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Evolving Role of Telemedicine in Health Care Delivery in India

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Abstract

Introduction: India is the world's largest democratic country, and second most populous country in the world. Despite recent successes in the economic front, India still faces many social challenges like poverty, illiteracy, sanitation, gender inequality, and lack of healthcare for all. The healthcare disparity is mainly due to shortage of trained health care professionals and lack of necessary infrastructure in remote areas of the country. Telemedicine as a tool for health care delivery, particularly in the rural areas where 68% of the population lives, has been addressed by the Government of India since the turn of the century using telemedicine. Telemedicine as a method of healthcare delivery has been successfully tested all over the country, and the results have been very promising.

Methods: Literature search was done on Medline, Web of science and Google search engines using keywords-telemedicine, India model of health care delivery.

Results: We found that telemedicine as a healthcare delivery system has been effectively used in several underserved areas of India, through the initiatives taken by the federal, state governments as well as private sector.

Conclusion: Although not a substitute for traditional healthcare system, telemedicine can be used to overcome healthcare disparities in the underserved areas. This approach for healthcare delivery can be replicated around the world, especially in the developing countries

Introduction

India: A story of paradoxes

India is the largest democratic country in the world, with over 1.2 billion people. It has a diverse, pluralistic, multilingual, and a multi-ethnic society. While global economy is facing recession, India remains the only major economy that has kept growing. Because of its human capital, Indian economy could be the engine of growth for the entire world. India received $34 billion of direct foreign investment in the year 2015 alone [1]. Still, the country faces many social and economic challenges including poverty, illiteracy, sanitation, gender inequality and lack of healthcare for all. Affordable healthcare to all has been one of the biggest challenges India faces today. According to the 2015 report by UNICEF, there has been slow but steady progress in India over the last two decades as reflected by the improvement in common healthcare indicators [2].

Between the year 1990 to 2013, in the children under 5 years of age, mortality rate decreased from 126 to 53 per thousand [2]. The infant mortality rate (IMR) decreased from 88 to 41 [2]. Life expectancy increased from 49 years in 1970 to 66 years in 2013 [2]. The universal immunization program (UIP) in India was launched in 1985. The immunization rates though still among the lowest in the world have shown steady improvement, with polio eradication being a major success story in modern public healthcare in India [3]. The physician population ratio in India is 0.6/1000 [4]. The hospital bed to population ratio in India is 0.7/1000 person [4]. These ratios are among the lowest in the world. While there are no gold standards for assessing the sufficiency of healthcare workforce, the WHO estimates that countries with fewer than 2.3 health-care professionals per 1000 population cannot achieve adequate coverage rates for key primary health-care interventions, prioritized by the United Nations all inclusive Millennium Development Goals [5].

The total healthcare spending in India in the year 2011 according to the National health policy draft was about 4.1% of GDP (gross domestic product) [6]. However, the actual public health spending was only 1.04% of GDP and was less than 30% of total healthcare spending. The healthcare spending in India is grossly inadequate for the maintenance of good public health, and this has been realized lately by the Government [6]. The direct effect of low government spending on public health has resulted in high out of pocket (OOP) expenditure. High OOP payments are the main deterrent to common man, especially in rural areas, to access healthcare services. Several studies have shown that high OOP expenditure is one of the important contributing factors in pushing common man into poverty [7-9].

In India, 68% of the population still lives in the rural areas. Rural health care system is plagued with several problems like severe shortage of healthcare professionals, lack of necessary medical supplies as well as non-medical infrastructure such as electricity, clean water, lack of planning and finances. About 60-80% of the physician positions in various specialties are vacant in the rural health care services [10]. Thus the task to reform healthcare is daunting. The rural/urban healthcare disparity is reflected in the healthcare outcomes as IMR in urban population is 27 whereas in rural population it is 44. Similarly, total fertility rate (TFR) is 1.8 in the urban population whereas in rural population it is 2.6 [6]. There are no straightforward solutions to India's heath care conundrum; however, use of India's advances in the field of information and communications technology (ICT) industry in healthcare delivery is an innovative idea to tackle healthcare disparity. The widespread use of ICT in medicine has opened new horizons to improve healthcare in India.

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Dawn of telemedicine in healthcare delivery

The origin of telecommunication in healthcare can be traced to the introduction of telegraphy in early 1900s when emergency disaster warnings were sent in Morse code to naval and commercial vessels at sea [11]. Modern telemedicine was first started in 1960s when two healthcare projects incorporated the principles of telemedicine in healthcare delivery in the United States [12-14]. The first project involved two-way audio-visual television system set up between Nebraska psychiatric Institute and a state mental hospital. This two-way communication process was utilized for medical consultation and for educational purposes for patients and healthcare professionals [12]. The second project involved Massachusetts General Hospital and Logan International Airport Medical Station in Boston. In this project, medical advice was given by audio-visual method from the hospital to the patients at the airport [13,14].

Telemedicine essentially combines state-of-the-art electronics, ICT and associated applications in the field of healthcare delivery and also helps in providing education to patients and healthcare professionals. Telemedicine applications can be classified into two basic types. First, store-and-forward or asynchronous type, and second, real-time or synchronous type. In the former there is exchange of pre-recorded data between two or more individuals at different times/places, whereas in the latter there is a real time exchange of information by methods such as in videoconferencing. These two basic approaches to telemedicine can be applied to a wide array of clinical services, including disease diagnosis, triage, management and follow up of diseases [15,16]. The ICT tools used in telemedicine include low tech tools such as telephones, fax machines, video cameras and monitors, and high tech tools such as advanced computers, digital imagery transfer, broadband internet connections and satellite support [15,16].

Telemedicine in health care delivery in India and its regional distribution

The potential of telemedicine, as a tool for delivery of healthcare was recognized by the Government of India in the year 2000. Since then the Government of India has been working on creating telemedicine infrastructure all over the country. The telemedicine initiative was formulated by the Government of India with the involvement of Department of Information Technology (DIT), Ministry of Communications and Information Technology and the Indian Space Research Organization (ISRO), various state governments, and several premier technical and medical institutions all over the country [17].

In early 2000, DIT started telemedicine projects in different parts of the country. As a prime organizer of telemedicine projects, DIT has undertaken major initiatives for the development of technology and standardization of telemedicine in the country. It has established more than 75 nodal centers all over the country to support research and development of telemedicine. In the state of West Bengal in the eastern part of India, several projects were undertaken in collaboration with Webel Electronic Communication Systems Ltd (Webel ECS), a state public sector enterprise under DIT, government of the State of West Bengal, Indian Institute of Technology (IIT)- Kharagpur and various regional tertiary and primary medical centers [18,19]. The main aim of these projects was to deliver healthcare to the most remote parts of the country. It covered various subspecialties like radiology, pediatrics, orthopedics, internal medicine, cardiology, neurology, oncology, HIV and dermatology [19]. These projects also created a database of patient healthcare statistics and their medical records. They also played an important role in the training of paramedical healthcare professionals and continuing medical education for healthcare practitioners in remote areas [18,19].

In the northeastern states of India, Department of Space (DOS), ISRO and the North Eastern Council (NEC) collaborated to establish North Eastern Space Applications Centre (NESAC) in the year 2000. NESAC started an ISRO-NEC telemedicine project in 2004 utilizing satellite communication through Very Small Aperture Terminal (VSAT) [20]. They formulated a plan to commission 72 telemedicine regional nodal centers in all districts of north-east, including the States of Sikkim, Nagaland, Arunachal Pradesh, Tripura, Mizoram, Assam and Meghalaya. The major objective of this project was to connect district level hospitals to other specialty tertiary care hospitals both in the region as well as outside the region. This project was a novel concept because northeastern parts of the country are particularly poor in infrastructure and healthcare services, and telemedicine could be very useful in healthcare delivery. Till date, a total of 25 regional telemedicine centers have been commissioned and remaining 47 are in various stages of implementation [20].

Another important initiative undertaken by NESAC is setting up of village resource center (VRC) in all the northeastern states of India. This is an important initiative, to bring the state-of-the-art technology to the rural masses. VRCs are expected to provide a variety of services besides telemedicine, including tele-education, creating and maintaining database on the natural resources, issuing interactive advisories to farmers and villagers on agriculture and weather forecasting [20]. Tripura, one the northeastern States of India, has become an example of successful implementation of telemedicine in the country. In Tripura, telemedicine setup has been implemented at 20 hospitals, including 3 referral hospitals and 17 nodal hospitals. All these centers are interconnected with internet speeds of 512 kbps/2 Mbps for data transfer and data management. This project has successfully treated over 30,000 patients by telemedicine from June 2005 to March 2013 [21].

Consequently, state of Tripura now has one of the best ratios for IMR, crude birth rate, and female literacy rates in the country. Tripura has IMR of 26 (national average 42), crude birth rate of 13.7 (national average 21.4) and female literacy rate of 83.6% (national average 65%) [22]. Although this achievement cannot be solely attributed to telemedicine services, and may in part be due to the high female literacy and good educational status of the community [23]. But telemedicine as a means of healthcare delivery system assumes great importance especially in the northeastern parts of the country, where terrain is treacherous, infrastructure is poor and health care requires extensive planning and expense. In these areas telemedicine can be a low cost complementary alternative to the traditional full scale hospital based services. Still, the role of telemedicine in public health needs more exploration, especially in the area of maternal and child health, in parts of the country where IMR and maternal mortality are very high.

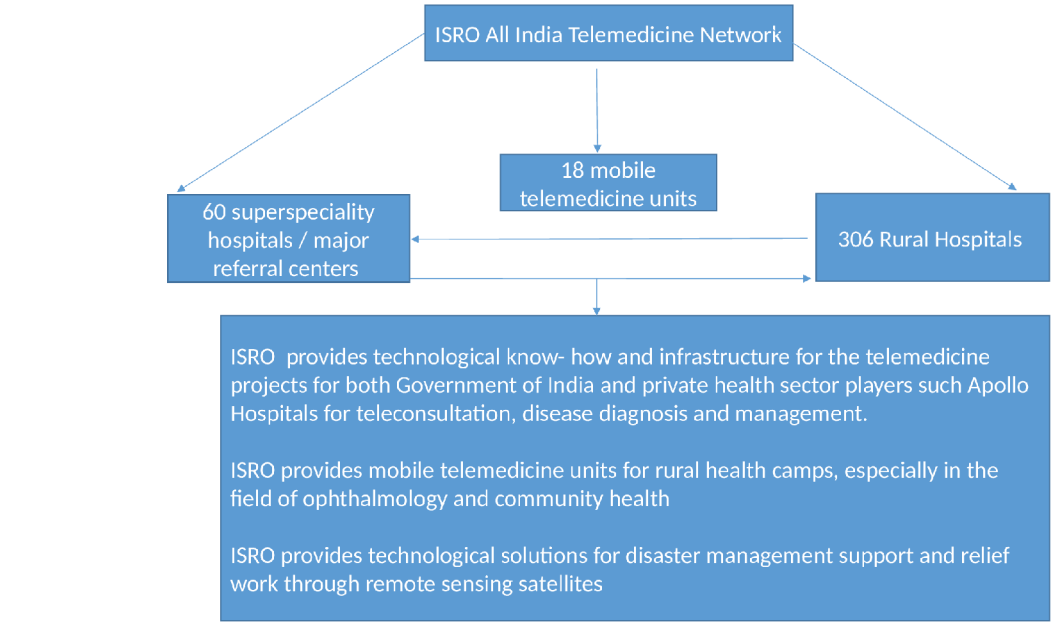
Another example of the role of ICT in healthcare delivery is in the southern part of the country. Kerala Oncology Network (Onconet - Kerala) telemedicine project has been successfully completed by the Centre for Development of Advanced Computing and Regional Cancer Center in Trivandrum. Its main aim was to explore the role of telemedicine in early detection of cancer, its treatment, pain management and follow-up services [24,25]. This project, launched in 2001 also included the creation of a web enabled Hospital Information System 'TEJHAS' (Telemedicine Enabled Java based Hospital Automation System) - an electronic database of patient's medical records, easily accessible to all the medical centers in the region [24,25].

The highlight of this project was the online sharing/data transfer of histopathology slides, electronic medical records and radiology images between the nodal health care centers and regional cancer center, which

facilitated the remote follow up of patients with oncologists through telemedicine. Telemedicine tools such as video-conferencing and web based transfer of electronic medical records were used [25]. After the successful implementation of Onconet - Kerala, the government of India decided to implement ONCONET-India network. In this ambitious project 25 regional cancer centers all over India will be connected to 100 remote-site peripheral healthcare centers/hospitals in India. The goal of this project is to create a knowledge network all over India for oncology services .It will provide telemedicine services in the field of cancer treatment, especially follow-up consultations for patients who already have a defined treatment plans as well as early cancer detection by the use of telepathology/teleradiology services [26,27]. ISRO is playing a key role in all these projects by setting up the technological expertise for the creation of telemedicine network in India (Figure 1) [28,29].

Involvement of private enterprise in the field of telemedicine in India

Private sector/healthcare industry has also recognized the potential of telemedicine. Through successful implementation of several pilot projects involving the government and private enterprises, telemedicine has been established as a solid and reliable healthcare delivery system in India (Figure 2). The Apollo Telemedicine Networking Foundation, a not-for-profit organization and a part of the Apollo Hospitals Group has been undertaking telemedicine projects. Under the leadership of



Source : http://www.isro.gov.in/applications/tele-medicine

Figure 1: ISRO telemedicine network in India.

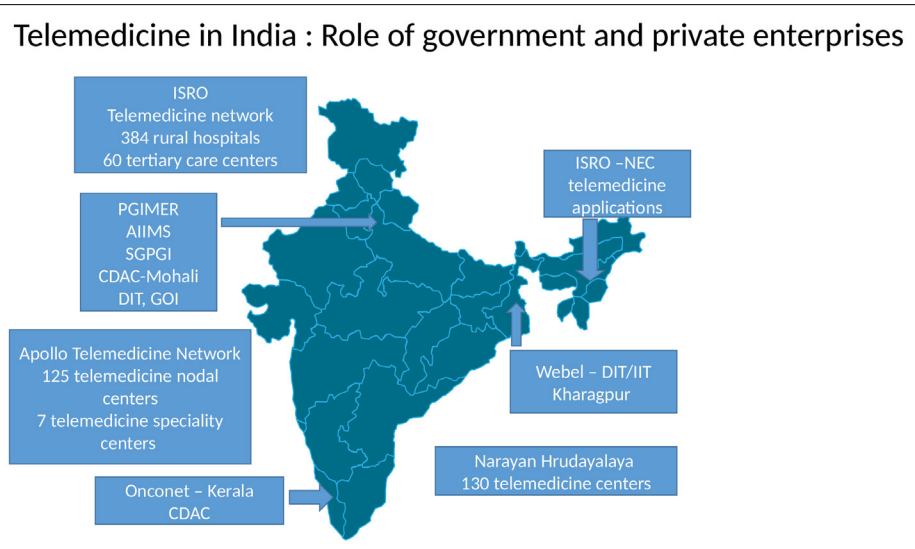


Figure 2: Telemedicine in India: role of Government and private enterprises.

Dr. Ganapathy, a prominent neurosurgeon and widely regarded as the father of Indian Telemedicine, Apollo Hospitals collaborated with ISRO to set up India's first Rural Telemedicine Center at Aragonda, a small village in the State of Andhra Pradesh. The world's first VSAT enabled, modern secondary care hospital was established on 24th March 2000. Since then Aragonda Apollo telemedicine center and Hospital has been the cornerstone case study model for the entire telemedicine healthcare industry. Today ATNF has emerged as India's single largest private healthcare provider in the area of Telemedicine with over 125 peripheral centers in India and 10 overseas [30].

The Apollo Telemedicine network includes a telemedicine specialty center and a telemedicine consultation center. Currently all the telemedicine specialty centers located at the tertiary care facilities of Apollo Hospitals are in big cities such as Chennai, Hyderabad, Delhi, Ahmedabad, Kolkata, Bangalore and Madurai are linked to telemedicine nodal centers all over India through variety of internet connectivity protocols such as VSAT, Integrated Services Digital Network line, internet protocol, or broadband internet [30,31]. More than 69,000 tele-consultations were provided by ATNF till May 2011, through the telemedicine specialty centers located at the Apollo tertiary care facilities [30,31].

The potential of telemedicine has been recognized in many subspecialties of medicine, including cardiology, neurology, dermatology, and ophthalmology. Narayan Hrudayalaya, a leading healthcare institution in the southern part of India has been working in the field of telecardiology. It was named among the 50 most innovative companies of the world by the popular online magazine Fast Company in the year 2012 [32]. The first pilot project of Narayan Hrudayalaya related to telemedicine was establishment of Cardiac Care Unit in the District Hospital, Chamarajanagar, Karnataka, in south India in February 2002. This project involved hardware and ICT support from ISRO and financial support from the World Bank with additional support from Karnataka Health System Development Project [33]. Since 2001-02, this project has established another 130 telemedicine centers all over India and treated over 64,000 patients, including 10,000 patients in coronary care units with tele-consultations [32-34].

Stroke is the third leading cause of mortality in India [35]. The role of ICT in the field of neurology, especially in stroke care and management of epilepsy has been recently emphasized in several studies [36-39]. Presently, there is a severe shortage of trained neurologists and stroke care specialists, particular in the rural areas in India [36]. There are many studies which have shown that telemedicine can substantially improve acute stroke care [37-39]. Most of the work in the field of neurology in telemedicine in India has been done by Apollo Telemedicine Networking Foundation and includes continuing medical education of health professionals and tele-consultations [30].

Dermatology is another clinical specialty that can make substantial use of the advances in ICT because of its inherently visual nature in both diagnosis as well as follow-up. This makes it ideal for the utilization of virtual medicine. In India, Kantiraj et al validated the store and forward teledermatology and videoconferencing in a large number of patients while using gold standard (face-to-face) comparison between teledermatologists and clinical dermatologists [40]. Nair and Nair also reported that teledermatology is a viable alternative to face to face encounters via both store and forward and videoconferencing options. Based on their experience, they implemented a project identifying common skin disorders via this approach [41]. It is of note that teledermatology can be used not only in the diagnosis and treatment of patients, but also in the education of healthcare professionals [42].

Similarly application of telemedicine in ophthalmology has been successfully implemented in India by Sankar Nethralaya and Aravind Eye Hospital in Chennai in the southern state of Tamil Nadu [43-46]. John et al treated over 54,751 patients by organizing telemedicine camps across four states in India [45]. They found that uncorrected refractive error was the commonest cause of avoidable blindness (59%), followed by cataract (30%). The other diseases include retinal diseases (3.3%), mainly diabetic retinopathy and corneal diseases (1%) [45]. Presently Teleophthalmology has been firmly established as a healthcare delivery system by various projects in rural India [43-46].

Telemedicine in public health: Improving healthcare utilization, and epidemiological surveillance

The farthest reaching contribution telemedicine can make in healthcare in India is in the arena of public health. Presently, most applications of telemedicine are concentrated in curative services. Telemedicine can play a major role in health promotion especially in improving the knowledge, beliefs and attitudes of common people. It is common knowledge that amongst the most common reasons for the underperformance of major public health programs in India, are the lack of knowledge of prevention of many communicable diseases by vaccines and erroneous beliefs and practices in the rural population [47,48].

Telemedicine can be helpful in disease prevention and health promotion in many areas. Telemedicine applications, such as audio-visual aids, video conferencing, and healthcare-related conversations with pediatricians/general physicians can be used to inform and motivate people. A variety of applications can advance and support primary, secondary and tertiary health promotion and disease prevention in the poor states of the country which have minimal infrastructure and scarce healthcare facilities. Notably, ISRO and North Eastern Space Applications Centre (NESAC) already have the required infrastructure in 25 nodal telemedicine centers in northeastern states and are working on 47 centers currently [20]. Besides Village Resource Centers, an important part of ISRO – NEC initiative, can play an important role in the dissemination of knowledge and brining about changes in healthcare attitudes and practices. There have been studies which show that simple quality improvement initiatives can improve vaccination rates in rural populations [49,50].

Telemedicine can also play an important role in the epidemiological surveillance with the development of Geographic Information Systems (GIS) [51,52]. GIS is a new method of studying healthcare data. It includes healthcare spending and outcomes in a particular geographic area and compares it to other area/s to develop ideal healthcare delivery systems and guide healthcare policy. Telemedicine applications and electronic health profile of populations can give insight into the geographical distribution of various diseases, their prevalence and overall health of a population [51,52]. The integration of GIS with telemedicine, in the telemedicine nodal hospitals/rural health centers can help bring real changes in healthcare in rural India. The integration of telemedicine and GIS can help in understanding of epidemiology of diseases ,especially the role of climate , environment and disease transmission in various communicable and vector-borne diseases, both regionally and nationally [51,52]. Both GIS and telemedicine network are needed for the public health programs all over India, especially in the areas of childhood vaccination programs, maternal mortality and IMR.

Telemedicine in India: National rural telemedicine network

The federal Ministry of Health and Family Welfare has also recognized the positive impact of telemedicine in improving healthcare in country. It has decided to set up national rural telemedicine network

1. Development and implementation of low cost rural telemedicine infrastructure in the rural peripheral health centers (PHC) for tele-consultation with the district/ regional hospital acting as hub.
2. Initiation of "Village Tele-ambulance System and rural emergency healthcare services/Trauma care healthcare delivery system", a new concept, through mobile telemedicine network.
3. Formation of Rural Health Knowledge Resource and national database for healthcare at Ministry of health and family welfare.
4. Supplementation of rural healthcare delivery systems.

Table 1: Aims of the National Rural Telemedicine Network in India.

[53]. In this project, a national network for interlinking all medical colleges/University Hospitals across the country has been proposed. This network named National Medical College Network is for continuing medical education and e-health services all over the country. Already 150 medical colleges around the country have been interconnected by high speed fiber - optic based internet under National Knowledge Network Project. In the field of healthcare delivery, National Rural Telemedicine Network is trying to interconnect peripheral healthcare centers in rural areas with district hospital/tertiary care centers and academic teaching hospitals [54,55]. The aims of this project are summarized in Table 1.

Telemedicine and global health care

The successful implementation of telemedicine projects in India has led to the envisioning of a regional telemedicine network connecting the Southeast Asian countries. This project called SAARC (South Asian Association for Regional Cooperation) e-Network Tele-Medicine project is an initiative by the Government of India to provide specialist healthcare facilities and treatment to the people of all SAARC nations. It will also help in the continuing medical education of health professionals in SAARC countries [56]. Regional countries like Bhutan, Nepal and Afghanistan have already signed a memorandum of understanding and several projects have already been initiated [56].

India also wants to share its expertise in the field of telemedicine with the African countries where there is widespread lack of basic healthcare infrastructure. India has started a Pan African e-Network Project which involves connecting hospitals in 53 African countries to 11 specialized tertiary care hospitals in India [57]. This project has been approved by the Government of India in 2007 at a total cost of Rs.542.90 crores (US$ 125 million). The main purpose of this network is to provide telemedicine services for the purpose of patient care and continuing medical education for healthcare professionals. Regular continuing medical education sessions have already been started and 654 continuing medical education sessions have already been conducted on this network project [57].

Health care outcomes and telemedicine

With the successful implementation of various telemedicine health care projects by both private and government sectors, there is growing optimism regarding the role of telemedicine in the health care sector in India. Social entrepreneurs like World Health Partners a private non-profit organization, have set up rural healthcare delivery system in India based on telemedicine. They have also replicated the same model in Kenya [58]. Unlike others they have focused on primary care and therefore can play a major role in changing the healthcare profile of the communities [59]. The role of telemedicine in health care delivery is an important factor in the success of business models of Aravind Eye Hospital and Sankar Nethralaya in the field of ophthalmology and Narayan Hrudayalaya in the field of cardiac surgery [43-46]. All around the world, several studies have shown a positive impact of telemedicine on healthcare delivery. In United States, 29 states have passed telemedicine parity laws mandating that commercial insurers reimburse telemedicine visits [60]. The use of telemedicine has improved has improved stroke management at Penn State Hershey Medical Center by increasing tissue plasminogen activator administration rate, decreased transfer rates, and reducing door-to-needle times for stroke patients [61]. Use of telemedicine in various other subspecialties have reduced the readmission rates for congestive heart failure patients and provided antenatal care to underserved areas in the United States [61].

Discussion

The main challenges faced by telemedicine regarding its widespread acceptance as a method of health care delivery, is in validating its impact on clinical outcomes with scientific rigor. There are other issues like standardization of the methods and techniques used for health care delivery, payment by insurers and cost benefit analysis that need to be resolved. Still, telemedicine as a means of health care delivery system has a role to play in global health care system. India's creditable use of telemedicine early gives it an edge. It is important to capitalize on the successful implementation of projects like Onconet Kerala and ISRO/ NEC projects in northeastern states of India [20,24-26]. At present the challenge is to integrate telemedicine nodal centers all across the country and utilize the services of these centers in the field of public health, especially in the area of maternal and child health. These healthcare projects can serve as role models for developing countries all across the world.

Support of federal government for a nationwide network has been critical for the success of telemedicine programs in India. International agencies, such as World Bank, UNICEF, private enterprises, and other regional players are the other key players in the success of these telemedicine programs. Recently, RAFT telemedicine network project has demonstrated that telemedicine and e-health can be used to improve basic healthcare in many low to middle income countries [62]. Telemedicine is already being recognized around the world to have a proven value in several subspecialties of medicine, such as cardiology, dermatology and neurology [63-65]. Its success in India and its extrapolation to the global platform is something that holds the key to universal health care.

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