Azadi Ka Amrit Mahotsav

G20 भारत 2023 INDIA

CURRENT TRENDS IN TELEMEDICINE IN INDIA

TECHNOLOGY INFORMATION, FORECASTING AND ASSESSMENT COUNCIL (TIFAC)

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About TIFAC

Technology Information, Forecasting and Assessment Council (TIFAC), an autonomous organization under the Department of Science and Technology (DST) , Government of India was established in 1988. TIFAC is a think tank with a government setup that looks up to technologies on the horizon, assesses the technology trajectories and supports technology innovation in select areas of national importance.

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Citation:
TIFAC (2022) Current Trends in Telemedicine in India . Technology Information, Forecasting and Assessment Council, New Delhi, India.

Contents

FOREWORD

Innovations and adoption of new and advanced technologies are the major growth drivers of almost all sectors in the world today. And Healthcare sector is no different, which is evolving at a rapid pace.

The COVID 19 pandemic has actually forced several countries world over to develop and use various technological applications/ platforms so as to empower healthcare practitioners as well as to maximize the doctor–patient consultations while maintaining social distancing.

In India, Healthcare sector is facing plethora of challenges ranging from shortage of healthcare professionals, asymmetrical patient-to-doctor ratio , lack of medical facilities, basic infrastructure, expensive health care services etc. These challenges were even more acute during the COVID 19 pandemic time. Therefore posing a serious challenge in delivering the health care services efficiently and uniformly throughout the country. This has underlined the need for technological interventions toward establishing a sustainable, connected, low-cost, efficient and secure model for inclusive healthcare delivery.

In this context, TIFAC's white Paper on 'Focused Interventions for 'Make in India': Post COVID19 , released on July 10, 2020 by Dr Harsh Vardhan, the then Hon'ble Minister for Science & Technology, Minister for Health and Family Welfare and Minister for Earth Science has strongly recommended 'Telemedicine' as an application of healthcare system towards making the reach of health care services all-inclusive to the Indian population.

Keeping this in view, TIFAC has taken up two activities : Study on “Current Trends in Telemedicine in India” and also conceptualized a scalable pilot demonstration telemedicine project focusing on the demonstration of the efficacy of cutting-edge technologies targeting an underprivileged population especially women and children living in remote areas of three districts (Varanasi and Gorakhpur in UP and Kamjong in Manipur) with quality medical care reaching out to a target population of ~60,000 in these three districts for collection of health data and also generate (Electronic Health Record) EHR.

Advanced Telemedicine system (using new and emerging technologies like IoT (Internet of Things), Cloud, Artificial Intelligence has the potential to bridge the gap by making the reach of healthcare services to unreachable in a cost effective and efficient manner to a large extend.

The Study report on Current trends in Telemedicine in India took stock of current Telemedicine Practices, Government programs policies, Regulations, current technological trends as well as the challenges and issues in large scale implementation of Telemedicine in India.

I hope , this report would be useful to stakeholders- Academia, R&D Institutions, Industry, and Government in prioritizing and in preparing their future action plan.

Prof. Pradeep Srivastava

Executive Director, TIFAC

PREFACE

Telemedicine in India is not a new concept, but the importance and necessity of using telemedicine services in India became evident like never before during COVID-19 pandemic. It has shown its advantages and limitations too.

In the recent past to support Telemedicine practices in India, the Indian government has put forth several initiatives and policies towards improving the delivery of healthcare services remotely and efficiently, to benefit both the patients and physicians - Telemedicne Practice Guidelines 2020, National digital Health Mission 2020 , National Digital Health Blueprint and protocols for EHR generation to name a few. Such initiatives are directed towards creating a national digital health ecosystem that ensures the security, confidentiality and privacy of health-related personal information.

However, in spite of several initiatives being undertaken by both public and private sectors, India is yet to see seamless countrywide deployment of Telemedicine services.

Telemedicine in India is matured to a certain level w.r.t. the integration and adoption of technologies and policies. However, Telemedicine platforms in the country are working in isolation at present and an integrated, interoperable and secure system is the need of the hour.

This report has outlined the major initiatives of the Government and the private players and analysed the challenges and issues towards seamless deployment and implementation of Telemedicine. Hopefully it will succeed in sensitizing the stakeholders and catalysing a much-needed concentrated effort.

I congratulate TIFAC for bringing out this report at the right time.

Prof. S. K. Mishra, MS, Dip NB, FAMS, FACS
Chairman Study Steering Committee
& Distinguished Visiting Professor,
Gangwal School of Medical Science and Technology,
Indian Institute of Technology, Kanpur (U.P.)

ACKNOWLEDGEMENT

As a technology think-tank under the aegis of the Department of Science and Technology (DST), Govt. of India, TIFAC is mandated to look ahead in technology trajectories and assess, identify the technology trajectories, prepare technology vision and roadmap documents and support technology innovation in the select areas of national importance.

TIFAC has brought out two major vision documents viz : **Technology Vision 2020** and the Technology Vision 2035 (**TV 2035)** . The TV 2035 document was released by Hon'ble Prime Minister Sh. Narendra Modi Ji in the year 2016.

Recently TIFAC has prepared two documents viz: white paper titled **"Focused Interventions for Make in India Post Covid-19"** and **" Action Agenda for Atma Nirbhar Bharat(AAAN) "** both of which were released by the then Minister of Science and Technology and Earth Sciences Dr. Harsh Vardan Ji on 10th July 2020 and 29th December, 2020 respectively. Both the white paper and AAAN document recommended creation of an enabling ecosystem for an "AtmaNirbhar" Bharat. The documents strongly recommend 'Telemedicine' as an application of healthcare system towards making the reach of health care services all-inclusive to the Indian population.

As a follow up to the recommendation, TIFAC initiated two activities in the area of Telemedicine : 1. Conceptualized a scalable pilot demonstration Telemedicine project and 2. preparation of Study report on " Current Trends in Telemedicine in India " . The present report is an outcome of the above recommendation.

This study aims to analyse the current Global and Indian status in Telemedicine technologies as well as emerging and future technology trends, best practices, challenges and issues, policy issues etc. the country is facing in implementing Telemedicine. It recommends strategies for development and deployment of advanced telemedicine technologies in India.

The data and the information were collected using primary and secondary survey, literature review and inputs received from members of the study Steering Committee were also consolidated. To analyse the current technological trends as well as business trends in Telemedicine in India a Survey of Start-ups working in the area of Telemedicine services was also conducted and the analysis of the survey is a part of this report.

I would like to express my gratitude to Prof. Pradeep Srivastava, Executive Director TIFAC, who inspired me to take up this topic and helped me to define the objective of the study.

The study report was prepared under the close guidance of the Study Steering Committee members Prof. S. K. Mishra, Distinguished Visiting Professor, Gangwal School of Medical Science and Technology, Indian Institute of Technology, Kanpur, in chair , Prof. Jayanta Mukhopadhyay Dept. of Computer Science & Engineering, IIT Kharagpur, Dr. Sanjay P. Sood, Project Director – eSanjeevani C-DAC Mohali , Prof. Biju Soman , Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum A very heartfelt thanks to all the committee members for their guidance and contributions in the report.

TIFAC also constituted an internal Project Review Committee to guide and review the progress of the such study reports carried by its scientists. I would like to thank all the members of the Project Review Committee: Dr. Gautam Goswami, Scientist G in Chair, Shri. Arghya Sardar, Scientist F, Ms. A. Jancy Scientist F, Ms. Sangeet Nagar, Scientist F, Mr. Brajeshwar Chandelia, Scientist C for their support and guidance in completing this report.

I am extremely grateful to TIFAC's team on Telemedicine demonstration project lead by Shri. Sanjay Singh Ex- Advisor and Senior Consultant TIFAC, Ms. Nirmala Kaushik, Scientist F, TIFAC for their support.

I trust the analysis of current trends, initiatives, policies and services by government and private players along with the challenges and issues mentioned in this report would be very useful in further refining and implementing the policies towards the implementation of integrated interoperable Telemedicine system in India.

Mukti Prasad
Scientist C
TIFAC

EXECUTIVE SUMMARY

India is a large country with a population of more than 1.35 billion. About 70 % of healthcare infrastructure is in cities, which cater to about 30% of the country's population. India spends only 3.9 % of its GDP (2017-18) on healthcare, which is less than the world average expenditure of 6%. India has shortage of doctors (1: 1457), and hence the healthcare facilities are not accessible uniformly to all. Doctor to patient ratio in India is approximately 1:1500 which is lower than WHO (1:1000) recommendation. The doctor to patient ratio is more skewed in rural areas (1:2500), and about 89 million population in India is below the poverty line, which poses a serious challenge in delivering the health care services efficiently and uniformly throughout the country.

Rising health care cost in India is also a major concern as ~ 60% of the health care expenses in India are out of pocket expenditure, which is highest among the other BRICS nations. India therefore needs a sustainable, connected, low-cost, efficient and secure model for inclusive healthcare delivery.

With this in view, adoption of new and emerging Information and Communication Technologies (ICT) would help in bridging the gap by making the reach of healthcare services to unreachable in a cost effective and efficient manner and also empower the doctors and researchers in this area to innovate new drugs/ vaccines, cells etc.

In recent decades, the world has witnessed an unprecedented increase in the use of information and communication technologies, thanks to the dwindling costs of the hardware and the availability of many free and open-source software solutions. As in other technological innovations, the medical industry adopted the new potential to improve efficiency and extend its reach to more areas.

The COVID-19, pandemic has stressed the importance and necessity of using telemedicine services and also showed its advantages and limitations to the physicians and patients in medicine and surgery. There are various technological and implementation challenges that we need to overcome to make telemedicine widely applied in our society. The digital communication infrastructure is the need of the hour. There is a great divide between rural and urban areas. Telemedicine could be instrumental in removing this gap greatly in health care sector.

This study is an attempt to cover current Telemedicine practices in India, Government programs policies, regulations, and also evaluated the technology platforms, the socio-economic benefit, available infrastructure current technological trends as well as the challenges and issues in large scale implementation of Telemedicine in India.

A review of the status of Telemedicine in India and globally was conducted covering both public and private players. This also includes Current trends and practices of Telemedicine globally.

Several telemedicine services in India are launched by the government as well as by private agencies few are very recent ones like eSanjeevni, Services eHealth Assistance and Teleconsultation-SeHATOPD, Swasth–app :(Launched in June, 2020) AYUSH Sanjivani' App (Launched in May 2020) Tele-Mental Health : ABHA (Ayushman Bharat Health Account), South Asian Association for Regional Cooperation (SAARC) and Pan-African e-network Project: Global Telemedicine Projects Initiated by India to name a few.

Several start ups started working in the area of Telemedicine like : Tata 1mg, NetMed, Pharmeasy-Medlife ,CureFit, DocOnline, Netmeds, Lybrate to name few and they are working in various applications of telemedicine which are covered in the report as well like Tele- Consultation Tele- Diagnostics, E- Pharmacy, Tele- Monitoring, Tele- Homecare, Tele-ICU, Tele-Rehabilitation, Robotics assisted, Tele- Physiotherapy etc.

To analyse the current technological trends in Telemedicine in India ,a Survey of Start ups working in the area of Telemedicine was also conducted. Details of startups on various parameters were collected for example Business Verticals, Impact of COVID-19, Turnover Technologies used, Remote Data Management, Challenges Faced, Future plans, Business started in the year etc. With respect to technological adoption and usage trends, it was found that most of the companies are using the technologies like Artificial Intelligence/machine learning just for commercial purpose i.e. to understand customer preferences, connecting them with relevant doctors, forecast demand & procurement requirements and accordingly suggest the product of their choice. However, advanced technologies like Blockchain, Robotics, Computer vision are the technologies that were used by the companies who have started their business in the last 3-4years.

Advanced emerging IT tools like Artificial Intelligence, Machine Learning, Big Data analytics, Blockchain, cloud etc. will enable doctors to make faster and more accurate decision about patient's health and also ensure secure data transfers and data storage. These advanced emerging technologies will play a crucial role in the advancement of Telemedicine system in the country. India being recognized as IT superpower in the world, should utilize its strength to become globally competitive in Telemedicine.

Major drivers of demand of Telemedicine in India identified in the report are: COVID 19, societal demand, higher mobile and Internet penetration, supportive government policies advanced and emerging technologies, role of private players , accessibility, affordability and convenience.

Regarding the policy and regulatory issues, the National Digital Health Blueprint (NDHB) of the Government of India defined minimum set of standards to be adopted for ensuring interoperability and the also the standards required in the major areas of healthcare, e.g.:

diagnostic content, terminology and codes for statistics and laboratory tests these includes: FHIR, DICOM, SNOMED, CT ICD-10, LOINC, Standard for EHR, TLS / SSL, SHA-256, AES-256 etc. and are covered in the report in detail. The report also talks about the medical device standards followed and adopted in the country and also touches upon the challenges in adopting and implementing the Telemedicine standards in the country.

Major challenges for Telemedicine in India include lack of availability of **Infrastructure**, Broadband connectivity 24X7electricity and need to standardized electronic medical records (EMR) to enable Interfaces to be interoperable to each other for seamless connectivity. Policy needs to be framed for securing personal information w.r.t. confidentiality, authentication, authorization of data etc. which is imperative to gain confidence of users w.r.t sharing of their data and large-scale acceptance of Telemedicine. Building and setting up Indigenous cloud is important so that the data can be stored in a cost effective and safe manner. The cost of hardware/ software should be such that it can be accessible to every citizen of the country. With the emergence of new and advanced IT tools, skilling of manpower plays a very instrumental role in the advancement and adoption of Telemedicine in India.

The following are the major recommendations of the report:

- **Connected Healthcare System**: Need for seamless integration amongst various available platforms and various services w.r.t. healthcare.
- **Interoperable Standardized Secure Data:** Need for **adoption of standards** like FHIR, DICOM, SNOMED CT etc.
- The **security and privacy** of data need to be compliant with the national and international legal framework.
- Facilitation of **deployment of 5G** and Satellite-based network (LEO) will enable seamless accessibility
- **5G :** Scope for new venture and Telemedicine applications like Telesurgery, Tele ICU will be practiced efficiently.
- **Affordable and efficient** : Need for the **private players and Government to join hands** (PPP).
- **Platform integration:** Hospital to Hospital to Diagnostics to Pharmacy is needed.
- **Integration with homecare:** Telemedicine services from a hospital should have seamless integration with homecare services.

- **Advanced Technologies** (Health 4.0) : Need to **leverage more applications** of : AI Analytics , IOMT, Cloud , Blockchain , Robotics, Computer vision etc. in healthcare in India.

- **Ensuring equity**: Ensure inclusive implementation of telemedicine services so that the most deprived sections of the community are not left behind.

- **Use of open source library** : OSL will lead to reduce the cost of deployment of the software for the Telemedicine system.

- **Medical insurance :** Need for the endorsement of Telemedicine with the medical insurance system.

- **Tele Health standards** to conform with the world standards.

CURRENT TRENDS IN TELEMEDICINE IN INDIA

1. INTRODUCTION

World over COVID-19 has brought a paradigm shift in social behaviour. The way we live, and work has been intensely impacted by the COVID-19 pandemic and has accelerated the need to shift towards the use of IT based solutions for fulfilling most of our needs.

Looking at post COVID 19 in health care sector, the sector will see an increase in demand of IT based platform for -online consultation, remote diagnostics, health monitoring etc. Advanced and emerging information and communication technology (ICT) tools like Artificial Intelligence (AI), Machine Learning (ML) , Data analytics, Robotics etc. have proven as the key tools in tackling such pandemic situation and will also be the mainstream solution for almost all areas of healthcare sector in future.

Applications of ICT in the health care sector will not only enable efficient diagnosis and delivery but also empower the doctors and researchers in this area to innovate new drugs/ vaccines, cells etc.

1.1 History of Telemedicine In India

While the explosion of interest in telemedicine over the past four or five years makes it appear as a relatively new use of telecommunications technology, the truth is that telemedicine has been in use in some form or the other for over thirty years.

Telemedicine project was initially initiated by the technical institutes like ISRO, MeitYand CDAC. ISRO initiated telemedicine in India (2001), and connected a rural hospital in Aragonda to Apollo hospital in Chennai.

In the year 1999, MeitY launched a major research & development project to develop indigenous Telemedicine Technology & System for which C-DAC, Pune & Mohali were identified as a technological agency and three major medical institutes were identified for deployment and evaluation – AIIMS, New Delhi, PGIMER, Chandigarh and SGPGI, Lucknow. In the year 2002 two telemedicine software and systems namely Mercury and Sanjeevni developed by C-DAC, Pune and C-DAC, Mohali respectively and were launched by MeitY.
Towards capacity building, Government of Uttar Pradesh set up a School of Telemedicine & Biomedical Informatics in the campus of SGPGIMS, Lucknow in the year 2003 which started functioning in the year 2006.

In 2005, using TelemediK-2005, the telemedicine system developed at IIT, Kharagpur, a telemedicine network comprising of two referral hospitals and six nodal hospitals were set up in Tripura [37]. The network was expanded in subsequent years to include more than 30 hospitals [38]. [39], the system was upgraded to a web based system, named iMediK [40], developed at IIT, Kharagpur.

Further , Ministry of Health & Family Welfare, Govt. of India constituted a national task force for Telemedicine in the year 2006 and later in 2009 launched two major national schemes – National Medical College Network and National Rural Telemedicine Network linking Sub-

centers and PHCs to specialist medical centers and medical colleges so-called AB-HWC Project. Subsequently in 2009 SGPGI, Lucknow was chosen by MOH&FW to spearhead the National Telemedicine Network by linking 50 medical colleges for collaborative knowledge sharing and serve community through tele-consultation services.

A few other initiatives on providing telemedicine services for specialized areas of health care by joint partnership of IIT, Kharagpur and Webel, Kolkata under the sponsorship of MeitY (then MCIT) are also worth mentioning.

The first one is in the area of paediatric HIV, where the web based telemedicine system, iMediK, was used for providing remote consultation to patients in North Bengal (Raigunj and Cooch Behar) from the Calcutta Medical College, Kolkata [41]. The other system was developed for managing patients of Neonatal Intensive Care Unit (NICU), in the Department of Neonatology, Institute of Post Graduate Medical Education and Research (IPGMER), Kolkata [42].

The system was operational from September 2009 to February, 2013, and about 1754 newborns were enrolled [43]. The system was connected to three more distant hospitals, namely M.R. Bangur Hospital in Kolkata, Government District Hospital of Hoshangabad, and Veer Surendra Sai Medical College in Burla.

e- Sanjeevni was one of the initial Telemedicine Software development project in India and has been acknowledged now as the national software for pan-India telemedicine deployment. Later in the year 2020, e-Sanjeevni telemedicine software system got the 'Digital India' award for best health IT innovation during Corona pandemic.

There are several initiative being taken up in the area of Telemedicine. The policies of government and various supportive schemes launched by the government in the recent past is creating and will create an enabling platform for further growth of Telemedicine in India . Telemedicine Practice Guidelines by MOH&FW along with NITI Aayog and National Digital Health Mission launched by Hon'ble Prime Minister of India during Independence Day 2020. Some of the major government initiatives, policies, and schemes launched are mentioned at section 2.1.

1.2 Healthcare Scenario In India

India is a large country with a population of more than 1.35 billion. About 70 % of its population live in rural areas which are lacking necessary physical infrastructure. At the same time, about 70% of the healthcare infrastructure and manpower is concentrated in urban areas

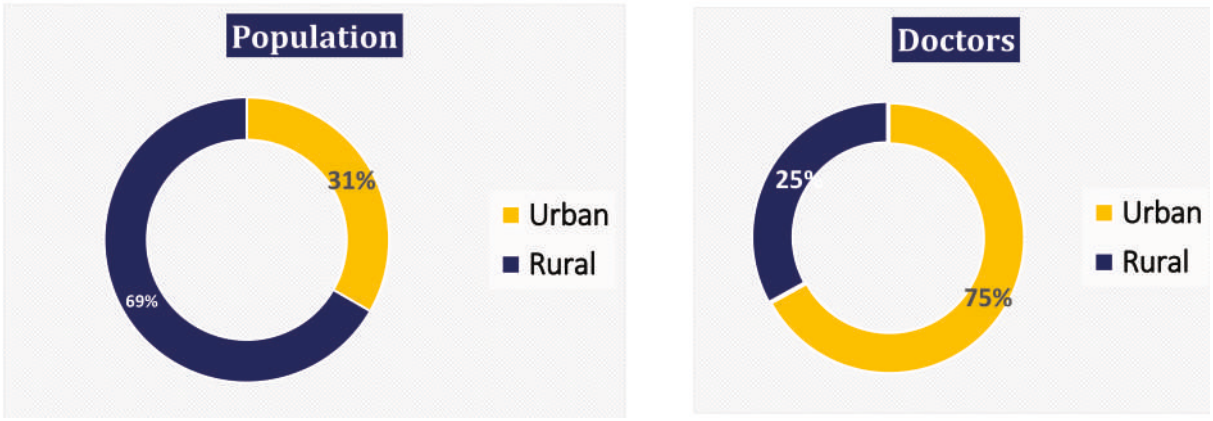


Figure 1: Doctor to Patient Ratio in Rural and Urban Areas

where only 30% percent of the population resides (Figure 1) . Doctor to patient ratio in India is approximately 1:1500 which is lower than what has been recommended by WHO (1:1000). The doctor to patient ratio is more skewed in case of rural areas and is about 1:25000 . Therefore posing a serious challenge in delivering the health care services efficiently and uniformly throughout the country.

Healthcare spending is also low in case of India , it is only 2.1% (2022-23)of its GDP lower than the world average of 6%. At the same time rising health care cost in India is again a major issue , about 60% of the health care expenses in India are out of pocket expenditure which is highest among the other BRICS nations . Infrastructure and resource availability is another challenge in India.(Fig 2 below) . India, therefore needs a sustainable, connected, low cost , efficient and secure model for inclusive healthcare delivery .

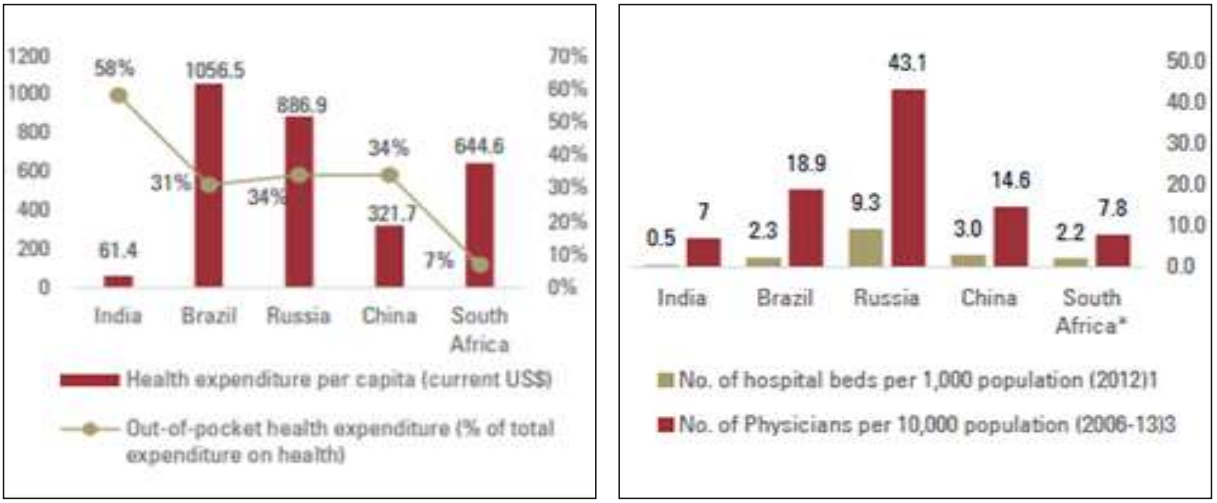


Figure 2 : Health care infrastructure in India Source : KPMG report

Technology is one of the solutions to bridge the gap. However, India is picking up with doption of new and emerging technologies, but the technology adoption rate in India is still far behind its Asia Pacific counterparts such as Australia, Japan, South Korea, Singapore, and Malaysia [1].

Adoption of new and emerging Information and Communication Technologies (ICT) will help in bridging the gap by making the reach of healthcare services to unreachable in a cost effective and efficient manner and also empower the doctors and researchers in this area to innovate new drugs/ vaccines, cells etc.

'Telemedicine 'is an evolution of digital healthcare system , it enables the use of IT tools for making healthcare services unrestricted by geographical location. Patients living in remote areas can access the best quality of care using a telemedicine system.

Telemedicine/e-health refers to the use of modern telecommunications and information technologies to transmit the necessary clinical information to deliver remote healthcare to individuals located at a distance. To realize 'live' telemedicine the medical devices in the health centre has to be connected to each other.
Telemedicine applications are based on two broad strategies for transmitting information : (i) Store and forward and (ii) 'Two way interactive (live) telemedicine.

Store and forward telemedicine relies on the acquisition of data, images, and video content and their transmission to the doctor , for an offline assessment. This is mainly practised for non-emergent cases. For example, tele-radiology, telepathology, tele - dermatology, etc. Whereas live (two-way interactive) telemedicine refers to the use of audio-visual communications over high bandwidth and low latency connections and requires the presence of both patient and doctor at the same time.

2. STATUS OF TELEMEDICINE IN INDIA

In India, several initiatives have been undertaken by both public and private sectors in initiating several telemedicine-based remote health care delivery services. Initial efforts are supported by technical ministries like Ministries of Electronics & Information Technology (MeitY) and Space. Indigenous technology development and pilot deployments were undertaken by Centre of Advanced Computing (C-DAC) and ISRO, the beginner in telemedicine in India (2001), connected initially to Apollo hospitals Chennai, and Chittoor, dist. A.P and provided telemedicine systems for 384 Hospitals, expanded to 15 super specialty and 45 rural & remote hospitals. It also facilitated satellite connectivity to 18 Mobile Telemedicine units in the country. ISRO- MoHFW, MeITY, Government of India connected the remote places like Andaman and Nicobar , Lakshadweep Islands, J&K , WB, Tamil Nadu, and the tribal areas in the north-east and central regions of the country. In West Bengal, another pilot project [35] during the same period was initiated by Indian Institute of Technology, Kharagpur and Webel Electronics and Communication System (WECS), Kolkata under the sponsorship of MeITY (then it was Department of Electronics) to make a telemedicine system using low bandwidth channels like POTS, for treating the patients of chronic tropical diseases, such as leprosy, Malaria, Kala-azar, etc. Under this project [36] two nodal centres were set up at the State General Hospital. The system, called TelemediK, started functioning from February 2002.

The most recent version of the telemedicine system of IIT, Kharagpur, iMediX, uses open source platforms, such as Linux operating system, MySQL RDBMS, Apache Tomcat HTTPS server, etc. It has reduced the cost of the deployment of software significantly. It is also made mobile responsive. Currently a PACS integrated version is deployed at Swasthya Bhavan of the Department of Health and Family Welfare, Govt. of West Bengal for availing teleradiology services. Another customized version for providing homecare services is also running in the B.C. Roy Technology Hospital, IIT Kharagpur. During COVID-19 pandemic, the residents of IIT Kharagpur campus were treated through remote consultation using this system. [44]

During the recent past, there is an increasing trend of adoption of Telemedicine in India especially post COVID19 (Figure 3&4). The telemedicine market in India is expected to grow at a compound annual growth rate (CAGR) of 31% for the period2020–25 and reach US$5.5b.[6] Due to pandemic , virtual care which includes tele–consultation, telepathology, teleradiology,and e–pharmacy are increasing in demand.

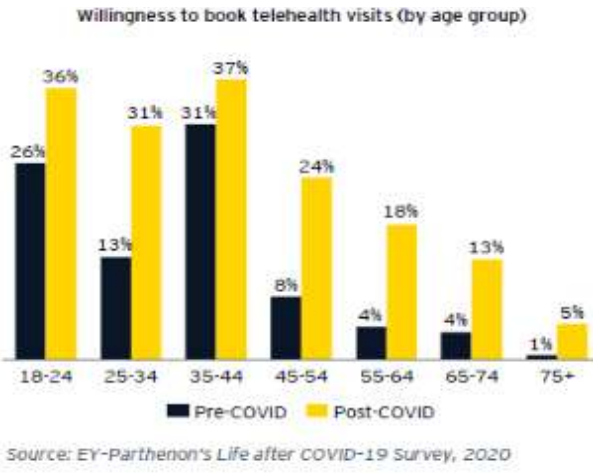


Figure 3 : Telemedicine market in India [6]

Figure 4 : Telemedicine growth rate during COVID 19 pandemic

A few examples of early adoption of telemedicine technology are mentioned below in Table 1:

State	Number of Telemedicine Nodes	Speciality Hospital
Jammu & Kashmir	12 District hospitals	Shere Kashmir Institute of Technology
Himachal Pradesh	19 District Hospitals	IGMC Shimla and PGIMER Chandigarh
Punjab	20 District hospitals	Government Medical College and Hospital and five polyclinics of the state
Uttar Pradesh	2 District hospitals	SGPGIMS, Lucknow
Jharkhand	22 District hospitals	
West Bengal	12 District hospitals	School of Tropical Medicine, NRS Medical College &Hospital, Kolkata, Burdwan Medical College & Hospital, Burdwan

Rajasthan	32 District hospitals	6 State Medical Colleges
North Eastern States	District hospitals of each of seven states	Narayana Hrudayalaya, Bangalore
Odisha	5 District hospitals	3 Medical Colleges that further linked with SGPGIMS
Chhattisgarh	2 Medical colleges	Government Medical Colleges at Raipur &Bilaspur
Kerala	14 District hospitals	Amritha Institute of Medical Sciences, Kochi, Sri Chitra Medical Science and Technology, Tiruanantpuram,
Tamil Nadu	6 District hospitals	Sri Ramachandra Medical College and Research Institute, Chennai,
Karnataka	26 District hospitals	Narayana Hrudayalaya, Bangalore
Tripura	2 District hospitals, 10 Subdivisional hospitals, 9 Primary Health Centers	1. Govinda Ballav Pant Hospital, Agartala 2. Indira Gandhi Memorial Hospital, Agartala, 3. Regional Cancer Center, Agartala
National Telemedicine Network	3 Tertiary level Hospitals for Teleradiology, Telepathology & Telecardiology	1. PGIMER, Chandigarh 2. AIIMS, New Delhi 3. SGPGI, Lucknow

Table 1 : Telemedicine network of various states in India [4] and [37]

2.1 Indian Players In Telemedicine E-services : Government And Private Sectors

In India, several private and public sector organization has started working in telemedicine area, some are mentioned here : C-DAC, Pune, Mohali ,Thiruvananthapuram; Indian Institute of Technology, Kharagpur; SGPGI, Lucknow, Apollo Telemedicine Network Foundation, Hyderabad; Online Telemedicine Research Institute, Ahmedabad; Televital India, Bangalore; Vepro India, Chennai; Prognosys Medical Systems Pvt. Ltd., Bangalore; Medisoft Telemedicine Pvt. Ltd., Ahmedabad; diagnosis Technologies, Ahmedabad; Karishma Software Ltd., New Delhi; Neurosynaptic Communications Pvt Ltd., Karnataka; Amrita Institute of Medical Sciences (AIMS), Kochi, Kerala; Larsen & Turbo, Mumbai; West Bengal Electronics Industry Development Corporation Ltd., Kolkata; and Space Hospitals Ltd., Chennai. Amrita Asia Heart Foundation (AHF), Narayana Hrudayalaya, Bangalore, Escorts Heart Hospital , Fortis and Sir Ganga Ram Hospital (SGRH), New Delhi [2],[4] to mention a few.

There are several telemedicine services available in India which are launched by the government as well as by private agencies. The few services are mentioned below :

eSanjeevani : Delivered via two variants of e-Sanjeevani- 'eSanjeevani AB-HWC', doctor to doctor telemedicine platform and "eSanjeevani OPD – Stay Home OPD", a doctor to patient telemedicine system.

- **eSanjeevani AB-HWC :** launched by the Ministry of Health and Family Welfare, Government of India in November 2019. This doctor to doctor hub and spoke model is being implemented in Health and Wellness Centres(HWCs) across the nation(Ministry of Health & Family Welfare, Government of India 2020). 'eSanjeevani AB-HWC' enables virtual connection between the doctor at the spoke (HWC) and the doctor/specialist at the hub(tertiary healthcare facility/hospital) via video conferencing. The key features of 'eSanjeevani ABHWC' include MIS based application, Comprehensive Electronic Medical Record (EMR), Teleconsultation and video-conferencing(Ministry of Electronics & Information Technology, Government of India 2021). Since November 2019 around 1200 hubs and more than 102,000 spokes have been set up in states & UTs and more than 5,20,00,000 consultations have been completed.

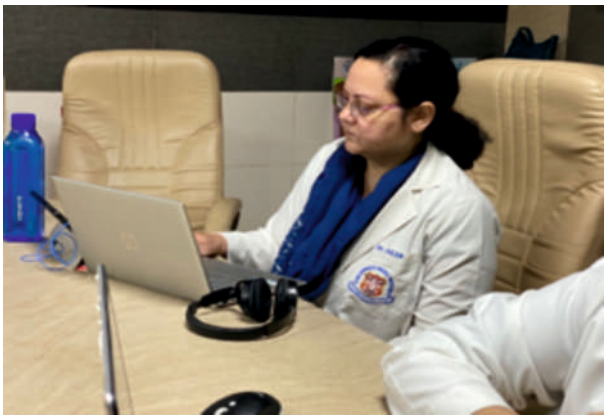
- **eSanjeevani OPD :** is a doctor to patient telemedicine system deployed under Ayushman Bharat Scheme of Government of India. Developed by the Centre For Development Of Advanced Computing situated in Mohali, India. It is the first of its kind online OPD service offered by a nation government to its citizens. It aims to provide healthcare advice online to the patients from doctors in their homes. This initiative has been very useful during COVID-19 pandemic.

- **eSanjeevani OPD :** is functional in 35 states and Union territories in the nation(ANI 2021). Overall, the eSanjeevani OPD portal has crossed more than 85,00,000 consultations since its launch in April 2020. More than 1100 speciality OPDs have been set up on eSanjeevani OPD and in many States eSanjeevani services are available round the clock 365 days a week.

- **eSanjeevani :** Doctor-to-Doctor portal has a huge potential to improve the efficiency of healthcare at the grassroots. This comes under the fourth tier of telemedicine as defined by the World Health Association, as consultations for healthcare management between healthcare providers.(54)

Through this portal, doctors working in remote peripheral hospitals can consult with specialists or super specialists from tertiary hospitals in the urban elite areas for effective management of their patients. A dedicated team of well-trained paramedics with a set of limited technical gadgets can assist the doctors in the periphery, without causing much disturbance to their routine work. In all eSanjeevani has so far served over 60 million patients, eSanjeevani network includes over 102,000 Health & Wellness Centres, 12000 Hubs, 1120 onlineOPDs and over 207,000 providers have been onboarded on eSanjeevani.

Govt. of India has included eSanjeevani amongst the population scale digital goods on offer in India Stack Global (Source: https://www.indiastack.global/esanjeevani/)



➢ **Swasth –app : (Launched in June, 2020)**

- Provides free telemedicine consultation through a mobile app.
- The app directs patients to various service providers –booking a test, buying medicines online, placing requests for homecare providers and searching for the nearest hospital updates on bed availability.
- About **100 leading hospitals, health tech start ups**developed this app.

- **AYUSH Sanjivani' App (Launched in May 2020) :** developed by Ministry of AYUSH and MeitY, it will help to generate data on acceptance and usage of AYUSH advocacies and measures and is targeted to reach 50 lakh people.
  India also leveraged the potential of digital healthcare with the Aarogya Setu app, to help people self-assess themselves for corona virus.

- **iMediX (Multitenant web-based Telemedicine in opensource platforms) :**
  - The base system was developed with a four tier secure architecture [40] by IIT Kharagpur in 2010.
  - The present version is mobile responsive, blends homecare with hospital care, and has integration with email and SMS services.
  - An opensource version for running remote clinics and e-OPDs is made available in 2021 in https://github.com/jmGithub2021/iMediXcare.

Different customized versions are deployed in a few places, such as, Swasthya Bhavan, Dept. of Health and Family Welfare, Govt. of West Bengal; B.C.Roy Technology Hospital, IIT Kharagpur, and Ramakrishna Mission Home of Services, Varanasi.

- **Services eHealth Assistance and Teleconsultation - SeHATOPD :** Witnessing the immense impact and inroads created by eSanjeevani, the Health Informatics Group at C-DAC Mohali has developed for the Ministry of Defense, Government of India - *SeHATOPD - Services eHealth Assistance and Teleconsultation* a telemedicine portal - https://sehatopd.gov.in . SeHATOPD enables remote medical consultations for defence personnel and their dependents. SeHATOPD is powered by eSanjeevani Telemedicine Technology, and was launched by the Hon'ble Minister of Defense Shri Rajnath Singh on May 27, 2021. It is now being reinforced with of a couple of additional innovative modules and workflows.

- **National Telemedicine Network for People Living with HIV/AIDS (PLHIV) :** National AIDS Control Organisation, a division of the Ministry of Health and Family Welfare and *Alliance India* have collaborated with C-DAC Mohali to launch eHIVCare - a dedicated specialised telemedicine service for People Living with HIV-AIDS (PLHIV) - https://ehivcare.com eHIVCare is an integrated platform that not only facilitates remote consultations but it has also computerised key workflows and processes at ART Centres and Centres of Excellence of NACO. eHIVCare aims to improve the care and support service accessibility, cost-effectiveness thereby increasing PLHIV engagement. eHIVCare allows healthcare providers to remotely evaluate, diagnose and treat patients through telemedicine.

2.2 Government Initiatives

Indian government has put forth several initiatives and policies towards delivering healthcare services remotely and efficiently, these include:

Key Initiatives by Government

- **National Digital Health Mission(NDHM)**: Government of India announced NDHM on 15th Aug, 2020 – open ups the door for universal digital healthcare system in the country. The vision is to create a national digital health ecosystem that supports universal health coverage in an efficient, accessible, inclusive, affordable, timely and safe manner, that provides a wide-range of data, information and infrastructure services. The system also uses interoperable standards and maintains the security, confidentiality and privacy of health-related personal information . It comprises of the following five key building blocks namely Health ID, Digi Doctor, health facility registry, personal health records and Electronic Medical Records. This will also include e-pharmacy and telemedicine services in future course of time. (Details can be accessed from- https://ndhm.gov.in)

- **Health ID:** Is a Unique Health ID (UHID) to identify and validate an individual, this will enable access of health information of individual patient securely by any doctor/ hospital/ Pathlab/ Pharmacy etc. with a consent from the individual.

- **Digi Doctor:** It is a database of doctors with details like name, institution, qualification, specialization and years of experience etc. The directory of doctors will be updated from time to time and mapped with the facilities and specialities those doctors are connected with.

- **Health Facility Register (HFR):** A database of Health Facilities across the country. Which will be maintained to facilitate data exchange of private and public health facilities in India. Periodically the health facilities will also get updated.

- **Personal Health Records (PHR):** A PHR is an electronic health-related information of an individual . The individual can access his/ her records from anywhere anytime and can also edit his/ her personal information if required.

- **Electronic Medical Records (EMR):** Is a web-based system that contains comprehensive health related information of a patient , treatment history of a patient. This will enable the clinicians, track their patients, monitor their health and suggest preventive check-ups and screenings.

- Bharat broadband net programme to connect every corner of the country through **National Optical Fibre Network (NOFN)** for internet connectivity is another important initiative which will help in deployment of nationwide Telemedicine services. The programme will connect about 6.3 lakh villages of the country will be covered by 2023.

- **National and state level Telemedicine Network** to connect to the distant areas by Government Healthcare Facilities by creating reliable, ubiquitous and high speed network backbone.

- **A National Telemedicine Network (NTN)** initiated by the MoHFW, Government of India to provide telemedicine Services to the remote and rural areas across the country. Telemedicine nodes are to be established across India inter connecting these healthcare facilities.

- **State Telemedicine Network** Under the Programme Implementation Plan (PIP) of National Health Mission (NHM), Ten States have been supported towards establishment of State Telemedicine Network. Towards creating reliable, ubiquitous and high speed network backbone.

- **SATCOM based Telemedicine nodes at Pilgrim Places** to reach to the various unreachable geographical locations . Space Technology Tools were used to set up Tele-medicine Nodes at Pilgrimage for providing tele-medicine facility between identified remote patient end health facility and specialty hospital in collaboration with Department of Space. This includes screening of Non-Communicable Diseases (NCDs) and specialty consultation to the devotees visiting the places like : Kashi Vishwanath Temple, Varanasi, (UP) Maa Vindhyavasini Mandir, Vindhyachal Dham, Mirzapur (UP) Sheshnag, Amarnath Pilgrimage (J&K) Pampa Hospital, Ayyappa Temple at Sabrimala in Kerala [53].

- **National Medical College Network:** 50 Govt. Medical Colleges are being inter-linked for tele-education, e-Learning and online medical consultation utilising National Knowledge Network (NKN).

- MoHFW has also come up with the **Telemedicine Practice Guidelines** ,this will enable practising the health delivery services remotely. Niti Aayog has put up building National Health Stack, a nationally shared digital infrastructure to support the healthcare ecosystem . It aims to enable the entire population's health management and research through a national health analytics platform leveraging Big Data and AI/Machine Learning (ML). NHS's objective is to seamlessly link the healthcare providers, payers and fulfilment agencies to national health electronic registries to lower cost by use nationally shared digital infrastructure and to promote wellness across the population. The digital infrastructure will be owned and operated by the government and will be accessible to anyone using open API software.

- **My Health Record**: provides a single online personal medical record storage platform to citizens of India to enable them to manage their own medical records in a centralized way, which greatly facilitates the storage, accessibility and sharing of personal health data. My Health Record can be accessed from anywhere, anytime by

the patients and also by physicians, thus increasing flexibility for a patient to visit any doctor without carrying the burden of physical files, and thus benefit both the citizens and the physicians. It helps the physician to understand patient's past medical history which is important to the treatment to be given and will have following benefits Include:

- It helps in recovering medical records which might be lost in physical form.
- The data stored in a standardized format can be used for data analytics to understand disease trend, etc.
- Reduces medical error and improves patient compliance.
- Helps patient in taking second opinion and provides emergency medical records for unconscious/unattended patients.

➢ **Mera Aspataal (My Hospital) :** This 'application is an IT based feedback system to collect information on patients' level of satisfaction using a multi-channel approach viz. Short Message Service (SMS), Outbound Dialing (OBD), Web Portal, and Mobile Application. The application automatically contacts the patient (out-patient after the closure of the OPD and the in-patient at the time of discharge) using the above tools to collect information on the patients' level of satisfaction. Currently more than 6000 hospitals have been covered.

➢ **Online Registration System (ORS) for patients**: The ORS is a framework that helps link various hospitals for online registration, payment of fees and appointment and online diagnostic reports, enquiring availability of blood online etc. As on date, more than 250 hospitals including hospitals like AIIMS, New Delhi and other AIIMS (Jodhpur; Bihar, Rishikesh, Bhubaneswar, Raipur, Bhopal); RML Hospital; Sports Injury Centre (SIC), Safdarjung Hospital; NIMHANS; Agartala Government Medical College; Jawaharlal Institute of Postgraduate Medical Education and Research (JIPMER) and others are on board ORS. So far more than 36 lakh appointments have been transacted online by users in 250 hospitals using the Online Registration System.

➢ **Tele-medicine services in Health & Wellness Centres (HWCs)**: Under the ambit of Ayushman Bharat Scheme, MoHFW is setting up 1.5 lakh Health & Wellness Centres (HWCs) in the States for providing preventive and promotive services. One of the components under services is to provide Telemedicine consultation service. States are being supported under NHM scheme for roll-out of Telemedicine services. CDAC Mohali has developed the Telemedicine application (eSanjeevani online OPD) and for providing training to all stakeholders in the States. Guidelines for the same have been finalised and issued to all States.

- **Tele-Radiology:** The need for Teleradiology begun due to the imbalance between the demand and availability of diagnostic services. In India approximately 10,000 radiologists - for a population of over 1.3 billion people are available. Majority of the radiologists are general radiologists who interpret all imaging formats (such as X-ray, ultrasound, CT, MRI). Very few are specialists who are able to examine particular imaging modality such as neuroimaging (focused on the brain and spine) or cardiovascular (focused on the heart and blood vessels). Lack of manpower as well as specialty expertise are the two major factors effecting the timely and accurate diagnostic services. To some extent, these problems can be overcome by utilizing robust communication and image transfer systems. This process whereby images are transferred to distant locations for the purpose of interpretation and diagnosis is termed teleradiology.

  Another reason for the growth of teleradiology is that most parts of rural India do not have good radiological services and personnel. With teleradiology, this deficiency can be overcome by using the help of more experienced personnel in the larger centers in the cities. Also, even in the cities, not all imaging centers have subspecialty expertise; difficult cases in specific areas of radiology can be sent to experts for their opinion.

  Interpretation of all non-invasive imaging studies, such as digitized x-rays, CT, MRI, ultrasound, and nuclear medicine studies, can be carried out using Tele radiology.
  The CollabDDS Online Radiology Services (CORS) is a web-based interface that is used among different health communities for resolution of radiological and dental issues. CORS will be accessible to local as well as remotely situated doctors for wish to seek guidance from expert radiologists. Radiologists in return provide doctors with diagnosis/diagnosis reports. Using CORS, doctors can either upload cases for forwarding to experts or can conduct real time collaboration with the experts, thereby reducing the turnaround time. The CORS project was launched with the objective of providing Online Radiology interpretation on reports, for Continue Medical Education (CME) for medical officers. This is acknowledged as a major step in helping mitigate the lack of Radiologists at primary health care institutes.

- **Web-portals and Mobile Applications National Health Portal (NHP)**: is functioning as a Citizen Portal for Healthcare providing Health related information to citizens and stakeholders in different languages (currently six languages). A voice portal, providing information through a toll-free number 1800-180-1104 and Mobile App has also been launched a) Various other portals/website viz Comprehensive Health Care-Non communicable diseases, National Programme for Health Care of Elderly, Pradhan Mantri Surakshit Matritva Abhiyan (PMSMA), Mera Aspataal, Surakshit Matritva Aashwasan (SUMAN), Intensified Mission Indradhanush-2 and National Tobacco Control Programme are also actively

supporting the different programs Health and Wellness Centres (HWCs) portal The HWC portal is helping monitor progress of HWCs under the Ayushman Bharat Scheme, Home-Based Care of New Born and Young Child portal to provide information and monitoring of the program. Along with this is the Central mental health authority website that is maintaining a register of all mental health establishments in the country. It also lists out the regulations and coordination mechanisms for availing mental health services under the Central Government in addition to the details regarding websites of agencies assisting the Ministry. a) Registry: A Master Register for Health Facilities by giving National Identification Number to Health Facilities (NIN) has been developed. This is being used in creating HWCs and seeding in Reproductive and Child Health (RCH), Drugs and Vaccine Distribution Management System (DVDMS), Labour Room and Quality Improvement Initiative (LaQshya), Mera aspataal, non-communicable diseases (NCD), Surakshit Matritva Aashwasan Initiative (SUMAN), Pradhan Mantri Surakshit Matritva Abhiyan (PMSMA) b) mHealth: As part of mHealth there are several mobile applications that are supporting the national health services. They include Ayushman Bharat: Health & Wellness Centres Mobile App, Mera Aspataal, NACO AIDS c) diabetes: This is a mobile app-based initiative that helps in the prevention and care of diabetes d) cessation: This is a mobile app-based initiative that is used for counselling and helping people quit tobacco. Its main focus is on increasing the health awareness and providing support [52].

- **Tele-Cardiology:** India is aging faster and it is expected that India will have about 20% of the population aged 60 years and above by 2050. This will pose a challenge to the healthcare providers. Thus the aging population will experience increased chronic disease burden from diabetes to high blood pressure, the demand for cardiologists is growing. At the same time in India there is a lack of specialist doctors, in rural areas availability of doctors is more acute. To overcome this issue Tele cardiology has been implemented in many hospitals in India. This was very useful during the COVID-19 pandemic time wherein social isolation and lockdown measures were executed to prevent the spread of virus which created enormous challenges to patient healthcare. In order to overcome these challenges, teleconsultation (telecardiology) was initiated. However, providing healthcare services for patients in remote areas without specialists, particularly in cardiac care, has created significant challenges in the health system. The high sensitivity of providing high-quality and timely healthcare services for patients with cardiovascular disease has led managers and healthcare providers to consider using information technology to provide these services. Telecardiology facilitates communication between different centers and provides specialized services and cardiac counseling.

2.3 Recent Initiatives

- **Tele- Mental Health :** The pandemic has accentuated mental health problems in people of all ages. To better the access to quality mental health counselling and care services and to address the huge burden of mental disorders and shortage of qualified professionals in the field of mental health, the government has launched 'National Tele Mental Health Programme' with NIMHANS, Bangalore being its nodal centre. This programme will include 23 tele-mental health centres of excellence. Bangalore based National Institute of Mental Health and Neuro Sciences (NIMHANS) will work as its nodal centre and International Institute of Information Technology- Bangalore (IIITB) will provide the necessary technical support and ensure quality mental health counseling for all.

- **ABHA (Ayushman Bharat Health Account) :** The government of India launched a digital health ID card called the "Ayushman Bharat Health Account" (ABHA) card. The goal of this mission was to provide all the citizens of India with a digital health ID that will facilitate easy access to medical records. This ID is a 14-digit identification number that can be used from anywhere in India. benefit includes-

  - All medical information like tests, diagnoses, medicine prescriptions, are accessible from anywhere.
  - Medical records can easily be share with hospitals, clinics, doctors, etc.
  - Healthcare Professional Registry (HPR) is a compilation of the details of all
  - the doctors in India is available on the portal.
  - Health Facility Registry (HFR) which is a list of all the government and private medical facilities in India is available on the portal.
  - This card is valid in AYUSH treatment facilities too. Treatments include Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy.

2.4 Global Telemedicine Projects Initiated by India

The Ministry of External Affairs (MEA) has undertaken a global telemedicine initiative in Africa and South Asia to extend its telemedicine-enabled healthcare and educational services under a South Asian Association for Regional Cooperation (SAARC) and Pan-African e-network Project.

- **SAARC Telemedicine Network :** The SAARC, created as an expression of the region's collective decision to evolve a regional cooperative framework, received a major impetus during the 14th SAARC Summit held in New Delhi in April 2007. The preparatory work for a pilot project connecting one or two hospitals in each of the SAARC countries with the super specialty hospitals that include AIIMS, New Delhi; SGPGIMS, Lucknow; PGIMER Chandigarh and CARE Hospital, Hyderabad of

India has been completed. Jigme DorjiWangchuck National Referral Hospital, Thimphu, Bhutan has been connected to SGPGIMS, Lucknow, and PGIMER, Chandigarh under this project, which was inaugurated in April 2009.

- **Pan-African e-network Project :** The MEA is implementing this project through Telecommunications Consultants India, Ltd. (TCIL) to Establish a Very Small Aperture Terminal (VSAT) infrastructure for 53 African Countries of the African Union by a satellite and fiber optic network that would provide effective tele-education, telemedicine, Internet, videoconferencing, and voice over Internet Protocol services. Ten super specialty hospitals in India have been identified to provide tele-health services to 53 remote African hospitals.

2.5 Telemedicine Business Models In India

Because of the Covid-19 outbreak remote consultation worked exceedingly well which not just bridge the gap but also creates an ecosystem designed to deliver better and faster quality healthcare within the environment. Several healthcare start-ups are working in the area of Telemedicine are slowly redefining the delivery of quality healthcare in India and few emerged as a Unicorn in the field.

Telemedicine players can broadly be categorized into

(1) Technology providers and

(2) Healthcare service providers or implementers.

Technology providers are companies focused on designing technology modules for healthcare services.

Examples include – Yolo, Neurosynaptics, Medongo, etc. Service Providers/ Implementers are companies operationalizing telemedicine solutions and providing last mile access to the patients. Examples include –Practo, Tata 1mg, Pharmeasy- midlife, Apollo Telehealth, Doc online etc.

Details of few of the Indian health tech start-ups that have reached the market peak are listed below in Table 2 :

Details of few Indian Health tech Start- ups that have reached peak in the market (Table -2)

Sr No	Name of the company	Founded in the Year	Valuation (in $Bn)	Services	Mobile based/ web based
1.	Practo	2008 Headquarters: Bengaluru Website: www.practo.com	904	Provides a comprehensive medical directory with services like online appointment booking, online consultation, medicine delivery and diagnostics.	Mobile app based
2.	Tata -1mg	2015	45	India's leading digital consumer healthcare platform. 1mg's services majorly include e-pharmacy, diagnostics and digital consultation.	Mobile app based
3.	Pharmeasy-Medlife	2014	1.5	PharmEasy is an online platform provider for ordering medicines and diagnostic tests. It offers a smartphone app for ordering medicines from a local pharmacy and home sample collection for diagnostic testing from nearby labs.	Mobile app based
4.	CureFit	2016 www.curefit.com. Bangaluru	8	The app provides workout classes across multiple formats : physical fitness —dance, yoga, workouts, healthy food and mental well-being strength, through the day.	Mobile app based
5.	DocOnline	2016 www.doconline.com Bangalore, Karnataka		Doc-Online gives access to online healthcare professionals ,users can also access regular blogs, healthcare tips/medical advice.	Both web and mobile app based
6.	Netmeds	2010 Headquarter : Chennai netmeds.com	-	Netmeds operates an online pharmacy in India for prescription products, OTC, and health and wellness produ cts. Its app also offers doctor consultation services.	Mobile apps

7.	Lybrate	2013 www.lybrate.com Faridabad, Haryana	-	Lybrate offers an online multi-specialty telemedicine platform for patients to consult with doctors over chat, phone or video call. Users can search the doctor based on their specialization, rating, and reviews and book an appointment for video consultation. Also offers appointment booking for physical visit to the doctor and online marketplace for diagnostic tests. It has a practice management solution for doctors to manage their medical practice.	Web based
8.	Doctor Insta	2015 Gurgaon, Haryana www.doctorinsta.com	$3M -as on Aug 08, 2016	DoctorInsta is an online video-based multi-specialty telemedicne platform. Patients can search for the doctor based on their requirement and specialization, and book an online consultation. Apart from doctor's consultation, it also offers consultation with psychologist and nutritionist. It provides access to quality healthcare professionals 24x7. This service is provided through voice and video calls and with the chat feature in its application.	Mobile app based
9.	MediBuddy	2000 www.medibuddy.in Bangaluru	$1.3 billion.	MediBuddy is a mobile app based online doctor consultation with other services. It provides an online platform where users can search for healthcare providers and can communicate with them for their treatments.	Accessible both as an online portal as well as a mobile app

10.	Ask Apollo	2013 Hyderabad, India	-	AskApollo offers an online telemedicine platform for remotely consulting doctors from apollo hospitals. Users can select the doctors, pay for the consultation charges, enter patient details, consult a doctor and get the prescription. Also offers a board of specialist for consulting on a complex or chronic disease. Users can also book physical appointment, health Checkup and diagnostics at home.	Mobile based app.

Table 2: Details of few Indian Health tech Start- ups that have reached peak in the market

As mentioned in the table above, there are several health tech start-ups working in the area of Tele health and performing well specifically the COVID 19 pandemic has increased the demand for remote consultation and monitoring. The above mentioned start-ups are just to get an idea of various services provided by the health tech start-ups in India .

With the advent of telemedicine based models, geographical barriers can be overcome and quality medical help can reach the remotest of areas in a timely manner. The use of ICT to deliver care can reduce cost for the patients substantially and the emphasis on regular monitoring can significantly bring down the chances of late diagnosis and increase in severity of illness, indirectly leading to a reduction in medical expenses. Several models have emerged that are leveraging technology to enhance access to healthcare. However, market based sustainability is yet to be proven. Telemedicine models must strive for superior technology that is simple to use, operate and is tailored to meet the requirements in remote areas. They should focus on creating a better customer experience by offering comprehensive care and long term sustainability.

2.6 Analysis of Telemedicine Technology Trends in Indian start-ups

Survey of Start-ups : To analyse the current technology trends in telemedicine in India ,a survey of startups working in the area of telemedicine was conducted. As the startups are the ones who

Bridges the gap between

- Patients & healthcare providers
- Traditional healthcare system and the Emerging healthcare needs

Creates

- Job opportunities and contribute to the country's economic growth.
- An ecosystem to deliver better and faster quality healthcare within the environment

- **Promotes**
  - Promotes Research & Development as well as Research & Innovation
  - Connection to knowledge institutions.

- **Adopt**
  - New and advanced technologies
  - Emerging healthcare demands: flexible striving to shape the industry on a global scale moving forward.

Initially the survey was conducted in Primary mode . But the results of the survey were not so encouraging , so secondary mode survey was conducted.

Entities Surveyed

- Business Verticals
- Impact of COVID 19
- Turnover
- Technologies used
- Remote Data Management
- Challenges Faced
- Future plans
- Business started in the year

Application Areas Targeted

- Tele- Consultation
- Tele- Diagnostics
- E- Pharmacy
- Tele- Monitoring
- Tele- Homecare
- Tele-ICU
- Tele-Rehabilitation
- Robotics assisted
- Tele- Physiotherapy

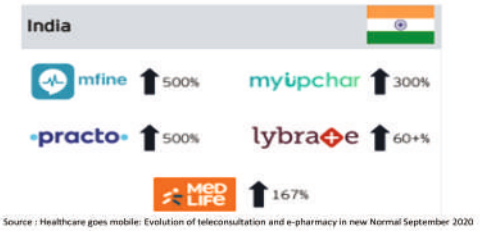
TeleConsultation	E-Pharmacy	Teledaignostics
Practo		
Tata-1mg		
CallHealth	**PharmEasy**	**Tele Vital**
Mfine		**Healthcubed**
Medcords		**Neurosynaptic**
Lybrate	**Netmeds**	**Yethi Medical**
Doctalk	**sastaSundar**	**RIJUVEN**
DocOnline		
Phoenix		
Medlife		
Doctor Insta		
MediBuddy DocsApp		
Helyxon		
MyUpchaar		
Iclinic		

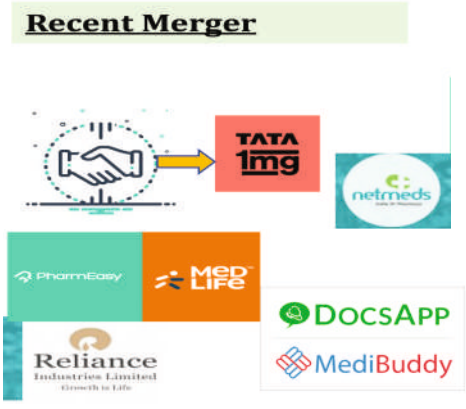
Telemonitoring

Tele-ICU services	Telemonitoring	Tele Home care
Cloud physician	Zealth.ai	Health Care at Home (HCAH)
	iNICU	
	Covacare	
	Nuclespace	
	Tenthaid	
	Telemedapp	
	Dozee	

Tele-Rehabilation

Telephysiotherapy	Gamified services	Roboticassisted services
HabTalks	BeAble health	Punar





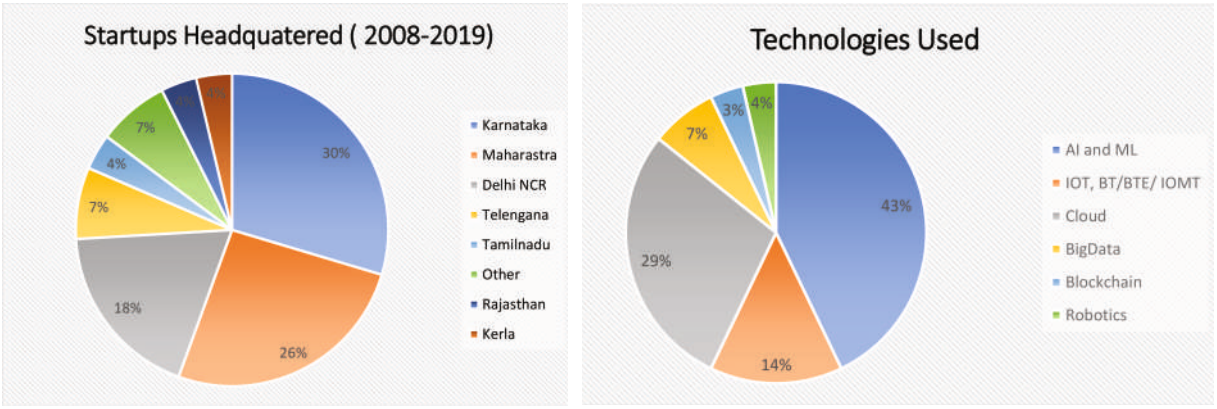


Figure 5: Applications of Telemedicine used by Indian start-ups

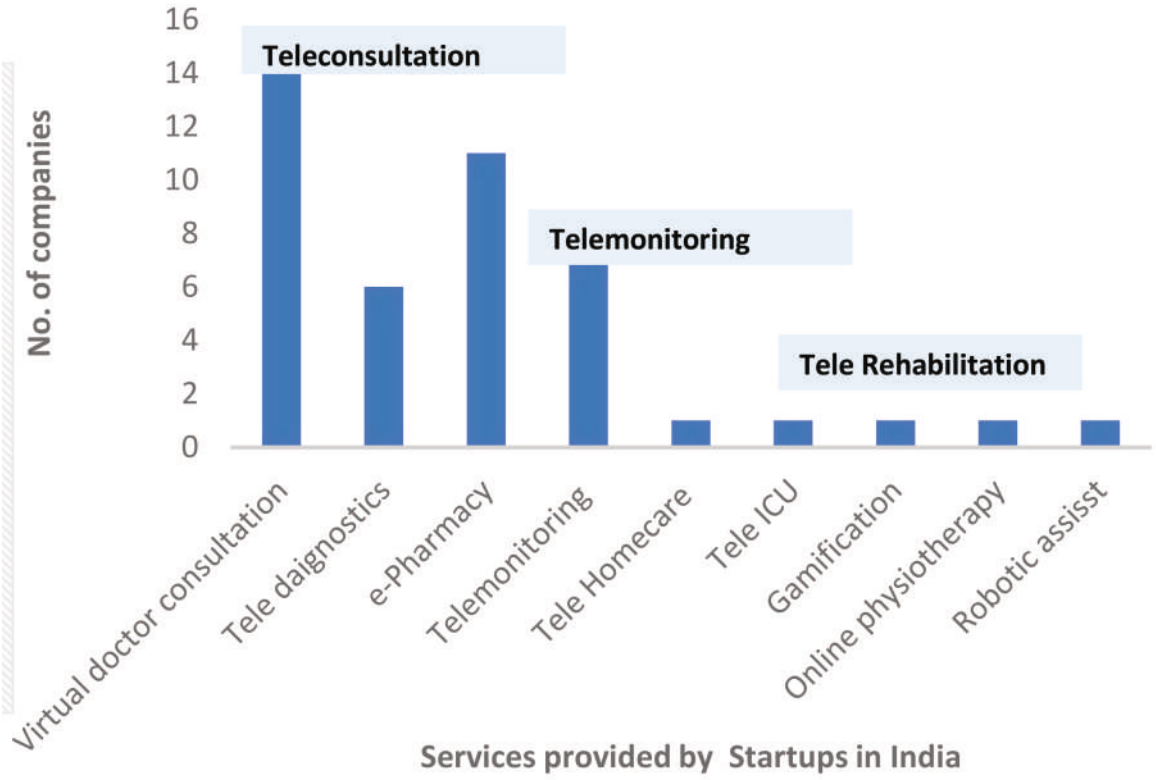


Figure 6: Survey result: Analysis of the survey of Start ups on various parameters.

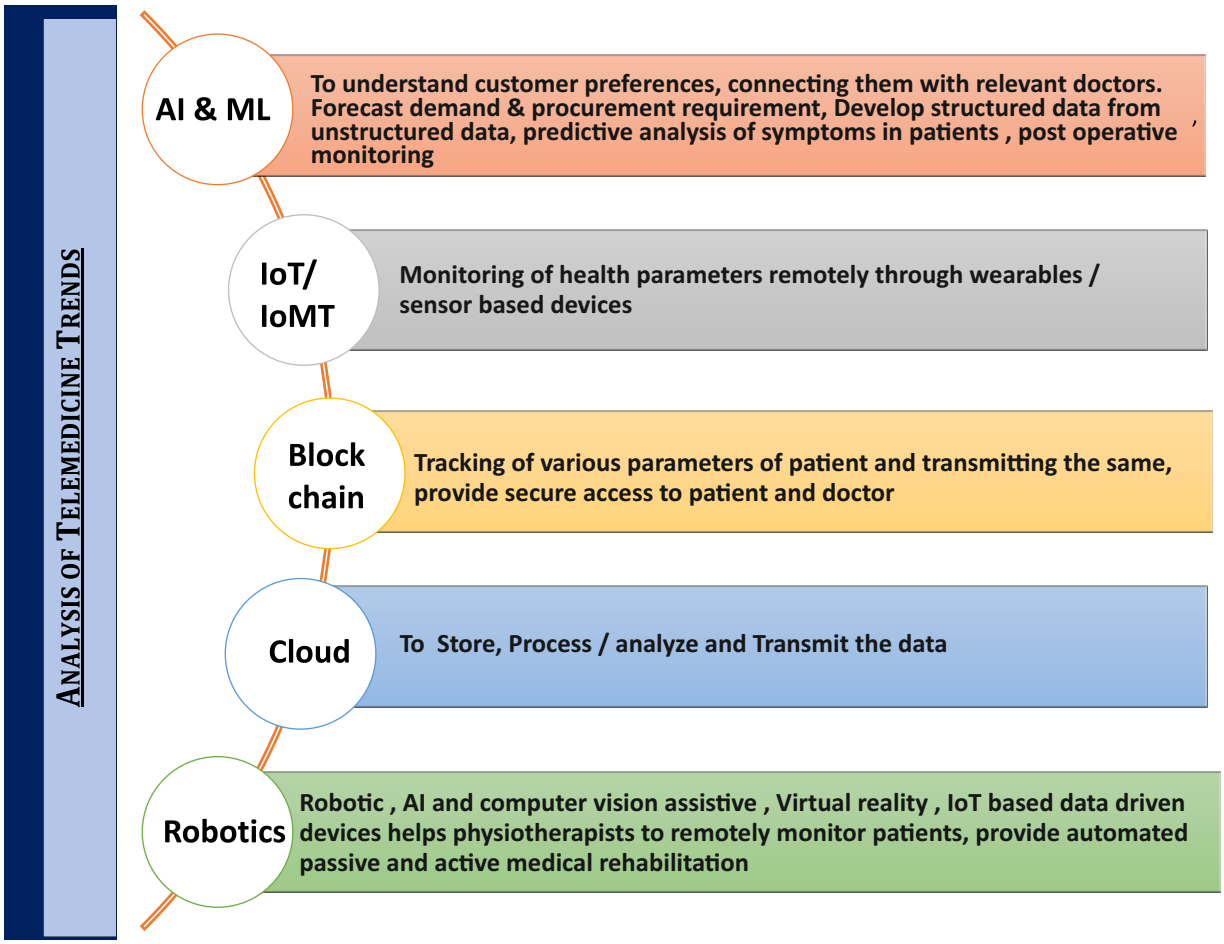


Figure 7: Analysis of Telemedicine Technology Trends in Indian start-ups

With respect to the technologies used and application for which the emerging technologies used. It was found that most of the companiesare using the technologies like Artificial Intelligence/machine learning just for commercial purpose i.e. to und accordingly suggest the product of their choice. However, advanced technologies like Blockchain, Robotics, Computer vision are the technologies that were used by the companies who have started their business in the recent past (during 2018-2019)

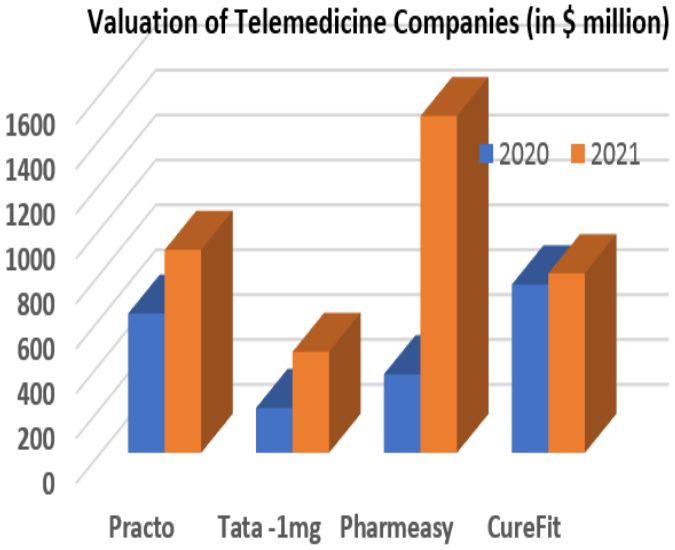


Figure 8 : Indian start-ups and their valuation

2.7 TIFAC's Initiative In Tele Digital Health

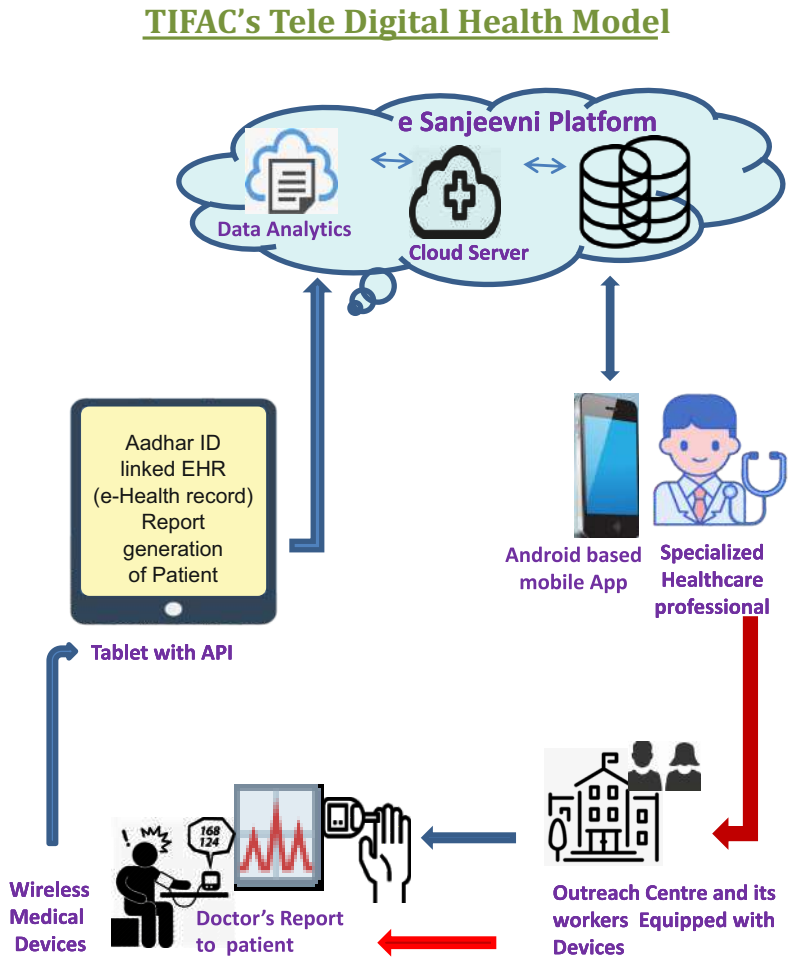


Figure 14 : Tele Digital Health Model

In line with Honbl'e PM Shri Modi ji's Vision of Swasthya Bharat, and generation of e- Health Record, TIFAC has initiated a Tele digital Health Pilot Project which provides all-inclusive healthcare, leveraging emerging Information and Communication Technologies (ICT)towards bridging the gap by taking healthcare diagnostic services to rural areas. With this in view, TIFAC, in collaboration with IIT Madras-Pravartak Foundation Technologies & CDAC Mohali, has launched a scalable Tele Digital pilot demonstration telemedicine project to provide quality medical care at an affordable cost to underprivileged women and children, and also generation of Electronic Health Record (EHR), linked to e- Sanjeevani portal. The pilot project is focused on the demonstration of the efficacy of cutting-edge technologies (Use of IoTs, wearables, eHealth apps, cloud & devices) targeting an underprivileged population, especially women and children living in remote areas of three districts (Varanasi and Gorakhpur in UP and Kamjong in Manipur) with quality medical care.

Towards prognosis of the test data generated, TIFAC has constituted a panel ofhighly eminent doctors and telemedicine practitioners associated with the pilot demonstration project. The doctors will advise a patient using Store and Forward, and two-way interactive communication channel. The key health parameters that would be analyzed are:

ECG, Heart Rate, Blood Pressure, Temperature, SpO2, Blood Sugar, Lipid Profile, Haemoglobin Fetal Doppler for child care with the help of portable Tele-diagnostic device kits.

A web-based interface with Mobile Application (Android) named e Sanjeevani TD – an integrated platform for telediagnosis would be developed to capture different diagnostic parameters, of patients, attained from integrated devices and to keep them for future reference of patients and also to send doctors for advice and generation of prescription with diagnosis. This android app would have Store & Forward based on Hub & Spoke model including several other features like Login Module for health worker, patient registration, doctor login and doctor consultation module and patient feedback etc.

About sixty thousand patients would be covered in three districts to begin with: Gorakhpur, Varanasi in U.P. and Kamjong in Manipur with respective Outreach Academic Partners: Deen Dayal Upadhyaya Gorakhpur University, Gorakhpur, BHU- Varanasi and NIT- Manipur for collection of health data and also generate EHR. In each district, around 20,000 people would be covered in a span of six months by two outreach persons.

3. GLOBAL STATUS

In several overseas countries like United Kingdom, Finland, Europe, Taiwan, North America Australia, China etc. various programs to facilitate remote healthcare services have been deployed, since last 10–15 years. Beside providing the remote healthcare facilities, few countries also provide tele-health programmes which includes medical education to train doctors, paramedical staff etc. Due to the COVID 19 pandemics, virtual consultation in several countries like United states America, China, Japan, France, Sweden, Russia etc. including India has increased.

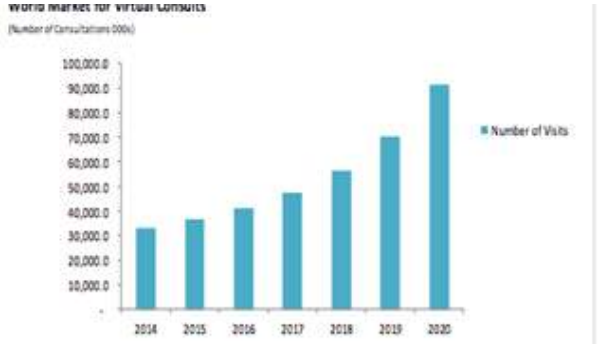


Figure 9 World market for Virtual consults[3]

Singapore is a front-runner in Asia in terms of telemedicine adoption and healthcare system efficiency. Canada is an early adopter of data protection in e- Health ; forerunner in binding national standards and interoperability. Canada was the only country to establish a certification process that targets market players' products and services. Japan uses telemedicine as a complement to face-to-face treatment.

The virtual consultations in North America and Western Europe, where sufficient internet bandwidth and accessibility of mobile aligned, virtual consultation is successfully working. South Korea is another good example of established healthcare system. South Korea also utilized its technological strength in the area of artificial intelligence and big-data analytics to control the corona virus spread in the country. Big-data analysis, facilitated integration of data from various entities like hospitals, government organizations, financial services, mobile operators etc. This helped to trace the information regarding the infected person (travel history/other activities) and the same can be communicated to the people in the locality through mobile notifications. Use of AI and data analysis enables the government to predict possible clusters of the virus, which helped in defining or to decide on the relevant aspects regarding management of COVID 19. The countries like Canada, Denmark, and Germany were able to handle the pandemic more effectively due to the presence of a strong public health system, political decisiveness, and better testing infrastructure [7]. Availability of digital data is one of the key enabler for digital healthcare system in these countries.

3.1 Global Trends: Telemedicine practices and services

From the beginning of the last century, various efforts on using telecommunication technology for remote consultation in medicine and surgery had been reported. Mostly they were run to demonstrate the societal application of the advancement of telecommunication technology in healthcare. Even after hundred years later, the same motivation strives ahead the societal application of telemedicine, until recently COVID-19

pandemics forced the society to take it more seriously and brought it into the forefront of delivery of healthcare. In subsequent sections, we trace a few typical examples on journey of telemedicine starting from the early twentieth century [45].

➢ Early Telemedicine systems

The use of telecommunication by transmitting biomedical signal was demonstrated by Willem Einthoven[46], the inventor of electro-cardiography (ECG)as early as in 1906. The string galvanometer designed by him required a lot of space and high technical skills for its manoeuvring. It was immobile equipment. For its clinical use, a telephonic connection from the physiology laboratory of the Leiden University of the Netherlands to the clinic at the Academic Hospital about a mile away was used and its use brought the term telecardiology for the first time [47]. Even after the advancement of medical instrumentation technology with a substantial reduction in cost and size, in USA in 1920s there ran services of remote diagnosis through transmission of ECGs and EEGs using telephone lines. There were reports of other kind of telemedicine related services, such as providing clinical consultation to maritime sailors from the off-shore using telegraphy and radio transmission of voices. In USA, various such efforts continued in mid-twentieth century. A typical example is of running tele-psychiatric services in 1950's, in a state mental hospital and the Nebraska State Psychiatric Institution [48] using microwave communication links. Around the same time, NASA and US Public Health Services ran a joint telemedicine programme to serve the Papago Indian Reservation in the state of Arizona [49]. In 1970's, paramedics of urban hospitals in remote Alaskan and Canadian villages were trained and supervised through remote guidance using ATS-6 satellite communication systems [50]. In Japan, in1970's a few pilot projects on telemedicine [51] were executed using telephone lines and cable television system.

➢ Telemedicine systems during digital revolution

After 1990's for about a decade and half, there has been rapid advancement of digital technology and the cost of data communication and multimedia systems have been drastically reduced. As a result, there were many efforts of using digital platforms and devices for the deployment of Telemedicine technology. However, still the systems were designed for dedicated communication links and data communication was the major bottleneck for using these systems, which impeded the growth of telemedicine services. We may note that the internet was still at its infancy during this period,and the web technology was yet to mature. A few examples of such systems are highlighted below.

In Japan, in 1994,a telemedicine network[8] was built up connecting National Cancer Centers in Tokyo and Chiba, which is at about a distance of 30 Km from Tokyo. The network was used for tele-educationof medical professionals. The data communication took place throughan optical leased line with 6 Mbps data rate. The link was later upgraded to support 18 Mbps data transfer rate using ATM protocol. In addition,a B-ISDN link with156 Mbps

data rate was used. Within few years, as many as 14 regionalcancer centerswere connected to this networkusing frame relaycommunication services [9] There were arrangements of TV conferencing also, through which participants discussed about any medical casesharing a still image of HDTV resolution .Annually more than 15000 medical professionals used this system to hold regular conferences on various areas such as, nursing, radiology, oncology, pathology, etc.

Use of telemedicine for handling accident and emergency cases, primarily managing orthopaedic cases[10] started in Lincolnshire, U.K., in 1996. The system facilitated tele-consultations between a specialist from a District General Hospital (DGH) at Boston to the doctors of two Minor Injury Units (MIU) at Skegness and Johnson using anISDN line at 128 Kbps data rate. The medical images, captured by digital scanners, digital cameras, etc., were transferred using store and forward technology, and online consultation had been taking place using a desktop video conferencing uniton a Pentium PC.There were also provisions for online transmission of X-Ray images. The system had been extensively used to treat patients predominantly suffering from fractures, sprains, strains and laceration.

A study of effectiveness of the use store and forward technology for data communication and compression in telepathology was taken up in South Korea[11]]. In this case, digital images of pathological slides from a microscope were captured, compressed using JPEG compression scheme of moderate quality, and transmitted to two specialist centers for diagnosis. The images were captured at the Samsung Medical Center, Seoul, and the pathologists of Korea University Hospital, Seoul and John Hunter Hospital New Castle, Australia, used to provide diagnosis from their remote ends. In addition, an independent pathologist was also engaged to provide the diagnostic reports by directly viewing the slides. It had been observed that there was a high degree of concurrence of pathological reports with the independent reports of the pathologist who directly viewed the slides.

Like telepathology, to study the efficacy of remote diagnosis using echocardiograms, they were transmitted real time as compressed videos[12] .The study was carried out at the Duke University Medical Center, Durham, North Carolina, which acted as the referral center for providing expert opinions to nine small centers, which were at distances from 9 Km to 200 Km (average 160 Km).Each of these centers had a USG imaging system. regular cardiologists for treatment of adults were posted there, but they lacked expertise in paediatric echocardiography. For transmission of cardiograms a video conferencing unit was used. The video was transmitted at 15-18 frames per second in real time using an ISDN link. For comparative analysis, there was an independent study by a paediatric cardiologist with the videotaped echocardiograms of higher quality. The study was carried out during the period between January'1998and January'2001. A high concurrence (383 cases out of 401) was reported. It was also observed that the system was not suited for interpreting color Doppler images.

Another notable pilot project was reported from Taiwan during this period[13]. In this project, remote clinical consultation was being provided using T1 leased line and ISDN link from the National Taiwan University Hospital(NTUH). Several nodal centers at remote sites were connected to it. The system was backed by a multimedia database. Diagnostic images of different modalities in DICOM 3.0 format such as CT, MR and X-Ray, etc. were used in consultations. The system also facilitated transmission of MPEG compressed videos of USG, endoscopes, etc. It has also the feature of store and forward image transfer. The system had a high degree of acceptances of patients, consulting physicians and technicians.

From Singapore, a pilot project [14] to study the effectiveness of tele-ophthalmology was reported. The study was carried out by the Tan Tock Seng Hospital (TTSH, Singapore). In this project, from a clinic medical videos of HDTV quality were transmitted to the referral end for diagnosis, and for online video conferencing between a patient at the clinic and an ophthalmologist at the hospital moderate to low quality videos were used. Appointments for teleconsultation were set before the consultation following a secured communication protocol between the hospital information systems at both ends. About 100 patients participated in the trial. There were two ophthalmologists who checked the patients. One of them checked the patients directly at the clinic, and the other expert independently used the telemedicine system for diagnosis and consultation. A high agreement between them in all the cases has been observed.

➢ Present-day Telemedicine systems

There has been phenomenal growth of internet and rapid advancement of web and mobile technology. The technology is matured enough now to provideremote health care delivery with a greater outreach, affordable price and maintaining high quality of data communication services. This has catalysed the emergence of national health networks in various countries and various telemedicine programs are reported across the globe. A few such national programs are cited below.

In Denmark, a central network [15] has been established to connect all the hospitals of the country. The systems are interoperable maintaining Electronic Medical Records (EMRs)and integrated e-Prescriptions. They are also supported by Radiological Information System (RIS) and Picture Archiving and Communication System (PACS).

In Israel, there operate four nationwide non-profit-making Health Maintenance Organizations (HMO), namely, Clalit, Maccabi, Meuhedet and Leumit. All health care services are provided by them under insurance coverage. Every hospital in the country as well as the HMOs use interoperable medical information systems [16] which are capable of sharing electronic medical records, information about health care services, etc.

In England, there exists a broadband network, the Health and Social Care Network (HSCN)(https://digital.nhs.uk/services/health-and-social-care-network), which connects all health and care organizations of the English National Health Service (NHS). The infrastructure is used in coordinating health and social care services through reliable exchange of medical information.

There has been significant increase in the number of telemedicine projects in different countries as the systems have become more user friendly and easily deployable. They are designed and developed using internet protocols and web technology. Their costs have been drastically reduced, as they could be accessed by standard internet browsers from remote locations and be hosted in cloud servers. Further, penetration of smart phones in our society and availability of highband width wireless data services, are accelerating the process. Various useful mobile apps are increasingly being reported [16]. A few typical initiatives on using telemedicine for running specialized health care services during this period are discussed below.

Brazil runs a national telehealth program Telessaude (www.telessaudebrasil.org.br) Since 2005, Brazilian universalized public healthcare system (SUS)[17], have been running tele-health care services on a state-wide network using a telemedicine system, called the Santa Catarina State Integrated Telemedicine and Telehealth System (STT).The Santa Catarina State Health Department(SES/SC) and the Federal University of Santa Catarina (UFSC) collaborated to develop the system. The services include remote diagnoses on several specialties such as, electrocardiography, dermatology, electroencephalography, radiology, etc. Later the system was integrated with a PACS system, which significantly increased its utilization. There have been also two other public telemedicine programs running since 2006 [18]. The Ministry of Health (MOH) launched the Brazilian National Telehealth Network Program and the Ministry of Science, Technology and Innovation started the RUTE-Telemedicine University Network to deploy telemedicine across Brazil. In a major initiative in 2006, physicians in Parintins, situated in the middle of the Amazon, telemedicine consultations between the local physicians and specialists in Sao Paulo have been started, and the program continues till date. For building necessary data communication infrastructure (e.g. WIMAX network), private technology companies, including Intel, were involved. In another major initiative the Brazilian MOH started tele-ICU programs to connect many hospitals in different regions with the rural parts of the country. The program reduced the need of transportation of patients to cities for health conditions such as heart attacks, strokes, and sepsis. It is possible for the physicians in urban areas to use PTZ cameras for visually inspecting a patient, and also to use telemedicine platforms to collect and interpret vital signs in real-time. The technology and software for virtual ICUs were mostly provided by Cerner, in partnership with Brazilian companies Intensicare and IMFtec. However, telemedicine is restricted as a consultation among healthcare service providers, as the doctors are not legally allowed to visit patients through video conferencing systems [19].

In other countries of Latin America, there are various initiatives for running telemedicine program[20] For example, in Mexico, healthcare services to employees in formal sector are provided by the social security network, which is facilitated by telemedicine services by private companies such as Lumed Health(http://www.lumedhealth.com/). There are also arrangements for performing telemedicine consultations among the physicians in the U.S. and Mexico with health systems such as the Mayo Clinic and Massachusetts General. In Chile, various projects on telemedicine are being executed. For example, AccuHealth (https://www.accuhealth.cl/), a Chilean company provides tele-monitoring services specifically to patients suffering from chronic conditions requiring home care. In Peru, a fiber optics network has been built by the Government across the entire country (www.proinversion.gob.pe/RedDorsal/) for supporting telemedicine services. In Argentina, the MOH and the Ministry of Federal Planning, and Public Investment launched the Cyber Health Project for installation of fiber optics and facilitating hospitals with videoconferencing systems.

The Young Adult and Family Center under Department of Psychiatry of Univ. of California, San Francisco (UCSF), USA, is running a telemedicine program to help young adults and adolescents suffering from mental health. (www.psych.ucsf.edu/telemedicine-project). For running these services, the center used various internet based technologies, text messaging, chats, video conferencing, and social media platforms, such as Facebook.

In another interesting application of telemedicine, a wearable smart garment has been designed and developed for the home monitoring of cardiac patients[21].There were devices monitoring ECG, respiration, and movement of a patient fitted with the garment. At the point of care using a touchscreen interface, captured signals were stored and analysed. The same digitized data were also sent to three cardiologists via email with the help of a universal mobile telecommunications system (UMTS) dongle. In a pilot study for a month, every day three patients participated in 3-minute tele-monitoring sessions using the platform. It has been observed that the system was effective in transmitting good quality of data for tele-monitoring.

In 2018, World Health Organisation has come up with clear definition for Digital Health Interventions(DHI) and its components.[54] Telemedicine is identified as a fast-evolving component of DHI which will impact the healthcare delivery system of lifestyle diseases[55] and infectious diseases in the recent future.[56] The report defines telemedicine as the provision of healthcare services at a distance. The telemedicine interventions are further grouped under the following four tiers.

- Consultations between remote client and service provider
- Remote monitoring of client health or diagnostic data by provider
- Transmission of medical data to provider
- Consultations for case management between healthcare providers

Effect of COVID-19 on telemedicine practices in different countries are mentioned in table 3 below

Table 3: Effect of COVID-19 on telemedicine practices in different countries

Country	Existence of Legal Regulations		Technology used	Comments	
	Before	After		Barriers	Changes and requirements
Europe					
Italy	Yes	Yes	Video Consultations	Lack of patient training, lack of familiarity with technology. Request written informed consent prior to video-consultation.	There are new initiatives on telemedicine in some institutions.
Netherlands	No	Yes	Phone calls., video-conferencing	Concerns for privacy and lack of experience and knowledge by care givers and patients.	Follow-up appointments taking place by phone. Video conferencing mostly taking place using Zaurus system integrated on Epic.
Spain	No	Yes	Phone calls. WhatsApp, Video conferencing through Skype Professional	Lack of experience and knowledge by care givers and patients	Follow-up appointments taking place by phone.
UK, Ireland	No	Yes	Phone calls	Lack of experience by patient/carers in using technically advanced platforms.	National policy on telemedicine may require revision to meet demand an infrastructural limitations.

America					
Argentina	No	Yes	Phone calls, emails, video visits using Skype, Zoom. WhatsApp, Doctor teleconsultation, Hangouts etc, Various hospital specific telemedicine platform used.	Lack of experience and knowledge by care givers and patients and technical limitations. Lack reimbursement for email or phone visits.	Increasing telemedicine practices even initiated for the first time in some locations during pandemic.
Canada	Yes	Yes	In some provinces such as Alberta, Manitoba and Ontario telemedicine studios with experienced coordinator providing services. In Ontario, only through Ontario Telemedicine Network systems platform services are provided. In Quebec, there are options of using three telemedicine software or simple telephone.	No major barriers but challenging for providing services to elderly patients. In the state Nova Scotia, the service is limited and also it suffers form and poor reimbursement policy.	Telemedicine decreased in Ontario and Alberta, as telemedicine centers were closed down, until relaxation of legislation to allow other software platforms and telemedicine could continue. Improvement in reimbursement in Nova Scotia was observed during pandemic and an enhanced COVID-19 telemedicine fee is taking place in Ontario. Only licensed physician can perform telemedicine visits, though there are Some variations by province

Chile	Yes	Yes	Video visits through teladoc	Limited by technical infrastructure.	
Colombia	Yes	Yes	Phone calls, video visits using Webex and, Microsoft teams	Limited by technical infrastructure, and reluctance of patients.	Increased regulation during pandemic encouraging to convert office visits converted to video visits. Expenses are also reimbursed at the same rate. High patient satisfaction observed, and physicians appreciating physician protection from infection risk while teleworking.
Cuba	No	Yes	Phone calls, Video visits, and Whatsup.	Limited by technical infrastructure and cos of availing services.	Increase in activities during pandemic observed.
Dominican Republic	Unk nown	No	Text messages	Limited by technical infrastructure	No changes due to pandemic.
El Salvador	No	Yes	Video visits using systems such as Doxy.me.	and availability of trained manpower.	No changes due to pandemic.
Guatemala	No	Yes	Video visits and phone calls	Reluctance of patients due to concerns for privacy.	New initiatives of Government to develop and regulate the use of telemedicine.
Hondurus	No	Yes	Text messages	Limited by technical infrastructure.	
Mexico	Yes	Yes	Video visits using systems such as Webex	Reluctance of patients.	
Paraguay	Not Kno wn	Yes	Video visits, Whatsup	Limited by technical infrastructure	Limited by technical infrastructure
Peru	Yes	Yes	Emails		Increasing efforts in bringing regulations for running telemedicine

					services during the pandemic.
Puerto Rico	Yes	Yes	Emails, Phone Calls,	Limited by technical infrastructure and availability of trained manpower. Poor reimbursement and high cost. Patients are also reluctant due to concern of privacy.	Usually certifications are required to run services and business. However, during pandemic these rules are eased out, allowing Insurance companies to reimburse telemedicine visits equivalent to office visits.
Uruguay	No	Yes	Phone calls, email, WhatsApp, though not regularly used. There are some telemedicine platforms used by a few private healthcare service providers.	Privacy concerns and limited by technical infrastructure and availability of trained manpower.	The crisis changed acceptance from patients. A new law was recently passed to regulate and increase telemedicine development.
USA	Yes	Yes	Video visits, phone calls, emails, asynchronous consults	Issues such as reimbursement, access of technology, and lack of trained man power.	Looser restrictions due to pandemic. Telemedicine for new patients and phone call visits allowed, and reimbursed similar to office visits by Medicare and private insurers.
Asia and Australia					

Australia	Yes	Yes	Mostly patients in remote places and nursing homes treated by phone calls, video conferences, emails, or using telemedicine platforms, e.g., in NSW, My virtual care,and e-health, PEXIP, approved by NSW health and academy of clinical innovation, in Victoria a proprietary platform produced for state government hospitals used. For videoconference in private practice Skype, and Zoom used.	To some extent lack of trained man power and barrier in using technology by patients and health workers. Only limited examination carried out, privacy/ safety issues.	Due to COVID-19 pandemic Government introduced new billing codes (item numbers) introduced and also allowed teleconference for all appointments if patients or doctor met certain high risk criteria. National regulations recommend recording patient consent. During pandemic, more than 90% of outpatient services moved to telehealth. .
China	Yes	Yes	Services provided through internet hospitals, specifically approved for telemedicine, through WeChat with text message, and videoconferencing.	Number on internet hospitals inadequate and insurance coverage not sufficient.	

Israel	Yes	Yes	Video conferencing, Zoom, email (Foxit) used in telemedicine clinics. During the COVID-19 pandemic, in absence of telemedicine infrastructure phone calls or WhatsApp messaging systems are used.	Reimbursement of expenses by insurance company not fully streamlined. A significant portion of populations not having smartphone access. Demotivation from users with high expectations on services.	Local care requires Israeli license. With global private professional insurance coverage can provide care to most countries. Need for training with technology and televisits.
Japan	No	Yes	Juntendo University Hospital in Tokyo has been running telemedicine since 2017 using iPad.	Too restricted by using expensive iPAD, could only carry out limited examination, and concerns for privacy of patients.	Due to pandemic rules are relaxed by arranging free use of Web based apps through IBM, and also allowing telephones for telemedicine in Tokyo, Fukuoka and other areas. Japanese government reimburses telemedicine by insurance but this is insufficient. Though telemedicine services were mostly absent before pandemic, telemedicine for Medical Information Systems). Telemedicine first recognized in 1997 by the Health Policy Bureau Director of the Ministry of Health and Welfare. In 2018, National Telemedicine Guidelines issued by the Ministry of Health, Labor and Welfare.

New Zealand	No	Yes	Services provided by various means such as phone calls, emails, text messages, Videoconferences,etc.. For stroke patients Polycom videoconferencing system used, for regular consultation – phone calls, Zoom, Facetime, WhatsApp, etc. used	In some areas, internet services not adequate, concerns of privacy of patients, lack of trained man power and challenging to provide service to elderly patients.	Absence of formal guidelines, and regulations at present, however there may be changes in the policy. Pandemic forces to offer remote care services in spite of adherence to privacy rules may not be strictly followed. Though telemedicine was not allowed in general before pandemic, for stroke patients it was allowed.
Pakistan	No	Yes	Emails, phone calls, or personal WhatsApp.	Lack of reimbursement	
Saudi Arabia	Yes	Yes	Mobile App such as Seha, Phone calls, video calls in tertiary centers.	Limited technical infrastructure, concerns of privacy, difficult to provide service to elderly patients.	Physicians need to have a license for providing services. Telemedicine covered by insurance.
Singapore	Yes	Yes	At least from 2015, telephone and asynchronous consultations via emails and text messaging have been in use in 1 institution.	Slow bandwidth, difficult to cover older population.	National Telemedicine Guidelines issued by Ministry of Health in 2015, are under revision. Earlier, only consultations for follow-up patients only allowed and no teleconsultation on first visits. But pandemic forced to loosen bureaucratic red tape. A 2-hour e-learning

			Through a contract with the national telecommunications Zoom being used maintaining stipulated data privacy standards, such as PDPA (Personal Data Protection Act).		module on telemedicine is prepared by the Ministry of Health prepared. For patients suffering from chronic diseases, Chronic disease management program (CDMP) guidelines followed and chronic conditions seen over video. The payment is the same as face-to-face consult, but patients are entitled to means-tested s ubsidies. Patients suffering from MDS unable to use government insurance/ health policy scheme (3 Ms), as neurological conditions are not included listed for government exception.
South Korea	No	Yes	Phone calls.	Limited by phone calls and lack of trained man power.	Illegal before COVID-19, and only telemedicine for research used with approval before pandemic. But now temporarily allowed, only for established patients.
Taiwan	Yes	Yes	Various modalities used as per convenience of patients and caregivers.	Limited infrastructure in rural areas, and challenging for geriatric patients and rural areas.	Ministry of Health and Welfare set rules for diagnosis and treatment by telecommunications, and later expanded to use telemedicine for home quarantine and stable chronically ill patients
Thailand	Yes	Yes	Phone call used first followed by video call with Zoom or 'LINE' (messenger app similar to WhatsApp).	Lack of trained man power, challenging to cover elderly patients.	During pandemic patients prefer not to come to the hospital, and Telemedicine used for home quarantine patients. It is required to take patient's consent.

Africa					
Cameroon	No	Yes	Phone calls, emails, Skype, WhatsApp, and other teleconferencing systems.	Lack of trained manpower, and lack of motivation of doctors.	
Egypt	No	Yes	Phone calls, WhatsApp, Zoom, Facebook	Poor internet connections and lack of trained manpower, low acceptability from patients.	
Ethiopia	Yes	Yes	Tele–neurology teaching program running with patient consent.	Poor infrastructure and internet services.	
Ghana	No	Yes	Phone calls and WhatsApp	Poor access of internet, concerns for privacy/confidentiality, time constraints of physicians	No change due to pandemic.
Morocco	No	Yes	Phone calls, video visits, sending radiology and laboratory results via photos, WhatsApp.	Poor infrastructure and absence of a national telemedicine platform for public services.	

Nigeria	No	Yes	Phone calls, SMS messages, WhatsApp, video conferences, video chat.	Poor infrastructure, cost of data communication high, low initiatives of Government, lack of confidence from patients,	During pandemic, increasing efforts by Government as well as privately run hospitals by offering telehealth services through dedicated phone numbers to contact physicians, scheduling appointments and electronic reviewing. In some states, for primary care consultations 24 hour remote visit service launched for residents via voice and video call using toll-free numbers in English and other local languages. Private hospitals launched also paid services through various platforms (telephone, Zoom, WhatsApp, and other video conferencing apps).
South Africa	No	Yes	Consultations mostly by phone calls, and sometimes through emails, text messages and video conferencing using systems such as Skype.	Limited in use for only established patients for basic follow up.	During pandemic, guidelines on ethics and medicolegal issues made available.
Tanzania	Yes	Yes	WhatsApp, text messages. And video conferences.	Poor internet availability in remote areas or phones with WhatsApp, lack of trained manpower, concern for breaching privacy and confidentiality	

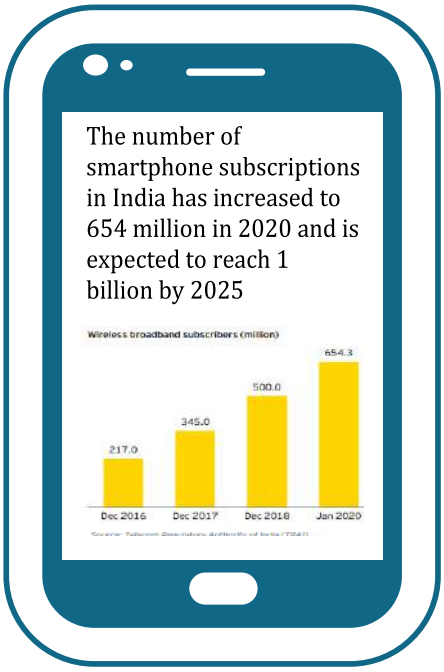
Tunisia	Yes	Yes	Emails, text messages, and video conferences.	Limited infrastructure	No changes due to pandemic. Only private practitioners allowed to use platforms offered by private companies.
Zambia	Yes	Yes	Phone calls, emails, Whatapp and video confrences.	Lack of organization training, and motivation of doctors	Legal regulations in the main tertiary hospital in Lusaka existing before pandemic.

Table 3: Effect of COVID-19 on telemedicine practices in different countries

4. GROWTH DRIVERS AND TECHNOLOGY TRENDS

Drivers of Growth :

- COVID 19 : Societal demand
- Higher mobile and Internet penetration
- Government Policies
- Advanced and Emerging Technologies
- Role of Private players
- Accessibility, Affordability and Convenience



4.1 COVID-19 Pandemic And Telemedicine

The reigning COVID-19 pandemic has made the frontline health workers, medical professionals and doctors the most vulnerable in getting infected by the SARS-COV-2 virus. A number of doctors and health workers across the countries died due to this disease. Many of them though recovered, needed to be rested for a long period. This worsened the situation, as the loss and absence of highly skilled and specialized medical professionals, affected the health care services significantly. The risk of exposures forced many hospitals and health care units to cut down their services to patients across various disciplines. Under this scenario, telemedicine is considered to be essential for managing patients, wherever possible. The acceptability of telemedicine practice for clinical consultation has been increased many folds, and in various countries regulations in running these services legally and identifying the roles and accountability of care providers are placed removing the existing barriers of grey zones of legal implications. This has been considered as a boon in disguise as commented by the medical director of Parkinson's Foundation in USA [22], that they had been fighting for getting telemedicine approved for a decade in treating the Parkinson's disease, but could not make any headway. However, COVID-19 could accomplish to bring necessary regulatory changes in ten days only. Similar examples could be cited in many other countries, in UK, prior to pandemic, telemedicine was non existent [23], but the National Health Service (NHS) quickly adopted the telelmedicine solutions as an alternative to face-to-face consultation at its onset [24]. In USA the multisite Mayo Clinic, which is the largest healthcare system in the country handling 1.2 million patients annually, has seen 10880% increase of video calls for treating patients at home through their digital healthcare services [25]during March-April, 2020. On the other hand, they had drastic reduction of in-patient visits (approx.. 78%) in the same period. In Brazil, the Ministry of Health brought an ordinance on 20th March, 2020, to regulate Telemedicine and use it on an exceptional and temporary basis for treating patients during pandemic. In the State of Sao Paulo, the State Department of Health, initiated a Tele-ICU project connecting ninteen

hospitals establishing a network of respiratory ICUs for remote monitoring 567 beds under the project [26]. The training of the staff is being also provided using the network. In South Africa, the Health Professions Council of South Africa (HPCSA) amended its guidelines of telemedicine during this period [27].

The physicians also felt the urgency of using technology for carrying out remote consultation under this situation, though many of them did not have any prior training on using the technology for the said purpose. In a survey conducted in UK among 114 health professionals (84% doctors) [28] during May last year, it is observed that 95% of the respondents did not have any prior training.

The patients are also more willing to use telemedicine services in the present situation and they are also finding them satisfactory in most cases. In a study [29] on the effectiveness of teleurology in the Department of urology at the hospital attached to the University La Paz, Madrid during March-April 2020, 200 patients participated in a survey over telephone. 61.5% respondents considered teleconsultation was effective, and according to physicians 72% cases were effectively treated through such consultations. It is expected with the increasing confidence of patients as well as physicians on telemedicine, the services will continue even after the end of this pandemic. In Israel a web-based survey[30] was carried out over 169 primary care paediatric physicians on the use of telemedicine during May, 2020. It has been observed that in the prepandemic period, only 24%, 15% and 1% of the respondents used text messages, images, and video clips. But during the pandemic, there were significant increases of the numbers of physicians for availing these services for the treatment. The fractions of physicians availing these services are 40%, 40% and 12%, respectively. The respondents expected that in the post-pandemic period, there will be decreasing use of text messages, though the use of video clips would keep increasing. A similar survey [31] was conducted in Germany on practice of telemedicine for paediatric surgery from June 2020 to October, 2020. It is observed that 21% of all the paediatric surgery departments provided telemedicine, out of which 57% started these services during this period. 48% patients felt that telemedicine is as good as traditional consultation, and 33% considered it is worse. Overall there is a high degree of acceptability of telemedicine of patients as well as doctors and it is expected that similar services will continue even after the pandemic is over.

In Table 3, a summary of states of affairs with reference to management of patients suffering from movement disorders in various countries is presented from [32]. Though it considers treatment of patients having movement disorders, there are generic observations on the states of affairs during pre-pandemic and the present period of ongoing pandemic. The study was carried out on forty countries around the globe (10 from Africa, 11 from Asia and Australia, 4 from Europe and 15 from America). It is observed that before the emergence of COVID-19 about 50% of the countries (Africa: 60%, Asia and Australia: 36%, America: 50%, Europe: 75%) did not have any regulations on running telemedicine services, though these

were run in many cases following conventional laws and rules of medical practice. But at the onset of the pandemic within three to four months, except one country, all other countries have brought forward rules and regulations for providing legal status to these services and to acknowledge a telemedicine service as another form of medical practice and healthcare service subject to the satisfaction of guidelines stipulated by respective Government agencies. Even in most cases, considering the emergency in using such services, established rules of ensuring privacy and confidentiality of patient are relaxed and conventional video conferencing and messaging platforms., are used for clinical consultation. For example, in USA healthcare service providers may now use apps, such as FaceTime, Zoom, Skype, etc., which are not fully compliant to Healt Insurance Portability Act of 1996 (HIPAA)[33].These have led to increasing uses of telemedicine across the globe. The study also revealed that though technology advanced considerably and made it possible to provide telemedicine services at the point of care with high quality video, audio and data transmission and their rendering at remote ends, many countries, including economically advanced ones, suffer from mass penetration of the boon of this advancement. There is a significant gap in infrastructure for running and supporting these services in rural and semi-urban areas. There are also other generic challenges to overcome in implementing telemedicine programs nationally such as, availability of trained man power, providing services to elderly people aswell as replacement of look and feel experiences of physical examinations etc.

4.2 Technology Trends & Emerging Technologies

In modern times technology is the primary driver of functionality in human society. The development of cutting edge technology such as Artificial Intelligence , Augmented reality, Virtual reality etc has actually enhanced the way we perform task in recent past. At the same time, the evolvement of digital platforms, mobile and e-healthcare technologies are leading to generate huge volume of data. Availability of huge volume of digital health records will lead to the emergence of advanced IT tools like Artificial Intelligence , Machine Learning , Big Data analytics and also the technologies like Blockchain to secure the transfer of data. **Artificial Intelligence and Machine learning** will help doctors to make faster and more accurate decision about patient's health. **Blockchain** technologies provide highly secure data transfers and data storage, which is paramount for healthcare apps that store sensitive patient data. **Internet of Medical Things** (IoMT**)** is one of the key enabler in connecting the various medical devices using communication technologies and wireless networks. IoMT is an ecosystem of smart devices like monitoring systems, sensor machines, and detectors that can capture real-time health information and can communicate with each other in a real-time environment and convey results. The IoT health monitoring system involves three major functions:

a. Identification and authentication
b. Sensing and Data collection
c. Tracking an object or patient

IoMT has devices which have intelligence and can collect data intelligently; they can process this data and send it to the network. It offers the following advantages to its users:

a. Fast computation
b. Easy to understand and analyze
c. Easy to implement
d. Widely deployed and better industry support

On the other hand, the need for the concept of health-cloud has emerged. Cloud computing is one of the enabler which provides the facility to access shared resources and common infrastructure in a ubiquitous manner, it also offers, services on demand over the network to perform operations in electronic healthcare application.

India has witnessed a rapid penetration of smartphones and internet over the last decade or so. An thereforethe adoption of e- health / Telemedicine by wider range of people in India is not so far.

The need to collect, store, and analyze patient data has driven the healthcare industry to embrace various trending digital technologies. Mobile telemedicine is a new and evolving area of wherein cellular systems has significantly enhanced telemedicine services through the creation of a flexible and heterogeneous network, and improved the quality, availability, and effectiveness of telemedicine. However, the integration of emerging wireless solutions into healthcare through mobile devices leads to several challenges, like data storage and management (e.g., physical storage issues, availability and maintenance), interoperability, security and privacy, unified and ubiquitous access.

While , telemedicine helps in capturing the information and providing appropriate health advice immediately. GIS, can help model spread of diseases through satellite imagery by isolating areas that are more susceptible to the disease spread and analyze health related events in a wider perspective. Information gathering using GIS tools will lead to understand the outbreak of an emerging infection in the region or locality and hence can be prevented / control / better managed.

Some of the future trends that will emerge through the integration of ICT tools and digitized health data are - analyzing patient's health record to enable remote diagnosis, early diagnosis of disease through the use of data mining of digital records, AI and ML tools which will analyse and provide valuable insights in decision making .Remote health monitoring and delivery of services efficiently, like performing tele-surgery using robots for a patient situated in a remote area by a very specialized doctor using virtual augmented reality and also to attend many other medical emergencies through the use of Virtual doctor, chatbots, and online patient engagement tools using inter-device and inter-system communication through the use of Internet of Medical Things (IoMT) are some of the applications which will empower the health care system to be efficient , connected and cost effective.

4.3 Telehealth - Future Trend

Key factors driving the futuristic telehealth trends:
Inclusive telemedicine ensuring accessibility of telemedicine for specially abled people as well – efforts are on at WHO-ITU and Nossal Institute of Global Health

- Advanced mobile telecommunication network e.g. 5G facilitating good quality videoconference and large data exchange
- National Health Authority laying policy and practice guidelines
- Personal Data Protection Bill will be in place
- Business Model getting matured, Start ups are being encouraged and incentivised by Government
- Telehealth business models are coming up in areas of remote monitoring of health , mobile based apps supplying drugs at door steps, facilitating doctor appointments, diagnostics. With respect to the tele digital devices and services following are the future trends :-

  - Product intelligence
  - Energy efficient
  - Miniaturization
  - BigData Analytics
  - Data Privacy & Security
  - Cloud based platforms
  - Standards (interoperable)
  - Portable wearable sensor based devices (IoT)- internet based
  - Connected / Networked
  - Mobile broadband

Eric Topol, in his books, provokingly state that the continued use of ICT in healthcare will end up in the creative destruction of middle-level hospitals and will end up in extreme patient empowerment[57], to the extent of flipping the doctor-patient power dynamics [57, 58]. Along with Ray Dorsey, he had predicted in 2016 that telemedicine would become famous, not for its ability to expand access, but for the ease/comfort of getting medical advice and reducing the cost of healthcare[59]. Increasing adoption of open international standards like Health Level Seven(HL7) and Digital Imaging and Communications in Medicine (DICOM), and the use of international codes like Systematized Nomenclature of Medicine - Clinical Terms (SNOMED-CT) and Logical Objection Identifiers, Names and Codes (LOINC) in the upcoming Electronic Health Records (EMR) have enabled interaction

of the many Free and Open Source Software (FOSS) and Of the shelf proprietary groups of EMR to speak to each other[60]. This installed base and the potential data analytics of the resultant digital health database will pave the way for increased telemedicine in the future[61, 62].The next-generation internet (5G) is sure to strengthen telemedicine's odds; however, the genuine concerns on its health hazards should not be overlooked[63].

5. TELEMEDICINE – APPLICATION AREAS

Geographical inequity in healthcare access is an age-old problem in every human society, though its magnitude and impact are more harmful in developing countries. It is a relative phenomenon that is highly context-specific and has a myriad of causes and effects. Apart from the inability to pay, the primary reason for this inequity, the other significant hurdle is the lack of threshold numbers for the healthcare business to sustain itself in sparsely (though relative) populated areas. The inequity in accessing healthcare is much evident in rural India despite the flurry of urbanization (though appallingly unplanned) initiatives.

In recent decades, the world has witnessed an unprecedented increase in the use of information and communication technologies, thanks to the dwindling costs of the hardware and availability of many free and open-source software solutions. As in other technological innovations, the medical industry adopted the new potentials to improve efficiency and extend its reach to more areas. The emergence of telemedicine and telehealth services should be seen in this context. This somewhat tardy progression mainly benefited the wealthy, young urbanites, as with any new technological adaptation. The recent Covid-19 pandemic has necessitated telemedicine in many countries, including the USA, which has enacted supportive legislation to improve access[64]. Many of the earlier apprehensions of losing the patient touch due to the technocentric approach have given way to the fast adaption of the technology[65]. Adaptation of the Telemedicine Practice Guidelines by the Government of India in March 2020(The Gazette of India, Extraordinary, Part III-Section 4, No.174) has opened up a flurry of activities in this line in the country. [66]

5.1 Telesurgery

Telesurgery is the integration of state-of-the-art technologies like virtual reality, haptics, 3-dimensional simulation techniques, and networking technologies. Telemedicine applications and emerging technologies like telementoring, teleproctoring, telepresence, and telerobotics fall under its domain.

Telesurgery has not only established itself as a procedurally possible technology but has also proved to be feasible, safe, useful, and highly promising. Inspired by avionics, applications of haptics surgical training simulators are replacing traditional surgical training procedures. This helps medical professionals not only by saving time, cost, and efforts but also by reducing the need to use animals and cadavers for evident advantages. [114]

5.2 Telemedicine and clinical services in India

The swift enactment of the Telemedicine Practice Guidelines(TPG) [66] in India has resulted in a quantum jump in telemedicine consultations. However, it was primarily driven by the dire need for medical consultation, wherein both the medical professionals and the healthcare seekers were afraid to come together due to the scare of Covid-19. Most of these encounters are only telephonic conversations, which was necessary due to the embargo on

intra-state or inter-state travel. Nevertheless, the very fact that people could realize their clinical needs without any physical proximity is a new experience for many in India. It has generated an interest in telemedicine adaptation in the country, and the experience was similar in other parts of the world[67]. The recent announcement of launching the National Digital Health Mission (NDHM) and its initiative to create cloud-based electronic health records for the citizens will further boost India's telemedicine uptake.

The champions of telemedicine in the public sector in India are three prominent institutes like the All India Institute of Medical Sciences(AIIMS)-New Delhi, the Sanjay Gandhi Post Graduate Institute for Medical Sciences (SGPGIMS)-Lucknow, and the Post Graduate Institute of Medical Education and Research (PGIMER)-Chandigarh. [68, 69] Almost all major private health establishments, including the Appollo group of hospitals, Fortis Health International, Amrita Institute, Narayana Hrudulaya, also had harnessed the new technology to expand and extend their services. [70] The Indian Space Research Organisation (ISRO), the Centre for Development of Advanced Computing (C-DAC), and the Department of Information Technology (DIT) provided the connectivity and technical support, respectively. The Taskforce on Telemedicine consituted in the year 2005, also gave an impetus to the movement. . IIT Kharagpur has also taken the lead in moving forward the technology development and its deployment in several Government hospitals in West Bengal and Tripura. The common pieces of equipment of the referral centre are depicted in Figure 9.

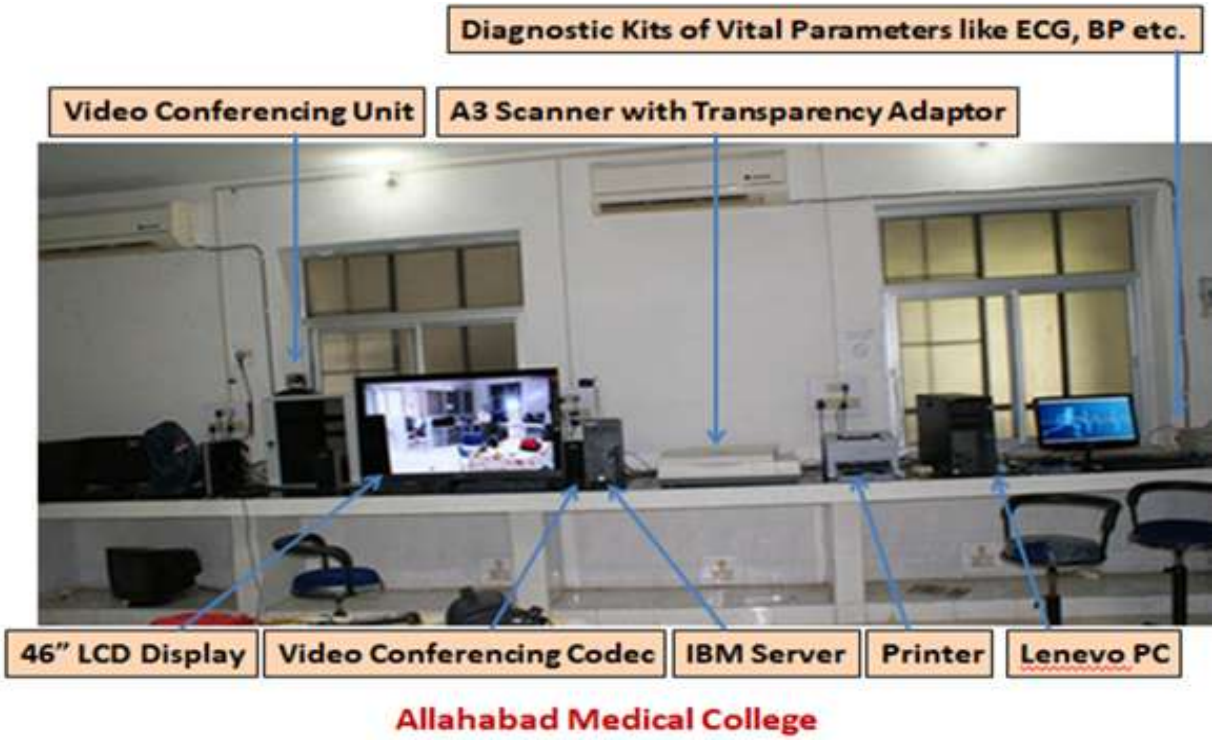


Figure 9 Infrastructure requirements at a Telemedicine referral centre

There are many remarkable examples of the use of telemedicine for clinical consultations in India. Bansal et al. have demonstrated the utility of telemedicine in the follow up of surgical patients[71] in India, and Mishra *et al.* have highlighted the advantages of telemedicine follow up of thyroidectomy patients over the conventional face to face interaction. [72] Another remarkable feat in the early crusades of telemedicine services in the country is the successful telementoring in surgery wherein a hospital in Kerala was assisted by experts from the SGPGIMS in Lucknow, bridging a distance over 2500 km. [73]

A critical appraisal of the use of telemedicine for clinical services, as given below, would help us to understand the scope and challenges of the Indian initiatives. Srivatsava emphasizes the importance of having a robust electronic medical records (EMR) system in the country[60], and Ateriya et al. elaborate on the need to remove certain legal impediments in establishing telemedicine services in India. [74] Furkhan Ali and colleagues give a graphic description of the need for establishing telepsychiatry services in the country and some of the issues to be addressed for their smooth functioning. [75]

Outpatient clinical consultations were one leading component that the telemedicine services were striving to provide, which were more productive in certain specialities like radiology, dermatology, pathology, etc. The main limiting factor for telemedicine consultation for clinical services is that only a fraction, though a significant fraction in many specialities, could meet their clinical need (medical demand) through such consultations. When a patient approaches a doctor with a clinical/medical problem, the patient should get the needed services to satisfy the clinical need (medical demand). The mere use of Tele conversation might not be sufficient to meet the patient's clinical need [76, 77]. For a successful telemedicine encounter, a competent provider and appropriate pieces of telemedicine equipment for that speciality are essential. The professionals involved in the telemedicine consultation should be adept at eliciting relevant medical history and the needed clinical parameters with the help of the caregiver/the medical auxiliary who is physically available at the patient end. The use of better means of communication, and augmenting verbal with non-verbal cues over virtual meetings, was found to enhance the utility and acceptability of telemedicine services[78].

Another fact is that telemedicine services are governed mainly by socio-structural factors rather than the technology itself. However, due to the undue emphasis on the hardware (technology), telemedicine implementations often neglected the focus on this software (socio-cultural adaptation, including the requisite training required for the providers). Most often, the top-down paternalistic approach of the implementation in most low-middle-income economies provides no window of opportunity for any stakeholder involvement. It is often wrongly pursued that once the technology is in place and a few teleconsultations occur, the program will get institutionalized in the system[79]. Unfortunately, this will not happen, and the undue expectation of the referrals from the periphery will not be a reality, as clearly demonstrated by Wootton in his experiences with the Collegium of Telemedicine Networks[80].

Training or re-training the healthcare providers involved in telemedicine services on deciphering verbal and non-verbal communication cues through video-conferencing interface is also an important consideration as vividly described by Nelson[81]. The adequacy of the telemedicine equipment; and the skill needed to handle those without undue discomfort to the patient are paramount for the program's buy-in [82].

There should be at least three levels of clinical consultations in telemedicine. One patient/caregiver to the provider(nurse/auxiliary staff/basic doctor) [83], provider nurse/basic doctor to a specialist, and basic doctor/specialist to superspecialist). The current emphasis is on the first level (the patient to provider)due to the pressing demands of the Covid-19 situation. Sufficient evidence is mounting on judicious use of telecommunication techniques to bring down the overall healthcare expenses, as demonstrated by the 'telephone first approach' initiative of the NHS, UK[84]. All first-time consultations should strictly follow this referral mechanism to optimize the utilization of the limited human resources. For example, a patient/caregiver directly approaching a specialist/superspecialist for their condition, without first consulting a basic doctor/specialist should be discouraged. However, deviation from this should be allowable for follow-up consultations for chronic diseases[85]. Similarly, care homes for the elderly or similar special need groups manned by trained nurse/auxiliary staff can have different yardsticks rather than sticking to the strict guidelines for referral[86].

In general, studies on patient satisfaction in telemedicine consultations[87]have reported low scores[88]. A definite workflow should be in place to benefit from telemedicine consultations; the availability of a functional electronic medical records (EMR) system, built on open standards, etc., were favourable factors. However, more clear protocols should be in place for society to get benefited from these initiatives.

First, there should be clear criteria set for emergency and elective consultations. The mandate and prerequisites for these two entities should be made clear to the stakeholders, reiterating that telemedicine is not a substitute for a functional healthcare system or a panacea for all ailments. Therefore, it is vital to have a screening/gatekeeping mechanism for selecting telemedicine modes (emergency/elective, real-time/store-and-forward, patient-to-provider/provider-to-provider), etc. A call centre staffed by a few healthcare auxiliary workers will be sufficient for such a gatekeeping mechanism. The call centre health worker can suggest the mode of telemedicine encounter, which could be adopted or even indicate the patient directly approach the hospital if the clinical condition demands so. In chronic disease follow-up, the patient can complete the recommended laboratory investigations before connecting with the specialist.

Telemedicine services were found to be cost-effective in the management of inpatients in the infectious disease department[89, 90] and radiology departments[91], acute care departments, and in self-care[92]. In India, too judicious use of telemedicine technology by the SGPGIMS-Lucknow could wade of a potential cholera outbreak during the Maha Kumbha Mela in Prayag in 2002/03, which is documented by Ayyagiri et al. [93]

The need for a provider-to-provider mode of telemedicine is a hidden health-system challenge to address the age-old issue of limited access to secondary and tertiary health care services in most of the world. The shortage of specialist doctors makes the rural-urban divide in specialist healthcare services more acute in developing countries. The upcoming telemedicine policies should proactively encourage the 'provider-to-provider telemedicine services, which could be highly cost-effective in the long run. The 'provider-to-provider outpatient consultations should be arranged so that they should be beneficial to both the patient and the healthcare system. This includes situations where a nurse/doctor is physically available at the patient end, and the interaction is with another doctor or specialist. This is a professional-to-professional interaction through ICT. In this case, diligent care should be taken in deciding on the pieces of telemedicine equipment to be kept in the peripheral units. One needs more sophisticated pieces of telemedicine equipment for the professional-to-professional telemedicine to get the full potential of the specialist's expertise.

The professionals should be well trained in the use of telemedicine tools and the etiquettes of their usage. India has a dire need for this telemedicine model to bridge its astonishing gap in secondary health care. The dismal figures of the doctor population ratio in rural areas are further skewed in the case of specialists. A thorough clinical workup of the patient, including the relevant laboratory investigations, is mandatory to tap the full potential of specialist advice over ICT. The absence of a prior workup will not provide any substantial advantage for the patient's condition. Therefore, all new patients should ideally have consulted a basic doctor before consulting a specialist over telemedicine; in a nutshell, one needs to follow the referral hierarchy meticulously in telemedicine practice. Unplanned opening up of specialized teleconsultations will end up in creating a specialist-craze in society without any substantial gain. A superspecialist teleconsultation should only be planned in a similar vein after a specialist has seen the patient. Also, one needs to ensure that the telemedicine system has the requisite equipment and tools for telemedicine consultation in that speciality or sub-speciality.

Apart from the above two forms of teleconsultation services, telemedicine is useful for providing healthcare services as homecare by connecting a patient directly to a doctor. Due to COVID-19 pandemic various systems have been developed toward this by embedding audio-video conferencing in the teleconsultation platform and giving direct access to a patient for making appointment and participating in teleconsultation. It is becoming a trend to develop telemedicine system as a part of the Hospital Information Management System (HIMS) for integrating homeare with hospital care. The other form of telemedicine is to carry out community outreach program from a referral center to periphery with the assistance of paramedical staff at those peripheral centers.

The e-Sanjeevini program launched by the Government of India in 2019 turned out to be a handy tool to address the dire need for clinical consultations during the Covid-19 pandemic. [94] BY August 2021, it has crossed one crore teleconsultations and caters to

around 75,000 consultations per day. Both doctor-patient and doctor-doctor types of teleconsultations are being provided through the utility. The *e-Sanjeevini* program; the Ayushman Bharat – Health and Wellness Centers (AB-HWC) that are being rolled out, and the Pradhan Mantri Jan Arogya Yojana (PMJAY) program are definite steps towards our goal of universal health care(UHC). [95]

5.3 Medical Education

Telemedicine, both the real-time and store-and-forward modes, is proved to be one prominent way of consultation in the years to come. Future healthcare professionals, be it doctors or nurses, should be trained in the effective use of ICT for healthcare, as this was identified as a significant hurdle in updating the technology[60]. The curriculum should include its potentials and conduct an excellent medical history taking through video/Tele conversation. Further, the graduate should be taught how to effectively use the remote health auxiliary person for the patient's medical examination over the telemedicine interface. Familiarity with the tools and equipment used in telemedicine should also be accessed in the graduates' competency testing. The broad guidelines are available from WHO can be customized for this purpose. The National Medical Council (NMC) could be expected to formulate further policies for India.

The inclusion of telemedicine in the medical curriculum should be initiated now. However, considering the immediate need to expand telemedicine in the country, short-term in-service training/short courses could be planned for the country's medical and nursing professionals. The SGPGIMS has made the National Resource Centre for Telemedicine in the National Medical College Telemedicine Network in India by the Ministry of Health and Family Welfare in 2010.(Figure. 10)

Figure 10 Telemedicine Hub at SGPGIMS

Telemedicine is a useful tool for Case Based Learning and Problem Based Learning recommended by National Medical Council. The technology can create an interactive scenario between teachers and students using graphic educational tools and resources. Web based knowledge resources are available free or with a minimal financial package. Live surgical procedures are available on the web for learning in a flexible time frame. Ministry of Health & Family Welfare has launched a green field project – National Medical College Network (www.nmcn.in) wherein 50 medical colleges have been equipped with the smart classroom and are networked with high speed internet through National Knowledge Network (www.nkn.in) backbone. Institutional knowledge repositories are created at few medical institutions where students can access master lectures delivered by eminent teachers. [96] Online CME can be made easy to access. During Covid times, all classes in medical institutions are being held online.

Telemedicine is increasingly used for medical education in India. SGPGIMS has a full-fledged set-up for providing continuing medical education (CME) through its telemedicine hub. [96, 97](Figure 2) It has been successful in providing training on radiation oncology [98], telementoring of endocrine surgery[99]. A recent systematic review of the telemedicine initiatives on surgical training in India also has lauded the efforts of SGPGIMSin this regard. [100]

Telestroke has been established as a promising clinical procedure. [101, 102] In India, Misra et al. have proved that teleneurology could be a pragmatic approach to bridge the scarce human resources in this specialized area and train future neurologists. [103, 104]

The Christian Medical College, Vellore, has been successfully running the 'two-year diploma in family medicine' course in the distance education mode, utilizing the facilities of its telemedicine units. [105] Telemedicine utilities are being used in the conduct of virtual conferences in India, as reported by Parthasarathi et al. [106]. Moreover, the perception and attitude of clinicians and teachers towards the use of information communication technologies for medical education is sliding in the positive direction in India too. [107]

Looking at the current trends, it is apparent that telemedicine would be increasingly used in India's medical education areas in the coming years, probably in higher proportions than it is being used in clinical practice.

5.4 Medical Tourism

The advent of electronics and information technology in medical devices / health care has made a meaningful impact on the healthcare system, attracting the tourists from different parts of the world. Medical tourism is increase in India. India is emerging as a preferred as a healthcare destination for neighbouring and far-off countries. Therefore the use of Telemedicine and e-Health tools has the potential to facilitate the exchange of electronic health information between hospitals across the globe. Ministry of External Affairs

deployed telemedicine projects in African subcontinent, SAARC and Central Asia which had facilitated telecare services in particular follow up after initial treatment in India. Many coroporate hospital in India have integrated telemedicine for their overseas clients as a routine.

Connected smartphones coupled with sensors can capture an ever–expanding range of data for disease diagnosis and management. The figure below illustrates that sensors will become highly widespread and collaborate outside the traditional health sector to extract and combine data from medical and non–medical sources. This data along with 5G network and Artificial Intelligence (AI)–based solutions has the potential to offer hyper–personalized healthcare.

5.5 Remote Diagnostics

Recent advances in bedside kits for diagnosis turns out to be highly advantageous for telemedicine services. A primary telemedicine facility should keep the bedside diagnostic kits for endemic ailments for that region. In the Indian situation, a digital glucometer, pulse oximetry meter, pregnancy test kit, etc. could be some of the laboratory aids, and a digital thermometer, digital sphygmomanometer (BP apparatus), digital weighing scale, digital stethoscope, a close examination camera, etc. could be some of the essential pieces of equipment that are needed. Certain specialities need more tools like X-ray digitalization utility or digital X-ray facility, USS scan facility, etc. Superspeciality consultation should be arranged only when the necessary diagnostic or prognostic facility is available in the peripheral telemedicine unit. However, inpatient follow-up, relaxations on the requirement of specific equipment could be made after concurring with the referred specialist.

Figure 11 Multipurpose compact bedside diagnostics

Collaborative Digital Diagnostic System (eCollab DDS) has been developed by National Informatics Centre, which has been integrated with all telemedicine software and Hospital Information Systems. This can enable digital X-rays and other image-based diagnostics to be integrated with clinical information and laboratory diagnostic results to transmit complete information about any patient. May private vendors have come up with innovative products, which combine multiple utilities into portable mobile units. (Figure 11) The advances in nanotechnology and the availability of numerous rapid test kits would help quickly adapt such diagnostics in telemedicine practices in India. The rapidly improving transportation facilities in the country and emergence of successful business models of centralized laboratories, as in the case of Thyrocare Technologies Limited, would be a favourable factor for the crusade of meaningful teleconsultations in the future in India. [108].

5.6 Home care and outreach

The most revered advantage of telemedicine lies in its potential for providing domiciliary care. Even in its very rudimentary mode, the enormous utility of telemedicine services during the Covid-19 pandemic is evidenced both in the developed and developing world[109]. Contrary to the apprehensions, this model of care was quite popular, in many places globally, including interior rural areas in India, during the Covid-19 pandemic. The timely enactment of the liberal Telemedicine Practice Guidelines (TPG) by Govt. of India(The Gazette of India, Extraordinary, Part III-Section 4, No.174) had boosted the practice, despite its appalling disregard for privacy and confidentiality concerns. What comes evident is the need for such an interface, where people can seek healthcare without stepping out from their households. In the UK and other developed nations, dedicated video-conferencing platforms are already integrated with their EMR. The Veterans Hospitals in the USA has come up with clear guidelines on which all patients could avail themselves of the various telemedicine services[110]

The homecare model should be arranged based on its potential utility. Directly linking the patient to a doctor or specialist might not be fruitful. The patient or the caregiver should first contact a nurse; after taking a detailed medical history, the nurse should decide whether a doctor can see the patient over telemedicine. Otherwise, the nurse can suggest another management line, like a mobile medical team visiting the patient at home or being transferred to the clinic. This is very important to streamline the patient load. Follow-up cases can directly be connected to their doctor or specialist.

This homecare model is beneficial to the elderly, often bedridden and confronted with almost identical health issues. Based on this initial medical interaction, the nurse/doctor can shift the patient to a care home or send a medical team to the diseased home for any potential minor procedures. This method has the advantage that the nurse/doctor get a glimpse of their client's living situation; even a snapshot of the patient in their home milieu conveys tons of information, helping them customize the care for the client.

Well-coordinated care pathways should be in place, both in the public and private sectors, to get the maximum output for such an intervention. We may need to tweet the health insurance mechanisms to meet such healthcare interventions' expenses, as done in the US, during the Covid-19 pandemic. People can be encouraged to buy long-time health insurance, with a commitment for five or more years, so that preventive and promotive services will become profitable for the insurance companies. Unnecessary hospital admissions can thus be avoided in addition to deter the suffering due to avoidable complications.

Figure 12 Mobile telehealth units in Wayanad managed by SCTIMST.

Hospitals, both in the public and private sectors, should be encouraged to have modular mobile medical teams sent out for home visits with the necessary equipment and professionals. In certain situations, the follow-up care of chronically ill patients could also be offered through this mode. SGPGIMS-Lucknow has successfully implemented many pilot projects wherein the follow-up of surgical patients can effectively be done through telemedicine routes. [71]

They have proven that telemedicine follow-up often would save time and money for the patient and the healthcare provider. [72] There are many successful mobile telemedicine initiatives in the country, including those run by SGPGIMS and the mobile telehealth units of the Sree Chitra Tirunal Institute for Medical Sciences & Technology (SCTIMST), Trivandrum in Wayanad. (Figure 12)

5.7 Telemedicine In Hilly Area

Telemedicine is the most appropriate facility for those living in hilly or remote mountainous areas. With the help of the facility of e-health telemedicine, the patient's diagnosis can be made immediately by the physician's specialist of Multispecialty hospital, and medicines can be ordered. The first telemedicine centre in Uttarakhand was compositely founded in Tehri (2018). Initially, a toll-free number "555" was launched to provide health care services to the rural public in Uttarakhand. Later, it expanded to 20 dispensaries and each telemedicine centre is connected to a video control room situated in the government hospital of Tehri. All centres are well equipped with a medical kit including ECG machine with Wi-Fi ECG recorder, glucometer, pulse oximeter, X-Ray view box and other important equipment, a complete pathological kit along with important medicines and diagnostic facility with portable hot spot, communication and data transfer with the district hospital. These centres are taken care by skilled pharmacists or nurses, specialist doctor at the control room in Baurari District Hospital and for further expert opinion these are connected with AIIMS, Rishikesh.[30] Nainital, is a hilly area with varied topography in the state of Uttrakhand. Patients residing in these areas have no option but to travel to main cities to avail superspeciaity health care services. Thus, making the cost of treatment so expensive for the patients of rural Uttrakhand. Because of challenging conditions of geography of the state, physician is not available in many areas. In this condition, telemedicine facility can be effective for needy population in rural area. Through telemedicine, patient and their relatives who come from remotes area can have easy access to multi-speciality hospitals.[31] Challenges in hilly or remote areas Worldwide, maximum people living in rural and remote areas are struggling to access appropriate and improved health care services. Accessibility of telemedicine helps in remote monitoring, storing and forwarding data and real time interaction between patient and consultants.[32-34] Telemedicine programs mainly depend on optimum internet network, therefore interrupted and poor connection lead to program failure. For succession it must not be interrupted. Expensive instruments and lack of service engineers in rural area pose hindrances in the implementation of tele services leading to underutilization of the services. Due to lack of orientation of use of tele instruments, villagers could not be handle tele equipment independently so privacy issues can evolve.

Lack of capacity building of staff and community is being a hurdle for full utilization of telemedicine services.[6] Expansion of telemedicine centres in rural areas is not easy due to lack of well trained staff in some identified areas where public health facilities still not exist.[33,35] Future possibilities Telemedicine has been effectively used for the betterment of patients while cutting down on healthcare costs. Health policy implementation such as national health protection scheme is one of the World's largest government funded health care programme. National rural telemedicine network is one of the low costs developmental telemedicine projects. The highlights of telemedicine are lower cost and better accessibility of health care services.[36] Currently the ISRO based services could be enhanced by improving mobile services and 4G networking and introducing technical inputs to improve audio-visual quality. Tele service sessions can be made patient approachable like some days in morning, evening and sometimes on weekends, to improve maximum patient and doctor participation. Telemedicine awareness can be created in order to reduce load of hospital OPD. Patients who come to OPD to meet doctors or staff that can be educated about the usage of telemedicine so that follow ups visits can be done by using tele facility at the village. Telemedicine implementation can support epidemiological surveillance by assisting in tracking issues of public health and clarifying trends in future.

6. POLICY ISSUES (REGULATORY COMPLIANCE)

As mentioned briefly in the above section, **Telemedicine Practice Guidelines, 2020** were released by the Ministry of Health and Family Welfare on the 25th March, to enable consultation between medical practitioners and patients remotely. Therefore to encourage incorporating telemedicine in their day to day practice.

The guidelines provide protocols and procedures relating to patient-physician relationship and subsequent privacy and confidentiality issues, the standard of care during the evaluation, prescription of drugs, penalties for negligence, exchange of information; prescribing; and reimbursement; health education and counselling. It also covered the legal aspects of telemedicine to safeguard the patients' interest.

Some of the key directives of the Guidelines are as under:

- **Identification of RMPs and Patient**: The telemedicine practice should not be anonymous and both, the RMP and the patient should know each other's identity. For fulfilling this requirement, the RMP should verify and confirm patient's identity by name, age, address, e-mail ID, contact number or any other identification .

- **Patient Consent for Consultation**: While treating a patient through telemedicine, it is necessary to obtain the consent of the patient, either through e-mail, text or audio/video message. The Guidelines also prescribed for two types of telemedicine consultation, namely, first consult and follow-up consult.

- **Medical Prescription**: The Guidelines prescribe that the concerned RMP will prescribe the medicine to the patient only when the RMP is fully satisfied that he/she has gathered all the essential and relevant information about the patient's medical condition and medicines prescribed are in the best interest of the patient.

- **Medical Ethics, Data Privacy and Confidentiality**: Indian Medical Council (Professional conduct, Etiquette and Ethics) Regulations, 2002 and Information Technology Act, 2000, data protection and privacy laws or any applicable rules notified from time to time for protecting patient privacy and confidentiality as well as handling and transfer of such personal information regarding the patient.

Subsequently Hon'ble Prime Minister of India Shri Narendra Modi announced the **National Digital Health Mission (NDHM)** on 15th August 2020. The objective is to create a national digital health ecosystem that supports universal health coverage in an efficient, accessible, inclusive, affordable, timely and safe manner, that provides a wide-range of data, information and infrastructure services, duly leveraging open, interoperable, standards-based digital systems, and ensures the security, confidentiality and privacy of health-related personal information.

6.1 Standards and Interoperability

Lack of standards and poor interoperability in the healthcare system are some of the longstanding challenge in deployment of ICT based healthcare system (Telemedicine) in India. Standards play a very important role in enabling ubiquitous sharing and accessibility to a larger set of data. This would enable patient records to be used across facilities.

Standards seek to address overarching issues, such as availability, integrity, and confidentiality of health information to enable ubiquitous sharing of medical data, accessibility to a larger subset of data.

Interoperability the other most important entity, allows components of health information systems to interact with each other. Broadly, interoperability provide tools and framework necessary to ensure health care providers from differing locations, specialties, and organizations to work together to provide care and services when and where the patient requires them.

NeHA "National eHealth Policy and Strategy" another initiative of Govt. to promote eHealth adoption, setting up of state health records repositories and health information exchanges (HIEs) to facilitate interoperability, laying down of data management, privacy and security policies, guidelines and health records of patients. There are two main generally accepted concepts / forms of interoperability.

a. **Syntax** – provides a structured format on how the data should be exchanged, it does not care or know about what is being exchanged.

b. **Semantics** – This ensures that the systems understand the data that is being exchanged usually by use of appropriate metadata.

Government of India has taken the initiative and formulated and published an Electronic Health Records (EHR) standard in September 2013 and consequently revised version published on 31st December 2016, with an objective that "A*ny person in India can go to any health service provider/practitioner, any diagnostic centre or any pharmacy and yet be able to access and have fully integrated and always available health records in an electronic format*". For EHR standards, Ministry of Health and Family Welfare (MoHFW) suggested the following standards :

- Systematized Nomenclature of Medicine – Clinical Terms (SNOMED CT) (2016),
- International Classification of Diseases (ICD 11) (2016)
- Logical Observation Identifiers Names and Codes (LOINC) (2016),
- National Drug Code(NDC) (2016)

- Content Exchange Standards (CES)
- Digital Imaging and Communications in Medicine (DICOM) (2016) and
- Health Level-7(HL-7) (2016)

Below table shows some of the of the standards used in India:

Recommended Standard	Purpose
Content & Interoperability Standards	
FHIR Release 4	Structured Clinical Information --Still Images / Documents Audio / Video
DICOM	Diagnostic Images (Radiology including CT, MRI, PET, Nuclear Medicine / US / Pathology), Waveforms (e.g. ECG)
SNOMED CT	All clinical terminology requirements in health
ICD-10	Coding System WHO ICD-10 --for statistical classification of diseases and related
LOINC	(for observation, measurement, test-panels, test items and units)
Standards for Privacy & Security	
TLS / SSL, SHA-256, AES-256	Security Digital Certificate
ISO 22600:2014 Health informatics - Privilege Management and Access Control (Part 1 through 3)	Access Control

Figure-13 : Standards for Electronic health records

Source : Standard electronic health care record for Indian healthcare system , Manohara M. Pai

An Electronic Health Record (EHR) is a collection of various medical records generated during any clinical events. Digitally collected medical records will facilitate better and evidence based care, increasingly accurate and faster diagnosis that translates into better treatment at lower costs of care, translating into improved personal and public health. Subsequently during Oct, 2019, Ministry of Health and Family Welfare (MoHFW) published – National Digital Health Blueprint(NDHB) . The document also recommended /defined the minimum set of standards to be adopted for ensuring interoperability within the National Digital Health Eco-system. Beside defining the standards for content, NDHB also defined the standards required in the major areas of healthcare, e.g. : diagnostic content, terminology and codes for statistics and laboratory tests. Detais of these standards mentioned above are briefly given below:

- **International Classification of Disease (ICD)** : maintained by WHO. The 10th revision (ICD 10) is the one used widely for collecting data regarding morbidity and mortality. Since ICD mainly serves the purpose of collecting information regarding morbidity and mortality, it focuses mainly on the diagnosis part of a medical record .

- **Digital Imaging and Communication in Medicine (DICOM)** Recent years have seen hospitals in India starting to use digital imaging, like the Ultra Sound Scan (USS), digital x-rays, Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Coronary Computed Tomography Angiogram (Coronary CTA). Investigative procedures like Coronary Angiogram and therapeutic procedures such as the laparoscopic apendicectomy are being recorded as digital videos. DICOM is the most commonly used standard for interchanging these radiological images, and now the scope of the standard is expanding to non-radiological images also. The standard supports transfer of images over point-to point and network environment. The standard has now been adopted to transfer clinical information regarding the image along with the image as metadata.

- **Systematized Nomenclature of Medicine – Clinical Terms (SNOMED-CT)** Maintained by IHT SDO, SNOMED CT is declared as a comprehensive and scientifically validated in content by the NHS of UK, it covers most areas of clinical information including disease, diagnosis, procedures and treatment . About 55 countries are the members of this standard including India.

- **Current Procedural Terminology (CPT)** This terminology standard was created by the American Medical Association (AMA) in 1966. It was primarily meant to code diagnostic and therapeutic procedures, but later this was adopted by the USA government for billing and reimbursement purpose. Though limited in scope and depth, this is the most widely used standards in the USA to report physician procedures and services for insurance reimbursement.

- **Logical Observation, Identifiers, Names and Codes (LOINC)** This was created to record data regarding laboratory tests and observations, therefore having the name Laboratory Observations, Identifiers, Names and Codes (LOINC). Now the system also includes non laboratory data like vital signs too. The standard is maintained by Registries Institute, Inc. USA. The standard is freely available for developers.

- **Messaging Standards in Healthcare IT** Health Level 7 (HL7) HL7 is a volunteer based SDO (Standard development organization) with members in more than 55 countries including India. Their data exchange standards are HL7 version 2 and Hl7 version 3, these two are the most widely used data exchange standards in the world Structure of a HL7 V2.

6.2 Standards For Medical Devices

Bureau of Indian Standard has published about 38 standards in the health domain. Currently the regulations in India recognize ISO and IEC international standards for medical devices . In addition to this ISO has also adopted IEEE11073 series of standard. The same is adopted by BIS . The complete list of standards adopted by BIS can be found at://www.services.bis.gov.in:8071/php/BIS/PublishStandards/published/standards.

The rule further states that if there are no relevant standards recommended by BIS, then relevant standards released by the International Organization for Standardization (ISO) or the International Electro Technical Commission (IEC), or by any other pharma standard would need to be followed.

Recently, Union health ministry has issued draft notification on Medical Devices Amendment Rules, 2021 to include American Standard Test Method (ASTM) in product standards for medical devices to enhance competitiveness of indigenous medical devices globally.

6.3 Initiatives Towards Adoption of EHR Standards

Several initiatives have already been taken by the government for the adoption of standards in Indian Healthcare system:

- India has become a member of SNOMED International in April 2014 with a view of widespread adoption of SNOMED CT in the country

- MoH&FW, Govt. of India had set-up **National Resource Centre** (NRCeS) -Centre of Excellence for EHR standards at C-DAC, Pune to accelerate and promote adoption of EHR standards in India. NRC is a single point of contact for assistance in developing, implementing and using EHR standards in India. NRC provides the knowledge base for EHR Standards and associated resources and facilitates acceptance and adherence to entire set of notified EHR Standards for India in healthcare applications (https://www.nrces.in).

- **Interoperable Electronic Health Records** : MoHFW has envisaged establishing a system for interoperable Electronic Health Records (EHRs) of citizens to be created, made available and accessible online to facilitate continuity of care, better affordability and better health outcome and better decision support system. Following initiatives have been undertaken-

➢ **EHR Standards:** (revised version of 2013 Standards) has been notified in December, 2016. The EHR Standards include standards for Disease Classification, Medicine and Clinical terminology, Laboratory Data exchange, Digital Imaging and Communication etc. for semantic interoperability.

➢ **Metadata & Data Standards (MDDS):** To enable semantic interoperability among healthcare applications MDDS standards were developed following the guidelines of Ministry of Electronics and Information Technology (MeitY) and open standards policies of GOI. The MDDS standards have more than 1000 data elements to be used in healthcare applications and are aligned with the global health IT standards. The approved MDDS standards have been notified by MeitY in August, 2018.

➢ **National Identification Number (NIN)**: to Health Facilities in India: a unique identification number, which a key requirement for achieving inter-operability and creation of EHRs, is being assigned to all health facilities (both public & private) to facilitate inter-operability among health IT systems deployed. So far approximately 99% of public health facilities have been allocated NIN. The process for setting up mechanism for allocating NIN to private facilities is underway.

➢ **Hospital Information System (HIS):** HIS is being implemented for computerized registration and capturing EHR/ EMR of patients in Public Health facilities upto PHC level. This will also facilitate workflow management leading to better delivery of services to patients and improvement in efficiency of processes in these facilities. So far, financial assistance provided to 21 States/ UTs for implementation of HIS application. Current status of HIS implementation is as below:

- **eHospital** : Implemented in more than 410 hospitals. The e-Hospital application is being offered as an as-is product to the Government Hospitals across the country through SaaS (Software as a service) model. The modules of e-Hospital application which are currently available on cloud are Patient Registration (OPD & Casualty), IPD (Admission, Discharge & Transfer), Billing, Lab Information System, Radiology Information System, Clinic, Dietary, Laundry, Store & Pharmacy and OT Management. NIC has developed the e-Hospital project with the vision to improve the delivery of healthcare services to the citizens across the country. The e-Hospital project was initiated with the following objectives:

  - To provide the e-Hospital, e-Blood Bank and ORS applications to Government hospitals
  - To provide online patient portal for delivery of citizen centric services like online appointment booking, access to lab reports online and blood availability status
  - To provide application related technical support to the hospitals through dedicated Call Centre/ Helpdesk

- **e-Sushrut (C-DAC Noida):** Implemented in more than 100 hospitals in the States of Maharashtra, Odisha, Punjab, Telangana, Rajasthan and Delhi.

- **National Digital Health Blueprint (NDHB)** The NDHB is an architectural fram work for digital interventions in Health in India and was released in October 2019 with a vision: "To create a National Digital Health Ecosystem that supports Universal Health Coverage (UHC) in an efficient, accessible, inclusive, affordable, timely and safe manner, through provision of a wide-range of data, information and infrastructure services, duly leveraging open, interoperable, standards based digital systems, and ensuring the security, confidentiality and privacy of health-related personal information."

In addition to the security requirement, EHRs are also regulated by country-specific privacy laws. There are few guidelines suggested by the United States of America under the Health Insurance Portability and Accountability Act (HIPAA) (Act 1996). HIPAA defines privacy rules on who has authority to access health information systems and specifies the security measures, including administrative, physical and technical safeguards.

Although India has begun its journey late in the standardization and digitization of health records, several new steps need to be taken up for the successful adoption of EHR. It requires a coordinated effort from all the stakeholders. The security & privacy techniques applied needs to be compliant with national and international regulations and standards.

At present, each hospital has its own way of giving a patient number to each visiting patient, but these are not recognized outside the organization.

In public healthcare institutions, the usage of ICT is limited to billing and registration. The private sector has a limited form of EMR, but it has not yet started the exchange of health information to improve the quality of care. However, the situation is changing due to the efforts being made by the government and industry.

The Ministry of Electronics & IT has been supporting the development and deployment of digital health solutions for a long time. It has deployed telemedicine systems in several states in the country. It has sponsored R&D projects in various areas.

6.4 Challenges in adoption of Standards in India:

Standards prescribed need to be tested and verify that the solutions are interoperable. For example, several IT solutions, which claim to conform to HL7, do not interoperate with each other when they implement optional features of HL7 in different ways. The government should put a mechanism in place to empanel agencies for this purpose.

There are many areas where it may not be possible to mandate standards as it may be a hindrance for innovation. In such cases, there is often the possibility of issuing guidelines for the benefit of stakeholders.

At present, each hospital has its own way of giving a patient number to each visiting patient, but these are not recognized outside the organization. A consensus is needed on how to assign a number to each patient.

7. CHALLENGES

The Govt. of India plan of having the Electronic Health Records (EHR) standards in 2013; the Digital Information Security in Healthcare Act (DISHA) in 2017; and the National Digital Health Mission (NDHM) in 2020; are in the right direction, given in the ever-increasing acceptance of the Unique Identification Authority of India(UIADI) 's Aadhaar card by the citizens. The initiatives mentioned above, along with the Unified Payments Interface (UPI) for a real-time payment system, have created the necessary an installed base in the country to benefit from the enactment of the Telemedicine Practice Guidelines (TPG) released in March 2020, partially in response to the Covid-19 crisis.(Medical Council of India, 2020)

These factors, along with the dire need to extend healthcare services to its vast rural population, with a skewed doctor population ratio and a big rural-urban divide, it is pretty natural that India should strive for enhanced use of telemedicine services. The enactment of similar acts to harness Ayush and Homeopathic systems to the telemedicine umbrella points to the governmental commitment to this initiative. The digital health eco-system suggested by the National Digital Health Mission that evolves along with the society in the spirit of the Social Shaping of Technology (SST) is a definite step in this road[111, 112].

Besides several initiatives[113-116], India is yet to see the seamless countrywide deployment of Telemedicine services. For large-scale implementation of telemedicine in India, it has to work on the issues such as :

- **Infrastructure :**
  - Availability of digital medical records
  - Broadband connectivity
  - 24X7electricity

- **Standardization :**
  - Standardized electronic medical records (EMR)
  - Standardization of medical devices to enable Interfaces to be interoperable to each other for seamless connectivity

- **Data :** Policy for securing personal information w.r.t. confidentiality, authentication, authorization of data etc. is required.

- **Indigenous cloud** to store large scale data

- **Cost effective** indigenous infrastructure and services
- **Lack of Skilled manpower**
- **Equity concerns**

There are inherent concerns that as more healthcare services turn the digital way, the young, educated, and privileged ones inappropriately will get benefitted. There is a dare need for proactive steps to ensure that the illiterate, remote rural folk, and the elderly are not getting side-lined in the process. Due care should be taken for inclusive development, especially in the cases of tribal people, urban slum-dwellers and people in the coastal regions.

The Indian healthcare industry is at the cusp of transformation. The key enablers that are driving this change are rising income levels, shifts in disease mix and demography, increased affordability, accessibility, awareness of health and wellness, and growth of digital technology. Smartphones and data networks connect us better today as compared to a decade ago. Connectivity has become even more important in the current times, particularly to manage uncertainties surrounding COVID–19. India will soon transition to 5G with Long-Term Evolution LTE (4G) accounting for 64% and 5G accounting for 18% of the subscriptions in 202511. 5G is expected to provide better speed, capacity, security and decongest the perpetually strained networks. This may facilitate better connectivity for innovative 5G healthcare applications.

Connectivity: Uninterrupted power and seamless internet connectivity with sufficient bandwidth is a pre-requisite for telemedicine. In remote locations, both inputs are unreliable and back-up in the form of battery/generator may increase operational cost substantially. Technology Adoption: Technology adoption challenges exist both for patients as well as doctors. Customers still prefer a certain amount of human touch/face to face interaction with the care provider. Telemedicine players need time and effort to build trust in the community to overcome this challenge. Human Resource: Providers not only need to enroll doctors to use technology, but recruit and train frontline (nursing or paramedic) staff. Availability of such human resource is a challenge in remote locations. Volume of Profitability: Building patient volume requires upfront investment in awareness generation and marketing. Most providers have been unable to generate volumes of paying customers to achieve profitability across their network. Access to Capital: Both technology as well as service providers need access to patient capital for investment in technology, manpower, capacity building and marketing for expansion.

8. CONCLUSION AND RECOMMENDATIONS

COVID-19 pandemic has stressed the importance and necessity of using telemedicine services and also showed its advantages and limitations to the physicians and patients in medicine and surgery. There are various technological and implementation challenges that we need to overcome to make telemedicine widely applied in our society. The digital communication infrastructure is the need of the hour. There is a great divide between rural and urban areas. As telemedicine could be instrumental in removing this gap greatly in health care sector, it is a must that data communication infrastructure needs to be improved and enhanced. There is also a lack of adequately trained manpower in providing digital health services. Overall, every member of our society should have the economic power and educational background to use this technology using smart phones, etc. This is the core fundamental issue, which cannot be resolved in isolation, unless there is overall progress and prosperity benefitting all sections of our society. The major technological limitation, that a physician felt during remote consultation, is the absence of information, which they acquire during physical examination. Various innovative technological solutions using robotics, novel audio-visual, tactile, and other forms of sensor based instrumentations, are put forward, but they are yet to be matured and tested in real life applications. In spite of all these barriers and bottlenecks, telemedicine has been found to be effective and necessary in today's healthcare services. In 2019, the market size of the telemedicine industry was 45.5 billion USD, which is forecast to grow at Cumulative Annual Growth Rate (CAGR) of 19.3% with a predicted volume of global business around 175.5 billion USD in 2026 [34].

In India, number of smart phone and internet users has increased drastically ,this trend can drive the adoption of telemedicine and other digital technologies in the country.

India can take the advantage of late beginner in the field as compared to other developed countries and hence it has the great opportunity to adopt not only the best practices from the world but also to implement the new and emerging future technologies for various applications in Telemedicine. Indian IT companies need to utilize its strength to develop solutions specific for Indian needs.

8.1 Recommendations

- **Connected Healthcare System**: Need for seamless integration amongst various available platforms and various services required by the patient.

- **Interoperable Standardized Secure Data:** Need for **adoption of standards** like FHIR, DICOM, SNOMED CT etc.

- The **security and privacy** of data need to be compliant with the national and international legal framework.

- Facilitation of **deployment of 5G** and Satellite-based network (LEO) will enable seamless accessibility

- **5G :** Scope for new venture and Telemedicine applications like Telesurgery, Tele ICU will be practiced efficiently.

- **Affordable and efficient** : Need for the **private players and Government to join hands** (PPP).

- **Platform integration:** Hospital to Hospital to Diagnostics to Pharmacy is needed.

- **Integration with homecare:** Telemedicine services from a hospital should have seamless integration with homecare services.

- **Advanced Technologies** (Health 4.0) : Need to **leverage more applications** of : AI , Analytics , IOMT, Cloud , Blockchain , Robotics, Computer vision etc.

- **Ensuring equity**: Care should be taken for inclusive implementation of telemedicine services to ensure that the most deprived sections of the community are not left behind.

- **Use of open source library** : OSL will lead to reduce the cost of deployment of the software for the Telemedicine system.

- **Medical insurance :** Need for the endorsement of Telemedicine with the medical insurance system.

- **TeleHealth standards** to conform with the world standards.

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