverage, etc. Flat rate charging systems can also be introduced to reduce the communication cost. The promotion for advancement in R&D technology, research promotion, lowering the cost of medical facilities and equipment could be an essential task for tele home care approaches. In some cases the malpractice issues are possible so that the laws from the concerned authorities can be introduced and implemented to control and resolve such issues. The patient's medical records are now shifting from paper based to computerized platforms with the guidelines and initiative by the health ministry which would facilitate telemedicine more significantly. The improvement in the internet facility in terms of security features also needs to be addressed with applications like Medical ID card system, Digital signature, certification authority, virtual private network, etc. to secure privacy as well as efficient applications of telemedicine [7].

Some of the future scopes of telemedicine are shown in Fig. 20.2.

The Indian government has already started taking initiative in national level projects on telemedicine and its planning and implementation is also modernized by the healthcare system by utilization of mobile and telecentres throughout the country specifically in areas where poor healthcare access is identified. ISRO initially started

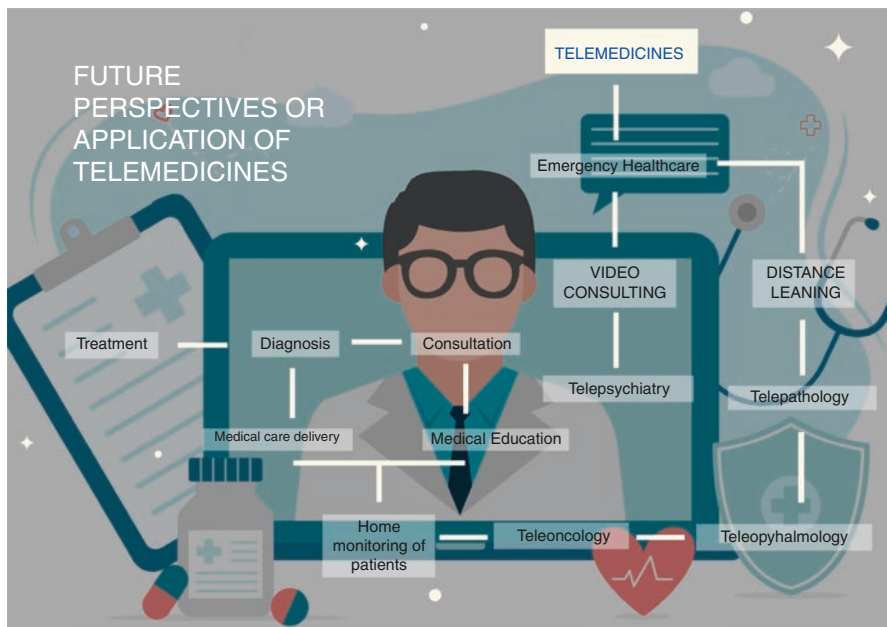


Fig. 20.2 Future scope of telemedicine

a telemedicine programme in 2001 and connected remote areas throughout India. Currently there are around 384 hospitals with 60 specialty hospitals connected under this programme in wide areas like general medicine, cardiology, ophthalmology, etc. ISRO has also provided communication software and hardware systems, equipment with satellite bandwidth, etc. The funds were allotted to hospitals for facility and manpower support. The various MoU's are signed with NGO's for effective implementation of the same. Recently around 139 telemedicine nodes are operational on INSAT-3A satellite and some on INSAT-3C and INSAT-4A. Efforts are continued by ISRO for maintenance. The testing and troubleshooting is now operated by monitoring mode established in DECU Ahmedabad [15].

The Ministry of health and family welfare has also taken up the initiatives for implementation of ONCONET project inspired from the success of Kerala ONCONET project model. Several regional and peripheral network centres planned to facilitate the National Cancer Control Program. Some initiatives also came up with the National Rural Health Mission.

This model gave several advantages in oncology practice with reducing the number of emergency visits at hospitals, unnecessary admissions, early diagnosis, routine follow-up, etc. Not only doctors but all healthcare professionals are involved in the service of ONCONET programme [16]. The department of information technology has also launched various projects in telemedicine in the development of a Web-Based Telemedicine System for Chronic Diseases, E Health Visualization and E-Health Associated Field, Advanced ICT for Health Care, etc. with various government organizations. It has also collaborated at international level with the European Union (EU) in various fields including e-governance and e-health. A MoU was also signed with Afghanistan to set up a telemedicine facility [17].

Globally in US occurrence of chronic diseases is at a faster rate which reflects 75% of the total healthcare expenditure and 70% of all deaths [18]. Recent data reveals telemedicine has captured the market in chronic disease management. It reduces certain obstacles like frequent visiting, number of admissions and emergency room load. The concept of hospital at home model is also becoming popular for patients who meet the specific criteria and can be stably treated at home for diseases like pneumonia, chronic obstructive pulmonary disease, etc. This model is found cost-effective, less treatment duration, etc. [19–21]. Success of telemedicine is also found in the conditions like radiology, intensive care, stroke and psychiatry, etc. in terms of mortality rate compared to conventional models [22, 23].

Several issues are also reported with this shift from conventional orientation to virtual platform with several factors like age, sex, etc. The younger generation is more open to this telemedicine platform and development than older generations since they are not familiar and comfortable with these technology platforms.

Telemedicine procedure is not a self-contained area; in this the open discussion as well critical evaluation and testing are essential procedures and it will be worthless if there is no proper involvement and acceptance by both patients and physicians [24, 25].

Video telemedicine is one of the technological advancements reported to have a more efficient and beneficial way of diagnosis and treatment [26]. Service provision

with cost reduction is also one benefit out of this. Other benefits of this technology are also reported like increased productivity and market share with novel development in practice of medicine that further create a competitive healthcare environment. Instead physical visit video telemedicine provides advantages in terms of patient counts nurse practitioners can assist physicians [27]. Telemedicine service now became business demand [28]. The concept of virtual health has existed for a longer period but there are not yet systematic approaches and communication methodology. This concept of telemedicine could help establish the interconnection and systematic approach in virtual healthcare. This can also help in maintaining the proper healthcare records electronically specific for patients and medical history details, etc. FluNet database is an example for the same which is a global monitoring database for influenza. Telepharmacy is also an emerging concept which is having equivalent benefits as telemedicine. Use of smart card technology is a platform which can interconnect the telemedicine and telepharmacy that also collaborate physicians and pharmacists to achieve the motive of the virtual platform. In telepharmacy, video telemedicine is found to be a beneficial remote area for patient counselling [29].

20.4 Future of Telemedicine

Telemedicine allows people from all types of geographic areas to reach healthcare whenever needed. This allows healthcare delivery and makes up for the lack of infrastructure in areas owing to geographical infirmities [1, 2]. Most of the time patients from these areas face long delays as they have to travel vast distances which can sometimes prove fatal. Another issue faced by them can be the unavailability of the same doctor who treated them last time. This can lead to differences in treatment method and understanding as well as difficulty in maintaining proper follow-up. In future these types of problems can be solved by telemedicine [8]. In this anxious situation of COVID-19 where the main problem is limited access to healthcare services, telemedicine can prove to be a breakthrough. As the pandemic extends for the unforeseeable future, the role of telemedicine will remain a vital component for continued healthcare delivery [30].

Video telepharmacy is an application of telemedicine through which pharmacists can dispense medicines as well as counsel patients without being physically present. This is helpful in cost reduction and is more efficient and patient specific. In today's condition of social distancing and sanitization, this can prove to be very helpful [11]. These problems of uneven distribution of healthcare, lack of vigilance, and rise in costs are not going to end even after the pandemic. We need to make more use of telemedicine beyond the role as an emergency connectivity tool in the future as telemedicine holds great potential to solve all our future problems [13]. Telemedicine will enable distribution of healthcare staff and resources throughout the system. It will also increase availability of doctors due to reduced unnecessary hospital admission and emergency room visits. Home monitor teaching can also be an imminent method for e-learning. Continuing education is important in the

medical field to keep up with the rapid advancements in research and development. E-learning allows everyone to gain knowledge without restrictions of time and place, as has been true for all the students who are attending online classes in today's situation. Various institutes and eye hospitals in India have established a mobile tele-ophthalmology service to help with early diagnosis and treatment of eye diseases. Many have established mobile tele-hospitals, mobile clinics as well as virtual channels that provide medical assistance instantly with an option of real-time interaction with doctors. Tele-dermatology is also a convenient and upcoming application of mobile telemedicine [1, 2]. We need to popularize and normalize the use of telemedicine more and more in the future and spread awareness about it so that people come to trust this method and understand the benefits of telemedicine. The government has also launched an e-medicine system all over the country. We need to maximize the usage of telemedicine in the future for the benefit of all citizens as everyone has the right to have availability of necessary healthcare services to improve the quality of life [12].

Telemedicine platform will be able to bring great revolution in the field of medicine and pharmacy with the utilization of technological advancements. It will facilitate to reach towards each individual in terms of healthcare in the large population and hetero geography of India. At all fronts India is taking initiatives in establishing and advancement in the telemedicine facilities with high-speed satellite, communication models, etc. There is still scope for upgrading the national policies, framework, laws, ethical framework, etc. to smooth implementation in healthcare services.

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