Telemedicine and tele-health services for cancer-care delivery in India

S. Sudhamony, K. Nandakumar, P.J. Binu and S. Issac Niwas

Abstract: Non-communicable diseases including cancer are emerging as major public health problems in India. Awareness of cancer and its management are being taken as a high priority at the national level because of the increase in the incidence of the disease in the country. Telemedicine provides expert-based health care to understaffed remote sites and advanced emergency care through modern telecommunication and information technologies. The incidence of cancer can be reduced if the people are aware of cancer and its root causes. Recently, the introduction of telemedicine in oncology plays a vital role. Telemedicine helps in prevention, early detection, a faster cure, palliative care and rehabilitation in the management of cancer. The status of telemedicine services for cancer care in Kerala, India, and how telemedicine can be an effective solution of cancer-care delivery in India are explored.

1 Telemedicine—an overview

Telemedicine is the transfer of electronic medical data (i.e. high resolution images, sounds, sometimes video briefings, records of specific operations and patient records) from remote areas to centres where experts or well-equipped hospitals are available [1–3]. Taking advantage of telecommunication, medical electronics and information technologies, telemedicine acts as a potential source to reduce health-care expense, improve health-care service in remote areas and support modern home health care and so on [1]. Telemedicine can deliver health-care services to places where distance is the critical factor. Recent works in communication technologies have inspired the development of telemedicine to a large extent. There are many different disciplines in telemedicine, such as teleradiology, telepathology, telecardiology and so on [2, 3]. The common problem faced during the development of a telemedicine system is how to integrate the existing techniques to meet requirements for telemedicine applications [4–6].

The people in India, particularly in rural and remote areas, are found struggling to receive timely medical treatment. The region of the country is characterised by densely populated communities spread over vast distances and there is a lack of expert physicians in certain sectors of the health service. Telemedicine originally emerged to serve rural populations or anyone who is geographically dispersed, where time and cost of travel make it difficult to receive the best medical care. Nowadays, telemedicine is forming a new structure in health-care services [7–10]. By using information and communication technologies, the health-care professionals in specialised fields, such as cardiology, urology, oncology, psychiatry, surgery and many others, can access or exchange information for diagnosis, treatment and prevention of disease. This new age concept also provides solutions for continuing education and research among health-care providers to improve the health of individuals and their communities [11–14]. Thus, telemedicine facilitates the delivery of the right medical advice at the right place at the right time using new computer-based communication technologies for medical purposes.

2 Impact of cancer and its eradication in India

Cancer, as experts say, is likely to emerge as the largest killer in India by 2020 if the present trend continues [15]. Data from population-based registries under the National Cancer Registry Programme indicate that the vulnerable sites of cancer are oral cavity, lungs, oesophagus and stomach among men and cervix, breast and oral cavity among women. World Health Organisation (WHO) has estimated that 91% of oral cancer in South-East Asia is directly attributable to the use of tobacco and this is the leading cause of oral cancer and lung cancer in India [16]. It is evident that the most common cancers are largely preventable. But, it is very difficult for these patients to get cured and they are always treated by palliative care with much cost and morbidity. The facilities for creating cancer awareness, screening, diagnosis, treatment, that is, multidisciplinary approach, radiation treatment facilities, availability of cancer chemotherapeutic agents and palliative care facilities are not sufficient to meet the needs of cancer-afflicted patients [17].

The tribulations are addressed as follows.

- Lack of information about prevention and other matters among the general public.
- Lack of facilities for early cancer detection in rural areas and also long travel for the patient to attend follow-up clinics.
- Non-availability of expert opinion at nodal centres and rural areas and of certain diagnostic equipment at nodal centres.
- Difficulty for oncologists and other doctors to keep up with the latest knowledge in cancer care and difficulty in updating the National Cancer Registry in time.
Need-based planning and optimal use of the limited resources is essential to control cancer in India. Therefore it is reasonable to postulate a strategy for cancer control in India to be focused on health education for the rural population and the creation of an infrastructure for cancer management [18]. There is an urgent need to increase the reach of the specialised services available and reduce the time delays in patient referral for specialist opinion. Presently, there are about 25 regional cancer centres (RCCs) in almost all the states of India. A few of them have reasonably well-advanced facilities for diagnosis and treatment. According to the survey, ~25 000 cancer patients will need follow-up consultations every month at the different RCCs in India [19].

3 Telemedicine in Oncology

Treatment of cancer has been a challenge to health-care providers worldwide. Cancer has been the subject of much research, and every year new discoveries are being made which contribute to patients’ treatment. Newer drugs, newer investigations and newer procedures for treatment have changed the outlook of the disease today. However, thousands of people are still suffering and having painful deaths every year. Added to all this chaos is the unease that the patient has to have follow-up consultations. Establishment of an oncology network can be an effective solution to provide telemedicine services in cancer detection, treatment, patient’s follow-up and continuity of care in remote-site hospitals [20–25].

4 ONCONET: cancer care for rural masses (ONCONET-Kerala)

Kerala is a state in southwest India with a population of 31 million. In this state, well-integrated health-care service is provided by the government and private sectors. Kerala is the first state in India to have formulated a cancer-control programme in 1988 [16]. The RCC, Thiruvananthapuram (RCC-T), Kerala, is a tertiary referral cancer hospital catering to South India. Approximately 10 000 new patients register and undergo treatment every year. Because of the geographical locality of Kerala, cancer patients have to travel long distances, spending relatively large amounts of money to come to the RCC-T for regular follow-up examinations (Table 4). The number of patients on follow-up is approximately 100 000 per year [19].

With a view to alleviate the suffering of cancer patients to the maximum extent, ‘ONCONET-Kerala’ telemedicine project was implemented by the Centre for Development of Advanced Computing, Thiruvananthapuram [C-DAC(T)], a scientific society of the Department of Information Technology, Ministry of Communications and Information Technology, Government of India, and launched at RCC-T.

4.1 Main objective

ONCONET-Kerala is a comprehensive telemedicine solution, which has established a knowledge-enabled oncology network connecting the specialty hospital at RCC-T with remote hospitals at various places in Kerala (Fig. 1). It provides telemedicine services in early cancer detection, follow-up consultation, treatment, prevention of cancer and tele-education.

4.2 System requirements

The system requirements include the following.

1. A high-bandwidth wide area network connecting RCC-T with its remote nodal hospitals to transfer electronic medical record (EMR) and for real-time audio/video communication enabling patient–doctor interaction.
2. Creation of EMR includes demographic details, expert opinion, clinical information consisting of pathological/radiological images and investigation reports.
3. Storage of the EMR at a central location at RCC-T.

Fig. 1 System architecture of ONCONET-Kerala
4. Access to the EMR from the remote centres by authorised users through the network.
5. Capturing medical images directly from clinical devices such as the digital microscope and X-ray film scanner.
6. Sharing images with expert doctors at the specialty hospital.
8. Compliance with industry standards such as HL-7 and digital imaging and communication in medicine (DICOM).
9. Redundant back-end servers, which act as central patient data repository at the data centre of RCC-T.

### 4.3 Major features

Features of ONCONET-Kerala include telemedicine network with 384 kbps bandwidth, furnished tele-consultation clinic, video-conferencing system, telemedicine software for real-time transfer of patient data, telepathology, teleradiology, web-based telemedicine system tightly integrated with the hospital information system (HIS) and the oncology resource centre.

### 4.4 Network architecture and connectivity

A tele-oncology network is established between RCC-T and early cancer detection centre at different remote places such as Kannur, Kochi, Palakkad, Kozhencherry and Kollam (Fig. 1). The project is endowing the telemedicine services to the remote nodal centres by using a high-bandwidth connectivity of 384 kbps through a very small aperture terminal (VSAT) (Fig. 2) provided by Indian Space Research Organisation (ISRO) which is the service provider of satellite network for telemedicine applications in India. The satellite network has a hub and VSATs based on IP technology. The connectivity is provided through a demand assigned multiple access (DAMA) pool by a central hub at Bangalore, which has a network monitoring control system. Currently, the connectivity is provided in the mesh configuration. Adoption of new technology viz. Digital Video Broadcast-Return Channel Satellite is being initiated with independent telemedicine hub [26].

This network will operate in Ku-band against the existing network in extended C-band. It will also operate in a star configuration to provide a low-cost solution, since transportation of a bigger terminal to the hilly terrain and scattered islands of the country are difficult and expensive. The Ku-band system is expected to reduce the size of VSAT antenna and the cost of the terminal to as low as about US $4000 [26]. The new technology has the capability to provide multi-node connectivity with low-cost electronics.

As a back-up arrangement, ONCONET-Kerala network also has the optional connectivity of 128 kbps by an ISDN connection through terrestrial lines. Network communication is achieved using TCP/IP as network protocol, which facilitates reliable data transmission and interoperability by different telecommunication means (Satellite and ISDN).

### 4.5 System design

The application system follows the recommended guidelines and standards for practice of telemedicine in India [27, 28].

#### 4.5.1 Video-conferencing system: Interaction between the patient and doctor is provided with the help of video-conferencing systems which meet the communication requirements as given in Table 1. The system has followed the international video-conferencing standards: H.320 for ISDN, H.323 for IP communication, H.264 for video codec, G.722 and G.728 for audio codec as well as T.120 for document sharing.

#### 4.5.2 Telemedicine infrastructure: Specialty centre at RCC-T includes the following infrastructure.

1. Telemedicine network: VSAT connectivity with a synchronous data-transfer rate of 384 and 128 kbps ISDN.
2. Video-conferencing system using multi-point-SONY PCS 1P [resolution: common intermediate format (CIF) 352 pixels × 288 lines; frame rate: maximum 30 fps; colour system: PAL system] [29] and 29” flat television.
3. Telemedicine PC.
4. Oncology Resource Centre with digital library connected to the RCC-T Intranet and VSAT network.
5. Digital microscope (Leica DM LS2) and A3 size X-ray film scanner (U-max) with transparency adapter.
6. Web-based HIS with redundant database servers, application servers and web servers (Xeon server on Linux platform).
7. PC at all departments of RCC-T (approximately 120 thin clients).

Each nodal centre includes the following infrastructure:

1. Telemedicine network with 384 kbps VSAT connectivity and 128 kbps ISDN.
2. Video-conferencing system using single point-SONY PCS 1600P (resolution: CIF-352 pixels × 288 lines; frame rate: maximum 30 fps; colour system: PAL system) [30] and 29” flat television.
3. Telemedicine PC.
4. Telepathology/teleradiology system with PC, digital microscope (Leica DM LS2) and A3 size X-ray film scanner (U-max) with transparency adapter.

#### 4.5.3 Web-based telemedicine software and HIS:

Telemedicine software is used to create, store and share the EMR of patients. Telepathology/teleradiology system with a digital microscope and an X-ray film scanner used for capturing medical images is compatible with this
Dicomography. The essence of the Dicom standard is that it prescribes a uniform, well-understood set of rules for the communication of digital images [32]. Dicom was originally developed for black and white still images in radiology. The current version Dicom 3.0 permits colour and moving images [33]. Non-Dicom images can also be captured and converted to Dicom format. The system can interface with any clinical equipments which are Dicom and TWAIN (standard for acquiring images from image scanners) compatible [34]. This software is installed in RCC-T and its remote hospital centres. Using this telemedicine software, the physician can quickly add notes on the patient’s progress, create reports, give advice and so on. Patients’ details including clinical information are captured as and when the patient approaches different departments such as the outpatient department, admissions/discharge/transfer, consultation and investigation room and so on. To seek the opinion of a specialist using tele-consultation, the doctor can connect to the specialist’s PC from within the telemedicine software. The advice, reports and so on, that are the outcomes of the tele-consultation are sent back to the presenting doctor, to print and pass on to the patient. There are times when the specialist would work alone; telemedicine software also provides for offline editing of the EMR and subsequent data uploading.

Case records are available over the network at the remote nodal centres, and using the unique identification number of each patient, relevant information can be retrieved. The telemedicine software tightly integrated with the web-enabled HIS software called telemedicine-enabled Java-based hospital automation system (TEJHAS) is deployed at RCC-T, with the identified 20 modules grouped under three main heads, viz. core services, support services and back office.

Table 2: Modules of web-based HIS-TEJHAS

<table>
<thead>
<tr>
<th>Modules of TEJHAS (Telemedicine Enabled Java-Based Hospital Automation System)</th>
<th>Core services</th>
<th>Support services</th>
<th>Back office</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient management</td>
<td>Cash and billing</td>
<td>Enquiry</td>
<td></td>
</tr>
<tr>
<td>Consultation</td>
<td>Central stores</td>
<td>Management information system</td>
<td></td>
</tr>
<tr>
<td>Surgical oncology</td>
<td>Purchase</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resource Scheduling</td>
<td>Blood bank</td>
<td>Master data</td>
<td></td>
</tr>
<tr>
<td>Investigation</td>
<td>Radiology</td>
<td>Users</td>
<td></td>
</tr>
<tr>
<td>Nuclear medicine</td>
<td>Engineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Radiation oncology</td>
<td>Central sterile services</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemotherapy</td>
<td>Department</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pharmacy</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Table 2: Modules of web-based HIS-TEJHAS

Table 3: Software architecture of TEJHAS

<table>
<thead>
<tr>
<th>Software architecture of TEJHAS</th>
<th>Front end</th>
<th>Back end</th>
</tr>
</thead>
<tbody>
<tr>
<td>HTML, JSP</td>
<td>RDBMS–Oracle 10 g</td>
<td></td>
</tr>
<tr>
<td>J2EE, EJB, JSP and Struts</td>
<td>JDeveloper 10 g</td>
<td></td>
</tr>
<tr>
<td>integrated development environment</td>
<td>Linux Enterprise Server 3.0</td>
<td></td>
</tr>
<tr>
<td>Operating system</td>
<td>Oracle 10 g AS</td>
<td></td>
</tr>
<tr>
<td>Application server</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.4.4 Oncology resource centre: Oncology resource centre is another major component of ONCONET-Kerala that provides cancer-related information to clinicians, researchers, health planners and administrators. An integrated oncology digital library with knowledge management capabilities has been set up at RCC-T. This digital library is available on the telemedicine network, hospital intranet and on the Internet for authorised users.

4.6 Benefits of ONCONET-Kerala

Expenditure from remote hospital centre to RCC-T per patient along with a helper is shown in Table 4. This expenditure included the travel expenses per patient along with the helper and their expenses for 2 days in Thiruvananthapuram. Table 5 shows the annual statistics report of ONCONET-Kerala during April 2005 to March 2006. It signifies the financial savings to both RCC and the cancer-affected patients from remote regions [19].

Some of the benefits of ONCONET-Kerala are as follows.

1. ONCONET incorporates the audio-, video- and data-conferencing capabilities. Most cancer patients on long-term follow-up need just reassurance from their doctor. Some patients might have a few specific problems that can be sorted out through follow-up tele-consultation. This enables collaborative clinical therapy by clinical discussion over the shared patient data and also enables expert opinion on patient treatment at remote sites.

2. Improved access to patient information. Medical test results are available at the remote sites. Patients on chemotherapy need their blood count checked and can obtain advice on this through tele-consultation. So, unnecessary patient referral to RCC-T is avoided.

3. Remote clinics obtain online suggestion on cytology images from experts at RCC-T. Oncologists can access up-to-date information on cancer treatment from anywhere.

Table 4: Expenditure per patient in US dollar (USD) along with a helper from each remote nodal centre to RCC-T

<table>
<thead>
<tr>
<th>Sl. no.</th>
<th>Name of the nodal centre</th>
<th>Distance from RCC-T in km</th>
<th>Expenditure per patient along with a helper to RCC-T in USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kannur</td>
<td>500</td>
<td>25.00</td>
</tr>
<tr>
<td>2</td>
<td>Kochi</td>
<td>220</td>
<td>14.00</td>
</tr>
<tr>
<td>3</td>
<td>Palakkad</td>
<td>372</td>
<td>21.00</td>
</tr>
<tr>
<td>4</td>
<td>Kozhenchery</td>
<td>140</td>
<td>7.00</td>
</tr>
<tr>
<td>5</td>
<td>Kollam</td>
<td>80</td>
<td>4.65</td>
</tr>
</tbody>
</table>

Table 5: ONCONET usage statistics during April 2005 to March 2006

<table>
<thead>
<tr>
<th>Name of the nodal centre</th>
<th>Number of follow-up patients using ONCONET in Kerala</th>
<th>Money saved by patients in USD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kochi</td>
<td>5859</td>
<td>102 681</td>
</tr>
<tr>
<td>Kannur</td>
<td>2012</td>
<td>49 755</td>
</tr>
<tr>
<td>Palakkad</td>
<td>159</td>
<td>2939</td>
</tr>
<tr>
<td>Kollam</td>
<td>112</td>
<td>700</td>
</tr>
<tr>
<td>Kollam</td>
<td>299</td>
<td>187</td>
</tr>
</tbody>
</table>

RCC-T can thus use its resources optimally and concentrate on patients who need active treatment.

4. The entire project will become a comprehensive system for the management of cancer at the state/national level.

5. Any private or government medical institution inside or outside the country can get connected to the ONCONET system and avail expertise from RCC-T oncologists.

6. Enables patients to have a real-time discussion with their specialist from a rural location and also enables the real-time transfer of patient demographics and images for the specialist’s interrogation.

7. Online registration and appointment at the specialty centre.

8. Facilitates to detect cancer at the early stages based on medical information of the patient and evacuate critical patients to RCC-T.

Thus, the project ONCONET-Kerala exhibits good quality in catering to the needs of cancer patient through video-conferencing and data-transfer functionalities. This venture has received a good response from thousands of patients in the rural areas of Kerala because of its benefits.

5 ONCONET-India

The epidemiological transition has already resulted in the emergence of cancer as a major public health problem in India. The success of ONCONET-Kerala stresses the point that it needs to be replicated so that the benefits of the telemedicine initiatives can reach all other parts of India.

Hence, it has been planned to implement the ONCONET-India network connecting 25 RCCs in India with the following objectives.

- To establish a knowledge-enabled oncology network among 25 RCCs and 100 remote-site hospitals in India and provide telemedicine services in cancer treatment, follow-up consultation, early cancer detection and cancer awareness generation through the network.
- To provide tele-education about cancer, a platform for uniform reporting, a base of surveillance and analysis of data about cancer patterns in the entire country.

In this proposed method, 25 RCCs will be connected to its remote-site hospitals with high bandwidth of 384 kbps VSAT connectivity from ISRO and also with uninterrupted high-bandwidth terrestrial broadband virtual private network connectivity of 512 kbps from Bharat Sanchar Nigam Ltd, India. By this method, a video-conferencing system, web-based telemedicine software to create, store and share the EMR of patients, and telepathology/teleradiology system with a digital microscope and an X-ray
film scanner to capture medical images will be installed at all locations. The proposed tele-oncology web portal will provide details about various departments, committees and directory of the member institutions associated with ONCONET-India and their responsibilities. It is also possible to access general interest articles, publications or journals related to cancer via the web portal. Hence, the rest of India is likely to follow the ONCONET-Kerala pattern in the coming years.

6 Conclusion

Telemedicine offers several advantages in the practice of oncology. The number of emergency visits to the hospital can be reduced. Unnecessary admissions can be avoided. At the same time, early intervention is facilitated. Routine follow-up visits by the patient can be limited in the remote-site clinic. Physician visits from the tertiary hospital to the rural/remote-site hospital can be cut down. Thus, by the use of telemedicine and tele-health services in ONCONET, not only doctors but also other professionals, researchers and decision makers can work to reduce the miseries of cancer patients. This system with appropriate low-cost technology might be able to be duplicated as a model for developing countries with low capital inputs.

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