Development of Telemedicine Technology in India: "Sanjeevani"—An Integrated Telemedicine Application

Sood SP, Bhatia JS*

C-DAC School of Advanced Computing (University of Mauritius), Mauritius, *C-DAC, Mohali (Punjab), India.

Correspondence:
Sood SP,
E-mail: sood@spsood.com

ABSTRACT

Telemedicine has been a technological takeaway for the developed countries. Even in the developing countries, it is increasingly being viewed as a tool for improving care and enhancing access to healthcare. Countries like India where the majority of the population lives in rural areas, where healthcare facilities are inefficient and inadequate, tools like telemedicine can contribute substantially in bridging the gap between the demand and supply. "Sanjeevani"–is an integrated telemedicine application that offers a suite of high utility features as a part of an Indian telemedicine technology. Sanjeevani is based on store and forward as well as real-time models.

PubMed ID : 16388174
J Postgrad Med 2005;51:308-11

KEY WORDS: Telemedicine, telemedicine technology, integrated telemedicine application, DICOM, teleradiology, telepathology, telecardiology

Telemedicine is an upcoming and an important tool for providing efficient healthcare. There have been numerous efforts to define the term telemedicine.[1-5] In simple terminology, it can be defined as the use of communication networks for the exchange healthcare information to enable clinical care. Since 1990, the number of telemedicine projects has increased spectacularly.[1] In five years (1990–1995), the number of non-radiological telemedicine programs rose from 10 to more than 100 in USA alone.[6] Telemedicine is currently being applied across many specialties of medicine.[7-15]

Telemedicine has been a technological takeaway for the developed world. Since the first documented use of telemedicine at the University of Nebraska College of Medicine in 1959,[16] telemedicine has been growing progressively. Of late applications like telesurgery[17-18] have pushed telemedicine a step further and are facilitating medicine's transformation into a domain with supernatural supremacy. Countries like Canada, France and USA that enjoy a state of the art broadband telecom infrastructure have already proved their capabilities in conducting remote telesurgeries.[17-18]

Factors like extent and maturity of networking infrastructure and technologies and IT "savvyness" of clinicians in the country not only determine the rate of growth of telemedicine and but they also define the nature of telemedicine linkages that the healthcare set-up can afford. For example, the availability of an efficient and modern broadband telecommunications infrastructure accentuates the growth of real-time telemedicine applications like tele-education etc. Earliest citation of telemedicine in a developing country dates back to 1986.[19] Owing to limited infrastructural capacities, developing countries primarily bank on store and forward concept of telemedicine. However, some telemedicine programs in developing countries with broadband connectivity have enabled telemedicine linkages quite comparable to those in the developed world.[20,22] These linkages use communication technologies like Integrated Services Digital Network (ISDN). Lesser endowed locations and telemedicine linkages depend on Plain Old Telephone System (POTS). POTS enables easy exchange of clinical information without heavy images or video clips through dedicated as well as web-based telemedicine applications. Telemedicine is gaining ground in developing countries and even many clinicians in these countries have started practising telemedicine out of their professional needs. In a very simple form they are reaping the benefits of telemedicine by exchanging clinical information and comments through emails.[23] Developing countries like India, Nepal and Bangladesh etc have opened up to telemedicine to address various issues being faced by their healthcare delivery system.[20,21]

On analyzing the role that telemedicine is playing in the de-

veloped and the developing world, it can be noted that, in the developed countries, telemedicine applications and utilities enact a virtual transportation in some sense. This "virtually realistic transportation" in critical situations, can be vital to the patient's survival and quality of life. On the other hand, in the resource poor countries, telemedicine improves care and enhances access to healthcare. This makes telemedicine truly instrumental in enhancing healthcare delivery services in the developing countries. Thus telemedicine may have a more profound impact on the healthcare scenario in the developing countries than in the developed ones.[24]

Background

India is a vast country with inherently contrasting geographical, cultural and economic features. This south Asian country has a high population growth rate, high rural percentage of population, high rates of illiteracy, poverty and unemployment.

Amongst other things, inadequacies of healthcare infrastructure are listed in Table 1. Indian healthcare services cannot be classified as efficient. Factors that impede efficient delivery of healthcare services include: inadequate health infrastructure and clinical services, and outflow of doctors to the developed world and lack of training facilities.[25] It may be noted that over 80% of India's main healthcare centres are located in the cities that host only 30% of the population.[26] Hence a gloomy healthcare scenario reflects that country's 20% quality healthcare facilities cater to almost 70% of the population. India's rural population is thus more vulnerable than its urban counterpart. Thus rural health care scene is characterized by: paucity of qualified doctors, almost non-availability of specialists and specialist care, several patients being serviced by unqualified practitioners, late discovery of ailment and delay in institution of appropriate treatment due also to greater time required for transport to urban/ district healthcare facilities and provision of healthcare by inexperienced primary healthcare service providers.[20]

Table 1: India: Key Indicators

INDIA	
General Information Total Surface Area : 3.2 million sq. kms.GDP (USD, in billions) : 750 (2005)GDP per capita (USD) : 685GDP growth : 7.1 (2005)	**Demographics** Total Population : 1,080,264,388 (July 2005 estimated) Population living in rural areas : 72% (2001)Population growth rate : 1.4% (2005 estimated)Literacy (age 15 & over can read): 59.5% (2003 estimated)Population below poverty line : 25% (2002 estimated)Human Development Index (2004) : static at 127
Health Indicators Expenditure on health : 6.1% (2002 Health expenditure per capita (in USD) : 30.0 (2002) No. of Hospital beds per 1000 Indians : 0.8 (1991)Number of physicians, density per 1000 population : 0.5125 (2004)Infant Mortality Rate per 1000 births : 56.25 (2005)Daily available calories per capita : 8,487	**ICT Infrastructure** Expenditure on ICT (USD, Millions) : 19,662 (2001) ICT as % of GDP : 3.9 (2001)ICT per capita (USD) : 19.0 (2001)Teledensity : 9 per 100 (2005)PC penetration : 14 per 1000 (2004)Internet users per 1000 population : 6.8 (2001)Digital Access Index : 0.32 (medium access)e-readiness rank (out of 65 countries) : 49th

Development of Telemedicine Technology

In 1999 Department of Information Technology at the Ministry of Communications and Information Technology (Government of India) launched a pilot project entitled 'Development of Telemedicine Technology' with the objective of reinforcing the national healthcare delivery system[27]. Key specifications of the project included:

- To identify appropriate technological tools and services for implementing telemedicine technology at three premier tertiary level hospitals in the northern parts of India, namely, the All India Institute of Medical Sciences (AIIMS), New Delhi; the Post Graduate Institute of Medical Education and Research (PGIMER) at Chandigarh and the Sanjay Gandhi Post Graduate Institute of Medical Sciences (SGPGIMS) at Lucknow (Uttar Pradesh).
- To develop and carry out system integration to enable telemedicine technology, for establishing telemedicine services (teleconsultation and tele-diagnostic facilities for the specialties of radiology, cardiology and pathology; and tele-education) at three tertiary level hospitals.
- To train clinicians in the use of telemedicine technology.

New Delhi being a metropolitan city and national capital enjoys the privilege of the best telecommunication services available in India. Chandigarh and Lucknow being provincial capitals also have reasonably good telecommunications connectivity with New Delhi and other bigger cities of the country.

Telemedicine technology developed at Mohali, has been centered on an integrated telemedicine solution (an application software) which offers a spectrum of tools, applications and services for telemedicine linkages. The software christened as 'Sanjeevani' enables teleconsultations (primarily tele-radiology, tele-pathology and tele-cardiology) in the following manner-: When the patient-end doctor feels the need for a second opinion, he/she uses Sanjeevani, to consolidate relevant clinical information of that patient into an Electronic Patient Record (EPR) and then seeks an opinion of the specialist using teleconsultation. After the connection to the specialist-end is established, the electronic patient record is uploaded. The specialist also has Sanjeevani installed. Using the software, the specialist then examines the clinical information, and suggests a course of action. If need arises, the doctors on both the ends arrange for a video conferencing to arrive at the diagnosis in a collaborative manner and decide upon the course of treatment in a participative manner. This advice is then formalized after the specialist sends back his opinion to the patient-end doctor. As a user of the integrated telemedicine software, the two doctors engaged in teleconsultation are able to get all the services from within Sanjeevani. The services include patient demographics, general information, patient's

medical-history, other information or data including clinical data like ECG, radiographs, pathological reports, clinical images, appending queries and advice, conducting a video conferencing etc. It also enables clinicians to create, edit and view electronic patient record, generate prescriptions, work out interpretations for radiographs and pathological reports besides annotating digitized images, acquire and display ECGs and conduct video conferencing. Sanjeevani generates various reports regarding diagnosis, treatment chart, next visit to hospital etc as desired by the doctor.

Majority of the features in Sanjeevani are provided through following discrete modules:

Electronic Patient Record (EPR)

Electronic patient record consists of patient demographics and other clinical details like general information, patient history, clinical examination reports, physical examination reports etc. This module handles complete database transactions regarding patient's data including medical images in a client server model. Access to patient's data is limited and defined. Electronic patient record defines a way for secured transfer of data. It facilitates assembling data at the referring doctor end and then packing it for transferring the clinical information to the specialist end. At the specialist end it facilitates disassembling the received data into its sub-parts and then saves the information into their corresponding data structures.

ECG Module

The module enables acquisition of 12-lead ECG of a patient and transferring it to the referral doctor. Leads carrying ECG signal from patient's body are connected to Brentwood's ECG recorder. This PC-based electrocardiograph is interfaced to Sanjeevani through this module. Low-level windows programming is used to implement serial communication for interfacing the machine with Computer. It can capture ECG for different time periods. Many other features like heart rate, setting speed of ECG graph, comparison of two ECGs of the same patient etc. are supported for better analysis. All the basic features of a Brentwood's PC-based electrocardiograph have been included in this module for Telecardiology applications.

Imaging and DICOM Compatibility

Sanjeevani's imaging module enables digitized radiographic images to be converted from general purpose image file formats like .tiff, .jpg, .gif etc into a .dcm format. This module offers a low cost solution for acquiring images in DICOM format. This is also useful in cases when the source of radiographic image is a celluloid film or a non-DICOM modality. Imaging module converts any raw data, from a twain compatible device, into its part 10 secondary capture DICOM format. The imaging module enables the doctors to annotate data on images. Doctors can also mark region of interest, enhance image's readability by zooming in/out, increase contrast, brightness, etc. For telepathology, Leica's TWAIN compliant video microscope has been interfaced to Sanjeevani.

Connection using Remote Access Server (RAS)

Sanjeevani being a stand-alone application, connects two computers either by POTS or ISDN lines. Sanjeevani uses windows RAS APIs for remote connections to detect the type of connectivity available. The communication protocol used is TCP/IP and all TCP/IP negotiations required for connections are executed automatically.

Data Transfer

Sanjeevani uses socket programming for transferring the data from one PC to another PC provided they are connected by some means to either LAN or WAN (ISDN or POTS). For ensuring proper transmission and reception, an error handling routine has been incorporated that takes care of complete process of connection and successful data transfer. A log is maintained till data gets transferred. Sanjeevani also provides real time communications with the help of the feature of video conferencing that is provided over the Microsoft Netmeeting technology as per the requirements of H.323 protocol.

During the development of telemedicine technology major challenges that were tackled were:[28]

- Design and approach towards the development had to be such that would not dislodge existing practice of working in hospitals.
- The communications service providers could not provide efficient services primarily because of lack of expertise in managing the communication services (ISDN).
- Majority of the potential users (clinicians and paramedical personnel) of this telemedicine technology were not computer literate.
- Medical peripheral devices being used in this telemedicine suite were PC based i.e. these devices were relatively high-tech for its potential users, the users relatively slower in mastering the use of these PC-based peripheral medical instruments.

Conclusions

Based on the data published, "Sanjeevani" is one of the rare applications of telemedicine developed in India. This development can be classified as a hybrid model of telemedicine that uses the store and forward as well as real time concept. An integrated video conferencing application enables real-time telemedicine. Two features of Sanjeevani namely: a) capability to adapt to different types of communications links (Plain Old Telephone System and Integrated Services Digital Network) and b) inherent flexibility to be used with low cost medical peripherals like a simple flatbed document scanner (with transparency adaptor), promise widespread adoption of telemedicine in healthcare setups in smaller cities as well. Initial interactions with users of Sanjeevani reinforce our thoughts of a simple and user friendly telemedicine technology for swifter diffusion of this application of IT in healthcare in India at a large scale.

Acknowledgements

Source of funding: Department of Information Technology, Ministry of Communications and Information Technology, Govt. of India

References

1. Perednia DA, Allen A. Telemedicine technology and clinical applications. JAMA 1995;273:483–8.
2. Stanberry B. Telemedicine:Barriers and opportunities in the 21st Century. J Intern Med 2000;247:615–8.
3. http://trc.telemed.org/telemedicine/primer.asp.
4. http://www.atmeda.org/news/definition.html accessed on 20.09.2005.
5. Ried J. A telemedicine primer:Understanding the issues, billings. MT:Innovative Medical Communication 1996:3–4.
6. Hayes T, Kinsella A, Brown NA, Perednia DA. The Telemedicine Information Exchange. J Telemed Telecare 1996;2:20–7.
7. Shanit D, Cheng A, Greenbaum RA. Telecardiology:supporting the decision-making process in general practice. J Telemed Telecare 1996;2:7–23.
8. Engelmann U, Schroter A, Schwab M, Meinzer H. Reality and perspectives in teleradiology:a personal view based on personal experiences. Int J Med Inf 2001;64:449–59.
9. Wells CA and C Sowter. Telepathology:A Diagnostic Tool for the Millennium? Journal of Pathology 2000;191:1–7.
10. Rohland BM, Saleh SS, Rohrer JE, Romitti PA. Acceptability of Telepsychiatry to a Rural Population. Psychiatric Services 2000;51:672–4.
11. Wysocki WM, Komorowski AL, Aapro MS. The new dimension of oncology:Teleoncology ante portas. Crit Rev Oncol Hematol 2005;53:95–100.
12. Rocca MA, Kudryk VL, Pajak JC, Morris T. The evolution of a teledentistry system within the Department of Defense. Proc AMIA Symp 1999;921–4.
13. Perednia DA, Brown NA. Teledermatology:one application of telemedicine, Bull MedLibr Assoc 1995;83:42–6.
14. Burgul R, Gilbert FJ, Undrill PE. Methods of measurement of image quality in teleultrasound. Br J Radiol 2000;73:1306–12.
15. Marescaux J, Rubino F. Telesurgery, telementoring, virtual surgery, and telerobotics. Curr Urol Rep 2003;4:109–13.
16. E-learning Resource Manual. American College of Physicians, Annual Session 2003.
17. Marescaux J, Leroy J, Gagner M, Rubino F, Mutter D, Vix M, et.al. Transatlantic robot-assisted telesurgery. Nature;413:279-380, 27 September, 2001.
18. Anvari M, McKinley C, Stein H. Establishment of the world's first telerobotic remote surgical service - for provision of advanced laparoscopic surgery in a rural community, Annals of Surgery. 2005;241:460–4.
19. Sood SP. Telemedicine in Benin. a W.H.O. report, February 2005.
20. Sood, Sanjay P. India telemedicine venture seeks to improve care, increase access. Telemedicine Today 2002:25–6.
21. Swinfen R, Swinfen P. Low-cost telemedicine in the developing world. J Telemed Telecare 2002;8:63–5.
22. Sood SP, Bhatia JS, Khandpur RS. Technologies for Telemedicine:An Indian Scenario. Proceedings of International Conference on Biomedical Engg. (ICBME) 2001, Chennai, January 2001.
23. Deodhar J. Telemedicine by email – Experience in neonatal care at aprimary care facility in rural India. J Telemed Telecare 2002;8:20–1.
24. Steven M Edworthy. Telemedicine in developing countries. BMJ 2001;323, 524–5.
25. Sood SP. Telemedicine on the right track in India. Asian Hospital and Healthcare Management, Journal of Asian Hospital Federation, 2002;69–71.
26. Pal A, Mbarika V, Cobb-Payton, F, McCoy S, Telemedicine diffusion in a developing country:The case of India (March 2004). IEEE Transactions on Information Technology in Biomedicine 2005;9:59–65.
27. Sood SP, Khandpur RS. Indian National Telemedicine Project - An Overview, (Abstract) Telemedicine & Telecare International Trade Fair(Luxembourg), 2002.
28. Sood SP, Khandpur RS. Challenges in development of an integrated telemedicine system in a developing country – the Indian experience (Abstract), Telemedicine & Telecare International Trade Fair (Luxembourg), 2002.