Telemedicine Diffusion in a Developing Country: The Case of India (March 2004)

Amrita Pal, *Member, IEEE*, Victor W. A. Mbarika, *Member, IEEE*, Fay Cobb-Payton, Pratim Datta, and Scott McCoy

***Abstract*—Telemedicine (health-care delivery where physicians examine distant patients using telecommunications technologies) has been heralded as one of several possible solutions to some of the medical dilemmas that face many developing countries. In this study, we examine the current state of telemedicine in a developing country, India. Telemedicine has brought a plethora of benefits to the populace of India, especially those living in rural and remote areas (constituting about 70% of India's population). We discuss three Indian telemedicine implementation cases, consolidate lessons learned from the cases, and culminate with potential researchable critical success factors that account for the growth and modest successes of telemedicine in India.**

***Index Terms*—Diffusion of technology, India, information technology, telemedicine, telemedicine implementation.**

I. Introduction

As FIVE-YEAR-OLD Thejas lay in bed in the consulting room at the Aragonda Apollo Hospital in the remote village of Aragonda, India, about 170 km from Chennai, India, doctors first diagnosed a murmur in the heart and he was put on a color Doppler. As the color Doppler images were transmitted to the hospital in Chennai using special electronic communication, Pediatric Cardiologist Prem Shekhar diagnosed the case as "Sallot's Tetrology" (multiple congenital defect of the heart). After a few hours of consultation with the surgeons and the hospital chairman, Dr. Pratap C. Reddy, the child was transferred to the Chennai Apollo Hospital for surgery. Dr. Reddy commented, "this facility has heralded telemedicine in India and that as a special case, Thejas would be operated free of cost and all the expenses borne by the hospital" [1].

This real-life example reflects one of many success stories of telemedicine diffusion in India, where patients in remote areas are diagnosed and treated for numerous medical conditions. Telemedicine is defined as "the use of telecommunication technology (involving audio, video, and graphic data) to deliver health-care services, health education, and administrative services to sites that are physically distant from the host or educator" [8], [9], [13]. This paper discusses how telemedicine is changing the delivery of medical services in India, a country with an exponentially high population growth rate, low teledensity (number of telephone landlines per 100 people), and a historically poor health-care delivery system. Table I summarizes India's health-care statistics—low life expectancy, high infant mortality, high birth rates, and a meager percentage of gross domestic product (GDP) dedicated to health care.

A. Need for Telemedicine in India

Several reasons have spurred the rapid growth of telemedicine in India. The country is geographically large with many towns and villages located in remote rural areas. Few medical facilities exist to serve the large population that resides in the villages. India has 80% of its main health-care centers located in cities that host only 30% of the population. These percentages reveal a dismal health-care scenario where only 20% of India's quality health-care facilities cater to 70% of Indians (approximately 770 million) confined to rural communities.

According to Sood [16], India's rural population is more vulnerable than its urban counterpart based on three particular reasons: late discovery of ailment, transport time to urban health-care facilities, and inexperienced primary health-care providers in rural areas. Telemedicine offers the potential to address these concerns and to save the patient extra costs associated with treatment, such as travel and other living expenses [3], [15].

II. Overview of India's Telemedicine Infrastructure

The feasibility of telemedicine adoption and implementation is growing with positive changes in public policy on infrastructure and sponsorship. Given that India's telecommunications infrastructure is largely government owned, telemedicine initiatives are constrained by existing state-sponsored networks, varying only in terms of equipment and software applications. Until recently, telemedicine remained contingent upon India's meager high-bandwidth landline telecommunications infrastructure. The popularity of wireless and India's home-grown satellite technologies developed by Indian Space Research Organization (ISRO) offers critical infrastructure to support teleapplications. The INSAT satellite system established in 1983 created one of the world's largest domestic communication systems with seven satellites and 130 C-band transponders linking many hundred earth stations in remote and rural areas along with thousands on very small aperture terminals (VSAT). This infrastructure enables the country to reach over 65% of the Indian landmass and 80% of its population.

The technical infrastructure for typical telemedicine projects in India is shown in Fig. 1. At the basic level, mobile

Manuscript received July 16, 2003; revised May 7, 2004, June 30, 2004, and August 23, 2004.

A. Pal is with Johnson Controls Inc., U.S. Geological Survey—National Wetlands Research Center, Lafayette, LA 70506 USA (e-mail: apal@usgs.gov).

V. W. A. Mbarika is with Southern University and A&M College, Baton Rouge, LA 70813 USA (e-mail: victor@mbarika.com).

F. Cobb-Payton is with North Carolina State University, Raleigh, NC 27695 USA (e-mail: payton379@aol.com).

P. Datta is with Washington State University, Pullman, WA 99164 USA (e-mail: pdatta@wsu.edu).

S. McCoy is with the School of Business, College of William and Mary, Williamsburg, VA 23187 USA (e-mail: scott.mccoy@business.wm.edu).

Digital Object Identifier 10.1109/TITB.2004.842410

TABLE I
COMPARISON OF HEALTH INDICATORS

Factors	India	USA	UK	Germany	Australia	Asia-Pacific
Population growth rate	1.55%	0.9%	0.23%	0.27%	0.99%	1.6%
Birth Rate (per 1000)	24.28	14.2	11.54	9.16	12.86	22.26
Infant Mortality Rate (per 1000)	63.19	6.76	5.54	4.71	4.97	40.91
Death Rate (per 1000)	8.74	8.71	10.35	10.42	7.18	6.3
Life Expectancy at birth (in years)	51.2	77.4	69.7	70.7	71.4	69.7
% of GDP on Health (WHO recommends 5%)	4.9	14.0	7.4	10.6	8.3	2.7
GDP per capita (in US dollars)	2,540	36,300	18,410	25,580	17,980	815

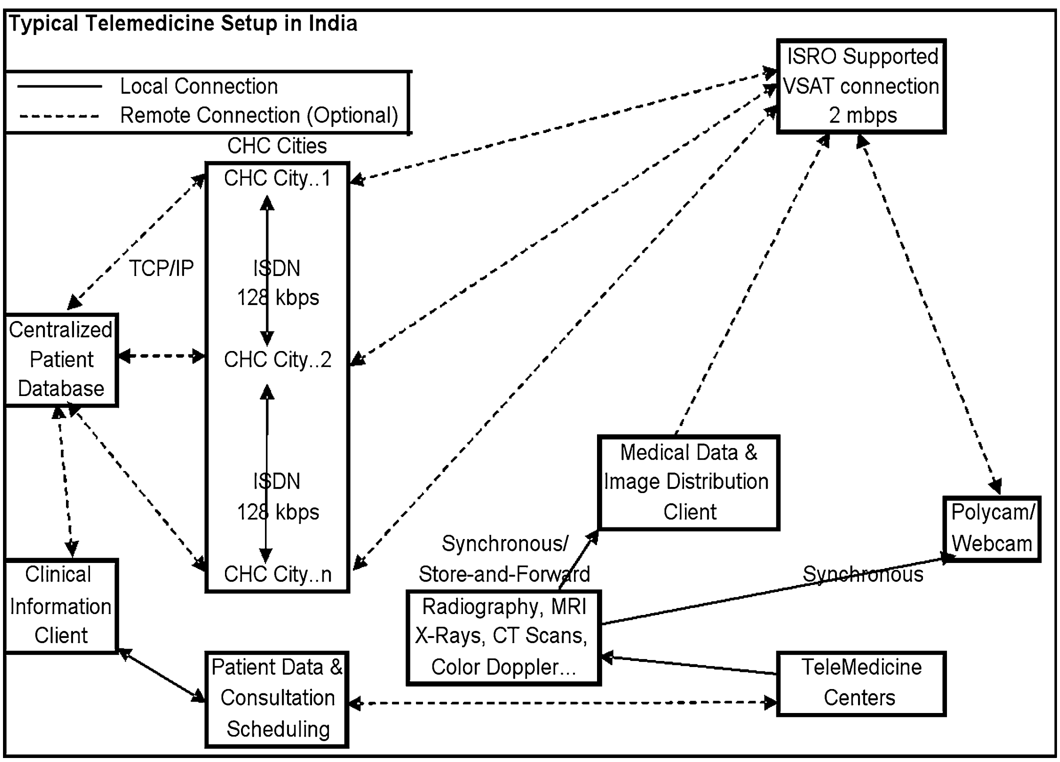


Fig. 1. Typical telemedicine service setup in India.

telemedicine technicians are housed in solar-powered telecenters equipped with portable telemedicine workstations for recording and transmitting objective medical information (electrocardiogram (ECG), blood pressure, heart rate, O_2 saturation) to other mobile-field hospitals or specialty centers. The next level of telemedicine facilities are either mobile or semipermanent structures containing the following equipment: a medical processing unit running on a network enabled Pentium CPU with necessary client software for image acquisition, processing, compression, and transfer; a pathological microscope; medical image digitizer (video-frame grabbers and TWAIN-compliant scanners using DICOM and JPEG standards); 12-lead ECG Machine; X-ray machine; pan/tilt/zoom camera for videoconferencing; event recorders (a low-footprint device (size of a television remote) to record ECG data and transmit it over regular telephones); and angiography convertible software. The output is fed to a polycam (a tight-cluster of cameras used to capture a large field of view) or a webcam for synchronous communication through videoconferencing. The output is captured, compressed, and transmitted using a medical data and image distribution client, such as GE's RadWorks, which provides a webserver and an intuitive client interface for collating medical data and images for easy transfer using DICOM standards. The client graphical user interface is shown in Fig. 2.

Collated and verified medical data is stored and transferred as batch files to specialized centers, mainly community health centers (CHCs). Today, wireless telephony and satellite net-

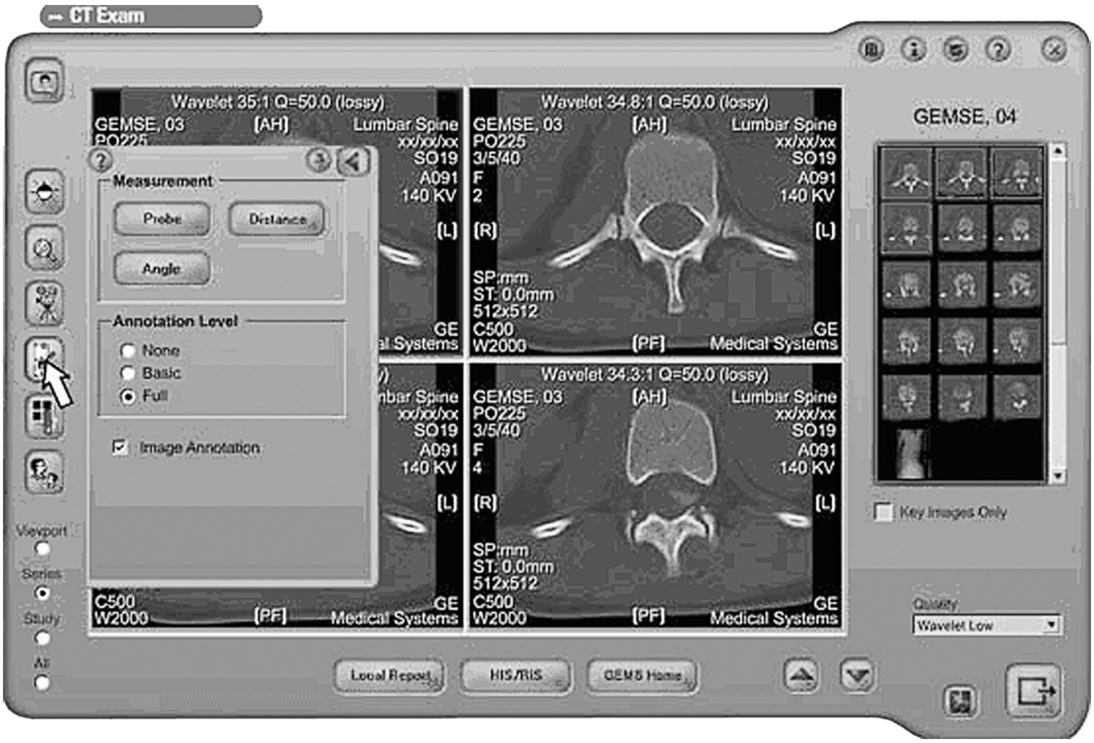


Fig. 2. Medical Data and Image Distribution Interface (Courtesy GE RadWorks).

works allow data transfers from conventionally inaccessible sites. For example, with VSAT, mobile cellular systems are used to link cellular technology to low-Earth-orbit satellites through a user mobile link that then communicate with earth stations via Gateway Links. In the absence of landlines, these gateway links provide communications between remote telemedicine facilities and the CHCs. The CHCs, located in major Indian cities, are connected via Integrated Services Digital Network (ISDN), with a redundant backup VSAT channel open.

Once a patient arrives at a telemedicine facility, the technician is informed of the patient's condition. The facility enters patient data into clinical-management software (e.g., GE's EMedscope) that allows maintenance, access, and transfer of clinical records. The clinical records are stored in a centralized database running on a secure server. Data transfers are made through the software's web interface or through Remote-Access Services. The software application stores images, provides hospital and referral information, schedules visitation, maintains account and clinical data, offers health education, allows reporting, and provides patients and physicians secure access to all updates over the Internet. Once patient records and history are entered and updated, a consultation is requested and a series of preliminary diagnostic tests are performed using available telemedicine equipment. Patient data is digitized and fed into the patient/image distribution client that is linked to the clinical-management software for scheduling remote consultations.

Most telemedicine services are free and aimed toward remote, underprivileged population with little or no access to necessary health care. For the rest, a nominal charge is stipulated to reconcile the marginal costs of communication and equipment maintenance. Installation costs per telemedicine unit are about \$30 000—quite expensive by Indian standards. The Indian government has stepped in to subsidize upcoming telemedicine ventures and defray end-user costs. In addition, ISRO's upcoming Telemedicine satellites are expected to reduce installation costs from \$30 000 to \$10 000 per facility—an average savings of about 66.7%.

III. Specific Cases of Telemedicine Projects in India

In recent years, India has had some successful telemedicine projects. In addition to treating ailments, telemedicine projects also provide health education and preventative health care to people in remote areas where ignorance is a primary reason behind ailments. Below are descriptions of three large initiatives.

Apollo Hospitals: One major institution providing telemedicine to people in India is the Apollo Hospitals Group. The Apollo Hospitals system, founded in 1987, has become one of Asia's largest private health-care groups and the seventh largest in the world. The Apollo Project has opened remote telemedicine centers that link villagers via satellite to specialist services. Table II offers an overview of Apollo's telemedicine infrastructure and services.

Apollo's Aragonda project was India's first rural telemedicine station [16]. Aragonda is typical of other Indian villages with few registered medical practitioners and rampant malaria, among other diseases. With the Aragonda project, the village was connected to the Apollo hospitals in Chennai bringing tertiary care to the doorsteps of patients [16]. Today, the Apollo project has expanded with telemedicine centers at Bangladesh and multiple sites in India. Each center is now connected to the tertiary care Apollo hospitals [16]. The Apollo Hospitals also facilitate Army Hospitals in South India via a network hub to its telemedicine facilities [11]. Given current

TABLE II
APOLLO TELEMEDICINE ENTERPRISES: INFRASTRUCTURE AND SERVICES PROFILE

Organization	Apollo Hospitals
Program Name & Inception	Apollo Telemedicine Enterprises Limited; 1999
Locations (States)	South India (Tamil Nadu, Andhra Pradesh), North India (Delhi), and East India (Orissa, Assam, Nagaland, West Bengal)
Health Network	Hospital (Private and Public), Outpatient Clinics, Military Bases
Application Orientation	Cardiology, Dermatology, Emergency, Radiology, Rheumatology, Nephrology, General Consulation
Non-Clinical Activities	Health Education, Web development, Research, and Administration
Number of Sites	45
Content Delivery	Telephone, Interactive with still and video images, Store and forward
Equipment	PC and Standalone Video-Conferencing, TeleRadiology System, Home Care Units
Peripherals	BP Monitor, Spirometer, Ultrasound, Tele-ECG, Digital Camera, Stethoscope, Glucometer, Document Camera
Connectivity	POTS/Wireless/VSAT/ISDN
Sponsors	Indian Government, ISRO, GE, Wipro

TABLE III
OTRI INFRASTRUCTURE AND SERVICES PROFILE

Organization	Online Telemedicine Research Institute (OTRI)
Program Name & Inception	Gujarat TeleMedicine Network (GTN) Project; 1998
Locations (States)	West India (Gujarat, Mahrashtra), South India (Karnataka), East India (Assam, Tripura, West Bengal), and North India (Uttar Pradesh)
Health Network	Private Hospitals, 225 Online Tele-Hospitals, Mobile Clinics, Military Bases
Application Orientation	Cardiology, Radiology, Pathology, Opthalmology, Nephrology, General Consulation
Non-Clinical Activities	Health Education, Web development, Telemedicine Systems Development, Research, Disaster Management, and Administration
Number of Sites	> 200
Content Delivery	Telephone, Interactive with still and video images, Store and forward
Equipment	PC and Standalone Video-Conferencing
Peripherals	BP Monitor, Ultrasound, Tele-ECG, Digital Camera, Stethoscope, Event Recorder, PTZ Camera,
Connectivity	POTS/Wireless/VSAT/ISDN
Sponsors	ISRO, Indian Government, Industry

plans, nine major army hospitals in five states will be linked to the two Apollo PHC facilities for consultation. These units have the capability to remotely serve soldiers in war time and during disaster relief [14].

Online Telemedicine Research Institute (OTRI, Gujarat): OTRI heralded a new era of expertise by starting the first ever statewide telemedicine network in India under the “Gujarat Telemedicine Network” Project. Table III provides an overview of OTRI’s infrastructure and services. OTRI has operation centers in several states, with application development and equipment manufacturing capabilities [1]. The institute has also introduced a health card which allows entire families to have complete physical examinations at a minimal cost without having to travel far to consult specialists.

OTRI has made a great impact on the lives of people living in the western part of India. On January 27, 2001 an earthquake devastated the western city of Bhuj and left thousands dead and many more homeless. Within a day, the OTRI in Ahmedabad, about 300 km from Bhuj, established satellite telephone links and set up all the equipment necessary to provide emergency medical care through telemedicine. The satellite phones were soon replaced by VSAT with phone lines and ISDN, and much of the imaging and data transfer were mediated by Pentium 3 based personal computers. A full-fledged telemedicine system was used for teleconsultation in pathology, radiology, and cardiology over ISDN lines, and between district hospitals near Bhuj and others in Ahmedabad. In one month, 750 sessions involving primarily X-rays and electrocardiographs of patients in the disaster area were transmitted to specialists in Ahmedabad thus saving lives [4].

TABLE IV
ASIA HEART FOUNDATION: INFRASTRUCTURE AND SERVICES PROFILE

Organization	Asia Heart Foundation
Program Name & Inception	Integrated Telemedicine and Telehealth Project; 1999
Locations (States)	North-East (Assam) and South India (Karnataka)
Health Network	Hospital (Private and Public)
Application Orientation	Cardiology, Pediatrics, Public Health, General Consulation
Non-Clinical Activities	Health Education, Research, and Administration
Number of Sites	18
Content Delivery	Telephone, Interactive with still and video images, Store and forward
Equipment	PC-Based Video-conferencing and Webcam
Peripherals	ECG, Event Recorder, Scanner
Connectivity	POTS/VSAT/ISDN
Sponsors	Indian Government, ISRO

Asia Heart Foundation: The Asia Heart Foundation is a not-for-profit charitable organization, established with the objective of providing cardiac care to the general populace. The Asia Heart Foundation’s telemedicine initiative “Integrated Telecardiology and Telehealth Project” (ITTP) aims at taking cardiac care to the nation’s deprived rural and remote population, thereby “bridging the critical knowledge gap” in cardiac care services provided in rural and metro areas. All of ITTP’s telemedicine units are linked to its CHCs in Calcutta and Bangalore. Several state governments provide the basic infrastructure and the Foundation’s doctors do all treatments. The Foundation uses innovations in information and communication technologies including space technology and VSATs developed by the ISRO [1]. Encouraged by the success of the first ITTP project at Siliguri, India, a second ITTP project was also started in the same state in July 2001. With strong support from state governments and ISRO, ITTP offers the largest telemedicine network in India. Table IV provides details of services offered by the Asia Heart Foundation.

IV. DISCUSSION

The role played by telemedicine in alleviating health-care crises during natural disasters, religious festivals, and military operations has triggered government sponsorship and elevated its status. A federally mandated telecommunications backbone and protectionist policies had allowed few entrants in this sector; however, the sector is slowly evolving to emergent competitors, especially in wireless telephony. But telemedicine adoption remains shrouded in a multitude of factors. Telemedicine facilities exist only in a few regions and communities in India. Initial costs of the technology and connectivity are still prohibitive. We identify several potential critical success factors that could help telemedicine proliferate in India.

1) Set Clear Program Objectives: Specific project goals need to be determined, drafted, and implemented in phases. This enables application developers and organizations involved to measure performance. For example, ITTP focuses on telecardiology while combining expertise in hospital management and consultancy. OTRI focuses on both generic and specialist telemedicine solutions ranging from radiology to general consultations.

2) Garner Government Support: The Indian government has provided strong support for telemedicine projects in the region. The federal government initiated the "Development of Telemedicine Technology" project to give impetus to telemedicine. This initiative was launched after the Ministry of Communications and Information Technology classified telemedicine as one of the thrust areas [17]. The government has reduced various import restrictions, and in some cases, eliminated import duty charges on medical equipment and communications technologies [16]. Successful telemedicine initiatives are funded by state governments. Although moves by the Indian government are encouraging and facilitating telemedicine, the process is still mired in bureaucracy and protectionist policies.

3) Adapt User-Friendly Interfaces: Simple user-friendly interfaces allow importing and exporting information to existing databases and the capability to integrate with other databases using any transmission channel [12]. India, with more than 20 official languages and many more unofficial ones, has commonly developed and used user interfaces in English, which is India's official language for business. Sadly, the choice of language reduces usability of the technology as most of the literate Indian population are versed only in their regional languages and follow their own scripts. There has been a nationwide initiative to use open-source systems (e.g., Linux, BSD) and customize them regionally to increase usability. For example, the "IndLinux" project by the Indian Institute of Information Technology in Bangalore is developing a customized operating system interface in two south-Indian languages.

4) Determine Accessibility Via Telecommunications and Internet Connectivity: Connectivity is a major concern, as many of the remote villages do not even have basic telephone lines. Most of the telemedicine projects tend to use the Internet to schedule consultations, transfer patient history, and transmit images and scans. The Internet seems to be a viable transmission alternative in cases where the level of service can be guaranteed, including a consistent level of bandwidth end-to-end as well as high reliability and security [6]. However, dire concerns remain for landline connectivity, given the low teledensity levels. To address this problem, most telemedicine projects use low-cost satellite connectivity such as VSAT for their routine transmissions [8]. With the diversity in terrain in India, satellite communication may be the best way to transmit images and information because they provide 100% uptime. ISRO has committed toward expanding India's reach and range with their indigenous satellites.

5) Implement Standards and Protocols: Standards for both telemedicine technology and telecommunications based on clinical practice requirements have enabled most sites and services technically interoperable (regardless of the communications vendor used). HL7 and DICOM are two standards that have been used for telemedicine in India [15]. Although these standards maintain the protocol to be followed in telemedicine [13], it should be cautioned here that there still exist potential legal and security issues, such as the ownership and dissemination of sensitive information—issues that must be addressed to protect the interest of both doctors and patients [16].

6) Measure Cost-Effectiveness and User Satisfaction: It is interesting to note that most of India's telemedicine services have been free and recipients have been generally satisfied. It is also to be noted that the concept of telemedicine is shrouded in hype. The very notions of remote health monitoring, consultation, and use of digital medical equipment tend to positively bias the general populace first encountering such technologies. It will be important to ensure that quality of services is perceived with equal optimism even when the patients are charged a nominal fee and have grown habituated to this "remote marvel." Efforts should balance costs and quality of health-care delivery.

V. Conclusion

Telemedicine can open a world of health-care delivery by building clinical bridges between patients and available health care, albeit contingent upon the costs and development of ancillary infrastructure and services [2], [8]. The telemedicine experiences in this study transcend India. Such experiences could have far-reaching benefits for poorer communities in developed countries as well as for developing countries. For example, there have been several implementations of telemedicine to address the extremely poor medical infrastructure in sub-Saharan Africa which is home to 33 of the 48 least developed countries of the world. The many health-care problems, such as HIV/AIDS, malaria, and other killer diseases, coupled with an acute shortage of health-care workers, have led to the adoption of telemedicine.

Telemedicine has and continues to benefit the Indian health-care system in terms of preventive care and disease treatment. Several technology companies (Tata Consultancy Services, Wipro, Pentafour Software, and Tata Unisys) are in the process of providing the telecommunication support needed for telemedicine [7], but much remains to be accomplished before telemedicine can reap its touted benefits for India's exponentially growing population.

India is in a unique position for building its telemedicine infrastructure. With its educated medical practitioners and an emerging technological industry, the country has the opportunity to create a multitude of products and services to cater to this evolving area. Given proper access and awareness, India seems poised to incorporate telemedicine beyond its current rudimentary projects to large-scale programs that can serve as a model for itself and the developing world.

References

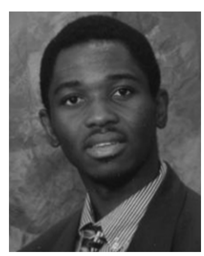
[1] (2003, Mar.) Telemedicine makes its debut in India. [Online]. Available: http://newsarchives.indiainfo.com/2000/04/12/tele.html

[2] F. Cobb Payton, "E-health leading to B2E commerce in the human resource function," *J. Organizational Computing Electron. Commerce*, vol. 13, no. 2, pp. 147–161, 2003.
[3] K. Ganapathy. (2002, Dec.) Telemedicine in India—The Apollo experience. [Online]. Available: http://www.thamburaj.com/telemedicine.htm
[4] G. Harris, "India: Telemedicine's great new frontier," *IEEE Spectr.*, vol. 39, no. 4, pp. 16–17, Apr. 2002.
[5] E. Haslino, "Health informatics in developing countries—Experiences and viewpoints," in *Proc. IFIP—IMIA World Congress on Medical Informatics and Developing Countries*, Westminster, Sep. 8–9, 1982.
[6] T. L. Huston and J. Huston, ""Is telemedicine a practical reality?" Association for computing machinery," *Commun. ACM*, vol. 43, no. 6, pp. 91–95, Jun. 2000.
[7] S. Kelly, "The jewel in the crown," *Comput. Weekly*, no. 34, pp. 22–24, Aug. 22, 1996.
[8] V. W. A. Mbarika, "Telemedicine in Africa—A possible panacea for sub-Saharan Africa's medical nightmare," *Commun. ACM*, vol. 47, no. 7, pp. 21–24.
[9] R. Milstein, "TeleMedicine—Creating virtual certainty out of remote possibilities. An international, comparative analysis of policy, regulatory and medico-legal obstacles and solutions," The Department of Human Services, State of Victoria, Australia, Jan. 1999.
[10] C. J. L. Murray and A. D. Lopez, *The Global Burden of Disease*: World Health Organization, Harvard School of Public Health, World Bank, 1996.
[11] "News-India: Army hospitals to have telemedicine facilities," Indo-Asian News Service, Jan. 3, 2003.
[12] W. Raghupati, "Health care information systems," *Commun. ACM*, Aug. 1997.
[13] "ISRO—Apollo pilot telemedicine project in India, Space technology applications—Satellite communications applications," United Nations, http://www.unescap.org/icstd/space/documents/telehealth/isro.htm., 2001.
[14] J. A. Rodger and P. C. Pendharkar, "Using telemedicine in the department of defense," *Commun. ACM*, 2000.
[15] S. Salam. (2002, Jun.) Telemedicine: Hype vs. reality. *Express Healthcare Management* [Online]. Available: http://www.expresshealthcaremgmt.com/20 020 630/medtech1.shtml
[16] S. P. Sood, "India telemedicine venture seeks to improve care, increase access," *TeleMedicine Today*, pp. 25–26, Oct./Nov. 2002.
[17] ——, "Telemedicine: Emergence of the virtual doctor," *Express Comput.*, Mar. 10, 2003.
[18] "Online telemedicine research institute," in *1st Annu. Conf. TeleMedicine Society of India (OTRI 2002)*, Lucknow, India, Oct. 22–24, 2002. Telemed 2002.
[19] (2003) TeleMedicineVision. [Online]. Available: http://apollohospitalgroup.com/vision.htm
[20] (2005, Feb.) TeleMedicine now in rural pockets of western India. *The Times of India* [Online]. Available: http://timesofindia.indiatimes.com/
[21] World Factbook 2002. Central Intelligence Agency. [Online]. Available: http://www.cia.gov/cia/publications/factbook/
[22] "World Health Report," World Health Organization, 2001.
[23] T. Finch, C. May, F. Mair, M. Mort, and L. Gask, "Integrating service development with evaluation in telehealthcare: An ethnographic study," *British Med. J.*, vol. 327(7425), pp. 1205–1209, Nov. 22, 2003. Rev.
[24] P. A. Jennett, H. L. Affleck, D. Hailey, A. Ohinmaa, C. Anderson, R. Thomas, B. Young, D. Lorenzetti, and R. E. Scott, "The socio-economic impact of telehealth: A systematic review," *J. Telemed. Telecare*, vol. 9, no. 6, pp. 311–20, 2003. Rev.
[25] R. Roine, A. Ohinmaa, and D. Hailey, "Assessing telemedicine: A systematic review of the literature," *Can. Med. Assoc. J.*, vol. 165, no. 6, pp. 765–771, Sep. 18, 2001.
[26] P. Swinfen, R. Swinfen, K. Youngberry, and R. A. Wootton, "A review of the first year's experience with an automatic message-routing system for low-cost telemedicine," *J. Telemed. Telecare*, vol. 9, pp. S63–S65, 2003. Supply 2.
[27] S. Tachakra, X. H. Wang, R. S. Istepanian, and Y. H. Song, "Mobile e-health: The unwired evolution of telemedicine," *Telemed. J. E. Health*, vol. 9, no. 3, pp. 247–257, 2003. Fall, Review.
[28] A. Ayyagari, A. Bhargava, R. Agarwal, S. K. Mishra, A. K. Mishra, S. R. Das, R. Shah, S. K. Singh, and A. Pandey, "Use of telemedicine in evading cholera outbreak in Mahakumbh Mela, Prayag, UP, India: An encouraging experience," *Telemed. J. E. Health*, vol. 9, no. 1, pp. 89–94, 2003.
[29] J. Deodhar, "Telemedicine by email—Experience in neonatal care at a primary care facility in rural India," *J. Telemed. Telecare*, vol. 8, pp. 20–21, 2002. Supply 2.

Amrita Pal (M'04) received the Masters degree in English from University of Calcutta, India, in 1996, the Masters degree in library and information science and the Masters degree in information systems and decision sciences from Louisiana State University (LSU), Baton Rouge, LA, in 2001 and 2003, respectively.

She has worked as a Data Analyst/Programmer at Shell, Houston, TX, from 2003 to 2004. At present she is the Systems Librarian with JCI at U.S. Geological Survey National Wetlands Research Center, Lafayette, LA. Her research interests include telemedicine, bioinformatics, diffusion of technology in developing countries, databases, and health care. She has been very involved with web development, systems networking, data warehouses, database security, data mapping, and data modeling using ETL tools, software applications for data processing, biological informatics, information science, information technology, and biological invasions.

Ms. Pal was formerly a Member of the Data Management Association, 2003–2004.



Victor W. A. Mbarika (M'00) received the B.S. degree in management information science (MIS) from the United States International University, Nairobi and San Diego, CA, in 1995, the Masters degree in MIS from University of Illinois at Chicago, IL, in 1997, and the Ph.D. degree in MIS from Auburn University, Auburn, AL, in 2000.

He is on faculty at the College of Business, Southern University and A&M College. His research in multimedia learning and telecommunications diffusion in developing countries has been published (or are forthcoming) in 20 academic journals, four book chapters, and over 35 national and international conference publications on information systems. He is Founder and President of Cameroon Computer and Network Center (CCNC). He has published a book *Africa's Least Developed Countries' Teledensity Problems and Strategies* (Yaoundé, Cameroon: ME & AGWECAMS Pub.).

Dr. Mbarika has received several instructional and research awards.

Fay Cobb Payton received the Ph.D. degree in information systems, with a specialty in health care information technology (IT), from Case Western Reserve University, Cleveland, OH.

She was a General Electronic Fellow with Case Western Reserve University. She is an Assistant Professor of Information Technology at North Carolina State University, Raleigh, NC. She has worked in the industry and/or collaborated on research projects with Ernst and Young/CAP Gemini, International Business Machines, Blue Cross Blue Shield of Ohio and North Carolina, Duke Medical Center, The North Carolina Medical Society, Quintiles Transnational, and Time-Warner. Her research interests include the digital divide, IT diversity, health care, and data management. She has published papers in *Communications of the ACM*, *Health Care Management Review*, *Information and Management*, *Journal of Organizational Computing and Electronic Commerce*, *Communications of the AIS*, and *International Journal of Technology Management*.

Dr. Cobb Payton was honored as the 2003 Greater Triangle YWCA Woman of the Year in Science and Technology.

Pratim Datta is an Assistant Professor of Information Systems at Washington State University, Pullman, WA. His research interests include information technology (IT) infrastructure design and productivity, virtual reality, knowledge management, and global IT. He has published papers in AIS and ACM journals and international conferences such as ICIS and HICSS.

Scott McCoy received the Ph.D. degree in information systems from the University of Pittsburgh, PA.

He is an Assistant Professor of Management Information Science in the School of Business, College of William and Mary, Williamsburg, VA. His research in cross cultural issues in information science, human–computer interaction, information technology accessibility, and telecommunications policy has been presented in several national and international conferences. Journals in which his work appears include *International Journal of Cross Cultural Management*, *Communications of the ACM*, *Communication of the AIS*, *Information Technology and People*, and the *Journal of the Association for Information Systems*.